Socio-demographic, behavioral, and health correlates of nutrition transition dietary indicators in San Juan, Puerto Rico

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ABSTRACT

Objective.   To identify socio-demographic, behavioral, and health-related correlates of food preferences in Puerto Rico that will help determine Caribbean-region populations vulnerable to nutrition transition.

Methods.   Data from a cross-sectional study of a representative sample of 858 adults residing in the San Juan Metropolitan Area of Puerto Rico were analyzed. Multivariable ordinal logistic regressions were used to model the frequency of consumption of 1) fruits and vegetables, 2) tubers/starchy root vegetables, 3) fried foods, and 4) Western-style fast foods as a function of socio-demographic, behavioral, and health-related characteristics.

Results.   Higher frequency of consumption of fruits and vegetables was associated with being physically active and older and having a medium to high level of education, whereas intake of tubers was associated with being older, having a low income, not using government insurance, and having elevated levels of triglycerides. Frequency of consumption of fast food was associated with younger age, higher income, 12–15 years of formal education, and a higher body mass index (BMI), whereas frequency of consumption of fried food was associated with being younger and male, not being a smoker, and having elevated levels of fasting blood glucose.

Conclusions.   The results indicate a nutrition transition in Puerto Rico with health consequences for the Caribbean region. The characteristics of this nutrition transition seem to be determined by income, education, and age, but may also be dictated by access to various food groups. These results set the stage for needed investigation of environmental and individual-level factors that could shape patterns in food consumption.

Key words   Diet; socioeconomic factors; health transition; nutrition, public health; Caribbean region; Latin America; Puerto Rico.

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Chronic noncommunicable diseases are the leading causes of death and disability worldwide (1), and are increasing rapidly in the Caribbean (2, 3). Obesity, hypertension, diabetes, and cardiovascular disease have grown exponentially in the region (4), and have often been accompanied with increased intakes of fats and refined sugars (4, 5), suggesting that the region is undergoing a nutrition transition (6).

Nutrition transition is defined as progressive shifts from traditional, nutrient-rich diets to energy-dense, nutrient-poor ultra-processed foods and increased sedentary lifestyle (7). Socio-demographic characteristics, such as income, education, sex, and location can often predict

which segments of the population will be worst affected by the nutrition transition (8), but this will depend on the macro- and micro-economic forces and sociocultural aspects inherent in each region (9).

Despite the increasing rates of obesity and metabolic diseases in the Caribbean, which are accompanied by a change in diet, there are limited data on socio-demographic, behavioral, and health-related correlates of this nutrition transition (4, 5, 10). This study aimed to elucidate associations between socio-demographic characteristics, health behaviors, and indicators of metabolic disorders (plasma glucose, serum lipids, blood pressure, and anthropometric measures) and the frequencies of consumption of foods that exemplify the shift from traditional nutrient-rich foods to ultra-processed ones in Puerto Rico.

Residents of Puerto Rico, the smallest island of the Greater Antilles, and a commonwealth of the United States, have the highest rates of diabetes, hypertension, obesity, and metabolic syndrome compared to other Caribbean and Latin American countries (11, 12). Puerto Ricans in the United States also have the highest burden of overall cardiovascular risk factors compared to other Hispanics (13). Exposing potential socio-demographic, behavioral, and health-related correlates of food preferences in Puerto Rico will help determine Caribbean-region populations vulnerable to this transition.

MATERIALS AND METHODS

Study population

The data used in the current analysis were from a population-based study conducted in the seven municipalities of the San Juan Metropolitan Area (SJMA) in Puerto Rico. The sampling frame was based on the maps of the SJMA census tracks.

A detailed description of the study design and recruitment process has been published elsewhere (14). Briefly, adults 21–79 years old living in the SJMA between 2005 and 2007 were recruited using a three-stage cluster household-survey sampling design. All eligible individuals in the randomly selected households were invited to participate in the study, which consisted of 1) a face-to-face interview designed to collect information

on socio-demographic, behavioral, and health-related characteristics (described in detail below); 2) a physical exam; and 3) the collection of biochemical measurements after an eight-hour overnight fast. Of the 1 200 eligible adults identified, 867 (72.3%) completed all three parts of the study. The final sample consisted of 858 subjects. The study protocol was approved by the institutional review board of the University of Puerto Rico Medical Sciences Campus.

Measures

Intake of selected food groups. To exemplify the shift from traditional nutrient-rich foods to ultra-processed ones, intake of the following four food groups was assessed using a food-frequency questionnaire: 1) fruits and vegetables, 2) tubers/starchy root vegetables, 3) fried foods, and 4) fast foods. Frequencies of consumption were assessed in face-to-face interviews with the following question: "In the last 30 days, how many times a day, week, or month did you consume [. . .]?" The following food groups and food examples were provided: 1) fruits (fruit and fruit juices such as mango, orange, banana, apples, and grapes); 2) vegetables (tomato, broccoli, cabbage, cole crop vegetables, carrots, and corn); 3) plantains and tubers or starchy root vegetables (*yautía, yam,* and *malanga);* 4) fried foods (*arepas, pastelillos, tostones, amarillos,* fried fish, french fries, and fried meat); and 5) fast foods (foods purchased in multinational corporations such as Burger King, McDonalds, Pizza Hut, Pollo Tropical, Subway, and Chili's). These food groups were selected based on the strong association between the frequency of their consumption and the risk of chronic noncommunicable diseases.

Socio-demographic variables. Information on age, education (formal years of schooling), annual household income, and type of health insurance was collected using a questionnaire.

Behavioral and health-related variables. Participants were asked about smoking, alcohol consumption, and physical-activity behaviors, and were considered 1) current smokers if they had smoked at least 100 cigarettes in their lifetime and were still smoking; 2) current alcohol users if they reported drinking at least

one alcoholic drink in the past 30 days; and 3) physically active if they practiced moderate-intensity activities for a minimum of 30 minutes five days per week, or if they practiced vigorous-intensity activities for a minimum of 20 minutes three days per week in the past seven days. Those whose physical activity was less than previously mentioned were considered sedentary.

Anthropometric measures. Weight, height, and waist circumference measures were collected by trained personnel according to National Health and Nutrition Examination Survey (NHANES) III anthropometric procedure videos (15). Body mass index (BMI) was calculated as kg/m^2 and categorized as follows: underweight (< 18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥ 30 kg/m^2). Elevated waist circumference (≥ 40 inches in men and ≥ 35 inches in women) was assessed according to the cut points for clinical identification of metabolic syndrome proposed by the American Heart Association/National Heart, Lung, and Blood Institute (16).

High blood pressure. Three resting blood pressure measurements were determined per adult, using the standard mercury sphygmomanometer read to the nearest 2 mm. Individuals with elevated blood pressure had a systolic blood pressure ≥ 130 mm Hg and a diastolic blood pressure ≥ 85 mm Hg (17), or were on antihypertensive drug treatment and had a history of hypertension.

Glucose and serum lipids. Triglycerides and high-density lipoprotein cholesterol (HDL-C) and plasma glucose were classified according to the cut points for clinical identification of metabolic syndrome (16) as follows: elevated triglyceride concentrations (≥ 150 mg/dL), low HDL-C (< 40 mg/dL in men and < 50 mg/dL in women), and elevated fasting glucose level (≥ 100 mg/dL). Individuals on drug treatment for elevated triglycerides, low HDL-C, or elevated glucose were considered to have elevated triglycerides, low HDL-C, or elevated fasting glucose, respectively.

Statistical analysis

Based on the data collected in the survey, frequency of consumption of

fruits, vegetables, and tubers per day and frequency of consumption of fried foods and fast foods per week were calculated. Fruits and vegetables were combined into one group, resulting in a total of four food groups: 1) fruits and vegetables, 2) tubers, 3) fried foods, and 4) fast food. All food groups had a skewed distribution and were described in terms of their medians and 25th and 75th percentiles. Significant differences in socio-demographic, behavioral, and health-related characteristics by frequency of food group consumption were assessed using chi-square tests for proportions and the Mann-Whitney-Wilcoxon test or Kruskal-Wallis test for medians (results not shown). Consumption of each of the four food groups as indicators of nutrition transition was categorized as tertiles, and the lowest category was used as the reference for multivariable analysis. Four multivariable ordinal logistic regressions were used to model the frequency of consumption in each food group as a function of socio-demographic, behavioral, and health-related characteristics that had been significantly associated with the outcome of interest in the bivariate analyses. All correlated variables were introduced simultaneously to each model. The satisfaction of the proportionality-of-odds assumption was assessed with the likelihood ratio test. Analyses using negative binomial and Poisson distributions for counts were also performed, but they did not affect results significantly, so the results of the multivariable ordinal logistic regression are presented by tertile. Data management and statistical analyses were performed using version 11.0 of the statistical package Stata (StataCorp LP, College Station, Texas, USA). A value of $P \geq 0.05$ was considered statistically significant.

RESULTS

The mean age of the study participants was 49.4 years (± 16.1), nearly 72% reported 12 years or more of formal education, 67.2% reported an annual income ≤ US$ 20 000, and 43.2.6% reported having government-administered or no health insurance (Table 1). Almost 80% of the population was either overweight or obese, and more than 45% had at least one metabolic syndrome component (elevated waist circumference, el-

evated fasting glucose level, elevated blood pressure, or reduced HDL-C). The prevalence of current smoking; alcohol consumption; and elevated triglycerides, blood pressure, and glucose levels was higher in males than in females ($P < 0.05$). The reverse was true for the prevalence of elevated waist circumference and reduced HDL-C ($P < 0.05$). There were no sex-related differences in the median frequency consumption in any of the four food groups studied.

Multivariable ordinal regressions models were used to assess correlates of frequency of consumption for each food

group as indicators of nutrition transition (Table 2). The four models used age and BMI as continuous variables. A higher frequency of fruit and vegetable consumption was associated with older age, having more than 12 years of formal education, and being physically active. Tuber consumption was positively associated with older age and having elevated triglycerides. Inverse associations were found between frequency of tuber consumption and having an annual income of US$ 20 000–49 999 (< US$10 000 annual income = reference) and some type of public health insurance (ver-

TABLE 1. Distribution of socio-demographic, behavioral, and health-related characteristics by sex in random population sample of adults, San Juan Metropolitan Area, Puerto Rico, 2005–2007[a]

Characteristic	Total (n = 858)	Male (n = 295)	Female (n = 563)	P[b]
Age (years), %				
21–29	14.8	15.6	14.4	0.76
30–39	16.4	14.9	17.2	
40–49	17.6	15.9	18.5	
50–59	19.2	19.3	19.2	
60–69	19.4	20.0	19.0	
70–79	12.6	14.2	11.7	
Formal education (years), %				
< 12	28.3	30.9	27.0	0.48
12–15	52.1	49.8	53.3	
≥ 16	19.6	19.3	19.7	
Annual income (US$)%[c] ($n$ = 752)				
< 10 000	43.9	32.0	50.0	< 0.001
10 000–19 999	23.3	29.3	20.2	
20 000–29 999	13.2	16.0	11.7	
30 000–49 999	11.6	13.3	10.7	
≥ 50 000	8.1	9.4	7.5	
Health insurance, %[c] (n = 854)				
Private	40.6	42.4	37.3	< 0.001
Medicare or Medicare/Advantage[d]	16.2	16.3	14.4	
State/local government	33.8	26.1	39.4	
None	9.4	15.3	8.9	
Current smoker, %[c]	19.9	24.0	17.8	0.03
Alcohol consumer, %[c,e] (n = 855)	45.6	58.7	38.8	< 0.001
Physically active, %[f]	38.9	37.3	39.4	0.54
Overweight / obese, %[c,g] (n = 840)	79.1	78.5	79.3	0.05
Elevated waist circumference, %	48.6	37.6	54.4	< 0.001
Elevated triglycerides, %	31.2	39.7	26.8	< 0.001
Reduced HDL-C,[h] %	45.8	34.6	51.7	< 0.001
Elevated blood pressure, %	45.6	55.9	40.1	< 0.001
Elevated fasting glucose, %	49.8	61.0	43.9	< 0.001
Food groups, median frequency				
Fruits, vegetables (per day) (n = 857)	1.86	1.7	1.9	0.11
Tubers[i] (per day) (n = 857)	0.14	0.29	0.14	
Fried foods (per week) (n = 857)	2.0	3.0	2.0	
Fast foods (per week)	0.46	0.23	0.69	

[a] Unless otherwise noted, n = 858.
[b] Based on Pearson's chi-square test.
[c] $P < 0.05$.
[d] U.S. federal government health insurance programs for persons > 65 years old (American citizens, nationals, and legal residents).
[e] Consumption of at least one alcoholic drink in the past 30 days.
[f] Self-assessment of moderate or vigorous physical activity in past seven days.
[g] Body mass index ≥ 25 kg/m^2.
[h] High-density lipoprotein cholesterol.
[i] Starchy root vegetables (e.g., taro, *cassava*, plantains, *malanga*, and *yautía*).

TABLE 2. Multivariate ordinal logistic regression models for tertiles of times-per-day or times-per-week consumption of food groups by socio-demographic, behavioral, and health-related characteristics in random sample of adults (*n* = 731[a]), San Juan Metropolitan Area, Puerto Rico, 2005–2007[b]

Characteristic	Odds ratios (95% confidence intervals)			
	Fruits and vegetables (per day)	Tubers (per day)	Fried foods (per week)	Fast foods (per week)
Age (years)	1.03 (1.02, 1.05)[c]	1.02 (1.01, 1.03)[c]	0.96 (0.95, 0.97)[c]	0.95 (0.94, 0.96)[c]
Sex (female)	1.32 (0.96, 1.82)	0.93 (0.66, 1.29)	0.45 (0.32, 0.63)[c]	1.21 (0.86, 1.71)
Education (years)				
< 12	Reference	Reference	Reference	Reference
12–15	1.59 (1.11, 2.29)[c]	0.82 (0.56, 1.19)	1.23 (0.85, 1.78)	1.55 (1.05, 2.31)[c]
≥ 16	1.62 (1.03, 2.54)[c]	1.03 (0.65, 1.62)	0.83 (0.52, 1.32)	1.53 (0.95, 2.47)
Income (US$)				
< 10 000	Reference	Reference	Reference	Reference
10 000–19 999	0.90 (0.62, 1.32)	0.70 (0.47, 1.05)	0.71 (0.48, 1.05)	1.88 (1.24, 2.85)[c]
20 000–29 999	0.93 (0.57, 1.50)	0.58 (0.35, 0.95)[c]	0.93 (0.56, 1.54)	2.59 (1.53, 4.39)[c]
30 000–49 999	0.82 (0.48, 1.38)	0.41 (0.23, 0.74)[c]	0.79 (0.46, 1.36)	2.23 (1.28, 3.92)[c]
≥ 50 000	1.04 (0.57, 1.88)	0.85 (0.46, 1.58)	0.67 (0.36, 1.24)	3.31 (1.79, 6.12)[c]
Health insurance				
Private	Reference	Reference	Reference	Reference
Medicare or Medicare/Advantage[d]	0.79 (0.51, 1.22)	1.10 (0.70, 1.74)	1.47 (0.93, 2.34)	1.36 (0.83, 2.22)
State/local government	0.72 (0.48, 1.07)	0.61 (0.40, 0.92)[c]	1.25 (0.83, 1.89)	1.46 (0.94, 2.26)
None	1.12 (0.66, 1.91)	0.70 (0.39, 1.22)	1.18 (0.69, 2.03)	1.03 (0.58, 1.80)
Smoking status ("Yes")	1.31 (0.91, 1.90)	1.10 (0.74, 1.63)	0.66 (0.46, 0.99)[c]	1.12 (0.76, 1.64)
Alcohol (current drinker)	0.92 (0.68, 1.24)	1.16 (0.85, 1.58)	1.18 (0.87, 1.59)	0.94 (0.68, 1.28)
Physical activity ("Yes")	1.39 (1.04, 1.85)[c]	1.31 (0.98, 1.77)	1.00 (0.75, 1.35)	1.12 (0.87, 1.51)
BMI (kg/m^2)	0.99 (0.96, 1.01)	0.98 (0.95, 1.01)	0.99 (0.97, 1.02)	1.04 (1.01, 1.07)[c]
Elevated waist circumference	0.95 (0.66, 1.38)	0.97 (0.65, 1.45)	1.41 (0.95, 2.10)	0.90 (0.60, 1.35)
Elevated triglycerides	1.05 (0.77, 1.44)	1.43 (1.02, 1.99)[c]	0.91 (0.65, 1.27)	0.78 (0.55, 1.09)
Reduced HDL-C	1.07 (0.80, 1.44)	0.94 (0.69, 1.27)	1.07 (0.79, 1.45)	0.92 (0.67, 1.25)
Elevated blood pressure	1.05 (0.75, 1.49)	0.92 (0.64, 1.30)	0.95 (0.66, 1.35)	0.71 (0.49, 1.01)
Elevated fasting glucose	0.87 (0.63, 1.20)	1.08 (077, 1.51)	1.50 (1.07, 2.10)[c]	1.24 (0.87, 1.74)

[a] Observations with missing values were excluded from this analysis.
[b] All models fitted to age categories; sex (male = reference); education categories; income categories; health insurance plans; smoking status ("No"); alcohol consumption in past 30 days ("Yes"); self-reported status on physical activity ("Yes; moderate or vigorous physical activity"); body mass index (BMI) category (normal, obese, or overweight); and elevated waist circumference, triglycerides, blood pressure, and fasting blood glucose, and reduced high-density lipoprotein cholesterol (HDL-C).
[c] *P* < 0.05.
[d] U.S. federal government health insurance programs for persons > 65 years old (American citizens, nationals, and legal residents).

sus private health insurance). Higher frequency of fried food consumption was associated with younger age, being male, non-smoking status, and having elevated fasting glucose. Higher frequency of fast food consumption was associated with younger age, having 12–15 years of formal education, higher annual income categories (< US$10 000 annual income = reference), and higher BMI.

DISCUSSION

To the best of the authors' knowledge, this is the first study to identify socio-demographic, behavioral, and health-related correlates of food groups that are considered indicators of a nutrition transition in Puerto Rico (fruits and vegetables, tubers or staple starchy root vegetables, fried foods, and Western-style fast foods). Results from this study suggest that the island is undergoing a nutrition transition distinctly characterized by income, educational attainment, and age. In sum: younger adults (with higher income and median education) reported

higher frequency of consumption of ultra-processed foods (fast foods) and had elevated BMI; older adults (with higher levels of education) reported higher frequency of consumption of fruits and vegetables; and older adults (with lower income) reported higher frequency of consumption of traditional tubers, and had elevated triglycerides. Given the increase in obesity and metabolic disorders in the Caribbean (3), particularly in Puerto Rico (11), the results of this study could be useful in the development of nutrition promotion programs.

The results on the determinants of fruit and vegetable consumption echo findings from previous studies in Puerto Rico where education, but not income, is associated with diet. A 2008 island-wide survey found that fruit and vegetable intake was positively associated with knowing the recommendations for fruits and vegetable consumption and having attained a higher education level, but not with income (18). A study among university students (18–30 years old) found that regardless of income

or social support, diets fell below the recommended intake for grains, fruits, vegetables, dairy, and protein. However, students from the medical school and school of public health had healthier dietary patterns than those from other schools (though still below recommendations) (19, 20). Interestingly, all of the students had adequate fat content in their diets.

In concurrence with reports from previous decades, the current findings suggest that Puerto Rico is undergoing a nutrition transition similar to those in resource-poor countries where choices are limited by income and physical access to nutrient-rich foods (21). For example, in 1966, high-income families in Puerto Rico had consumed salad vegetables and fresh fruits (other than bananas) more frequently than lower-income families, whereas tuber consumption was high across all income groups (10). Today, according to the study results, as income increases, so does frequency of ultra-processed fast food consumption, whereas tuber consumption is more frequent among low-income groups

(< US$ 10 000). However, for fruits and vegetables, income seems to play a lesser role as a determinant, and remains low across all income groups (19, 20). A partial explanation could be that limited physical access to fruits and vegetables (i.e., availability and affordability) and greater access to cheap, nutrient-poor foods shape individual behaviors (purchase and consumption) and eventually food preferences (22). Researchers in resource-poor countries have observed that income effects (i.e., the ability to afford a more diversified diet) can be limited by physical access to nutrient-rich choices (21). It is possible that in Puerto Rico, as in the rest of the Caribbean, where most foods are imported (23) and the availability of cheap, nutrient-poor, processed foods is high, higher-income individuals diversify their diets with processed foods. In Barbados, the nutrition transition was characterized by increased availability of fats and sugars (4), possibly in the form of processed foods. Further research is needed to test this hypothesis and to identify the role that education (or health awareness and knowledge) would play among these individuals in the context of nutrient-rich environments.

If the above observations hold true, public health actions to improve access to nutrient-rich foods are imperative, given the higher prevalence of cardio-metabolic risk factors among frequent consumers of fried and fast foods, and tubers. Western-style fast foods have been associated with weight gain (24–26) or obesity (27), insulin resistance (25), and poorer dietary indicators (such as higher consumption of energy, fat, sugar, and sugar-sweetened beverages, and less fiber, milk, and fruits and vegetables) (24, 26, 28) in studies worldwide. Fried foods have been associated with cardio-metabolic risk in some (29–31), but not all (32, 33), studies—possibly depending on the type of oil used for frying (34). In Puerto Rico, the traditional cooking fat is lard (10), and more recently, vegetable oil (35), but the frequency and purpose of use of each at the population level is unknown. In the current study, frequent consumption of tropical starchy root vegetables and tubers was associated with elevated triglycerides. The traditional diet of Puerto Rico and the Caribbean is rich in tuber consumption, as well as traditional white breads and rice (not captured in this study) (36). Long-term consumption of foods high in carbohydrates has been associated with higher triglycerides levels and type 2 diabetes (37).

These study results indicate Puerto Rico is experiencing a nutrition transition with health consequences for the Caribbean region. The characteristics of this nutrition transition seem to be determined by income, education, and age, but may also be dictated by access to various food categories. These results set the stage for needed investigation of factors that could shape food consumption, including income and education within the context of access and availability.

Conflicts of interest. None.

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RESUMEN

Correlatos sociodemográficos, conductuales y de salud de los indicadores alimentarios de transición nutricional en San Juan, Puerto Rico

Objetivo. Determinar los correlatos sociodemográficos, conductuales y relacionados con la salud de las preferencias alimentarias en Puerto Rico a fin de ayudar a determinar las poblaciones vulnerables con respecto a la transición nutricional en el Caribe.

Métodos. Se analizaron datos procedentes de un estudio transversal de una muestra representativa de 858 adultos que residen en el área metropolitana de San Juan, en Puerto Rico. Se usaron regresiones logísticas ordinales con múltiples variables para modelar la frecuencia de consumo de 1) frutas y verduras, 2) tubérculos feculentos, 3) alimentos fritos y 4) comida rápida de estilo occidental, como una función de las características sociodemográficas, conductuales y relacionadas con la salud.

Resultados. Se asoció una mayor frecuencia de consumo de frutas y verduras con un comportamiento físicamente activo y mayor edad, al igual que un nivel de escolaridad de medio a alto, mientras que la ingesta de tubérculos se asoció a una edad mayor, ingresos bajos, no usar el seguro del gobierno y niveles elevados de triglicéridos. La frecuencia de consumo de comida rápida se asoció con una edad menor, ingresos más altos, de 12 a 15 años de educación formal y un índice de masa corporal mayor, mientras que la frecuencia del consumo de alimentos fritos se asoció con una edad más joven y el sexo masculino, no fumar y niveles elevados de glucemia en ayunas.

Conclusiones. Los resultados indican una transición nutricional en Puerto Rico con consecuencias para la salud en el Caribe. Las características de esta transición nutricional parecen estar determinadas por los ingresos, la escolaridad y la edad, pero también podrían estar determinadas por el acceso a diversos grupos alimentarios. Estos resultados establecen las condiciones necesarias para la investigación de los factores ambientales e individuales que podrían configurar los modelos de consumo de alimentos.

Palabras clave Dieta; factores socioeconómicos; transición de la salud; nutrición en salud pública; región del Caribe; América Latina; Puerto Rico.