J. Racial and Ethnic Health Disparities (2017) 4:497–506
DOI 10.1007/s40615-016-0251-y

Availability and Consumption of Fruits and Vegetables Among Non-Hispanic Whites, Blacks, Hispanics, and Asians in the USA: Findings from the 2011–2012 California Health Interview Adult Survey

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Received: 18 November 2015 / Revised: 15 April 2016 / Accepted: 1 June 2016 / Published online: 22 June 2016

Abstract Racial and ethnic disparities in fruit and vegetable consumption have been widely studied in the USA. While previous studies focused on the differences of fruit and vegetable availability between racial groups, the equivalence of the association between consumption and availability across racial groups has been rarely examined. The purpose of this study was to investigate the relationship between availability of fruits and vegetables and their consumption across racial groups. The 2011–2012 California Health Interview Survey data ($N = 36{,}302$) were used for the study. Results of negative binomial regression show that the association between perceived availability of fruits and vegetables on consumption differs significantly between non-Hispanic Whites, Hispanics, Blacks, and Asians: (1) the association between fruit consumption and availability is only significant for non-Hispanic Whites (IRR = 1.303, 95 % CI 1.188, 1.429), and (2) the association between vegetable consumption and availability is only significant for non-Hispanic Whites (IRR = 1.242, 95 % CI 1.152, 1.340) and Hispanics (IRR = 1.141, 95 % CI 1.025, 1.271). This study highlights the importance of interventions that emphasize not only potential access but also social and cultural factors that relate to realized access to healthy food.

Keywords Fruits · Vegetables · Food access · Food intake · Diet disparity · Race

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Mathematics Subject Classification 62 J12.

Introduction

A healthy diet is an important factor that influences multiple aspects of an individual's health. Fruits and vegetables are nutrient-rich foods that, when regularly consumed, are associated with lower risks of numerous adverse health conditions, such as obesity and overweight, type 2 diabetes, high blood pressure, and stroke heart disease [1–6].

There are many benefits that are linked to the consumption of fruits and vegetables; however, consumption is largely influenced by the availability of these food items. Most of the population-based studies have focused on the impact of neighborhood food environment on dietary behaviors [7]. Using multistate data, Morland and associates [8] found that each additional supermarket in a census tract was associated with 32 % increase of fruit and vegetable intake for Blacks and 11 % for White Americans. In investigating four contiguous census tracts in New Orleans, Bodor and colleagues [9] found that fresh vegetable shelf space and total vegetable shelf space within 100 m of residence are both positively associated with vegetable consumption. However, neither fresh fruit shelf space nor total fruit shelf space within 100 m of residence is significantly associated with fruit intake. Blanchard and Lyson [10] were the first to introduce the concept of "food deserts" to address the influence of food access on residents' diet. A neighborhood is considered a "food desert" if 50 % or more of the population resides more than 10 miles away from a supermarket, supercenter, or wholesale club. In rural locations, adults living in food deserts were 23.4 % less likely to consume the recommended five or more servings of fruits and vegetables per day than those who are not living in food deserts after controlling for sex, age, race, and education [10].

Although workplace, as another important setting for grocery shopping, has rarely been considered in population-based studies, intervention research studies show that both fruit and vegetable intake are significantly associated with their availability in people's workplace [11, 12].

Racial disparities in fruit and vegetable consumption have been evidenced by numerous studies in the USA. In 2005, the estimated prevalence of eating fruits and vegetables more than five or more times per day was significantly higher among Asians and Pacific Islanders than other ethnic groups for both men and women [13]. However, this study did not consider availability of fruits and vegetables at the neighborhood level, which may impact the association between family food environment and dietary behaviors. In fact, supermarkets are often unevenly distributed in urban communities based on racial components of population. For example, an analysis of grocery stores within 28,050 zip codes, Powell and associates [14] found that chain supermarkets, which typically have more healthy and affordable foods than small grocery stores and non-chain supermarkets, were more prevalent in areas that were predominantly White as compared to areas that were predominantly non-White. The study also showed that areas that were predominately non-Hispanic White had significantly more chain supermarkets than areas that were predominately Hispanic [14]. In addition, Morland and Filomena [15] found that census tracts with lower higher proportions of Blacks tend to carry fewer stores with numerous types of fresh fruits and vegetables. Racial disparities in diet and nutrition intake deserve attention of public health researchers and professionals, as in the long run, they may contribute to the disproportionate increase of chronic health conditions, such as obesity and diabetes, among racial minorities [16, 17].

Numerous health promotion programs and policies have been implemented to increase access to healthy food by attracting or developing healthy food stores and markets, and improving transportation to food stores and markets [18]. However, whether interventions that only aim to improve access to healthy food can have the same impact on consumption of fruits and vegetables across populations from different racial backgrounds still remains unexplored. The purpose of this paper, therefore, is to examine the relationship between race and perceived availability on fruit and vegetable consumption after controlling for socioeconomic status. The research questions for the present study are twofold:

(1) Is perceived availability of fruits and vegetables equally associated with fruit and vegetable consumption across racial groups controlling for socioeconomic status?
(2) Is perceived availability of fruits and vegetables associated with racial disparities of fruit and vegetable consumption controlling for socioeconomic status?

By examining the interaction effect between race and healthy food access on dietary patterns, the findings of the present study addresses the importance of social and cultural adaptation of community nutrition interventions to improve healthy diet for population from different social, economic, and cultural background.

Methods

Data Source and Sample

The present study used data from the 2011–2012 California Health Interview Survey (CHIS) for adults, which is a random-digit dial telephone survey of California households representative of non-institutionalized adults containing a wide range of information regarding people's health status and health behaviors [19]. In this study, race is defined, according to the criteria from UCLA Center for Health Policy Research [20], by self-reported racial identity, which seeks to take the broad racial category the respondents self-identified mostly with into consideration. For respondents with multiple racial backgrounds, only those who responded yes to whether they most identified with one single racial group were categorized based on the criteria [21]. Due to the limited number of respondents of other racial groups, only non-Hispanic Whites, Hispanics, Blacks, and Asians were selected into the final sample. In addition, respondents who reported never eating or shopping for fruits and vegetables in their neighborhoods were not inquired about their perceptions of availability, and were thus excluded from the study. The final sample thus includes 36,302 adults, including 24,492 non-Hispanic Whites, 6162 Hispanics, 1966 Blacks, and 3682 Asians.

Measures

Fruit and vegetable consumption was measured based on self-reported numbers of times per week eating fruits and vegetables. Participants were asked the following questions: (1) "during the past month, how many times did you eat fruits? (Do not count juices)" and (2) "during the past month, how many times did you eat any vegetables like green salad, green beans or potatoes? (Do not include fried potatoes.) ". The responses were standardized to times of eating per week.

Perceived availability of fruits and vegetables was constructed based on participants' response to two questions: (1) "how often can you find fresh fruits and vegetables in your neighborhoods", and (2) "how often can you find fresh fruits and vegetables at or near your workplace". The two responses were aggregated into one variable with two categories: (1) cannot always find fresh fruits and vegetables (either in the neighborhood or near workplace) (reference) and (2) can always find fresh fruits and vegetables (either in the

neighborhood or near workplace). Those who do not work or work at home were treated as not always finding fresh and vegetables near workplace. Thus, their perceived availability of fruits and vegetables was exclusively determined by neighborhood availability.

Variables regarding demographic information include (1) race—non-Hispanic Whites (reference), Hispanics, Blacks, and Asians as defined by the UCLA Center for Health Policy Research, (2) age, (3) sex—male (reference) and female, (4) education—not having a college degree (reference) and having an associate degree or above, (5) income—family total income divided by federal poverty level (FPL) and top-coded at 24, and (6) nativity—being born outside the USA (reference) and being born in the USA.

Statistical Analysis

Four types of models should be considered in analyzing count data: (1) Poisson model, (2) negative binomial model, (3) zero-inflated Poisson model, and (4) zero-inflated negative binomial model [22]. The Poisson model is used for count data whose variance and mean are approximately equal. Negative binomial model is an extended form of Poisson model for overdispersed data that accounts for unobserved heterogeneity. The two zero-inflated models are used for events that contain excess zero-count data by generating a logit model that predicts the "membership" of a group of people who are not capable of having a certain event. Since participants having the "membership" of never eating or shopping for fruits or vegetables were excluded from the study, zero-inflated Poisson model and zero-inflated negative binomial model are thus not appropriate for the analysis. Recognizing times of eating fruits and vegetables per week is both overdispersed; the negative binomial model was chosen over Poisson model for the present study.

To thoroughly address the interaction effect for the study, the following four steps were presented as recommended by Knol and VanderWeele [23]: (1) incident rate ratios (IRRs) were presented for each stratum of race and perceived availability with a single reference category (i.e., non-Hispanic Whites who cannot always find fresh fruits and vegetables); (2) IRRs of the effect of race on fruit and vegetable consumption in strata of perceived availability of fresh fruits and vegetables, and IRRs of the effect of perceived availability of fresh fruits and vegetables on fruit and vegetable consumption in strata of race were both presented; (3) measures of effect modification were presented in both (a) additive interaction terms, quantified as interaction contrast ratios (ICRs) [24], known as relative excess risk due to interaction (RERI) in the context of health and diseases, and (b) multiplicative interaction terms, quantified as ratios of IRRs (RIRRs); and (4) potential confounders, for which the relation between race and food intake and for which the relation between food access and intake were adjusted, should be listed. Methods for obtaining the interaction effect parameters and their 95 % confidence intervals are elaborated by VanderWeele and Knol [25].

Stata 14 was used for statistical analyses for the present study. Results of negative binomial models were weighted on account of complex survey design effects to represent the California population [26].

Results

Descriptive Statistics

Descriptive statistics for the sample are summarized in Table 1. The sample includes 67.47 % non-Hispanic Whites, 16.97 % Hispanics, 5.42 % Blacks, and 10.14 % Asians. A total of 58.15 % of the subjects are female. There are 48.84 % who have an education level of associate degree and above. And 75.59 % of the subjects are born in the USA. The average age of the sample is 54.252. The average household income of the sample is 4.626 FPL. The means of times eating fruits and vegetables per week among the sample are respectively 8.475 and 7.808. The means of two variables are both smaller than the squared values of standard deviations, indicating overdispersion of the outcome data, which confirms that the negative binomial model is more appropriate than Poisson model for this study.

Negative Binomial Models

To obtain the IRRs in reference to a single reference category—Whites who cannot always find fruits and vegetables—two negative binomial models were estimated to show the association between the combined group of race and

Table 1 Sample characteristics ($N = 36,302$)

Variables	Mean(sd)/percentage
Times eating fruits per week	8.475 (7.390)
Times eating vegetables per week	7.808 (6.043)
Can always find fresh fruits / vegetables	89.22 %
Race	
Non-Hispanic Whites	67.47 %
Hispanics	16.97 %
Blacks	5.42 %
Asians	10.14 %
Age	54.252 (17.610)
Female	58.15 %
Associate degree or above	48.84 %
Income	4.626 (4.622)
Born in the USA.	75.59 %

perceived availability of fruits and vegetables, and fruit and vegetable consumption respectively after controlling for age, sex, education, income, the quadratic term of centered income, and nativity, as displayed in Table 2. In general, age had a significant positive association with fruit consumption (IRR = 1.003, 95 % CI 1.002, 1.004), but did not have a significant association with vegetable consumption (IRR = 1.001, 95 % CI 1.000, 1.002). Being female and having an associate degree or above were associated with times of eating fruits (IRR = 1.249, 95 % CI 1.208, 1.290) and vegetables (IRR = 1.292, 95 % CI 1.249, 1.337). Income had a significantly positive association with both the times of eating fruits (IRR = 1.013, 95 % CI 1.008, 1.019) and vegetables (IRR = 1.017, 95 % CI 1.011, 1.022). However, the centered quadratic term of income shows a significantly negative association with both the fruit and vegetable consumption (IRR = 0.999, 95 % CI 0.999, 1.000), indicating that income has a positive effect on fruit and vegetable consumption until a turning point is reached. Being born in the USA has a significantly negative association with the times of eating fruits (IRR = 0.917, 95 % CI 0.871, 0.966), but a positive association with the times of eating vegetables (IRR = 1.095, 95 % CI 1.050, 1.142).

Interaction Effects

Table 3 and Table 4 respectively present the interaction effects between race and perceived availability of fruits and vegetables on fruit and vegetable consumption after controlling for age, sex, education, income, the quadratic term of centered income, and nativity.

The IRRs of the effect of race on fruit consumption in strata of perceived availability in Table 3 provide information regarding disparities of fruit consumption across racial groups stratified by perceived availability. Among those who cannot always find fresh fruits and vegetables, the results indicate (1) Hispanics (IRR = 1.238, 95 % CI 1.083, 1.416) consumed significantly more fruits than non-Hispanic Whites, and (2) fruit consumption among non-Hispanic Whites is not significantly different from that among Blacks (IRR = 1.139, 95 % CI 0.892, 1.455) and Asians (IRR = 1.126, 95 % CI 0.966, 1.312). The results obtained from people who can always find fresh fruits and vegetables are not consistent with those obtained from people who cannot: (1) fruit consumption among non-Hispanic Whites is not significantly different from that among Hispanics (IRR = 1.048, 95 % CI 0.991, 1.108), (2) non-Hispanic Whites consumed significantly more fruits than both Blacks (IRR = 0.810, 95 % CI 0.745, 0.881) and Asians (IRR = 0.897, 95 % CI 0.846, 0.950). Comparing the IRRs of the effect of perceived availability on fruit consumption in strata of race, the results show that always finding fresh fruits and vegetables is significantly associated with increased consumption of fruits only for Whites (IRR = 1.303, 95 % CI 1.188, 1.429), but not for Hispanics (IRR = 1.103, 95 % CI 0.997, 1.220), Blacks (IRR = 0.927, 95 % CI 0.720, 1.192), and Asians (IRR = 1.038, 95 % CI 0.906, 1.189). The interaction effects of being in a racial minority group and always finding fresh fruits and vegetables on fruit consumption are

Table 2 Negative binomial models on fruit and vegetable consumption in the past week (N = 36,302)

	IRR (95 % CI)[a]	
	Times eating fruits in the past week	Times eating vegetables in the past week
Race and perceived availability (ref: Non-Hispanic Whites who cannot always find)		
Non-Hispanic Whites who can always find	1.303*** (1.188, 1.429)	1.242*** (1.152, 1.340)
Hispanics who cannot always find	1.238** (1.082, 1.416)	0.815** (0.725, 0.916)
Hispanics who can always find	1.366*** (1.231, 1.516)	0.930 (0.850, 1.018)
Blacks who cannot always find	1.139 (0.892, 1.455)	0.860* (0.741, 0.998)
Blacks who can always find	1.056 (0.921, 1.210)	0.987 (0.897, 1.086)
Asians who cannot always find	1.126 (0.966, 1.312)	1.106 (0.976, 1.253)
Asians who can always find	1.169** (1.043, 1.309)	1.160** (1.059, 1.270)
Other covariates		
Age	1.003*** (1.002, 1.004)	1.001 (1.000, 1.002)
Female	1.249*** (1.208, 1.290)	1.292*** (1.249, 1.337)
Associate degree or above	1.186*** (1.140, 1.233)	1.210*** (1.176, 1.244)
Income	1.013*** (1.008, 1.019)	1.017*** (1.011, 1.022)
Income (quadratic term of mean income)	0.999*** (0.999, 1.000)	0.999*** (0.999, 1.000)
Born in the USA	0.917** (0.871, 0.966)	1.095*** (1.050, 1.142)

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

[a] All results are weighted to account for complex survey design effects to represent the California population

Table 3 The interaction effect between race and perceived availability of fresh fruit and vegetables on fruit consumption in the past week ($N = 36,302$)

		Perceived availability of fresh fruit and vegetables		IRR (95 % CI) for perceived availability within strata of racial groups (ref: Cannot always find)
		Cannot always find	Can always find	
Non-Hispanic Whites	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	1.000	1.303***[a,b] (1.188, 1.429)	*1.303*** (*1.188*, *1.429*)
Hispanics	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	1.238** (1.083, 1.416)	1.366*** (1.231, 1.516)	*1.103* (*0.997*, *1.220*)
	IRR (95 % CI) for Hispanics within strata of perceived availability (ref: Non-Hispanic White)	*1.238*** (*1.083*, *1.416*)	*1.048* (*0.991*, *1.108*)	ICR −0.175* (−0.339, −0.012) RIRR 0.847* (0.739, 0.970)
Blacks	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	1.139 (0.892, 1.455)	1.056 (0.921, 1.210)	*0.927* (*0.720*, *1.192*)
	IRR (95 % CI) for Blacks within strata of perceived availability (ref: Non-Hispanic White)	*1.139* (*0.892*, *1.455*)	*0.810*** (*0.745*, *0.881*)	ICR −0.387* (−0.679, −0.094) RIRR 0.711* (0.550, 0.919)
Asians	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	1.126 (0.966, 1.312)	1.169** (1.043, 1.309)	*1.038* (*0.906*, *1.189*)
	IRR (95 % CI) for White within strata of perceived availability (ref: Non-Hispanic White)	*1.126* (*0.966*, *1.312*)	*0.897*** (*0.846*, *0.950*)	ICR −0.260** (−0.429, −0.092) RIRR 0.796** (0.688, 0.923)

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

[a] Results are weighted to account for complex survey design effects to represent the California population

[b] IRR is adjusted for age, sex, education, income (including both linear term and quadratic term), and nativity

significant for all three racial groups in both additive and multiplicative terms: (1) Hispanics (ICR = −0.175, 95 % CI −0.339, −0.012; RIRR = 0.847, 95 % CI 0.739, 0.970), (2) Blacks (ICR = −0.387, 95 % CI −0.679, −0.094; RIRR = 0.711, 95 % CI 0.550, 0.919), and (3) Asians (ICR = −0.260, 95 % CI −0.429, −0.092; RIRR = 0.796, 95 % CI 0.688, 0.923), indicating that increased availability of fruits and vegetables has a significantly less impact on fruit consumption for all of the three other racial groups than for non-Hispanic Whites. The results above can be confirmed with the predicted margins plot displayed in Fig. 1.

In Table 4, the IRRs of the effect of race on fruit consumption in strata of perceived availability revealed racial disparities in vegetable consumption stratified by perceived availability. Among those who cannot always find fresh fruits and vegetables, the results show (1) non-Hispanic Whites consumed significantly more vegetables than Hispanics (IRR = 0.815, 95 % CI 0.725, 0.916) and Blacks (IRR = 0.860, 95 % CI 0.741, 0.998) and (2) vegetable consumption among non-Hispanic Whites is not significantly different from that among Asians (IRR = 1.106, 95 % CI 0.976, 1.253). The results of vegetable consumption for people who can always find fresh fruits and vegetables are inconsistent with those for people who cannot: among those who can always find fresh fruits and vegetables, non-Hispanic Whites consumed more vegetables than all of the other three groups: (1) Hispanics (IRR = 0.749, 95 % CI 0.707, 0.792), (2) Blacks (IRR = 0.794, 95 % CI 0.747, 0.845), and (3) Asians (IRR = 0.933, 95 % CI 0.888, 0.981). Thus, increased perceived availability of fresh fruits and vegetables seems to accompany a widened disparity of vegetable consumption between non-Hispanic Whites, Hispanics, and Blacks. Comparing the IRRs of the effect of perceived availability on vegetable consumption in strata of race, the results show that always finding fresh fruits and vegetables is significantly associated with increased vegetable consumption for non-Hispanic Whites (IRR = 1.242, 95 % CI 1.152, 1.340) and Hispanics (IRR = 1.141, 95 % CI 1.025, 1.271), but not for Blacks (IRR = 1.148, 95 % CI 0.995, 1.323) and Asians (IRR = 1.049, 95 % CI 0.936, 1.175). Compared with non-Hispanic Whites who can always find fresh fruits and vegetables, (1) the interaction effect of being Asians and always finding fresh fruits and vegetables on fruit consumption is significant in both additive (ICR = −0.188, 95 % CI −0.333, −0.044) and multiplicative (RIRR = 0.844, 95 % CI 0.742, 0.960) terms; (2) the interaction effect of being Hispanics and always finding fresh fruits and vegetables on vegetable consumption is significant in additive term (ICR = −0.127, 95 % CI −0.250, −0.004), though not in multiplicative (RIRR = 0.919, 95 % CI 0.806, 1.047) term; (3) the interaction effect of being Blacks and always finding fresh fruits and vegetables is not significant in either additive (ICR = −0.115, 95 % CI −0.260, 0.029) or multiplicative

Table 4 The interaction effect between race and perceived availability of fresh fruit and vegetables on vegetable consumption in the past week (N = 36,302)

		Perceived availability of fresh fruit and vegetables		IRR (95 % CI) for perceived availability within strata of racial groups (ref: Cannot always find)
		Cannot always find	Can always find	
Non-Hispanic Whites	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	1.000	1.242***[a,b] (1.152, 1.340)	*1.242*** (*1.152*, *1.340*)
Hispanics	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	0.815** (0.725, 0.916)	0.930 (0.850, 1.018)	*1.141** (*1.025*, *1.271*)
	IRR (95 % CI) for Hispanics within strata of perceived availability (ref: Non-Hispanic White)	*0.815*** (*0.725*, *0.916*)	*0.749**** (*0.707*, *0.792*)	ICR −0.127* (−0.250, −0.004) RIRR 0.919 (0.806, 1.047)
Blacks	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	0.860* (0.741, 0.998)	0.987 (0.897, 1.086)	*1.148* (*0.995*, *1.323*)
	IRR (95 % CI) for Blacks within strata of perceived availability (ref: Non-Hispanic White)	*0.860** (*0.741*, *0.998*)	*0.794**** (*0.747*, *0.845*)	ICR −0.115 (−0.260, 0.029) RIRR 0.924 (0.790, 1.080)
Asians	IRR (95 % CI) (ref: Non-Hispanic Whites who cannot always find)	1.106 (0.976, 1.253)	1.160** (1.059, 1.270)	*1.049* (*0.936*, *1.175*)
	IRR (95 % CI) for Asians within strata of perceived availability (ref: Non-Hispanic White)	*1.106* (*0.976*, *1.253*)	*0.933*** (*0.888*, *0.981*)	ICR −0.188* (−0.333, −0.044) RIRR 0.844* (0.742, 0.960)

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

[a] Results are weighted to account for complex survey design effects to represent the California population

[b] IRR is adjusted for age, sex, education, income (including both linear term and quadratic term), and nativity

(RIRR = 0.924, 95 % CI 0.790, 1.080) term. The results suggest that increased availability of fruits and vegetables has the same impact on vegetable assumption for non-Hispanic Whites as for Blacks. But the impact is significantly less for Hispanics and Asians. The results above can be confirmed with the predicted margins plot in Fig. 2.

Discussion

Findings from this study extend the understanding of the racial disparities on fruit and vegetable consumption. This study confirms that the availability of fruits and vegetables is positively related to their consumption, specifically for non-Hispanic Whites and Hispanics, and hence validated the importance of increasing healthy food access through interventions such as attracting grocery stores and supermarkets to "food dessert" neighborhoods, enhancing public transportation system in "food dessert" communities and increasing use of mobile grocery markets. Nevertheless, the association between perceived availability of fresh fruit and vegetables and consumption vary by race after controlling for individuals' socioeconomic factors. In general, the association between perceived availability and fruit consumption was strongest for non-Hispanic Whites, followed by Hispanics and Asians, and weakest for Blacks. The association between perceived availability and vegetable consumption was strongest for non-Hispanic Whites, followed by Blacks and Hispanics, and weakest for Asians. This finding has far-reaching implications on community intervention of health and nutrition. In addition to socioeconomic factors, racial, and ethnic differences in the effects of health promotion intervention include but are not limited to (1) differences in initial health behaviors, (2) differences in response to interventions due to social situation, and (3) differences in reactions to interventions due to cultural reasons [27]. Applied to the context of healthy diet, differences in dietary behaviors can be contributed by individuals' life-course experience with food, dietary influence from the community, and food culture and tradition. The differences in those factors across racial groups will result in racially differential impact of healthy food availability on diet. Therefore, in addition to investigating the gap in community access to fruits and vegetables, researchers and community health promotion professionals should also take those social, cultural, as well as historical factors in account when examining the racial and ethnic differences in dietary behaviors.

Evidence of differences in sociocultural and historical factors between Blacks, Hispanics, and non-Hispanic that might potentially modify the effect of fruit and vegetable access and availability on healthy eating has been reported in numerous studies. For example, Yeh and colleagues

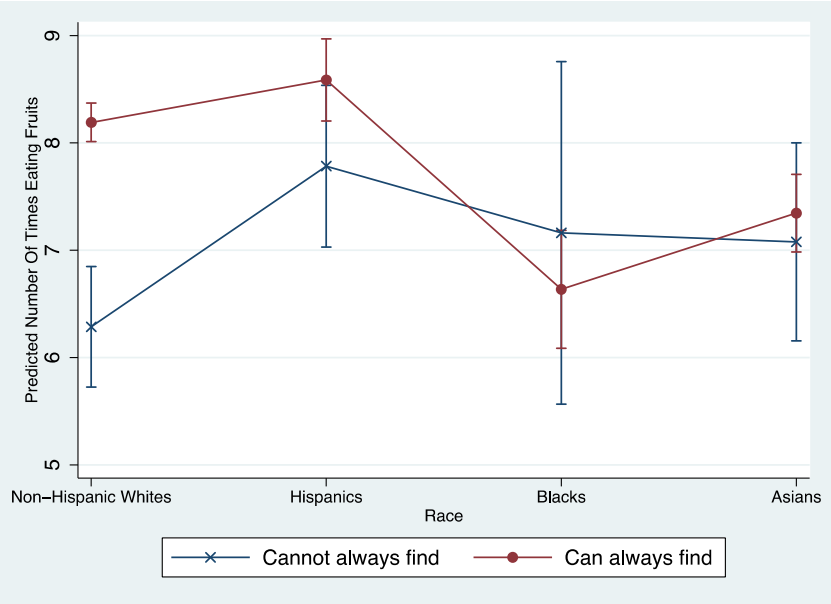

Fig. 1 Predictive margins of race and perceived availability on fruit consumption

[28] conducted a series of focus groups among 147 participants, including Whites, Blacks, and Hispanics, and found several unique determinants that facilitate and impede fruit and vegetable consumption for Blacks and Hispanics: (1) Blacks, unlike other racial groups, tend to use churches and primary care clinics as appropriate settings for health behavior interventions; (2) fruit and vegetable intake among Hispanic populations, particularly for immigrants, can be greatly influenced by food experience in their home countries; (3) both Blacks and Hispanics highlighted the important influence of "developing a taste" for fruits and vegetables while growing up. By contrast, literature that inspects the determinants of eating behaviors among Asians remains highly inconsistent due to heterogeneity of the population. Nevertheless, the findings discussed in the previous and present studies still convey important information of community health promotion. Improving access to healthy, by itself, will not necessarily lead to improvement in dietary behaviors. The impact and effectiveness of interventions increasing availability of healthy food can be severely undermined if they are not culturally appropriate and sensitive to the serving population. In addition to increasing access, community health professionals should also incorporate other

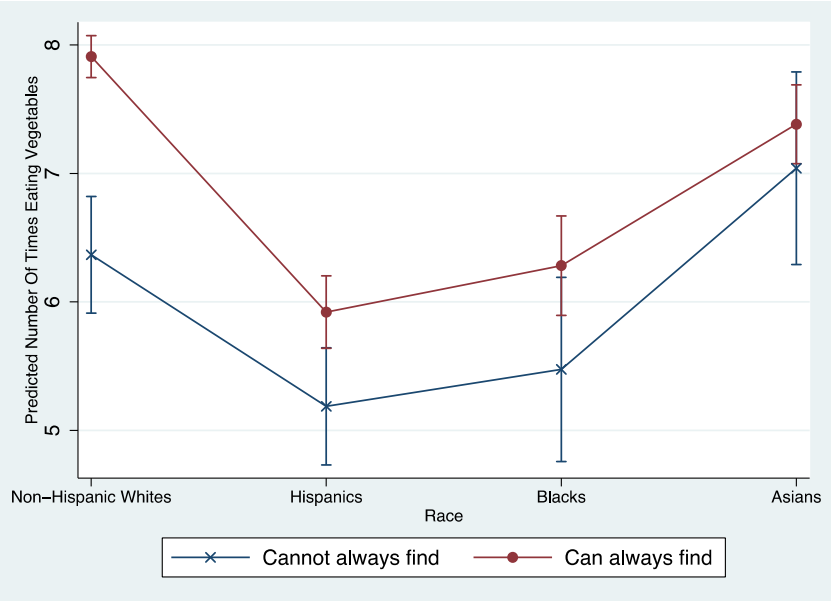

Fig. 2 Predictive margins of race and perceived availability on vegetable consumption

interventions such as working with food industries to bring diversity of fruits and vegetables in local grocery stores, designing and implementing nutrition and culinary education that is tailored for population from various backgrounds, and promoting healthy diet in settings that can involve communities of color.

Compared to previous similar studies, this study has three strengths. First, the study has a fairly large sample size, accounts for complicated sample design of the survey, and hence provides a population-based estimate of the association between food access and intake in the State of California. Second, unlike most studies that measured dietary access using spatial and objective data, this study has enhanced the understanding of the influence of food access on dietary behaviors using self-perceived availability of fruit and vegetables in the neighborhood, which may potentially reduce the confounding effects of factors such as transportation and physical constraints. Third, this study reported additive interaction in addition multiplicative interaction. The importance of additive interaction has been increasingly recognized as the most appropriate manner of analyzing interaction effects in the field of public health over the past 30 years [23]. Additive interaction, although requiring more effort to obtain than multiplicative interaction, has the advantages of comparing the effectiveness of treatments across subgroup populations, providing more insight in mechanistic form and having more statistical power [25]. In general, using either additive or multiplicative interaction varies by settings. The best recommended practice is to report interaction effects in both additive and multiplicative terms [23, 25].

A few limitations of this study deserve mention. First, using cross-sectional data makes it difficult to infer causal relationship between fruit and vegetable availability and intake. Second, research evidenced the health benefits of eating frozen and canned fruits and vegetables especially for those who cannot access fresh fruits and vegetables for financial and proximity reasons [29]. However, the dataset for this study does not capture information regarding availability of frozen or canned food. In addition, the association between dietary access and behaviors may vary within each racial group, which cannot be captured with the data for this study in view of limited sample size for certain ethnic groups. This limitation particularly pertains to the Asian group, which includes large varieties of ethnic background, such as East Asians, Southeast Asians, and South Asians. While this study presents a broad racial differences in fruit and vegetable consumptions, ethnic heterogeneity within each racial category should be addressed in future research. Finally, whether the findings from the state of California can be generalized to the context of the USA calls for more complicated investigations.

Despite the limitations, this study shows that the impact of self-perceived fresh fruit and vegetable availability on fruit and vegetable intake is consistently greater for non-Hispanic Whites than for Hispanics, Blacks, and Asians. Understanding the differences of those associations is a critical step toward reducing the dietary disparities and thus improving overall nutrition and health in communities. According to Sharkey et al. [30], eating behaviors can be determined by potential access (availability) and realized access (utilization) to food. Potential access is influenced by characteristics of food environment such as number, location, type, and size of food stores, food price and quality, and food store services, while realized access is mostly influenced by characteristics of potential consumers including but not limited to residence, vehicle ownership, access to public transportation, home environment, food preference, and culture [30]. Characteristics of both food environment and potential consumers can function as either barriers or facilitators in altering individuals' food choice and eating behaviors [30]. Race was often treated as one of the potential access variables to explain difference in availability of healthy food as a reason for the dietary disparities in previous studies. However, race may also convey information of realized access, including but not limited to food culture, food preference, and food experience, which may moderate the effect of food access on dietary behaviors. Future research in nutrition and dietary disparities should keep in mind that race is not the real cause of the moderation effect of food availability on consumption, but rather a "master category" incorporating an unknown set of various factors related to the influence of both potential access and realized access on diet that differ significantly across racial groups. Researchers should both quantitatively and qualitatively investigate those factors to "unwrap" this master category and obtain insights that improve the effectiveness of future nutrition interventions.

Compliance with Ethical Standards

Funding There was no funding source for this study.

Conflict of Interest The author declares that he has no competing interests.

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Appendix

Table 5 Negative binomial models on fruit and vegetable consumption in the past week with main effects and interaction effects (N = 36,302)

	IRR (9 5% CI)[a]	
	Times eating fruit in the past week	Times eating vegetables in the past week
Main effects of key independent variables		
Race (ref: Non-Hispanic Whites)		
Hispanics	1.238** (1.083, 1.416)	0.815** (0.725, 0.916)
Blacks	1.139 (0.892, 1.455)	0.860* (0.741, 0.998)
Asians	1.126 (0.966, 1.312)	1.106 (0.976, 1.253)
Can always find fresh fruits/vegetables	1.303*** (1.188, 1.429)	1.242*** (1.152, 1.340)
Interaction effects between race and perceived availability of fresh fruit and vegetables		
Hispanics × always find fruit/vegetables	0.847* (0.739, 0.970)	0.919 (0.806, 1.047)
Blacks × always find fruit/vegetables	0.711* (0.550, 0.919)	0.924 (0.790, 1.080)
Asians × always find fruit/vegetables	0.796** (0.688, 0.923)	0.844* (0.742, 0.960)
Other covariates		
Age	1.003*** (1.002, 1.004)	1.001 (1.000, 1.002)
Female	1.249*** (1.208, 1.290)	1.292*** (1.249, 1.337)
Associate degree or above	1.186*** (1.140, 1.233)	1.210*** (1.176, 1.244)
Income	1.013*** (1.008, 1.019)	1.017*** (1.011, 1.022)
Income (quadratic term of mean income)	0.999*** (0.999, 1.000)	0.999*** (0.999, 1.000)
Born in the USA	0.917** (0.871, 0.966)	1.095*** (1.050, 1.142)

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

[a] Results are weighted to account for complex survey design effects to represent the California population

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