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Exploratory Study of the Relationship Between Hypertension and Diet Diversity Among Saba Islanders

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Synopsis

The relationship between diet diversity and hypertension was examined in a cross-sectional exploratory study of 82 randomly selected adult residents of Saba Island, Netherlands Antilles, in the eastern Caribbean Basin. Blood pressure measurements, taken over 4 years, and the appropriate use of antihypertensive medications, were used to identify chronic hypertensives. A 24-hour dietary recall, semi-quantitative food frequency interviews, and ethnographic confirmation techniques were used to calculate diet diversity, a measure of the overall dietary pattern.

Results suggest hypertension is associated with lack of an overall balance of food groups in the daily diet beyond any imbalance of a particular dietary cation such as sodium, potassium, or calcium. Bivariate analyses found a significant association between a poorly diversified diet and hypertension (odds ratio [OR] = 4.25, 95 percent confidence intervals [CI] = 1.47,12.30). Dietary intake of sodium, potassium, and calcium was also examined and found not to be associated with the presence of hypertension in bivariate analyses. Including these cations individually in logistic regression models, which also included diet diversity, did not diminish the diet diversity-hypertension association. Multiple logistic regression models in which other potential confounding variables were individually entered as a control variable (body fat, skin color, age, sex, perceived stress, alcohol intake, aerobic activity, and socioeconomic status) did not alter this result. Analysis of the presence or absence of individual food groups indicate a lack of legumes in the daily diet is also associated with the diagnosis of hypertension (OR = 4.71, 95 percent CI = [1.71,13.01]).

THE RELATIONSHIP between diet and hypertension remains an area of controversy and research interest (*1,2*). In most earlier studies, the goal was to relate one dietary constituent, usually a cation such as sodium (*3,4*), potassium (*5,6*), magnesium (*7,8*), or calcium (*9,10*), to blood pressure. McCarron and coworkers succinctly described problems with this approach in 1982 (*11*). Different nutrients coexist in the same foods and are absorbed differentially depending on the combination of foods eaten. Studies now confirm the multicollinearity of the dietary factors (*12*). Recent investigations explore the role of dietary cations in the development and maintenance of hypertension (*13–15*); however, few examine the diet as a whole (*16*). This more expansive perspective suggests an alternate research question: Do differences in overall food intake patterns differentiate hypertensives from nonhypertensives?

An exploratory cross-sectional study was designed to test the a priori hypothesis that a food intake pattern in which one or more food groups is habitually absent is associated with the presence of hypertension. We tested this hypothesis on a randomly selected sample of adult residents of Saba Island in the Netherland Antilles, a dormant 2,690-foot volcano that has been continuously inhabited by Dutch and English settlers since 1640 (*17*). The island has an area of 5.1 square miles and a population of 985 in 1985.

Methods

Study population and design. Saba residents were selected because of the high prevalence of elevated blood pressure among them, the availability of medical records on the island, and the islanders' recent change to a more varied diet. One of the investigators (DKE) noted a 52-percent prevalence of high blood pressure during a community blood pressure survey conducted in 1982. Improvements in transportation links and modernization of Saba's infrastructure since World War II have enabled the population to vary its dietary intake. Dietary, psychosocial, and lifestyle data on factors that have been associated with hypertension were collected from 1983 through 1986.

Selection of sample. The sample was drawn from a study population of adults ages 21 and older from all households on the island. A detailed map locating all residential dwellings in the four island villages was drawn and each house assigned a number. A random sample of 20 percent of the homes in each village was selected. All 163 persons age 21 and older in each of the 132 homes selected were approached and all except 2 persons consented. People with blood pressures greater than 140/90 millimeters of mercury (mm Hg) who were regularly ingesting medication that can elevate the blood pressure, such as appetite suppressants, decongestants, or oral contraceptives, were not eligible. Of the 161 consenting subjects, 20 did not meet these eligibility criteria and were excluded. To control for possible correlation of blood pressures among persons living within the same household, one person was randomly selected from each of the 27 households with more than one eligible respondent, leaving an initial sample of 112 people. Two households, however, had three eligible respondents. A total of 13 subjects dropped out before completion of data collection and another 16 were lost to emigration. One person was excluded from the analyses due to obvious inaccuracies in dietary data. The final sample consisted of the remaining 82 people.

Measurement of variables. Blood pressures were measured in May each year from 1983 through 1986, and they consisted of two different readings taken pre- and post-interview (approximately 90 minutes apart) for a total of eight measurements per person. Measurements were taken by trained research associates on the nondominant arm with the individual sitting, quiet, and with the arm resting at heart level using standard size aneroid sphygmomanometers calibrated daily against a mercury sphygmomanometer. If the arm circumference was greater than two-thirds the length of the standard size cuff (greater than 16 centimeters) a larger cuff was used. Measurement reliability was checked by random repeat measures during the interview day by an independent observer. A difference in blood pressure greater than 10/5 resulted in repeating the measurement, a situation that occurred only on two occasions.

The primary concern of this study was the chronic disease, hypertension. The presence or absence of hypertension was based on blood pressure measurements and the use of antihypertensive medications. A person was considered hypertensive if all eight diastolic blood pressure measurements were greater than or equal to 90, all eight systolic blood pressure readings were greater than or equal to 140, or the person was being treated appropriately with antihypertensive medication. Since there

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is only one source of health care and only one physician on the island, complete records were available on medication use. The use of medication was deemed appropriate if the average of three diastolic blood pressure measurements prior to therapy exceeded 140 and three systolic measurements exceeded 90. These conservative criteria for the diagnosis of hypertension were chosen to minimize the misclassification bias noted in cross-sectional studies of blood pressure (*18,19*).

Three different methods were used to collect nutritional data in an effort to assure reliability and validity. First, a 24-hour dietary recall was obtained in each respondent's home in May 1983. The recall data were used to generate a list of all the different foods consumed in the population, to determine "usual serving size" for each food item, to calculate nutrient composition, and to determine food preparation methods. Second, in May 1984 and 1985, a semi-quantitative food frequency interview was conducted to determine the number of times different food items were ingested each week over the past year. Since the interview was conducted in the home, the participant was able to indicate, using the household dinnerware, "usual serving size" estimates. Each participant was presented a list of 340 foodstuffs, 69 beverages, and 72 seasonings (*20*) in a format similar to that used in other reports (*21-23*) except for a substantially longer food list because of the interest in diet diversity. Finally, in May 1986, discrepancies and inconsistencies within and between the two food frequency collections were clarified by reinterview and by ethnographic observation during home and grocery store visits.

The food intake pattern was operationalized using a revised basic food group taxonomy. The traditional four-food group taxonomy consisting of dairy products, fruits and vegetables, cereals and breads, and meats was deemed inappropriate for Saba Island on two accounts. In meal planning and conversations on Saba, vegetables and fruits are considered separate groups, whereas meat, fish, and dairy products are lumped together. In addition, Saba Island underwent a dramatic change in diet following World War II with the introduction of automobiles, refrigerators, air service, electrification, and a supermarket. These changes converted a self-sustaining subsistence farming-fishing diet into an imported processed food diet (*17,24*). The basic four-food group taxonomy does not capture the traditional dietary diversity of legumes and vegetables still consumed by a minority of Sabans.

A third reason for a different taxonomy is theoretical. Legumes, such as peas and beans, are proposed as a separate food group because they represent an important staple for most of human prehistory and history (*25*). Legumes were the primary source of protein and calcium before dairy products were added to the diet.

Diet diversity was operationalized using the following five-food group taxonomy: grains and tubers, vegetables, fruits, legumes, and animal products. A person was coded as having little diet diversity if one or more of these food groups were habitually absent from the customary daily diet. A food group was considered habitually absent from the daily diet if two or fewer servings were eaten per week. Foods eaten only once or twice a week are not considered habitual enough to be part of the customary daily diet. Foods eaten five or six times a week, on the other hand, were included to capture the variety in daily dietary pattern. Diet diversity represents a measurable reflection of overall dietary pattern (*26*).

A number of potential confounding variables were also measured for inclusion in multiple variable analyses. These included nutrient intake (sodium, potassium, calcium), percent body fat, skin color, age, sex, perceived stress, alcohol intake, aerobic activity, and socioeconomic status. Each of these variables has been cited as associated directly or inversely with arterial blood pressure (*27,28*).

Nutrient intake was calculated by multiplying each food item's frequency intake per week by the "usual serving size" and dividing the result by seven, yielding a quantitative "unit" representing a modal quantity of that food item ingested per day for each person. These "units" were converted into milligrams (mg.) of sodium, calcium, and potassium using the U.S. Department of Agriculture handbook of nutritive values (*29*). Analysis of water cisterns in the different villages revealed differing sodium content that was corrected for in the sodium calculations.

People were coded as low versus not low for potassium and calcium cation intake and as high versus not high for sodium cation intake. The cutoff points were determined a priori based on the consensus in the literature regarding the level at which the cation influences blood pressure: high sodium was greater than 2 grams per day; low potassium was below 2 grams per day; low calcium was less than 1 gram per day (*30*).

Percent body fat was indirectly measured in 1983 and 1984 using the triceps skinfold (*31*). If the difference between the two measures was greater than or equal to 2 millimeters, the skinfold was remeasured in 1985 and the most dissimilar measure was discarded. The mean of the two measurements was used to estimate percentage of body fat. Each subject was coded into one of the five following percentage body fat groups using the race and sex-specific reference data from the NHANES I dataset: lower than the 10th percentile, 11th-25th percentile, 26th-74th percentile, 75th-89th percentile, and higher than the 90th percentile (*32*).

Data were also collected on alcohol-drinking behavior. Alcohol consumption was classified as no intake (includes never and former drinkers), light-to-moderate intake (occasional drink or up to four drinks per day), or heavy intake (five or more drinks per day). One 12-ounce beer, one 6-ounce glass of wine, 2 ounces of whiskey, or 2 ounces of Saba Spice (a local liqueur) represented one drink of equivalent percent alcohol.

Each participant's aerobic activity was estimated as light, moderate, or heavy, based on detailed ethnographic observations of the different occupational activities and using the physical activity intensity units developed by Taylor and colleagues (*33*). On this extremely rugged, perpendicular island, which has almost no level ground, walking of any type is equivalent to climbing stairs; therefore, a subject who never or rarely used a car was classified one activity level higher.

As part of the 1986 questionnaire, each respondent was asked if the following statement applied almost none, some, much, or almost always: "Over the past year, I have experienced much upset, hassle, and worry." This gross indicator (not validated elsewhere) of perceived stress over the preceding year was dichotomized into "high stress" (almost always) versus "not high stress."

A participant's socioeconomic status was derived from an occupational status index, in which primary occupations and income were ranked as low, medium, or high, and a house status index was based on size, number of rooms, and condition of the house. Ethnographic data were used to operationalize the indices. Each participant's socioeconomic status was ranked as low, middle, or high based on the mean of the two index means.

Table 1. Frequency distributions of demographic and independent variables for 82 subjects with and without hypertension: Saba Island study, 1983–86

	Hypertension		
Variable	*Yes (N = 40)*	*No (N = 42)*	*Total group (N = 82)*
Mean age (years)	64.4	48.1	56.2
Sex:			
Men	17	16	33
Women	23	26	49
Skin color:			
Black	18	18	36
White	22	24	46
Sodium intake:			
Not high (≤2 g per day)	26	29	55
High (>2 g per day)	14	13	27
Potassium intake:			
Low (<2 g per day)	24	29	53
Not low (≥2g per day)	16	13	29
Calcium intake:			
Low (<1 g per day)	31	33	64
Not low (≥1 g per day)	9	9	18
Percent body fat:			
≤10th percentile	2	4	6
11–25th percentile	5	9	14
26–74th percentile	23	18	41
75–89th percentile	4	8	12
>90th percentile	6	3	9
Alcohol consumption:			
No intake	23	14	37
Light to moderate	13	26	39
Heavy	4	2	6
Aerobic activity:			
Light	19	17	36
Moderate	13	15	28
Heavy	8	10	18
Perceived stress:			
Low to moderate	25	31	56
High	15	11	26
Socioeconomic status:			
Low	15	13	28
Medium	24	18	42
High	1	11	12

Statistical analysis. Bivariate analysis comparing diet diversity with hypertension is performed by calculating an odds ratio with 95-percent confidence intervals. The diet diversity-hypertension relationship is further examined in logistic regression models with potential confounding variables by fitting models both with and without diet diversity and comparing for a significant improvement in the likelihood ratio chi-squared statistic. Beta (*b*) coef-

Table 2. Coefficients (β), adjusted odds ratios (e^{β}), and confidence intervals ($e^{\beta \pm 1.96\ (SE\beta)}$) calculated from logistic regression models for diet diversity as a predictor of hypertension among 82 subjects when controlling for potential confounding variables, Saba Island study, 1983–86

Confounding variable[1]	β	*SE*	*OR for diet diversity*[2]	*95 percent CI*
Sodium intake	2.203	0.7277	9.05	2.17, 37.69
Potassium intake	2.660	0.8427	14.30	2.74, 74.57
Calcium intake	1.670	0.5972	5.31	1.65, 17.12
Percent body fat	1.466	0.5461	4.33	1.48, 12.63
Skin color	1.452	0.5423	4.27	1.48, 12.36
Age (years)	1.317	0.5964	3.73	1.16, 12.01
Sex	1.456	0.5430	4.29	1.48, 12.43
Perceived stress	1.418	0.5441	4.13	1.42, 11.99
Alcohol consumption	1.373	0.5478	3.95	1.35, 11.55
Aerobic activity	1.452	0.5431	4.27	1.47, 12.38
Socioeconomic status	1.368	0.5510	3.93	1.33, 11.56

[1] Refer to table 1 for measurement units.
[2] When controlling for confounding variable.
NOTE: SE = standard error, OR = odds ratio, CI = confidence interval.

Table 3. Two-dimensional distributions and bivariate associations calculated by logistic regression models for hypertension and dichotomous variables measuring the absence of each of five food groups in the diet of 82 subjects, Saba Island study, 1983–86

	Hypertension			
Food group	*Yes*	*No*	*Odds ratio*	*95 percent CI*
Grains	...	...	1.50	0.47, 4.79
Lacking	8	6		
Present	32	36		
Vegetables	...	...	1.09	0.46, 2.61
Lacking	19	19		
Present	21	23		
Fruits	...	...	2.70	1.10, 6.60
Lacking	24	15		
Present	16	27		
Legumes	...	...	4.71	1.71,13.01
Lacking	33	21		
Present	7	21		
Animal	...	...	1.54	0.58, 4.07
Lacking	13	10		
Present	27	32		

ficients and standard error terms from models including confounding variables are then used to calculate an adjusted odds ratio and 95-percent confidence intervals for the diet diversity-hypertension relationship while controlling for each confounder.

Results

The demographic characteristics of the 82 study subjects, shown in table 1, approximate those of the island population as described in Saban government census figures in 1985. The sample, consisting of 33 men (40.2 percent) and 49 women (59.8 percent), has the following age distribution: 36.6 percent ages 21–44, 31.7 percent ages 45–69, and 31.7 percent ages 70 and older. There was no significant difference between the 30 nonparticipants and the final study sample with regards to sex ($\chi^2 = 0.854$, df = 1, $P = 0.356$), skin color ($\chi^2 = 1.436$, df = 1, $P = 0.231$), village $\chi^2 = 5.287$, df = 2, $P = 0.071$), or mean diastolic blood pressure at selection (sample mean DBP = 78.7 versus dropout mean DBP = 82.0). The 30 nonparticipants were significantly younger (mean age of 47.3 vs. 56.2 for the study sample). This difference is partly explained by the 16 emigrants who had a mean age of 34.5. A pattern of emigration of young adults has characterized Saba for the past century (*34,35*). Although the literature indicates migration could introduce bias (*36*), the blood pressures of these 16 emigrants (mean DBP = 75.3) and the 82 study subjects was not significantly different.

Bivariate analysis reveals that hypertension was significantly associated with poor diversity of diet (OR = 4.25, 95 percent CI = 1.47,12.29); those Saban adults with little diet diversity were 4.25 times as likely to have hypertension as those with more diversity in their diet. This two-dimensional relationship for the 82 persons in the sample follows:

	Hypertension	
Diet diversity	*Yes*	*No*
Little	34	24
Much	6	18

Multiple logistic regression analyses were used to examine the relationship between diet diversity and hypertension in models that include individually potential confounding factors. Each potential confounding variable was first run in a bivariate logistic regression model and then run again with the addition of diet diversity to determine if there was a significant increase in the model likelihood ratio chi-squared value. In each case there was a significant improvement in the likelihood ratio chi-squared, indicating that the effect measure for poor diet diversity was stable with adjusted odds ratio values ranging from OR = 3.73 to OR = 14.30 (table 2). More complex models were not examined due to limitations in sample size.

The relationship between hypertension and the absence of a particular food group is evaluated by examining bivariate associations of missing any particular food group with the presence or absence of hypertension, and the results are shown in table

3. The absence of legumes in the daily diet is significantly associated with hypertension (OR = 4.71). Of the 40 hypertensives, 33 were missing legumes from their daily diet and only 7 normotensives did not regularly ingest legumes. There is also a significant but less strong relationship between the absence of fruit and hypertension (OR = 2.70).

Discussion

This study indicates that there is a strong association between diet diversity and hypertension. Controlling for potential confounding variables in logistic regression models does not alter this association. The absence of legumes from the daily diet is also significantly associated with hypertension. This inverse association was also noted by Trevisan and associates (*37*). This finding is consistent with research relating vegetarian and high fiber diets to blood pressure-lowering effects (*38*).

If hypertension is related to overall dietary balance and diversity or to the absence of legumes cannot be determined from this study. Recent studies suggest a possible mechanism for a blood pressure-lowering effect of legumes. Bean flakes and pea fiber have lowered postprandial blood glucose and, more importantly, have significantly lowered serum insulin levels more than other fibers (*39,40*). Hyperinsulinemia has been proposed as a possible etiologic mediator in the pathogenesis of essential hypertension (*41,42*).

These results are exploratory, and there are a number of significant limitations to the study. The cross-sectional design makes it impossible to infer causation to the relationships. The sample size is relatively small and increases the chance for an error in dietary assessment to influence the analysis (*21,43*). The identified associations may also be related to some other, as yet unidentified, dietary variable or a confounding factor such as a hypertension subtype. It is also possible that poor diet diversity is the result of dietary changes resulting from the diagnosis and label of hypertension, thus explaining the increase in adjusted odds ratio when controlling for cation intake (table 2).

These results may only be true for Saban adults and thus need replication in another population. Future research will ideally involve a larger sample size, urinary electrolyte measurement, a more refined assessment of diet diversity, the identification of hypertension subtypes, and a longitudinal design.

In conclusion, this exploratory study suggests that among Saban adults a diverse and balanced diet is important in differentiating those with and without hypertension. If confirmed, these data have clinically important pathophysiologic and therapeutic implications. Diet diversity and legumes in the daily diet may influence the development or perpetuation of hypertension or both. These associations should be more thoroughly investigated.

'This study indicates that there is a strong association between diet diversity and hypertension. Controlling for potential confounding variables in logistic regression models does not alter this association. The absence of legumes from the daily diet is also significantly associated with hypertension.'

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