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Adherence to recommendations for fruit and vegetable intake, ethnicity and ischemic heart disease mortality

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Abstract *Background and aims:* Ischemic heart disease (IHD) accounts for one-third of annual deaths in the U.S. and mortality rates vary by ethnicity. The association between adherence to dietary guidelines for fruit and vegetable intake with IHD mortality among different ethnic groups has not previously been examined.

Methods and results: A prospective cohort design was used to examine the incidence of fatal IHD among participants in the Multiethnic Cohort Study. Participants included 164,617 men and women from five ethnic groups: African American, Native Hawaiian, Japanese American, Latino, and Caucasian. Cox proportional hazards models, stratified by ethnicity and sex, were used to examine associations between adherence with recommended dietary guidelines for fruit and vegetable intake and risk for fatal IHD. The results did not provide evidence that the association between adherence with dietary recommendations for fruit or vegetable intake and IHD mortality varies by ethnicity. Pooled data did provide evidence that adhering to the recommendations for vegetables lowered risk among men (RR = 0.84, 95% CI: 0.74—0.96) and women (RR = 0.80, 95% CI: 0.69—0.94). No significant effects were observed for fruit intake.

Conclusions: The effect of dietary intake of fruit and vegetables did not vary by ethnicity, providing evidence that recommendations do not need to be individualized for these special populations. The protective effect observed for vegetable intake among both sexes confirms previous findings and supports the evidence base for promoting diet modification in this direction.

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Introduction

Ischemic heart disease (IHD) is the most common type of heart disease with the highest mortality rate in the U.S. It accounts for almost one-third of annual deaths (approximately 425,000 deaths in 2006) and is also projected to be a major cause of death in the developing world [1,2]. The rate of fatal IHD varies substantially by ethnic group within the U.S. The age-adjusted death rate of IHD, per 100,000 US population, was 161.6 in African Americans, 136.0 in non-Hispanic Caucasians, 106.4 in Latinos, 97.4 in American Indians or Alaska Natives, and 77.1 in Asian or Pacific Islanders in 2005 [2].

Environmental factors, especially diet, have long been suspected to cause these ethnic variations but few large-scale datasets have been available. There is evidence of a protective effect of fruit and vegetables on risk of IHD but most previous studies have not used standardized methodologies or been conducted in large multiethnic populations [3—5]. Previous studies in the Multiethnic Cohort (MEC) have revealed ethnic differences in the types of food consumed, as well as variation in adherence with dietary recommendations for fruit and vegetable intake [6,7]. The dietary recommendations developed by the United States Department of Agriculture (USDA) for daily consumption of fruits and vegetables are standardized for the general U.S. population [8]. However, to our knowledge, there are no studies examining the association of adherence to these recommendations with risk of fatal IHD among different ethnic groups.

Since the percentage of the U.S. population from minority ethnic backgrounds is increasing, there is a recognized need for ethnic-specific health data to identify high risk subgroups [9]. The aim of this study was to examine associations with adherence to the USDA dietary recommendations for dietary intake of fruits and vegetables and risk of fatal IHD among a large representative sample of five ethnic groups in the U.S.

Methods

Study population

Recruitment procedures, study design and baseline characteristics have been reported previously [10]. In brief, MEC participants included representative samples of African—American, Japanese—American, Native Hawaiian, Latino, and Caucasian men and women between the ages of 45 and 75, living in Hawaii and the Los Angeles County area between 1993 and 1996. All participants completed a comprehensive mailed questionnaire at baseline including a detailed quantitative food frequency questionnaire (QFFQ). A total of 201,257 respondents from the five ethnic groups completed the questionnaire, with response rates varying from 20% among Latinos to 49% in Japanese—Americans. Participants with missing smoking information (n = 6080), implausible diets based on energy and macronutrient intakes as well as food group consumption (n = 12,346), implausible or missing anthropometric information (n = 3251), and who reported a history of heart attack or angina (n = 14,880), were excluded, leaving a total of 72,866 men and 91,751 women in the present analyses. All participants provided informed consent, and the study protocol was approved by the institutional review boards of the University of Hawaii and the University of Southern California.

Dietary assessment

The development of the QFFQ has been described elsewhere [11]. In brief, three-day measured dietary records from 60 men and 60 women of each ethnic group served as the basis for the selection of food items for the QFFQ. A minimum set of food items contributing at least 85% to the consumption of nutrients of interest for each ethnic group were selected, complemented by ethnic-specific foods, irrespective of their nutrient contribution. The QFFQ captured intake frequency over the past year, based on 8—9 categories ranging from "Never or hardly ever" to "2 or more times a day", as well as the amount of food consumed, based on a choice of three portion sizes represented in both photographs and amounts.

A validation and calibration substudy using 24-h dietary recalls was conducted [11]. Average correlation coefficients for all nutrients based on absolute intakes ranged from 0.26 in African—American women to 0.57 in Caucasian men. Average correlations for nutrient densities were much higher, ranging from 0.57 to 0.74 across sex- and ethnic-specific strata.

A food composition table (FCT) specific for this multiethnic population was developed at the University of Hawaii Cancer Center [10]. The FCT includes a large recipe database and many unique foods consumed by the multiethnic population. The food groups and servings were based on the USDA dietary guidelines, including vegetables, fruit, meat and meat alternatives, grains and dairy products [8]. The number of servings across the appropriate food items on the QFFQ was summed to calculate each individual's number of food group servings. Mixed dishes were broken down into their component ingredients. Mean servings of food groups by ethnic-sex group were presented previously [6,7].

The USDA recommendations for fruit and vegetable intake are based on an individual's caloric intake. Accordingly, subjects were categorized into four groups according to their caloric intake: $\leq$6698 kJ ($\leq$1600 kcal), 6699—9209 kJ (1601—2200 kcal), 9210—11,721 kJ (2201—2800 kcal), $>$11,721 kJ ($>$2800 kcal). The recommendation for these caloric intake groups was 3, 3, 4, and 5 servings/daily for vegetables, respectively; and 2, 3, 3, and 4 servings/day for fruit, respectively. The percentage of the daily servings of each food group over its recommended servings at the matched caloric intake level was calculated to determine the degree of adherence.

Identification of heart disease deaths

For this analysis, we linked the MEC data with state death files and the National Death Index. Death from IHD includes ICD9 codes 410—414.9 or ICD10 codes I20—125.9. Follow-up for this study ended at the earliest of the following dates: the date of death or December 31st, 2001 (the closure data for this study).

Statistical analysis

To determine the associations between adherence to the USDA recommendations for fruit and vegetable intake and fatal ischemic heart disease, we applied Cox proportional hazards models using age as the time metric to calculate relative risks (RR) and 95% confidence intervals (CIs). The degree of adherence to the recommendations for each food group was categorized into quintiles based on the consumption patterns of the entire MEC subjects and trends were assessed across quantiles of degree of adherence by assigning the median of the appropriate quantile. Models were also assessed using a binary outcome measure for adherence with recommendations for dietary intake. A binary outcome based on cut-points of 75 and 100% adherence produced similar results, but the 75% cut-point diminished associations, thus the cut-point of 100% was chosen for the binary exposure variable. Ethnic-sex stratified models are presented. The following covariates were used as adjustment factors: ethnicity when appropriate (as a stratum variable), time on study ($\leq$2, 3–5, and $>$5 years, as a stratum variable), years of education, energy intake (logarithmically transformed), smoking (including current smoking, past smoking, and pack-years), body mass index, physical activity (defined as average hours of moderate or vigorous physical activity per day), history of diabetes, alcohol intake (grams per day), and intake of other food groups (i.e., meat, grain, and dairy products). In addition, the models for women included history of hormone replacement therapy. After evaluating complex smoking models, including time-dependent duration of smoking and time since quitting, we found that a model with indicator variables for current and former smokers and pack-years was appropriate. Tests based on Schoenfeld residuals showed no evidence that any of our analyses violated proportional hazards assumptions. All analyses were performed using SAS software, version 9.1 (SAS Institute Inc., Cary, NC, 2005), and all p values were 2-sided.

Potential variations in the effects of adherence to dietary recommendations for fruit and vegetable intake on

Table 1 Characteristics of cases of fatal ischemic heart disease and total participants.

Characteristics	Men		Women	
	Cases (n = 1140)	Total participants (n = 72,866)	Cases (n = 811)	Total participants (n = 91,751)
Age at cohort entry (years)	65.8 ± 7.7	65.7 ± 7.6	66.4 ± 7.1	59.3 ± 8.8
Energy intake (kcal)	2206 ± 1028	2309 ± 974	1866 ± 941	1885 ± 834
% Energy from fat	31.6 ± 7.1	30.3 ± 7.1	30.5 ± 7.3	29.7 ± 7.0
% Energy from saturated fat	9.6 ± 2.7	9.0 ± 2.6	9.1 ± 2.6	8.7 ± 2.6
% Energy from alcohol	3.4 ± 7.5	4.2 ± 7.4	1.6 ± 5.8	1.6 ± 4.7
Hours in moderate or vigorous activity per day	1.0 ± 1.3	1.3 ± 1.5	0.8 ± 1.0	1.1 ± 1.2
Pack-years (number of cigarettes per day × years smoked/20)	18.7 ± 19.0	13.7 ± 16.4	10.8 ± 15.2	6.5 ± 12.0
Ethnicity (%)				
Caucasian	23	26	19	26
African American	23	13	40	18
Hawaiian	9	7	8	7
Japanese	22	31	16	29
Latino	23	23	17	20
BMI (kg/m^2) (%)				
$\leq$18.5	2	24	5	4
18.5–24.9	41	28	35	48
25–29.9	42	22	31	30
$>$30	15	26	28	18
Smoking status (%)				
Never smoked	24	32	45	57
Past smoker	50	50	30	29
Current smoker	26	18	25	14
Repeatedly consumed alcohol (%)	49	63	27	39
Medical history (%)				
History of diabetes	30	11	37	10
History of hypertension	58	38	69	36
Education (%)				
Graduated college	19	31	13	26
Grade 11/12-some college	56	53	61	58
$\leq$10 yrs education	25	16	26	16
Currently married (%)	71	77	41	60

fatal ischemic heart disease were examined using the ethnic-sex stratified models, considering direction of point estimates, extent of confidence interval overlap, as well as the plausibility of non-uniform effects based on supporting literature when available [12].

Results

A total of 1140 male and 811 female cases of fatal IHD were identified in the MEC through December 31st, 2001. The total cohort and cases are described in Table 1. Cases reported more pack-years of cigarette smoking than the entire cohort. In addition, a higher proportion of cases were current smokers, reported a history of diabetes and hypertension, were overweight (BMI $\geq$ 25.1), and had $\leq$10 years of education compared to all participants. In addition, the cases had a lower proportion of married persons, particularly among women.

Baseline levels of adherence for the participants included in these analyses are presented in Table 2. Across most ethnic groups, women exhibited higher levels of adherence than men. Across ethnic groups, adherence levels varied more for vegetable intake, ranging by approximately 13 and 10% for the highest level of vegetable intake (for women and men respectively). The proportion of participants whose fruit intake met or exceeded the dietary recommendations ranged among the different ethnic groups by approximately 6% for women and 8% for men.

The ethnic-sex specific associations between degree of adherence to the food group recommendations and risk of fatal IHD are presented in Table 3. Significant protective associations were observed for vegetable intake among Latino men (RR = 0.62, 95% CI: 0.40–0.95) and Caucasian women (RR = 0.64, 95% CI: 0.43–0.96) consuming between 100 and149% of recommended intake levels and African American women with all intake levels except the third quantile (RR = 0.64, 95% CI: 0.43–0.96 for the highest quantile). Inconsistent results were observed for fruit intake. An elevated risk for ischemic heart disease mortality was observed among African American men with fruit intake in the second quintile (RR = 1.98, 95% CI: 1.38–2.83), while a protective association was observed among Caucasian men with fruit intake in the third quantile (RR = 0.64, 95% CI: 0.43–0.96) and no associations were observed among women. As comparison of the confidence intervals across strata did not provide any strong evidence that ethnicity modified the effect of adherence with recommended dietary intake on risk of IHD fatality, pooled results for men and women are presented in the final column of Table 3. A protective association was observed among men and women with vegetable intake at or above the dietary recommendation. A significant protective association was also observed among women with vegetable intake between 50 and 74% of the dietary recommendation (RR = 0.67, 95% CI: 0.50–0.88). A significant decreasing trend for the association between vegetable intake and ischemic heart disease was observed among Latino men (p_{trend} = 0.02) and men overall (p_{trend} = 0.05).

Ethnic-specific results for adherence to the USDA recommendation based on a binary outcome measure (<100%

Table 2 Baseline levels of adherence with USDA dietary recommendations for fruit and vegetable intake, by sex and ethnicity.[a]

Ethnic group	African American		Native Hawaiian		Japanese American		Latino		Caucasian		All ethnic groups	
Sex	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
	n = 16 801	n = 9557	n = 6572	n = 4929	n = 26,700	n = 22,539	n = 18 285	n = 16,809	n = 23,293	n = 19,032	n = 91,751	n = 72,866
Vegetable intake												
Q1 (<50%)	13.3	16.0	5.7	6.9	4.9	6.7	9.1	10.2	6.5	6.8	7.7	8.8
Q2 (50–74%)	17.7	20.8	12.0	14.3	11.9	14.9	14.4	16.7	12.3	13.7	13.6	15.7
Q3 (75–99%)	18.3	20.3	15.2	19.5	16.8	20.8	16.6	19.9	16.3	18.8	16.8	19.9
Q4 (100–149%)	26.3	25.3	29.2	31.2	31.4	32.5	28.9	29.5	30.2	32.5	29.5	30.8
Q5 (≥150%)	24.4	17.6	37.9	28.1	35.0	25.1	30.9	23.7	34.8	28.1	32.4	24.8
Fruit intake												
Q1 (<50%)	20.7	30.1	26.4	37.6	19.2	33.2	18.9	26.2	19.5	28.4	20.0	30.2
Q2 (50–74%)	13.1	17.0	15.4	17.4	13.3	17.0	12.8	16.0	14.4	17.4	13.6	16.9
Q3 (75–99%)	12.9	12.9	12.3	12.1	13.5	14.0	11.9	14.2	14.3	14.5	13.2	13.9
Q4 (100–149%)	20.2	18.0	19.3	16.7	22.3	19.0	20.4	19.0	22.8	20.0	21.5	19.0
Q5 (≥150%)	33.1	22.0	26.7	16.2	31.6	16.9	36.1	24.6	29.0	19.8	31.8	20.0

[a] Values are % of participants in the specified ethnic-sex group for the indicated adherence level.

Table 3 Degree of adherence to USDA dietary recommendations and risk of death from ischemic heart disease, by ethnicity and sex.[a]

	African American	Native Hawaiian	Japanese American	Latino	Caucasian	All ethnic groups
Men — cases/non-cases	**267/9290**	**99/4830**	**247/22,292**	**269/16,540**	**258/18,774**	**1140/71,726**
	RR (95% CI)	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**
Vegetables						
Q1 (<50%)	1.00	1.00	1.00	1.00	1.00	1.00
Q2 (50–74%)	0.73 (0.49–1.08)	0.91 (0.39–2.15)	0.77 (0.45–1.31)	0.84 (0.55–1.30)	1.27 (0.76–2.12)	0.85 (0.69–1.06)
Q3 (75–99%)	0.81 (0.54–1.22)	0.72 (0.30–1.69)	0.85 (0.52–1.41)	0.89 (0.58–1.37)	1.17 (0.71–1.93)	0.88 (0.71–1.09)
Q4 (100–149%)	0.76 (0.51–1.14)	0.96 (0.44–2.12)	0.73 (0.45–1.20)	**0.62 (0.40–0.95)**	0.90 (0.55–1.48)	**0.74 (0.60–0.91)**
Q5 (≥150%)	0.74 (0.46–1.17)	1.14 (0.52–2.53)	0.74 (0.44–1.24)	0.63 (0.40–1.01)	1.01 (0.61–1.67)	**0.77 (0.62–0.97)**
p Trend	0.53	0.13	0.67	**0.02**	0.13	**0.05**
Fruits						
Q1 (<50%)	1.00	1.00	1.00	1.00	1.00	1.00
Q2 (50–74%)	**1.98 (1.38–2.83)**	1.49 (0.86–2.57)	0.97 (0.64–1.46)	0.90 (0.61–1.34)	0.82 (0.56–1.21)	1.14 (0.96–1.37)
Q3 (75–99%)	1.35 (0.88–2.09)	0.49 (0.20–1.18)	0.89 (0.58–1.37)	1.06 (0.72–1.56)	0.93 (0.63–1.38)	1.00 (0.82–1.21)
Q4 (100–149%)	1.38 (0.94–2.03)	1.02 (0.54–1.90)	1.26 (0.87–1.82)	0.87 (0.59–1.27)	**0.64 (0.43–0.94)**	0.98 (0.82–1.18)
Q5 (≥150%)	1.19 (0.80–1.77)	1.15 (0.64–2.08)	0.88 (0.59–1.33)	0.82 (0.57–1.18)	0.80 (0.55–1.17)	0.91 (0.76–1.09)
p Trend	0.83	0.71	0.95	0.19	0.2	0.15
Women — cases/non-cases	**322/16,479**	**65/6507**	**126/26,574**	**141/18,144**	**157/23,236**	**811/90,940**
Vegetables						
Q1 (<50%)	1.00	1.00	1.00	1.00	1.00	1.00
Q2 (50–74%)	**0.54 (0.35–0.83)**	0.81 (0.25–2.63)	1.70 (0.56–5.17)	0.78 (0.40–1.53)	0.64 (0.34–1.18)	**0.67 (0.50–0.88)**
Q3 (75–99%)	0.76 (0.51–1.14)	0.94 (0.31–2.81)	2.24 (0.77–6.50)	0.79 (0.40–1.55)	0.77 (0.44–1.34)	0.85 (0.65–1.11)
Q4 (100–149%)	**0.65 (0.44–0.95)**	0.54 (0.18–1.61)	1.56 (0.54–4.51)	0.74 (0.39–1.41)	**0.41 (0.22–0.74)**	**0.63 (0.40–0.82)**
Q5 (≥150%)	**0.64 (0.43–0.96)**	0.56 (0.19–1.65)	1.16 (0.39–3.44)	0.90 (0.48–1.71)	0.67 (0.38–1.17)	**0.68 (0.52–0.88)**
p Trend	0.58	0.49	0.15	0.72	0.96	0.15
Fruits						
Q1 (<50%)	1.00	1.00	1.00	1.00	1.00	1.00
Q2 (50–74%)	1.06 (0.71–1.60)	1.49 (0.64–3.47)	1.54 (0.74–3.23)	1.55 (0.83–2.90)	0.53 (0.28–1.01)	1.07 (0.82–1.38)
Q3 (75–99%)	0.98 (0.65–1.47)	1.25 (0.51–3.07)	1.28 (0.59–2.77)	1.31 (0.67–2.58)	0.80 (0.46–1.42)	1.03 (0.79–1.34)
Q4 (100–149%)	0.83 (0.57–1.22)	0.92 (0.38–2.22)	1.46 (0.74–2.90)	1.01 (0.53–1.90)	1.03 (0.64–1.66)	0.96 (0.76–1.22)
Q5 (≥150%)	0.94 (0.66–1.33)	0.95 (0.42–2.15)	1.48 (0.76–2.87)	1.29 (0.73–2.28)	0.68 (0.41–1.11)	0.97 (0.77–1.12)
p Trend	0.95	0.97	0.61	0.63	0.2	0.81

[a] Cox regression with age as the time metric adjusted for ethnicity, time on study, maximum years of education, energy intake (logarithmically transformed), smoking behavior (including current smoking, past smoking and pack-years), body mass index (kg/m^2), physical activity (defined as average hours of moderate or vigorous physical activity per day), history of diabetes, and alcohol intake (grams per day). The models for women were additionally adjusted for use of hormone replacement therapy. Statistically significant ($p \leq 0.05$) values are indicated in bold.

adherence versus ≥100%) are presented in Table 4. With the exception of Native Hawaiian men, the point estimates for adherence with vegetable intake suggested a protective effect for the risk of fatal IHD among all groups. However, in the ethnicity-stratified models, this effect was only significant among Latino men (RR = 0.70, 95% CI: 0.53–0.91) and Caucasian women (RR = 0.70, 95% CI: 0.49–0.99). No effects were apparent for associations with fruit intake and risk of IHD. Pooled results for men and women with the ethnic groups combined are presented in the final column of Table 4. Adherence with the recommendations for vegetable intake was associated with a significantly lower risk of IHD among both men (RR = 0.84, 95% CI: 0.74–0.96) and women (RR = 0.80, 95% CI: 0.69–0.94). The point estimates for the associations with fruit intake suggested a protective effect in both men and women, but these results did not reach statistical significance.

Table 4 Associations between adherence with dietary recommendations and risk for ischemic heart disease mortality.[a]

	African American	Native Hawaiian	Japanese American	Latino	Caucasian	All ethnic groups
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Men — cases/non-cases	267/9290	99/4830	247/22,292	269/16,540	258/18,774	1140/71,726
Reference[b]	1.00	1.00	1.00	1.00	1.00	1.00
Vegetables	0.92 (0.70–1.21)	1.25 (0.81–1.94)	0.87 (0.66–1.14)	**0.70 (0.53–0.91)**	0.81 (0.62–1.05)	**0.84 (0.74–0.96)**
Fruits	0.93 (0.71–1.20)	1.07 (0.70–1.65)	1.13 (0.86–1.47)	0.85 (0.66–1.10)	0.77 (0.59–1.01)	0.91 (0.80–1.03)
Women — cases/non-cases	322/16,479	65/6507	126/26,574	141/18,144	157/23,236	811/90,940
Reference[b]	1.00	1.00	1.00	1.00	1.00	1.00
Vegetables	0.88 (0.68–1.14)	0.61 (0.33–1.09)	0.72 (0.48–1.07)	0.99 (0.67–1.47)	**0.70 (0.49–0.99)**	**0.80 (0.69–0.94)**
Fruits	0.88 (0.69–1.13)	0.76 (0.44–1.33)	1.11 (0.78–1.73)	0.93 (0.64–1.35)	1.04 (0.74–1.47)	0.94 (0.80–1.09)

[a] Cox regression with age as the time metric adjusted for ethnicity, time on study, maximum years of education, energy intake (logarithmically transformed), smoking behavior (including current smoking, past smoking and pack-years), body mass index (kg/m^2), physical activity (defined as average hours of moderate or vigorous physical activity per day), history of diabetes, alcohol intake (grams per day) and food group intake (meat, grain, dairy products). Statistically significant ($p \leq 0.05$) values are indicated in bold.
[b] Reference group: nonadherent with dietary recommendations.

Discussion

To our knowledge, this is the first study to explore the effects of adherence to the USDA recommendations for fruit and vegetable intake on risk of fatal IHD among multiple ethnic groups in the United States. As the proportion of ethnic minorities in the U.S. population increases, it is important to determine whether risk factors for disease vary among ethnic groups in order to identify high risk groups and target appropriate interventions. The impact of very cost-effective interventions such as diet modification is particularly relevant considering the growing burden of chronic diseases such as IHD.

The baseline results for adherence with USDA dietary recommendations for fruit and vegetable intake observed in this study indicate that the proportion of persons consuming the recommended intake of fruits and vegetables varies by ethnicity, as well as sex. These findings are similar to adherence rates with dietary recommendations observed among all MEC participants in previous work, with the exception of a slightly higher proportion (approximately 4%) of African American men and women consuming less than 100% of the USDA recommendation for fruit intake in the current study [6,7]. Although differences in food consumption patterns and adherence levels appear to exist [6,7], the results from this large multiethnic cohort suggest that dietary intake of fruit and vegetables does not differentially impact the risk of IHD among different ethnic groups. The current study examined associations between fruit and vegetable intake and ischemic heart disease using quantile levels of adherence, as well as a binary exposure for adherence with dietary recommendations, with similar conclusions. However, our results did show that, overall, men and women who met or exceeded the dietary recommendations for vegetable intake had a reduced risk of IHD death. The findings based on quantile levels of adherence, using less than 50% adherence as a reference, also indicate that the protective association increases with greater vegetable consumption, particularly among men. Similar findings on the protective effect of vegetable intake have been reported by others [13,14]. This dose–response effect suggests the need to re-evaluate the dietary guidelines for possibly an even higher recommended level of vegetable intake to reduce risk of chronic disease and improve overall health, particularly in groups known to be at higher risk (e.g., people with family history) [15,16].

Some previous studies found an inverse association between risk of IHD and consumption of vegetables alone [17], as well as vegetables and fruit combined [3,4,18]. A number of components of fruit and vegetables, such as polyunsaturated fatty acids, plant sterols, fiber, polyphenolic compounds, vitamin C, and vitamin E are considered as protective factors for IHD [19—21]. Phytochemicals, including fiber, have the potential to reduce hyperlipidemia and the reabsorption of bile salts [22,23]. However, one cohort study found no association between dietary fiber and IHD mortality [15]. Vitamin E and vitamin C have been shown to be particularly beneficial in the prevention of inflammation in atherosclerotic plaque development, and in endothelial dysfunction, respectively [16,24]. In contrast, vitamin D has been shown to be a risk factor for IHD [19], and a meta-analysis of cohort studies concluded that the specific components in fruit and vegetables responsible for the protective effects are unknown [25]. It is also possible that the null findings for fruit consumption in our study are due to opposing effects of different types of fruit. More studies on subgroups of fruit are necessary to clarify the current observations.

The MEC study provided a unique opportunity to examine associations between diet, IHD mortality and ethnicity using large representative samples from five ethnic minorities living in the United States. Collection of dietary information using a common QFFQ, including ethnic-specific foods and portion sizes, facilitated comparison across ethnic groups, and with other studies. We also had access to information on a wide variety of covariates which allowed adjustment of our models for possible confounders. Limitations of this study include possible over reporting of food consumption, as well as recall bias [26]. However, the QFFQ used in the MEC has been validated and appears to capture total intake relatively well [11]. In addition, changes in diet over a person's lifetime, which cannot be captured with the assessment of food consumption over a narrow time period, may have influenced the associations between diet and risk for IHD. Although this analysis was based on large samples of each ethnic group, there were a large number of exclusions, and with the variation in response rate among the different ethnic groups, selection bias is also a concern. Nonetheless, our findings are consistent with previous reports, which support the validity of our findings.

Conclusions

The results from this study did not provide any evidence that the effects on the risk of IHD mortality associated with adherence to the U.S. dietary recommendations for fruit and vegetable intake vary by ethnicity. However, given the increasing ethnic diversity in the United States and the growing burden of chronic diseases such as IHD, it is particularly salient to examine the potential impact of simple cost-effective interventions such as diet modification. The protective effect of vegetables observed in this study is supported by previous work and further demonstrates the importance of promoting diet modification in this direction.

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