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Associations between variety of fruits and vegetables consumed, diet quality and socio-demographic factors among 8th and 11th grade adolescents in Texas

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Abstract

Objective: To examine demographic and dietary correlates of consumption of a variety of fruits and vegetables (FV) among Texas adolescents. Different types of FV are needed for adequate dietary intake of vitamins and phytochemicals for proper development and functioning throughout the lifespan.

Design: Cross-sectional analysis from the Texas Surveillance of Physical Activity and Nutrition (Texas SPAN) data comparing consumption of a variety of fruit and vegetables by gender, race/ethnicity and region (Texas-Mexico border/non-border).

Setting: Middle, high schools in Texas.

Participants: 8th, 11th grade Texas adolescents (*n* 9056 representing *n* 659 288) mean age 14·8 years.

Results: Within this sample, mean fruit and vegetable variety scores (0–7) ranged from 2·47 to 2·65. Boys consumed a significantly greater variety of fruit than girls (mean = 1·12 compared with 1·04). Adolescents in non-border regions consumed a greater variety of vegetables and FV compared with those in border regions. FV variety was associated with healthier eating in the full sample, particularly in the highest socio-economic status (SES) tertile. Within the highest SES tertile, a one-unit increase in variety of fruit, vegetable and FV was associated with significant increases ($P < 0·001$) in a healthy eating measure, the SPAN Healthy Eating Index: Fruit variety ($\beta = 1·33$, SE = 0·29), vegetable variety ($\beta = 0·90$, SE = 0·28) and FV variety ($\beta = 0·81$, SE = 0·19).

Conclusions: Consumption of a greater variety of FV appears to be associated with a healthier overall diet. Associations of FV variety with healthy eating were most significant in the highest SES tertile. These findings support the need to further examine consuming a variety of FV within healthy eating behaviour.

Keywords
Fruit
Vegetable
Variety
Adolescent
Dietary
Nutrition

Adequate fruit and vegetable (FV) consumption is critical for proper physical and psychosocial development[1–4]. Low FV consumption is one of the top ten risk factors for mortality worldwide[1]. Approximately 14 % of gastrointestinal cancer deaths, 11 % of IHD deaths and 9 % of stroke deaths are estimated to result from inadequate FV consumption[1]. Despite widespread efforts, FV consumption in the USA remains below recommendations[1,4]. The 2015–2020 US Dietary Guidelines for Americans recommend 2·5-cup equivalents of vegetables/d and 2-cup equivalents of fruit/d for a 2000-calorie diet[4]. Further, weekly vegetable variety recommendations by subgroup based on 1800–2000 calories/d are starchy vegetables (5 cups), red/orange vegetables (5·5 cups), dark green vegetables (1·5 cups), other vegetables (4 cups) and legumes/beans and peas (1·5 cups)[4]. Aside from emphasising whole fruit over fruit juice, there are no fruit variety recommendations in the 2015–2020 Dietary Guidelines. Only 8·5 % of US high school students meet fruit recommendations and 2·1 % meet vegetable recommendations[5].

Consuming a variety of FV is another dimension of FV intake beyond overall quantity consumed, for example

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types or subgroups of FV consumed. Because different micronutrients are present in different types of FV, both FV variety and quantity are critical for optimal nutritional benefit[4,6]. For example, root vegetable consumption has been shown to be positively associated with β-carotene serum status, and consumption of citrus fruits has been shown to be positively associated with vitamin C and β-carotene status[6,7].

FV consumption and associated vitamin and nutrient intake are important for healthy growth and development during childhood and adolescence, and healthy functioning, including immune function, at all ages[4,6,8]. Health behaviours, including dietary behaviours, formed in childhood tend to track into adulthood[4], so FV consumption is important throughout childhood into adulthood.

A variety of demographic factors are associated with FV consumption in childhood and adolescence, including gender, age, race/ethnicity and socio-economic status (SES)[9,10]. Gender is associated with FV consumption and food preferences among adolescents[9–11]. School-age girls showed significantly higher preference for FV over boys[11]. Preferences explained 81 % of gender differences in FV consumption, which was higher among school-age girls than boys[12]. Links between child and adolescent FV consumption and age are documented, with FV consumption tending to decrease with age[13].

Multiple studies found significant differences by race/ethnicity in predictors and correlates of FV intake among youth[10,14–16]. Among low-income youth, FV intake was consistently higher among Hispanic youth compared with African American and White youth in a systematic review of FV intake determinants[14]. In contrast, in a nationally representative school-based survey of high school students, the median number of times of FV consumption/d was higher among White students than Hispanic/Latino or Black/African American students[17]. Further, significant differences have been found in FV intake correlates by minority/non-minority status[18] and SES[19].

While research on variety of FV consumed is limited, a recent study found that the reasons children reported for consuming or not consuming vegetables varied by type of vegetable. Some vegetables are consumed because they are liked (e.g. tomatoes, carrots, pumpkin, maize). Others are consumed because they are hidden among other ingredients (e.g. red peppers, onions, spinach), or because parents made the children eat them (e.g. zucchini). This study found varying reasons that vegetables are not consumed including because of texture (e.g. lettuce), colour (e.g. eggplant, cauliflower, green beans), taste (e.g. eggplant, beetroot, broccoli) or smell (e.g. cauliflower, broccoli). These differences by vegetable suggest that consumption behaviours cannot be generalised across vegetables[20]. Better understanding of behaviours and factors influencing consumption of a variety FV is crucial because of the importance of nutrient intake in childhood and adolescence, and the role of FV variety in nutrient and vitamin intake.

The purpose of this study is to examine associations between consumption of a variety of FV and demographic factors in a multi-ethnic, representative population of Texas adolescents in 8th and 11th grade. A second objective is to examine associations between consumption of a variety of FV and dietary quality as characterised by a healthy eating index and to determine whether these associations are modified by school-level SES.

Methods

Study design, setting, study population

This study used cross-sectional data collected as part of the 2015–2016 Texas School Physical Activity and Nutrition (Texas SPAN) surveillance study. Texas SPAN is a periodic, cross-sectional survey measuring obesity, diet and physical activity behaviours, and other health-related and demographic factors in a representative sample of students from selected grades across the state[21]. SPAN student questionnaires were administered in Texas middle and high schools with 8th grade and 11th grade students during the 2015–2016 school years[21]. Texas SPAN uses sampling representative of the Texas population by gender, race/ethnicity and grade[21]. A total of 9056 students were sampled, representing *N* 659 288. Data are weighted by gender, race/ethnicity (Hispanic/Latino, African American/Black and White/other) and region (Texas-Mexico border *v.* non-border) using a multistage probability-based study design[21,22].

The overall sample size (number of schools, with assumed constant cluster size of fifty students at each school) was powered to estimate the primary outcome of the study – true prevalence of obesity. For the state as a whole, the margin of error was ≤3 %, with power of 80 %, type-I error-level of 0·05, using a two-sided test. The prior round of SPAN data collection was used to estimate mean prevalence of obesity and expected participation rate for each grade level. More details on the sampling frame are published elsewhere[21,22].

Human subjects

Study protocols and measurement instruments were approved by (blinded). District- and school-level approvals were obtained for all measurements. Research staff were certified for research with human subjects and passed background checks prior to measurement. Student surveys were administered in classrooms with parental consent and child assent[21].

Measures

Fruit intake and variety

The Texas SPAN survey instrument includes two items assessing fruit intake, treated as two distinct fruit groups: whole fruits and 100 % fruit juice. Items measuring fruit and 100 % fruit juice have demonstrated reproducibility

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respectively (agreements = 73 %, κ statistic = 0·61, Spearman correlation coefficient = 0·79) and (agreements = 81 %, κ statistic = 0·71, Spearman correlation coefficient = 0·87)[23]. The items have acceptable validity relative to a 24-h dietary recall for fruit (agreements = 55 %, κ statistic = 0·33, Spearman correlation coefficient = 0·53) and 100 % fruit juice (agreements = 54 %, κ statistic = 0·33, Spearman correlation coefficient = 0·40)[23].

Response options refer to frequency of consumption during the previous day, and possible responses were 0 times, 1 time, 2 times and 3 or more times. Fruit intake scores range from 0 to 6. A fruit variety score was developed for this study, operationalised as having consumed an item at least once the day prior to measurement. One point was assigned for consumption on the previous day, while zero points were assigned if the item was not consumed. Possible scores were 0–1/item, with a total range of 0–2 for fruit variety (Table 1).

Vegetable intake and variety

The Texas SPAN survey instrument included five items assessing intake of vegetable subgroups: starchy vegetables, orange vegetables, green vegetables, other vegetables and beans/legumes (Table 1). Beans are included based on inclusion of legumes (beans and peas) as a distinct vegetable group in the 2015–2020 US Dietary Guidelines for Americans[4]. The item assessing legume/bean intake has demonstrated reproducibility (agreements = 93 %, κ statistic = 0·78, Spearman correlation coefficient = 0·85) and validity compared with a 24-h recall (agreements = 83 %, adj κ statistic = 0·59, Spearman correlation coefficient = 0·68)[23]. The item assessing vegetables from which these items were adapted also shows good reproducibility (agreements = 72 %, κ statistic = 0·60, Spearman correlation coefficient = 0·73) and acceptable validity as compared with a 24-h recall (agreements = 51 %, κ statistic = 0·32, Spearman correlation coefficient = 0·57)[23].

Response options for vegetable intake are consistent with those for fruits: 0 times, 1 time, 2 times and 3 or more times. Vegetable intake scores were calculated as the sum of times vegetable items were consumed; possible scores range from 0 to 15. For variety, each vegetable group was coded to a binary 1/0 measure based on whether or not the item was consumed at least once the day prior. Thus, the vegetable variety score created for this study was operationalised as a sum of the five vegetable groups for a total range of 0–5.

Total fruit and vegetable variety

Total FV variety was measured by summing the items used to measure fruit variety and vegetable variety. Total FV variety is operationalised here as the sum of different types of vegetables and different types of fruit measured by the Texas SPAN instrument (fruit variety and vegetable variety summed together). For example, consuming two types of vegetables (e.g. orange and green) and one type of fruit (whole fruit or fruit juice) would be scored as a total FV variety score of 3. Food selection questions from the Texas SPAN survey are shown to have good reproducibility (agreements ≥ 85 %, κ statistics 0·68, correlation coefficients ≥0·68) and are considered to have similar or better reproducibility than other instruments for this age group[22].

Variety tertiles

Approximate tertiles were created for vegetable variety and FV variety scores based on actual distribution of the data. Fruit variety tertiles were not created as there are only three possible scores (0, 1 or 2). The tertiles created for vegetable variety were low (0 types of vegetable; 30·79 % of respondents), middle (1 vegetable type; 27·24 % of respondents) or high (2 or more vegetable types; 41·96 % of respondents). FV variety tertiles were categorised as low (0–1 types of FV; 31 % of respondents), middle (2–3 types of FV; 42 % of respondents) or high (4 or more types of FV; 27 % of respondents).

Total fruit and vegetable intake

Total FV intake was operationalised as the number of FV servings consumed the day prior to data collection. This variable was constructed using the same items measuring FV variety; however, the number of times an item was consumed was quantified. Scoring was based on the number of times each of two fruit items was consumed: 0 times (0 points), 1 time (1), 2 times (2) or 3 or more times (3 points). Vegetable intake was scored using the same approach. Number of times consumed was used as a proxy for servings. Scoring and measurement items are presented in Table 1. Total FV intake scores were calculated as the sum of fruit and vegetable intake scores with a possible range of 0–21.

Surveillance of Physical Activity and Nutrition Healthy Eating Index

Healthy eating was described using a modified version of the SPAN Healthy Eating Index (SHEI). The SHEI is a composite variable that considers a variety of healthy foods and unhealthy foods. Healthy foods and unhealthy foods are scored, and the total unhealthy score is subtracted from the healthy foods score for a composite SHEI score scaled 0–100. This is shown to have good construct validity[21]. The SHEI was modified for this study to include a greater variety of foods. Healthy foods in the modified SHEI (mSHEI) include items such as grilled or baked meats, nuts and nut butters, brown rice, brown pasta, whole fruit, green vegetables, orange vegetables, starchy vegetables, other vegetables, beans, unflavoured milk and yogurt[21]. Unhealthy foods in the mSHEI include fried meat, red meat, salty fried snacks, sugar-sweetened drinks (sodas, punches and flavoured milks) and dessert items (candy, frozen desserts, sweet baked goods).

Table 1 Fruit and vegetable items from Texas SPAN survey and response options with points for consumption and variety scores

Food groups and sub-groups	Survey item	Response options	Consumption scoring	Variety scoring
Fruit			0–6	0–2
Fruit	'Yesterday, did you eat fruit? Fruits are all fresh, frozen, canned, or dried fruits'	'no I didn't eat any fruit yesterday'	0	0
		'yes, I ate fruit 1 time yesterday'	1	1
		'yes, I ate fruit 2 times yesterday'	2	
		'yes, I ate fruit 3 or more times yesterday'	3	
Fruit juice	'Yesterday, did you drink fruit juice? Fruit juice is a drink that is 100 % juice, like orange, apple, or grape juice'. (excludes: punch, Kool-Aid, sports drinks, or other fruit-flavoured drinks like Sunny D or Capri Sun)	'no I didn't drink any fruit juice yesterday'	0	0
		'yes, I drank fruit juice 1 time yesterday'	1	1
		'yes, I drank fruit juice 2 times yesterday'	2	
		'yes, I drank fruit juice 3 or more times yesterday'	3	
Vegetables			0–15	0–5
Starchy vegetables	'Yesterday, did you eat starchy vegetables like potatoes, corn or peas' (exclude: French fries, fried potatoes, potato chips, or any other type of chips)	'no I didn't eat any starchy vegetables yesterday'	0	0
		'yes, I ate starchy vegetables 1 time yesterday'	1	1
		'yes, I ate starchy vegetables 2 times yesterday'	2	
		'yes, I ate starchy vegetables 3 or more times yesterday'	3	
Orange vegetables	'. . . any carrots, squash, sweet potatoes, or any other orange vegetables'	'no I didn't eat any orange vegetables yesterday'	0	0
		'yes, I ate orange vegetables 1 time yesterday'	1	1
		'yes, I ate orange vegetables 2 times yesterday'	2	
		'yes, I ate orange vegetables 3 or more times yesterday'	3	
Green vegetables	'. . . salad made with lettuce, or any green vegetables like spinach, green beans, broccoli, or other greens'	'no I didn't eat any green vegetables yesterday'	0	0
		'yes, I ate green vegetables 1 time yesterday'	1	1
		'yes, I ate green vegetables 2 times yesterday'	2	
		'yes, I ate green vegetables 3 or more times yesterday'	3	
Other vegetables	'any other vegetables like peppers, tomatoes, zucchini, asparagus, cabbage, cucumbers, mushrooms, eggplant, celery, or artichokes'	'no I didn't eat any other vegetables yesterday'	0	0
		'yes, I ate other vegetables 1 time yesterday'	1	1
		'yes, I ate other vegetables 2 times yesterday'	2	
		'yes, I ate other vegetables 3 or more times yesterday'	3	
Beans	'beans such as pinto beans, baked beans, kidney beans, refried beans, or pork and beans' (excludes green beans)	'no I didn't eat any beans yesterday'	0	0
		'yes, I ate beans 1 time yesterday'	1	1
		'yes, I ate beans 2 times yesterday'	2	
		'yes, I ate beans 3 or more times yesterday'	3	

BMI

Weight status was categorised using BMI. Anthropometric measures were conducted in schools by trained research staff following a standardised protocol using stadiometers (Perspectives Enterprises Portable Adult Measuring Unit PE-AIM-101) and calibrated Tanita BWB-800S or SEXA 770 scales[21,24]. Weight status was based on current age- and gender-specific Centers for Disease Control and Prevention growth charts[25]. An adolescent with a BMI of > 85th percentile–95th percentile is considered to have overweight and an adolescent with a BMI ≥ 95th percentile is considered to have obesity[25]. Three weight status categories were used in analyses: underweight/normal weight (combined), overweight and obesity.

Socio-economic status

SES was measured at the school level based on the percentage of students who are economically disadvantaged at each school. School-level SES was assigned to each respondent individually, and tertiles were constructed, so that the highest school-level SES tertile included children from schools with the lowest percentage of economically disadvantaged students, and the lowest SES tertile referred to children from schools with

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the highest percentage of economically disadvantaged students.

Demographic factors

Other demographic factors considered include gender, race/ethnicity and grade – 8th and 11th. Three racial/ethnic categories were used: Hispanic/Latino, Black/African American and White/other.

Data analysis

Descriptive statistics, including means and standard deviations, were computed. To estimate FV variety and group differences in FV variety intake, *t*-tests and logistic regression analyses were used after confirming that data satisfied model assumptions. Chi-square tests were conducted to test for differences in FV variety scores by demographic factors. Logistic regression was used to predict the proportion of each socio-demographic group that consumed each FV group at least once the day prior. Logistic regression was conducted to test for differences in mSHEI scores across school-level SES tertiles. Probability of previous day consumption of each distinct fruit group and vegetable group across socio-demographic factors was estimated via logistic regression, while means of composite variety measures were estimated via linear regression. Analyses were adjusted for state survey weights or Texas-Mexico border/non-border survey weights, as appropriate. All analyses were performed using STATA software, version 14.2 (StataCorp.). The level of significance was set at $P < 0.05$. Outliers were replaced with missing values for all key variables such as BMI and age during data cleaning.

Results

Demographics of the sample stratified by gender are shown in Table 2. The study sample was 51·1 % male; 52·7 % of participants were in 8th grade. Most participants self-reported as Hispanic or Latino (50·9 %), with 12·5 % of self-reporting as non-Hispanic Black or African American, and 36·6 % of the sample self-reporting as White non-Hispanic or other. Mean age of participants was 14·8 years old (SD 1·58). Most participants were normal or underweight (59·8 %), 17·9 % had overweight and 22·3 % had obesity. Most respondents lived in non-border areas (78·1 %). No significant differences were found in demographic characteristics by gender aside from weight status ($P = 0.022$); fewer girls had obesity (18·8 %) compared with boys (25·6 %).

Table 2 Demographic characteristics of 8th and 11th grade students by gender

	Male	Female	Total	*P*-value
Total	51·1	48·9	100·0	
Grade				
8th	53·1	52·3	52·7	
11th	46·9	47·7	47·3	0·85
Race/ethnicity				
White (non-Hispanic)	36·7	36·5	36·6	
Black or African American (non-Hispanic)	12·5	12·6	12·5	
Hispanic or Latino/a	50·9	36·5	50·9	1·00
Weight status				
Normal or underweight	57·7	62·0	59·8	
Overweight	16·7	19·2	17·9	
Obese	25·6	18·8	22·3	0·022*
Border status				
Border region	22·0	21·7	21·9	
Non-border region	78·0	78·3	78·1	0·87

*$P < 0.05$.
Weight status classification using BMI was based on current age- and gender-specific CDC growth charts[24]. An adolescent with a BMI of > 85th percentile–95th percentile is considered to have overweight and an adolescent with a BMI ≥ 95th percentile is considered to have obesity.
n 9056; *N* 659 288.
Chi-square tests were conducted to test for group differences.

Demographic differences in consumption of specific fruit and vegetable and fruit and vegetable variety

A number of FV consumption behaviours were examined across demographic characteristics (Table 3). These included consumption of two distinct fruit groups (whole fruit, and 100 % fruit juice) and five vegetable groups (starchy vegetables, orange vegetables, green vegetables, beans, other vegetables) which were each coded as binary measures. Fruit variety, vegetable variety and combined FV variety, and fruit intake, vegetable intake and combined FV intake were each coded as continuous measures.

Significant differences in these behaviours were found across socio-demographic categories. Across grades, only intake of starchy vegetables showed a difference: a greater proportion of 8th grade students reported consuming starchy vegetables than 11th graders ($P = 0.044$). A higher percentage of boys consumed orange vegetables ($P = 0.038$); a higher percentage of girls consumed green vegetables ($P = 0.038$). Boys also consumed significantly higher fruit variety than girls as indicated by fruit variety scores ($P = 0.049$), and more boys consumed fruit juice ($P = 0.001$). A smaller percentage of Black/African American respondents consumed orange vegetables ($P = 0.049$) and green vegetables ($P = 0.009$) compared with other racial/ethnic groups. A larger proportion of Black/African American adolescents consumed fruit juice than either Hispanic ($P = 0.004$) or White/other ($P = 0.001$) adolescents. Further, a smaller percentage of Black/African American adolescents consumed whole fruit compared with Hispanic ($P = 0.036$) or White/other ($P = 0.018$) adolescents.

Significant differences in FV variety consumption were found by school-level SES tertile. A greater percentage of adolescents in the highest school-level SES tertile consumed ‘other vegetables’ compared with the lowest tertile ($P = 0.039$). A smaller percentage of adolescents in the highest SES tertile ($P = 0.000$) and middle ($P = 0.016$) SES tertile consumed whole fruit than in the lowest school-level

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Table 3 Consumption of specific fruit and vegetables, and variety of fruit and vegetables consumed, among 8th and 11th graders by socio-demographic characteristics

	Estimated percentage of group consuming FV item at least once in previous day							Predicted variety scores mean types (SE)					
								V variety 0–5		F variety 0–2		Total FV variety 0–7	
	Starchy vegetable	Orange vegetables	Green vegetable	Beans	Other vegetables	Whole fruit	Fruit juice	Mean	SE	Mean	SE	Mean	SE
Grade													
8th	38·6	24·8	35·2	23·4	33·7	69·1	44·2	1·52	0·04	1·10	0·04	2·61	0·06
11th	34·4*	24·4	35·1	24·3	34·5	66·7	41·3	1·51	0·05	1·07	0·04	2·58	0·08
Gender													
Male	38·0	27·1	33·1	23·0	33·3	67·6	47·7**	1·52	0·05	1·12	0·04*	2·64	0·05
Female	35·1	22·0*	37·3*	24·6	34·9	68·3	37·7	1·50	0·05	1·04	0·03	2·55	0·08
Race/ethnicity													
White (non-Hispanic)	37·2	26·6*	40·9*	17·7	36·4	70·6	38·6**	1·59	0·07	1·02	0·05	2·61	0·10
Black or African American (non-Hispanic)	36·1	17·3	30·3	23·9	30·5	60·1*	54·9	1·36	0·12	1·14	0·06	2·49	0·15
Hispanic or Latino/a	36·2	25·1	32·1	27·9	33·2	67·9	42·8	1·50	0·05	1·11	0·03	2·61	0·07
Weight status													
Normal weight	37·5	23·6	32·9	24·1	34·7	68·8	44·3	1·52	0·05	1·10	0·03	2·62	0·07
Overweight	32·9	25·0	38·4	20·6	34·6	66·9	42·5	1·49	0·12	1·08	0·05	2·57	0·16
Obese	37·1	27·1**	38·7*	25·5	31·8	66·7	39·1	1·55	0·07	1·05	0·05	2·61	0·07
Border status													
Border region	33·0	20·3*	32·7*	24·0	32·5*	62·3**	42·5	1·39*	0·03	1·08	0·01	2·47*	0·03
Non-border region	37·6	25·8	35·8	23·2	34·5	69·5	42·9	1·55	0·04	1·08	0·03	2·63	0·06
School-level SES tertiles†													
High	35·4	25·5	37·2	23·1*	37·2*	63·5**	36·2*	1·58	0·04	0·99***	0·03	2·57	0·06
Middle	37·6	24·6	34·5	20·9	33·5	67·4*	47·5	1·46	0·06	1·12	0·04	2·58	0·08
Low	37·4	23·3	32·6	27·0	30·2	74·3	47·8	1·46	0·07	1·19	0·04	2·65	0·10

FV, fruit and vegetable; V, vegetable; F, fruit; SES, socio-economic status.
Statistical significance:
*$P < 0·05$.
**$P < 0·01$.
***$P < 0·001$.
†Measured at the school-level and categorised into tertiles, low (85–100 % economically disadvantaged), middle (70–84 % economically disadvantaged) and high (<70 % economically disadvantaged).
Linear regressions were conducted to predict mean variety types.
Logistic regressions were conducted to predict proportion consuming each fruit or vegetable type the previous day.

Table 4 Estimated values of mSHEI for each level of fruit variety, vegetable variety and total fruit and vegetable variety for full sample and by school-level SES tertile†

	Full sample	Low SES	Middle SES	High SES
Variety scores	Predicted mSHEI	Predicted mSHEI	Predicted mSHEI	Predicted mSHEI
F variety (0–2)				
0	53·92	54·48	54·45	53·32
1	55·18	54·34	53·95	56·36
2	54·11	53·19	53·19	55·95
P-value for trend	0·98	0·15	0·12	0·000***
Tertiles of V variety (0–5)				
Low (0)	53·69	53·89	53·49	53·68
Middle (1)	53·76	53·17	52·55	55·15
High (2–5)	55·6	54·49	54·79	56·76
P-value for trend	0·000***	0·32	0·08	0·000***
Tertiles of FV variety (0–7)				
Low (0–1)	53·73	54·16	53·89	53·36
Middle (2–3)	54·35	53·67	52·90	55·87
High (4–7)	55·71	54·13	55·04	57·20
P-value for trend	0·0009***	0·99	0·25	0·000***

F, fruit; V, vegetable; FV, combined fruit and vegetable; SPAN, School Physical Activity and Nutrition survey; mSHEI, modified SPAN Healthy Eating Index (does not include fruit and vegetables); SES, socio-economic status.
Mean values were significantly different:
****P* < 0·001.
†Measured at the school-level and categorised into tertiles: low (85–100 % economically disadvantaged), middle (70–84 % economically disadvantaged) and high (<70 % economically disadvantaged).
Analyses adjusted for demographic factors including age, gender and socio-economic status.
n 9056; *N* 659, 288.
Linear regressions were conducted to estimate mSHEI scores predicted by variety scores.

SES tertile. Fruit juice consumption was significantly lower among adolescents in the highest SES tertile ($P = 0{\cdot}013$), compared with other groups.

For most FV types examined, a smaller percentage of respondents in Texas-Mexico border regions reported consumption compared with non-border adolescents. Significantly smaller percentages of adolescents in border regions consumed orange vegetables ($P = 0{\cdot}001$) and whole fruit ($P = 0{\cdot}002$). The difference between proportion of adolescents in border regions and non-border regions consuming starchy vegetables approached significance ($P = 0{\cdot}068$), with fewer adolescents in border regions consuming starchy vegetables. Adolescents in non-border regions also consumed a higher variety of vegetables as indicated by vegetable variety score ($P = 0{\cdot}001$) and greater total FV variety (0·024) than in border regions.

Finally, a greater percentage of adolescents with obesity consumed green vegetables compared with normal/underweight adolescents ($P = 0{\cdot}005$). No other significant differences by weight status were identified in percentage of adolescents consuming specific FV types. No significant differences were found in mean variety scores by weight status.

Fruit and vegetable variety and overall healthy eating

We examined if consumption of a variety of fruit, vegetables and combined FV variety was associated with a measure of overall healthy eating (mSHEI), in the full sample and within SES tertiles (Table 4). Significant positive associations of each of the three variety scores with mSHEI were seen in the full sample and within specific SES tertiles. Fruit variety was a significant predictor of overall healthy eating in the middle SES tertile ($P = 0{\cdot}026$). Additionally, across increasing levels of fruit variety, mSHEI increased within the high SES tertile ($P = 0{\cdot}000$) (Table 5). Within the high SES tertile, a one-unit increase in fruit variety score was associated with significant increases in mSHEI ($\beta = 1{\cdot}33$, SE = 0·29, *P*-value = 0·000).

Likewise, each tertile increase in vegetable variety was associated with significant increases in mSHEI scores in the full sample ($P = 0{\cdot}000$) and within the highest SES tertile ($P = 0{\cdot}000$). A one-unit increase in vegetable variety was associated with significant increases in mSHEI scores in the full sample ($\beta = 0{\cdot}69$, SE = 0·16, *P*-value = 0·000). In the middle SES tertile, a one-unit increase in vegetable variety was associated with significant increases in mSHEI ($\beta = 0{\cdot}66$, SE = 0·17, *P*-value = 0·000) and in the high SES tertile ($\beta = 0{\cdot}90$, SE = 0·28, *P*-value = 0·001).

Similarly, FV variety was positively associated with mSHEI scores in the full sample ($P = 0{\cdot}0009$) and within the high SES tertile ($P = 0{\cdot}000$). A one-unit increase in FV variety score was associated with a significant increase in mSHEI scores ($\beta = 0{\cdot}45$, SE = 0·13, *P*-value = 0·001) and within the high SES tertile ($\beta = 0{\cdot}81$, SE = 0·19, *P*-value = 0·000).

In addition to variety, the impacts of a one-unit increase in total consumption of fruit, vegetables and combined FV

Table 5 Estimated change in modified SPAN Healthy Eating Index scores (mSHEI) for a 1-unit increase in fruit variety, vegetable variety and total fruit and vegetable variety for full sample and by school-level SES Tertile†,‡

	Full sample		Low SES		Middle SES		High SES	
	Change in mSHEI for one-unit increase in predictor		Change in mSHEI for one-unit increase in predictor		Change in mSHEI for one-unit increase in predictor		Change in mSHEI for one-unit increase in predictor	
FV variety	β	SE	β	SE	β	SE	β	SE
Fruit variety	0·01	0·28	-0·73	0·50	-0·64	0·41	1·33***	0·29
Vegetable variety	0·69***	0·16	0·35	0·28	0·66***	0·17	0·90**	0·28
FV variety	0·45**	0·13	0·10	0·25	0·30	0·16	0·81***	0·19

F, fruit; V, vegetable; FV, combined fruit and vegetable; SPAN, School Physical Activity and Nutrition survey; mSHEI, modified SPAN Healthy Eating Index (does not include fruit and vegetables); SES, socio-economic status.
Mean values were significantly different:
***P* < 0·01.
****P* < 0·001.
†Measured at the school-level and categorised into tertiles: low (85–100 % economically disadvantaged), middle (70–84 % economically disadvantaged) and high (<70 % economically disadvantaged).
‡Linear regression was conducted to predict changes in mSHEI scores from variety scores.
n 9056; *N* 659 288.

(i.e. measures that combine variety and amount) on mSHEI scores were examined in the full sample and within SES tertiles (Table 6). Notably, the direction of association depends on SES tertile. In the low and middle SES tertiles, total fruit consumption was negatively associated with healthy eating scores. A one-unit increase in fruit consumption was associated with significant decreases in mSHEI scores in the low SES tertile (β = -0·8581, SE = 0·3329, *P*-value = 0·011) and in the middle SES tertile (β = -0·5567, SE = 0·2609, *P*-value = 0·034). In the high SES tertile, however, total fruit consumption was positively associated with healthy eating scores (β = 0·8762, SE = 0·2360, *P*-value = 0·000). Likewise, positive associations of total FV consumption with healthy eating were only observed in the highest SES tertile (β = 0·3976, SE = 0·1544, *P*-value = 0·011), with non-significant associations in the other SES groups. Total vegetable consumption was not associated with overall healthy eating scores in the full sample or within any of the SES tertiles.

Discussion

Overall, FV variety appears to be associated with overall healthy eating patterns in a diverse adolescent population, though some results varied by SES and food group. For both FV variety and total FV intake, patterns were more pronounced in the high SES tertile. When examined by food group, fruit intake and FV intake were associated with better eating patterns in the high SES tertile. Fruit variety, vegetable variety and FV variety consumption were each associated with better eating patterns in the highest SES tertile, and vegetable variety was associated with better eating patterns in the middle SES tertile. Fruit, vegetable and combined FV variety scores were associated with significant increases in overall healthful eating behaviour scores. Likewise, amount of fruit and FV consumption (but not amount of vegetable consumption) were associated with increases in healthy eating scores. Within this sample and using the mSHEI, vegetable consumption is not enough to predict overall higher healthy eating scores for the full sample. Because the mSHEI is composed of both healthy foods (excluding fruit and vegetables) and unhealthy foods, one or more of several reasons may account for this lack of association. It may be that vegetables may be regarded as sufficient to constitute a healthy diet; thus, children with high intake of vegetables may choose to not consume other components of a healthy diet; alternatively, consumption of unhealthy foods may be compensated by a high intake of vegetables. Whatever the reason, the results suggest that vegetables do not necessarily displace or substitute unhealthy foods in the diet. Moreover, we found fewer differences in vegetable consumption than expected across groups; this lack of variability may partly explain the lack of an association. Limited range of vegetable consumption might be influenced by the fruit and vegetable options provided to students in school, where many students from lower income households consume a majority of their calories. There may not be high variability in the variety of fruits and vegetables available to students within and across schools, which in turn may affect the variability of vegetable consumption among students in schools.

The significant increases in healthy eating behaviours predicted by a tertile increase in variety suggest that increasing variety may be associated with other healthy eating behaviours outside of FV, such as higher consumption of healthy food items and lower consumption of unhealthy food items. In the current study, within the full sample, across increasing vegetable variety tertiles and FV variety tertiles, mSHEI scores increased. These associations were not present

Table 6 Predicted change in modified SPAN Healthy Eating Index (mSHEI) for a 1-unit increase fruit consumption, vegetable consumption and total fruit and vegetable consumption for full sample and by school-level SES tertile†,‡

	Full sample		Low SES		Middle SES		High SES	
	Change in mSHEI for one-unit increase in predictor		Change in mSHEI for one-unit increase in predictor		Change in mSHEI for one-unit increase in predictor		Change in mSHEI for one-unit increase in predictor	
FV consumption	β	SE	β	SE	β	SE	β	SE
Fruit consumption	-0·08	0·21	-0·86*	0·33	-0·56*	0·26	0·88***	0·24
Vegetable consumption	0·27	0·14	0·06	0·27	0·26	0·15	0·38	0·21
FV consumption	0·13	0·11	-0·14	0·19	-0·02	0·13	0·40*	0·15

F, fruit; V, vegetable; FV, combined fruit and vegetable; SPAN, School Physical Activity and Nutrition survey; mSHEI, modified SPAN Healthy Eating Index (does not include fruit and vegetables); SES, socio-economic status.
Mean values were significantly different:
*$P < 0·05$.
***$P < 0·001$.
†Measured at the school-level and categorised into tertiles: low (85–100 % economically disadvantaged), middle (70–84 % economically disadvantaged) and high (<70 % economically disadvantaged).
‡Linear regression was conducted to predict changes in mSHEI scores from variety scores.
n 9056; *N* 659, 288.

in the middle or low SES tertiles; however, mSHEI scores increased within the high SES tertile across increasing fruit variety tertile, vegetable variety tertile and FV variety tertile.

Boys had significantly higher fruit variety scores than girls, but no significant differences were found in vegetable variety or FV variety by gender. Adolescents in non-border regions of Texas had significantly higher vegetable variety scores and FV variety scores than adolescents in Texas-Mexico border regions. FV variety and quantity consumed by adolescents in border regions should be further examined.

Within the sample of adolescents in Texas SPAN, across all groups, mean FV variety scores ranged from 2·47 to 2·65 out of a possible 7 total points. The number of items included in the variety measure in this study (fruit – 2 items; vegetables – 5 items) make it difficult to compare to variety findings with other scoring structures. Even so, in a study of Australian adolescents, with possible scores that ranged from 1 to 11 for fruit and 1 to 16 for vegetables, fruit variety ranged from 1·4 to 1·8 and vegetable variety from 2·3 to 3·1[26]. More studies using consistent scoring structures are needed for comparability.

Gender differences in fruit variety in this current study were not expected. In several studies, FV intake has been found to be higher for girls than boys[12], and preference, an important determinant of FV intake[12,27], has also been found to be higher for girls than for boys[11]. We did not measure preference in this study, only consumption. We found higher fruit variety scores for boys than girls, and boys also had significantly higher fruit juice consumption, but no significant differences in whole fruit consumption. Thus, it is the differences in 100 % fruit juice consumption which drives the higher F variety scores for boys. In a nationally representative sample using comparable items to measure total fruit consumption (100 % fruit juice and whole fruit), males were found to have significantly higher total fruit consumption[28]; European adolescent males were found to have higher fruit juice consumption[29]. Girls may consume a greater variety of whole fruit that was not captured in the two fruit items included in F variety in this study. Fruit consumption behaviours may differ from vegetable or FV behaviours, and variety may not follow overall FV consumption patterns. As this study uses cross-sectional data, no causal inferences can be made.

The current study did not find significant differences in fruit, vegetable or combined FV variety between racial/ethnic groups as expected. In contrast, a systematic review of quantitative research on determinants of FV intake among low-income youth found higher FV intake among Hispanic youth compared with African American and White youth[14]. A descriptive study of 6513 children and adolescents aged 2–18 years also found that Mexican Americans were more likely to have adequate fruit intake[16]. Other studies found significant differences in FV consumption and correlates across race/ethnicity[10,14–16], including higher FV consumption among White children[15]. In a nationally representative sample, non-Hispanic Whites were found to have lower total fruit variety consumption (100 % fruit juice and whole fruit) than other racial/ethnic groups, higher whole fruit consumption than non-Hispanic Black participants and the lowest 100 % fruit juice consumption[28]. These studies included different measurement tools[14] and different ages[14,15] than the current study, and most were not measuring variety. Additionally, some of the findings in existing literature of association of race/ethnicity and FV consumption are somewhat mixed in terms of higher or lower FV consumption by racial/ethnic groups. While the current study finds that Black/African American adolescents had higher fruit variety scores and lower vegetable and combined FV variety scores than Hispanic/Latino adolescents and non-Hispanic White/other adolescents, these differences were not significant. These differences in findings further suggest that influences on FV variety behaviours may differ from overall FV consumption. As we found fewer differences in vegetable consumption than expected across groups, this lack of variability in consumption may partly explain the lack of association including with regard to race/ethnicity. There may be other associations with race/ethnicity that are not captured here that warrant further exploration, or other factors that are associated with fruit and vegetable consumption that are more similar across the sample aside from race/ethnicity.

In our model, a smaller percentage of adolescents in the high SES tertile was estimated to consume whole fruit, or fruit juice, than adolescents in the lower and middle SES tertiles. Further, a one-unit increase in fruit consumption predicted lower healthy eating scores in low and middle SES tertiles, but significantly higher healthy eating scores in the high SES tertile. Based on these data, associations between fruit consumption and healthy eating behaviours appear to be complex. Fruit consumption should be further explored, and SES should be considered in future research around fruit consumption and healthy eating due to the differences in direction of association of fruit consumption by SES tertile. In a nationally representative sample, 100 % fruit juice consumption was highest among racial/ethnic minorities, children and lower SES groups[28]. The authors of that study suggest that composition of fruit/fruit juice consumption varies by SES characteristics, and that replacing 100 % juice with whole fruit may be challenging for some groups[28]. One study found lower FV consumption among lower-income adults but that FV consumption did not vary by income among adolescents[26]. Another study found that FV intake among children and adolescents decreased decreasing SES[30]; similarly, in the current study, positive associations were found in the highest SES tertile between dietary quality and variety. It is possible that FV consumption in middle and high schools in the USA may be influenced by FV item provision in the school lunch programme, which requires selection of a minimum number of FV items per meal in order to be reimbursed by the federal government[31]. There may be other differences in fruit consumption behaviours and associations with SES that are not captured here. It is possible that higher-SES students have access to more FV at home or are otherwise less limited by what is provided in schools, while perhaps lower-income students with less access to FV outside of school choose or consume more fruit at school. More examination of choice, consumption and reason for consuming fruit is needed across demographic groups.

In the current study, estimated mean fruit variety scores were higher for boys, and no significant differences were found in estimated variety scores of any kind between grades. No significant associations were found between predicted mean variety scores (fruit, vegetable or combined FV) and weight status in the current study. These findings underscore the need for further exploration of FV variety and consumption, overall healthy eating behaviours, SES and the applicability of tailoring efforts to increase consumption of a variety of FV within health promotion interventions to reach specific groups.

The contrasting directions of the associations between increasing fruit consumption and overall healthy eating as measured by mSHEI scores were unexpected. While greater FV variety scores were expected in the highest school-level SES tertile, it was not expected that those associations would be significant only within the highest SES tertile. These findings suggest there may be other factors related to healthy eating behaviours, SES and consumption of a variety of FV. More differences by school-level SES tertile were expected, as several aspects of SES are associated with differences in FV intake among children, including parental educational attainment, parental occupational status and parental SES; all of which have been positively associated with child FV intake[32,33]. The findings may be due to the assignment of school-level SES to individuals, as well as the distribution of school-level SES tertiles which was skewed towards low SES. In this sample, 32·16 % of adolescents were in the lowest school-level SES tertile (85–100 % of students economically disadvantaged), 38·26 % of individuals in the middle tertile (70–84 % economically disadvantaged) and 29·58 % in the highest tertile (<70 % economically disadvantaged).

Strengths and limitations

This study uses a large, multiethnic, representative sample, and measures have demonstrated validity and reproducibility[23], to address a significant gap in research on FV variety among children and adolescents. The sampling methods, measures and the contribution to a gap in the literature constitute strengths of this study. There are limitations to generalisability and causal inference due to the cross-sectional nature of this study. Although this study is descriptive, we believe the findings meaningfully contribute to a greater understanding of the correlates of consuming a variety of FV.

Nevertheless, the self-reported dietary measures do present limitations due to recall bias. The self-report dietary measures also present limitations, particularly for measurement of fruit variety, where components were limited to two items: whole fruit and 100 % fruit juice. However, because this study looks at fruit variety, vegetable variety and FV variety together, these analyses still provide meaningful insight into overall FV variety behaviours. The use of number of times consumed as a proxy for servings may be a limitation; however, the use of times is relevant for consideration of variety. While the SHEI has not been validated, it has been shown to have good construct validity[20]. Additionally, assignment of SES at the school level to individuals may be a limitation but still likely represents at least

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some school and community-level environmental factors that could influence FV consumption and variety.

Conclusion/public health implications

Significant differences in variety consumption by demographic factors including gender, border status, race/ethnicity and SES support the need for tailored interventions according to socio-demographic factors. Unexpected findings in directionality of associations of demographic factors with FV variety compared with expectations based on existing literature about FV consumption show a need for further measurement and research into variety behaviours. Given the representative nature of this sample, demographic trends in the state of Texas with Hispanics/Latinos projected to increase as proportion of the population[34] and similar predictions at the national level[35], findings of this paper may be used to help inform interventions at the national level. Additionally, as FV consumption, FV variety and vegetable variety were found to be predictors of improved healthful food intake, targeting FV variety and vegetable variety in conjunction with FV consumption and other health lifestyle behaviours may be important in improving overall eating habits for adolescents. Notably, associations were found between healthful eating and vegetable variety, and between healthful eating and FV variety, while the association between FV consumption and healthful eating appears to be driven by fruit consumption. Further, reasons for consuming FV differ by FV item, which may have implications for understanding and influencing FV variety composition[20]. The findings of this paper support the need to examine healthy lifestyle behaviours and eating patterns for adolescents including within the context of demographic factors.

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