The Relationship between Vitamin C Intake, General Health Practices, and Mortality in Alameda County, California

JAMES E. ENSTROM, PHD, LINDA E. KANIM, MA, AND LESTER BRESLOW, MD

Abstract: To evaluate the relation between vitamin C intake and mortality, a prospective follow-up study was carried out among 3,119 noninstitutionalized adult residents of Alameda County, California who had completed a detailed lifestyle questionnaire around the beginning of 1974. During 10 years of follow-up, 276 deaths have been identified. The questionnaire information and mortality data indicate that this sample is fairly representative of the county population and similar to the United States population. There is no important relation between the estimated 1974 vitamin C intake at levels above and below 250 mg per day and subsequent mortality from cancer, circulatory disease, all other causes, or all causes combined. However, there is an inverse relation between combinations of several health habits and total mortality. The health habits include never smoking cigarettes, regular physical activity, moderate or no use of alcohol, 7–8 hours of sleep per day, and maintaining proper weight. The conclusions with regard to vitamin C are limited by the crudeness with which the dietary intake has been estimated and changes in intake over time. Nevertheless, these results are not consistent with any substantial relation between vitamin C intake and subsequent mortality (*Am J Public Health* 1986; 76:1124–1130.)

Introduction

There has been much interest in recent years in the possible role of vitamin C (ascorbic acid) in the prevention and/or treatment of cancer and other disease.[1] Among its several biochemical functions, ascorbic acid is found to maintain the integrity of tissue ground substance, synthesize collagen, and stimulate lymphocytes to a higher level of immunocompetence. It is known to inhibit hyaluronidase upon which tumor invasiveness is supposedly dependent; and increased levels of ascorbic acid have been hypothesized to inhibit cell proliferation. The inhibitory action of ascorbic acid on the nitrosation process has been observed in animals,[2] and arguments have been made that ascorbic acid may prevent human stomach cancer.[3] Although the RDA (recommended dietary allowance) is generally considered to be sufficient intake for most Americans,[4] Cameron and Pauling have suggested that substantially higher intake may be beneficial.[5]

Epidemiologic data on this subject are sparse and inconclusive.[6] A 1948 survey examined 577 elderly residents of San Mateo County, California with respect to their dietary intake of vitamin C. Seven-year mortality follow-up through 1955 showed that 399 individuals consuming more than 50 mg per day had a death rate only one-half that of 130 individuals consuming less than 50 mg per day.[7]* Follow-up studies of 103 elderly Michigan women[8,9] and 300 elderly Scottish residents[10] have provided inconclusive evidence regarding vitamin C intake and survivorship. A major study determined the 1967 dietary intake of 17,000 Norwegian adults; follow-up through 1978 found that those with the highest vitamin C intake had a mortality rate from stomach cancer only half that of those with the lowest vitamin C intake,[11] but there was no relation with lung cancer.[12] Results were not reported with respect to total cancer and total mortality rates. A few case-control studies have tended to indicate an inverse relation between vitamin C intake and stomach cancer but the data are tentative.[11] All of these studies examined levels of vitamin C intake around the RDA, currently 60 mg per day.[4]

Blood levels of vitamin C were estimated for a random sample of 159 terminally ill patients in an acute geriatric hospital in England in 1968 and found to be strongly and inversely related to mortality during the year following admission after controlling for the severity of the initial illness.[13] A clinical trial was conducted in this same geriatric hospital among 538 patients admitted during 1970–71. The administration of 200 mg per day of vitamin C did not substantially influence mortality during the six months of follow-up, although there was an indication of an inverse relation between low blood levels of vitamin C and subsequent mortality.[14] Another clinical study indicated that 100 terminal cancer patients in Scotland receiving 10 grams of vitamin C per day had up to four times longer survival than 1,000 matched historical controls not receiving vitamin C.[15] However, two randomized controlled trials of terminal cancer patients in Minnesota have shown no benefit of these same high doses of vitamin C.[16] In another study examining mortality in elderly persons consuming high levels of vitamin C, the results were inconclusive.[17]

Since half of all United States adults now use vitamin supplements,[18,19] and because of the suggestive but inconclusive epidemiologic data, we have undertaken a prospective follow-up study of a general population sample in Alameda County, California.

Methods

This is a prospective mortality follow-up study of 3,119 adults aged 16 years and above who were a representative sample of noninstitutionalized residents of Alameda County, California in early 1974.[20] This survey was conducted by the Human Population Laboratory (HPL) of the California State Department of Health Services in Berkeley, California; it is related to a larger ongoing study of 6,928 Alameda County adults who were first interviewed in 1965.[21,22] The 1974 survey used a systematic subsample of the 1965 housing units, supplemented by a stratified probability sample of Alameda County housing units newly constructed or converted between July 1965 and June 1973.[20] All occupants of each selected housing unit were eligible for the study if they were at least 20 years old or 16–19 years old and married. Out of 2,531 addresses, 2,312 housing units were occupied and found to have 4,209 eligible occupants. An enumeration list

*Drake RM, Buechley RW, Breslow L, Chope HD: A seven-year follow-up of the San Mateo Nutrition Study Population. Presented at the Western Branch meeting of the American Public Health Association, Long Beach, CA, 1957.

From the School of Public Health and Jonsson Comprehensive Cancer Center, University of California at Los Angeles. Address reprint requests to James E. Enstrom, PhD, School of Public Health, University of California, Los Angeles, CA 90024. This paper, submitted to the Journal May 29, 1984, was revised and accepted for publication February 24, 1986.

was completed on 3,883 occupants who were solicited to participate in the study, and 3,119 (74 per cent of the eligible occupants) were successfully interviewed between October 1973 and June 1974.

Each respondent completed a 28-page detailed lifestyle questionnaire which contained items on health/illness status, various personal (e.g., smoking and drinking) and other lifestyle characteristics, health care patterns, various demographic information, and vitamin supplement usage. Of primary interest to the present investigation was the question on vitamin pill usage, particularly vitamin C. The question asked "do you take vitamin pills or other vitamin supplements never, regularly, or occasionally?" It also asked the number of such pills taken per day and the number of mg of vitamin C contained in each. Two additional questions asked how many small glasses of orange, tomato, or grapefruit juice on an average day are drunk and how often at least two servings of fruits or vegetables in a day are eaten. No additional dietary data on vitamin C intake were collected, and no biochemical measurements were made. Exact wording of the vitamin C questions is given elsewhere.[20]

An estimate of vitamin C intake per day has been computed from the available data on liquid, food, and supplement sources. Each small glass of orange, tomato, or grapefruit juice was assumed to contribute 40 mg of vitamin C. Two servings of fruits and/or vegetables per day were assumed to contribute 50 mg of vitamin C. Finally, the supplement intake was estimated from the number and strength of each vitamin C pill taken per day for regular users. For "occasional users," the supplement intake was assumed to be zero. The total daily intake was considered to be the sum of the intake from these three sources, although these people obviously had some intake from other sources.

Seven questions about cigarette smoking status, physical activity, drinking, weight to height ratio, sleep, eating breakfast, and eating between meals have been used to form three health practice indices that have some relationship to vitamin C intake and mortality. These indices are important because they relate to previous findings on the Alameda County population. A seven-component index (HPI 7) has previously been shown to be strongly related to mortality in the 1965 Alameda County cohort.[21] A five-component index (HPI 5), the first five components of HPI 7, was subsequently shown to be strongly related to mortality in the 1965 cohort.[23] A simple two component index (HPI 2), involving only cigarette smoking status and physical activity, has been introduced here because these two variables have the strongest independent relationship to mortality. In addition, a general index of self-reported health status has been based on the question whether an individual's health was generally excellent, good, fair, or poor. A more specific index of self-reported health status (physical health spectrum) has been formed from questions about symptoms, chronic conditions, energy level, and degree of disability. These last two indices measure relative health status as of 1974. Other questionnaire variables have not been analyzed here.

Mortality follow-up has been conducted from January 1, 1974 through December 31, 1983 using procedures similar to those in related studies.[17,24] The primary means of mortality ascertainment was checking the entire cohort against 10 years of California death records. Alphabetical microfiche lists and computer tapes containing all 1974–83 California death records were obtained from the Vital Statistics Section of the California State Department of Health Services in Sacramento. An additional means of follow-up was the matching of cohort names with the California Department of Motor Vehicles (DMV) files on licensed drivers and registered vehicles. The DMV information is regularly updated (annually for vehicle registration and usually every four years for a driver's license), yielding a relatively current residence address for the vast majority of cohort members who drive. Driver's license renewal is positive confirmation of alive status as of the time of last renewal. In addition, several hundred cohort members were resurveyed by HPL in early 1983 as a direct means of follow-up.

Based on these sources, the January 1, 1984 follow-up status of the cohort is as follows: 9 per cent (276) are known dead in California; 68 per cent have currently valid California driver's licenses; 5 per cent have had California driver's licenses but are no longer California residents according to the DMV; 5 per cent have expired California driver's licenses but most likely still live in California; 2 per cent have no California driver's license but currently have a vehicle registered jointly with their spouse; 11 per cent have no California drivers license or vehicle registration and their current address is uncertain, but they are not known to have died in California. We have not attempted to ascertain the estimated 5–10 per cent of deaths that occurred outside of California or were otherwise missed by the matching program.

An estimate of expected deaths during 1974–83 is about 340 (180 males and 160 females) based on concurrent death rates for both Alameda County and the US. The observed number of 276 deaths is less than the expected number by about the proportion (19 per cent) seen previously among the noninstitutionalized Alameda County questionnaire respondents surveyed in 1965.[21,24] This deficit is presumably due to the cohort selection of only noninstitutionalized residents and the inability to ascertain all deaths. For the most unbiased analysis, we have limited ourselves to internal comparisons within the cohort itself.

The statistical analyses examine vitamin C intake and the health practice indices in relation to each other and to mortality. The standardized mortality ratio (SMR) for each subgroup of the cohort is the number of observed deaths divided by the number of expected deaths. The number of expected deaths is based on the mortality experience of all males and all females within the cohort. By this definition the SMR is 100 for all males and all females in the cohort. This procedure of indirect standardization has been used in previous HPL analyses.[21,22] Indirect standardization using SMRs is not the preferred method of calculating and comparing death rates; however, it is necessary when the number of deaths is so small that age-specific death rates have large statistical variability as is the case for most of the mortality results presented in this study. For comparison, direct standardization has been used by age-adjusting the proportion of deaths among persons initially aged 0–34, 35–44, 45–54, 55–64, 65–74, and 75+ years to the age distribution of the entire cohort of 3,119 persons. In addition, a multivariate technique was used to investigate vitamin C while controlling for age, sex, initial health status, and smoking status.[23,25] Specifically, we used the logistic regression procedure from Statistical Analysis System SAS.[26]

Results

A composite demographic picture of the 1974 Alameda County adults compared with US adults as depicted in the 1979 National Survey of Health Habits[18] indicates that the Alameda County population is similar to the 1979 US popu-

TABLE 1—Detailed Percentage Distribution of Estimated Vitamin C Intake in 1974 among a Representative Sample of 3,119 Noninstitutionalized Alameda County Adults

Estimated Vitamin C Intake (mg/day)	Number of Subjects	Per Cent of Total
0	414	13.3
40	262	8.4
50	522	16.7
80	45	1.4
90	701	22.5
100	31	1.0
120	15	0.5
130	183	5.9
140	80	2.6
150	20	0.6
160–190	113	3.6
200	10	0.3
210–240	43	1.4
250	37	1.2
260–490	166	5.3
500	14	0.4
510–990	170	5.5
1000	8	0.3
1010–1490	78	2.5
1500	3	0.1
1510–1990	49	1.6
2000	0	0.0
2040–2490	20	0.6
2500	0	0.0
2510–5250	39	1.3
Unknown	96	3.1

Vitamin C intake estimated as Total VC = Pill VC + Drink VC + Eat VC. Pill VC = (No. vitamin C pills) × (50, 100, 250 or 500 mg/pill) × (0 for occasional use or 1 for regular use); Drink VC = (No. small glasses of orange, tomato, or grapefruit juice) × 40 mg/glass; Eat VC = 50 mg (if eat at least 2 servings of fruits and vegetables perday. No other food sources of vitamin C are included. All possible values of Total VC are given up to 150 mg.

lation in most demographic and health-related variables studied. Both samples were roughly the same with respect to race, marital status, educational level, occupational level, mean height and weight, initial health status, smoking status, and consumption of alcohol, coffee, and tea. Detailed presentation of the Alameda County demographic data is given elsewhere.[20] Also, the mortality experience of the Alameda County cohort appears to be reasonably representative of the Alameda County and US populations within the limitations discussed earlier.

Table 1 gives the percentage distribution of estimated daily vitamin C intake for the Alameda County cohort. This distribution assumes that occasional use of vitamin C pills equals zero use and the distribution is not changed substantially by other assumptions about occasional use of vitamin C pills. The crudeness of the vitamin C intake measure results in a spiked distribution at 0 mg, 40 mg, 50 mg, and 90 mg. The Alameda population had a greater consumption of vitamin C (median of about 90 mg and mean of about 200 mg with 27 per cent above 150 mg) than the US (HANES I) population in 1971–74 (median of about 60 mg and mean of about 90 mg with 16 per cent above 150 mg).[27] The 1976–80 (HANES II) survey of the US population shows a median of about 70 mg and a mean of about 100 mg with 22 per cent above 150 mg.[28]

The vitamin C categories of 0–249 and 250+ mg per day were chosen in order to obtain two distinct subgroups of the cohort. As shown in Table 2, these two categories depend primarily on vitamin pill intake (15 per cent regular users vs 96 per cent regular users). Finer subdivision of the cohort has not been done because of the crudeness of the vitamin C intake and its variability over time. In Table 2, percentage distributions are presented for several variables indicating initial health status (the history of heart trouble and/or cancer, general health status, and physical health spectrum) and health habits (cigarette smoking status and health practices index). For the vitamin C intake groups, no large differences were found for the initial health status variables. The distribution of cigarette smoking status indicates that male smokers tended to use less vitamin C. The distribution of health practice indices (HPI 7, HPI 5, HPI 2) suggests that individuals consuming 250+ mg per day of vitamin C had a slightly higher health practice index than those individuals consuming 0–249 mg per day. Although not shown, the distribution of age, education, income, height, and weight did not differ by vitamin C intake. In summary, the demographic, health status, and health practice variables discussed above show little or no association with the two vitamin C categories.

The observed deaths, the expected deaths that are calculated from total death rates for all males and all females in the cohort, and the standardized mortality ratio (SMR) for all causes of death as a function of the two 1974 estimated vitamin C consumption levels are presented in Table 3. The SMRs are also presented for cancer, all circulatory diseases, and all other causes. No major differences in SMRs were noticed as a function of vitamin C consumption for all causes combined or any specific cause of either of the sexes or both sexes combined.

To examine the relationship between other health practices and mortality in this cohort, the SMRs for smoking status are presented in Table 4. "Current smokers" had the highest mortality ratio and "never smokers" had the lowest ratio, in agreement with past epidemiologic studies. Table 4 also shows the relation between mortality and a health practice index (HPI 7) that was constructed from the following seven good health practices: never smoking cigarettes, regular physical activity, moderate or no use of alcohol, 7–8 hours of sleep regularly, maintaining proper weight, eating breakfast regularly, and not eating between meals.[21] Results using the five-practice index (HPI 5) and the two-practice index (HPI 2) are also shown in Table 4. Further refinement by us indicates that cigarette smoking and physical activity are the two most important practices (HPI 2), and the most important single health practice is never smoking cigarettes. Finally, Table 4 presents corresponding SMRs for the 1965 Alameda County cohort based on previous analyses of these health practices.[21–23] The findings for the 1965 and 1974 cohort are consistent within the limits of statistical fluctuation. These results indicate that it is possible to identify factors that consistently show a strong relationship to mortality.

Since the SMRs presented in Tables 3 and 4 may be somewhat inaccurate due to the method of indirect standardization, age-adjusted risks of death using the method of direct standardization are presented in Table 5. The results are limited to the variables of vitamin C intake, cigarette smoking status, and health practice index (HPI 2), for which it is possible to form reasonably stable age-specific total death rates. These results, although slightly different, are statistically consistent with the corresponding SMR results.

To further explore the relationship of vitamin C consumption, initial health status, and health practices to mortality, a series of logistic multiple regression models has been created and fit to the binary dependent variable of mortality (alive versus dead). Table 6 summarizes the logistic coefficient and relative mortality for each variable. The first model

TABLE 2—Percentage Distribution of Health-related Characteristics Across Four Levels of Vitamin C Intake for Alameda County Males and Females in 1974

Variables	Estimated Vitamin C Intake (mg/day)					
	Males			Females		
	0–249	250+	Total	0–249	250+	Total
Number in sample	1128	241	1409	1311	343	1710
Initial Health Status						
Disease history:						
heart trouble	5.5	7.5	5.8	6.0	7.9	6.4
cancer	1.6	0.4	1.4	1.7	1.8	1.7
General health status:						
excellent	35.0	34.4	34.9	28.5	31.2	29.0
good	52.2	52.7	52.3	51.7	46.7	50.7
fair	10.1	8.7	9.9	16.1	19.8	16.9
poor	2.5	3.7	2.7	3.6	2.0	3.3
Physical health spectrum:						
lesser disability	4.9	6.2	5.1	7.0	9.0	7.4
severe disability	7.0	8.7	7.3	12.6	11.1	12.3
Health Habits						
Cigarette smoking status:						
current	39.8	29.9	38.0	32.8	33.4	32.9
former	25.8	34.9	27.4	15.7	17.9	16.2
never	34.4	35.3	34.5	51.5	48.7	50.9
Health practices index (HPI 7):						
0, 1 or 2	3.2	3.3	3.2	4.3	2.6	4.0
3	12.7	7.5	11.8	11.8	6.4	10.6
4	25.5	19.9	24.5	21.6	19.2	21.1
5	27.5	31.5	28.2	28.9	32.4	29.6
6	22.6	25.3	23.1	24.1	27.4	24.8
7	8.5	12.5	9.2	9.3	12.0	9.9
Health practices index (HPI 5):						
0 or 1	2.8	1.2	2.5	2.8	2.3	2.7
2	11.4	11.2	11.4	11.1	7.0	10.3
3	32.0	29.9	31.6	26.2	24.2	25.8
4	38.4	39.4	38.6	38.3	41.7	39.0
5	15.4	18.3	15.9	21.5	24.8	22.2
Health practices index (HPI 2):						
0	7.0	6.6	6.9	9.5	8.2	9.3
1	61.8	60.2	61.5	50.7	48.4	50.2
2	31.2	33.2	31.6	39.7	43.4	40.5
Vitamin C Sources						
Use vitamin pills or other supplements?						
yes, regularly	12.3	95.9	27.0	17.3	97.4	33.9
yes, occasionally	28.6	1.7	23.9	31.7	1.8	25.6
no	59.0	2.5	49.1	51.0	0.9	40.6
Drink at least one glass of orange, tomato or grapefruit juice every day?						
yes	54.8	63.1	56.2	63.0	70.3	64.6
Eat two servings of fruits and/or vegtables almost every day?						
yes	59.6	75.5	62.4	71.2	81.9	73.5

*Totals include persons with unknown level of vitamin C intake.

contains the independent variables of age (in single year increments) and sex. Age is by far the most important predictor of mortality and sex is also a significant predictor. Thus, they are used in subsequent models as control variables. Each of the next six models introduces a single lifestyle variable in an ordered categorical form as defined in Table 6. After controlling for age and sex, the lifestyle variables in order by decreasing relationship with mortality are: health status, physical health spectrum, HPI 2, cigarette smoking, HPI 5, and HPI 7. These results are consistent with the SMRs in Table 4. The last three models introduce the following variables (after controlling for age and sex): vitamin C intake; cigarette smoking and vitamin C intake; health status and vitamin C intake. In all three models, vitamin C intake is an unimportant predictor of mortality, consistent with the SMRs found in Table 3. The models involving age, sex, smoking, and/or health status explain the greatest amount of variability in mortality with the least number of independent variables.

Discussion

In spite of suggestive theories and some previous epidemiologic evidence, this study shows no clear relation between estimated 1974 vitamin C intake in the HPL sample and subsequent 10-year mortality. However, the study did show a relation of total mortality with cigarette smoking and three indices of health practices (HPI 2, HPI 5 and HPI 7), consistent with previous results for the 1965 Alameda County cohort.[21–23]

As this was not primarily a dietary survey, the absolute intake of vitamin C was crudely measured. Each subject's estimated vitamin C intake was computed from a single self-report of selected dietary habits that are fairly loosely

TABLE 3—Standardized Mortality Ratio (SMR) and 95% Confidence Interval (CI) for Major Causes of Death during 1974–83 as a Function of Vitamin C Intake in 1974 as Calculated in Table 1

Estimated Daily Vitamin C Intake	No. Alive in 1974	All Causes			Cancer		All Circulatory Diseases		All Other Causes	
		Observed Deaths	Expected Deaths	SMR (95% CI)	Observed Deaths	SMR	Observed Deaths	SMR	Observed Deaths	SMR
Males										
0–249 mg	1128	110	108.7	101 (83–122)	28	104	49	96	33	106
250+ mg	241	24	25.1	96 (62–143)	5	83	14	116	5	71
Females										
0–249 mg	1311	103	103.6	99 (81–121)	26	95	53	104	24	95
250+ mg	343	27	26.4	102 (67–149)	9	115	11	87	7	119
Both Sexes										
0–249 mg	2439	213	212.3	100 (87–115)	54	100	102	100	57	101
250+ mg	584	51	51.5	99 (74–131)	14	101	25	101	12	93
Totals	3023	264			68		127		69	

TABLE 4—Standardized Mortality Ratio for Total Mortality during 1974–83 as a Function of Cigarette Smoking Status and Health Practice Index based on 2, 5, or 7 health practices[a]

	1974–83 Study						1965–74 Study		
	Males		Females		Both Sexes		Both Sexes		
	No. Alive in 1974	SMR*	No. Alive in 1974	SMR	No. Alive in 1974	SMR	No. Alive in 1965	SMR	(95% CI)
Cigarette Smoking Status									
Current	532	129 (45)	564	142 (45)*	1096	135 (90)*	3051	134 (276)*	
Former	385	99 (47)	278	112 (22)	663	103 (69)	1088	96 (127)	
Never	490	83 (47)	858	76 (69)*	1348	82 (116)*	2724	84 (307)*	[75–94]
Health Practice Index (HPI 2)									
0	98	175 (28)*	163	175 (29)*	261	175 (57)*	650	153 (122)*	
1	864	102 (81)	863	111 (70)	1727	106 (151)	4048	107 (408)	
2	447	69 (31)*	684	66 (37)*	1131	67 (68)*	2230	72 (180)*	[62–83]
Health Practice Index (HPI 5)									
0–2	197	120 (30)	230	133 (32)	427	127 (62)	893	167 (157)*	
3	445	113 (46)	440	111 (49)	885	112 (95)	2074	114 (260)	
4	545	93 (49)	665	90 (41)	1210	92 (90)	2798	84 (227)	
5	222	70 (15)	375	63 (14)	597	67 (29)*	1163	61 (73)*	[48–77]
Health Practice Index (HPI 7)									
0–3	216	157 (23)	254	122 (21)	470	131 (44)	862	178 (99)*	
4–5	735	98 (68)	866	108 (74)	1601	97 (142)	3623	109 (388)	
6	329	98 (40)	421	88 (32)	750	93 (72)	1775	85 (182)	
7	129	60 (9)	169	66 (9)	298	63 (18)*	668	52 (48)*	[38–69]

[a]Health practice index 7 is the number of positive responses to the following 7 items: never smoked cigarettes; physical activity (often or sometimes engage in active sports, swim or take long walks, or often garden or do physical exercises); drink not more than four drinks at a time; weight for men between 5% under and 20% over desirable weight for height and weight for women not more than 10% over desirable weight for height; usually sleep 7 or 8 hours; eat breakfast almost every day; eat between meals once in a while, rarely or never. Health practice index 5 is the number of positive responses to the first 5 of the above 7 items. Health practice index 2 is the number of positive responses to the first 2 of the above 7 items.

A comparison is given with 1965–74 Alameda County data.[21] Number of observed deaths upon which each SMR is based is given in parentheses and * indicates SMR has a 95% confidence interval that does not include 100.

defined. A list of food items considered to be "fruits and vegetables" was not presented and the knowledge of such specific foods within the categories was assumed. Foods containing vitamin C that are neither fruits nor vegetables were not included. The information about mere frequency of consumption does not allow the absolute intake of vitamin C to be accurately determined. This general categorization scheme is obviously only a crude measure of the relative vitamin C intake. But, by dividing the cohort into those consuming more or less than 250 mg per day, the classification is based primarily on vitamin supplement usage and is relatively unaffected by changes in dietary intake of vitamin C. However, measurement errors and intake variability over time would tend to obscure a relation between mortality and vitamin C,[29] and our results must be interpreted with this problem in mind.

ACKNOWLEDGMENTS

This research was supported by the National Center for Health Services Research Grant HS00368, the Wallace Genetic Foundation, Hoffmann-La Roche, Inc., and the Foundation for Nutritional Advancement. Dr. Enstrom has received support from National Cancer Institute Preventive Oncology Academic Award CA 00748. The authors gratefully acknowledge the technical assistance provided by the staff of the Human Population Laboratory, Drs. Jack Y. Krakower and Roger E. Bolus, Samuel J. Tobin, Richard J. Biermann, and Shiva Rastani. The authors also thank Dr. Linus Pauling and the Linus Pauling Institute of Science and Medicine for valuable assistance.

TABLE 5—Age-adjusted Risk of Death (proportion dying during 1974–83) as a Function of Vitamin C Intake, Cigarette Smoking Status, and Health Practice Index (HPI 2)

	Males			Females		
	No. Alive in 1974	Observed Deaths	Age-adjusted Risk of Death	No. Alive in 1974	Observed Deaths	Age-adjusted Risk of Death
Estimated Daily Vitamin C Intake						
0–249 mg	1128	110	.109	1311	103	.074
250+ mg	241	24	.110	343	27	.079
Cigarette Smoking Status						
Current	532	45	.121	564	45	.166
Former	385	47	.105	278	22	.087
Never	490	47	.082	858	69	.063
Health Practice Index (HPI 2)						
0	98	28	.213	163	29	.142
1	864	81	.147	863	70	.083
2	447	31	.071	684	37	.049
Total Cohort	1409	140	.108	1710	136	.074

TABLE 6—Logistic Regression Models Fitting Various Health-related Variables in 1974 to Vital Status (alive versus dead) at the End of 1983

	Model Statistics			
Model Variables	Logistic Coefficient	Standard Error	Relative Mortality for High vs Low	95% CI for High vs Low
Age	.098	.005	1000	500–2000
Sex	.551	.147	1.7	1.3–2.3
Cigarette Smoking	.418	.091	2.3	1.6–3.3
Health practices (HPI 2)	.701	.113	4.1	2.6–6.4
Health practices (HPI 5)	.261	.070	3.7	1.8–7.4
Health practices (HPI 7)	.170	.058	3.3	1.5–7.4
Health status	.524	.075	4.8	3.6–6.5
Physical health spectrum	.255	.044	4.6	3.5–6.0
Vitamin C	−.036	.184	1.0	0.7–1.4
Cigarette smoking/	.428	.093		
Vitamin C	−.054	.185	1.0	0.7–1.4
Health status/	.561	.078		
Vitamin C	−.043	.187	1.0	0.7–1.4

Variables used: age (single years from 18 to 95), sex (female, male), cigarette smoking status (never, former, current), health practice index (7 to 0, 5 to 0, and 2 to 0 health practices), general health status (excellent, good, fair, poor), physical health spectrum (no complaints through severe disability), and daily vitamin C intake (0–249 mg vs 250+ mg). The variables, except vitamin C intake, are ordered (low to high) in an expected direct relationship with mortality. The last nine models control first for the variables of age and sex.

REFERENCES

1. Cameron E, Pauling L, Leibovitz B: Ascorbic acid and cancer: a review. Cancer Res 1979; 39:663–681.
2. Mirvish SS, Wallcove L, Eagen M, Shubik P: Ascorbate-nitrate reaction: Possible means of blocking the formation of carcinogenic N-nitroso-compounds. Science 1972; 177:65–68.
3. Weisburger JH, Marquardt H, Mower JF, Hirota N, Mori H, Williams G: Inhibition of carcinogenesis: vitamin C and the prevention of gastric cancer. Prev Med 1980; 9:352–371.
4. Food and Nutrition Board, National Academy of Sciences: Recommended Dietary Allowances, 9th Ed. Washington, DC: NAS, 1980.
5. Cameron E, Pauling L: Cancer and Vitamin C. Menlo Park: Linus Pauling Institute of Science and Medicine, 1979.
6. Enstrom JE: Assessing human epidemiologic data on diet as an etiologic factor in cancer development. Bull NY Acad Med 1982; 58:313–322.
7. Chope H, Breslow L: Nutritional status of the aging. Am J Public Health 1956; 46:61–67.
8. Schlenker E: Nutritional status of older women. Dissertation from Michigan State University, East Lansing, MI, 1976.
9. Mickelsen O: The possible role of vitamins in the aging process. *In:* Rockstein M, Sussman, ML (eds): Nutrition, Longevity and Aging. New York: Academic Press, 1976.
10. Gilmore AJJ: Some characteristics of non-surviving subjects in a three-year longitudinal study of elderly people living at home. Gerontol Clin 1975; 17:72–79.
11. Bjelke E: The recession of stomach cancer: selected aspects. *In:* Magnus K (ed): Trends in Cancer Incidence. Washington, DC: Hemisphere, 1982.
12. Kvale G, Bjelke E, Gart JJ: Dietary habits and lung cancer risk. Int J Cancer 1983; 31:397–405.
13. Wilson TS, Weeks MM, Mukherjee SK, Murrell JS, Andrews CT: A study of vitamin C levels in the aged and subsequent mortality. Gerontol Clin 1972; 14:17–24.
14. Wilson TS, Datta SB, Murrell JS, Andrews CT: Relation of vitamin C levels to mortality in a geriatric hospital: a study of the effect of vitamin C administration. Age Aging 1973; 2: 163–171.
15. Cameron E, Pauling L: Supplemental ascorbate in the supportive treatment of cancer: reevaluation of prolongation of survival times in terminal human cancer. Proc Natl Acad Sci 1978; 75:4538–4542.
16. Moertel CG, Fleming TR, Creagan ET, Rubin J, O'Connell MJ, Ames MM: High-dose vitamin C versus placebo in the treatment of patients with advanced cancer who have had no prior chemotherapy: a randomized double-blind comparison. N Engl J Med 1985; 312:137–141.
17. Enstrom JE, Pauling L: Mortality among health-conscious elderly Californians. Proc Natl Acad Sci 1982; 79:6023–6027.
18. US Department of Health and Human Services: Basic data from Wave I of the National Survey of Personal Health Practices and Consequences: United States 1979. National Center for Health Statistics, Series 15 No. 2. Hyattsville, MD: NCHS, August 1981.
19. Schutz HG, Read M, Bendel R, Bhalla V, Harril I, Monagle JE, Sheehan ET, Standal BR: Food supplement usage in seven Western states. Am J Clin Nutr 1982; 36:897–901.
20. Shapiro LR, Samuel S, Breslow L, Camacho T: Patterns of vitamin C

intake from food and supplements: survey of an adult population in Alameda County, California. Am J Public Health 1983; 73:773–778.
21. Breslow L, Enstrom JE: Persistence of health habits and their relationship to mortality. Prev Med 1980; 9:469–483.
22. Berkman LF, Breslow L: Health and Ways of Living: The Alameda County Study. New York: Oxford University Press, 1983.
23. Wingard DL, Berkman LF, Brand RJ: A multivariate analysis of health related practices: a nine-year mortality follow-up of the Alameda County study. Am J Epidemiol 1982; 116:765–775.
24. Belloc N, Arellano: Computer record linkage on a survey population. Health Serv Rep 1973; 88:344–350.
25. Truett J, Cornfield J, Kannel W: A multivariate analysis of the risk of coronary heart disease in Framingham. J Chronic Dis 1967; 20:511–524.
26. Harrell F: The LOGIST Procedure. *In:* SAS Institute Inc SUGI Supplemental Library User's Guide, 1983 Edition. Cary, NC: SAS Institute, 1983.
27. US Department of Health, Education, and Welfare: Dietary Intake Source Data, United States, 1971–74. DHEW Pub. No. (PHS) 79-1221. Hyattsville, MD: National Center for Health Statistics, September 1979.
28. US Department of Health, Education, and Welfare: Dietary Intake Source Data, United States 1976–80. DHEW Pub. No (PHS) 83-1681. Hyattsville, MD: National Center for Health Statistics, March 1983.
29. El-Lozy M: Dietary variability and its impact on nutritional epidemiology. J Chronic Dis 1983; 36:237–249.

Wiley Announces Publication of *Toxicity Assessment Quarterly*

John Wiley and Sons, Inc. recently launched *Toxicity Assessment: An International Quarterly*, concerned exclusively with the field of toxicity, genotoxicity, and mutagenicity assessment with emphasis on the use of microorganisms and microbial products. Designed for publication of original papers in toxicity assessment, it concentrates specifically on procedures used to test for toxicants.

Each issue of the journal provides a toxicity assessment method presented in a detailed "cookbook" style in ASTM or ISO formats that enables laboratories to readily use these techniques. Readers will be introduced to adaptations of earlier assessment methods as well as major new screening tests both characterized by their simplicity, economy, sensitivity, and rapidity of result.

Toxicity Assessment will provide information on new developments of interest to a wide range of researchers in government agencies dealing with environmental and industrial health, public health and toxicological research, as well as food science and pharmacology, and university departments such as environmental sciences, microbiology, biology, industrial hygiene and chemical and sanitary engineering. Industries concerned with chemical production, toxic waste handling, and oil and waste treatment will also find news applicable to their field.

Also included is a "letters to the editor" section, as well as information fo upcoming international meetings and symposia, new publications, and educational opportunities. For further information, contact John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158.