

Patterns of Vitamin C Intake from Food and Supplements: Survey of an Adult Population in Alameda County, California

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Abstract: Use of vitamin C in food and pills and its association with health habits and health status were investigated in a random sample of 3,119 adults in Alameda County, California. Vitamin C intakes of nearly 80 per cent of respondents met or exceeded Recommended Daily Dietary Allowances. Fourteen per cent or fewer appeared to have inadequate vitamin C intake. Vitamin C supplements were taken daily by 29 per cent, occasionally by 21 per cent. Most respondents obtained 100 mg or less of vitamin C daily; 2 per cent had more than 2000 mg. Proportionately, more women than

men took vitamin C pills daily. Men aged 16 to 44 were the most likely to have neither vitamin C foods nor pills. Persons 45 years and older tended to take vitamin C pills daily, younger persons to take them occasionally. Respondents who did not eat breakfast or who smoked cigarettes had lower vitamin C intakes. People in poor health took more vitamin C than those in good health. Health status may have influenced vitamin C intake rather than vitamin C intake influencing health status. (*Am J Public Health* 1983; 73:773-778.)

Introduction

Interest in vitamin C use and its health benefits has been stimulated anew by the recent publication of the National Research Council, *Diet, Nutrition, and Cancer*.¹ That study report reviews research evidence suggesting that consumption of foods containing vitamin C is associated with lower risk of certain cancers. Quantitative data about vitamin C intakes of various United States population groups are available from food consumption studies²⁻⁴ and nutrition surveys.^{5,6} However, there is limited information about use of food sources of vitamin C versus vitamin C pills, use of vitamin C in large doses, and the relationship of vitamin C intakes and health status. This paper describes a study of vitamin C use by an adult population and attempts to answer some of these questions.

The Vitamin C Controversy

When this study was undertaken in 1974, diverse opinions about vitamin C were rampant in the scientific community. The basic question was whether large doses of vitamin C are effective in preventing and treating the common cold.

Pro and con arguments about clinical effects of vitamin C had been published as early as the 1940s⁷⁻¹³; among the general public the association of vitamin C with the common cold was achieving the status of folk medicine,¹⁴ encouraged by popular writers.^{15,16} With the publication in 1970 of Linus Pauling's *Vitamin C and the Common Cold*,¹⁷ the controversy became more intense.¹⁸⁻²⁸ Pauling's claim for preventive and therapeutic benefits of large doses of vitamin C was challenged in a double blind study,²⁹ from which an unexpected finding emerged, namely, that disability from all types of acute illness was 30 per cent lower in subjects who received 1000 mg of vitamin C daily than in those who received placebos. A subsequent double blind study³⁰ led to the conclusion that a large therapeutic dose of vitamin C at

the time of acute illness may help diminish disability from acute infection.

The first of these reports²⁹ was published as plans were proceeding for the 1974 *Health and Ways of Living Study* in Alameda County, California, under the direction of the Human Population Laboratory (HPL) of the California Department of Health.* Accordingly, questions about use of vitamin C were included.

Population and Methods

Alameda County is part of the San Francisco-Oakland Standard Metropolitan Statistical Area. Located on the east side of San Francisco Bay, it has a land area in excess of 700 square miles extending along the Bay and then east to the San Joaquin Valley. The population is over one million,³² of which only 1 per cent is rural. The area along the Bay includes several contiguous cities with industries, business, and service facilities mingled with large residential areas. The largest city is Oakland, a major center for commerce, transportation, and industry. Bordering Oakland to the north is Berkeley, location of the oldest campus of the University of California.

Respondents were adult, non-institutionalized residents of Alameda County, drawn from a probability sample of housing units. All occupants of a selected housing unit were eligible for the study if they were 20 years of age or older, or 16 years of age or older and had ever been married.

Of 4,209 eligible adults in the sample, 3,119 (74 per cent) filled out and returned questionnaires. Demographic characteristics of the study population, similar to those of the county, are shown in the first two columns of Table 1.

Information was obtained through a 28-page self-administered questionnaire which was left in the home for each eligible person by the enumerator. Completed questionnaires were returned by mail to HPL.

Three groups of questions specific to vitamin C intake from pills and food were included (See Appendix). Because the questionnaire was lengthy and self-administered, de-

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*The study was part of research initiated in 1959 focusing on physical, mental, and social health and their association with a wide range of independent variables—demographic, environmental, economic and cultural factors, and personal characteristics and habits called "ways of living."³¹

TABLE 1—Percent of Respondents at Five Levels of Vitamin C Intake from All Sources, Taken Daily, by Demographic Variables

	Vitamin C Intake Level: I II III IV V						
	Respondents with Daily Vitamin C Intake (mg)						
	Total N	%	0 ^a %	1-50%	51-100%	101-1000%	>1000%
Sex							
Female	1632	55	10	25	27	31	6
Male	1354	45	18	27	24	25	6
Total N	2986						
						p = <.0001	
Age (Years)							
16-24	346	12	17	25	23	30	6
25-34	795	27	17	26	26	24	7
35-44	518	17	16	27	26	26	5
45-54	532	18	11	28	25	30	6
55-64	392	13	11	25	26	31	7
65-74	241	8	6	27	27	34	6
≥75	162	5	9	24	31	34	3
Total N	2986						
						p = <.001	
Ethnicity							
White	2920	76	13	25	26	29	7
Black	353	12	15	28	25	30	3
Mexican-American	155	5	28	27	21	23	2
Chinese, Japanese American	109	4	10	34	30	23	3
Other	97	3	10	27	30	29	4
Total N	2920						
						p = <.0001	
Education							
Grade School	360	12	16	31	23	28	2
Some High School	379	13	18	29	21	29	4
High School Graduate	844	28	16	28	22	28	6
College	1002	34	12	25	29	28	6
Graduate School	389	13	7	17	35	30	11
Total N	2974						
						p = <.0001	
Income^b							
Inadequate	444	16	13	25	26	31	5
Marginal	357	12	12	29	24	31	4
Adequate	1195	42	16	29	25	25	4
High	854	30	11	21	28	30	10
Total N	2850						
						p = <.0001	

Note: Total respondents in this and other Tables differ from the actual respondents (3,119) because of differences in numbers of responses to various questions.

a) Zero intake includes respondents with no daily intake of vitamin C from pills or specified food.

b) See text for definition.

tailed questions about food sources of vitamin C could not be asked. Therefore, certain assumptions and generalizations were made in analyzing responses. The following categories of vitamin C intake were established: 1) total vitamin C from all sources—i.e., pills and specified foods; 2) from pills only—taken *regularly* (synonymous with daily), *occasionally*, or *never*; 3) from specified foods eaten *almost every day*, *sometimes*, or *rarely or never*. (See Appendix for details.) Vitamin C intakes were compared with demographic characteristics, health habits, and indicators of health status.

Results

Vitamin C Intake

Vitamin C intakes from all sources used daily—food and/or pills—ranged from 0 to 7000 mg. Over half were in the range 1-100 mg. Eight per cent of respondents reported daily intake higher than 1000 mg, including 2 per cent higher than 2000 mg, whereas 14 per cent reported no regular use of any of the specified sources of vitamin C (Table 2). Twenty-nine per cent of the study population reported daily use of vitamin pills containing vitamin C, and an additional 21 per cent reported *occasional* use of such pills. Nearly 70 per cent of respondents reported eating two servings of fruit or vegeta-

bles almost daily, and 61 per cent reported one or more glasses of the specified juices on an average day.

Vitamin C and Demographic Characteristics

Respondents were classified into five groups according to their daily vitamin C intake (Table 1). The groups were

TABLE 2—Frequency Distribution of Vitamin C from All Sources used Daily

Vitamin C Intake mg	Respondents	
	Number	%
0	411	14.0
1-50	780	26.0
51-100	774	26.0
101-200	417	14.0
201-500	256	8.5
501-1000	171	6.0
1001-1500	75	2.5
1501-2000	45	1.5
2001-2500	20	0.7
>2500	37	1.0
TOTAL	2986	100

TABLE 3—Number of Respondents at Five Levels of Vitamin C Intake from All Sources, Taken Daily, by Health Habit and Health Status Variables

Vitamin C Intake Level:	I	II	III	IV	V	
	Respondents with Daily Vitamin C Intake (mg)					
	All N	0 %	1-50 %	51-100 %	101-1000 %	> 1000 %
Cigarettes						
Smokes	1044	19	27	22	27	5
Used to Smoke	642	14	24	28	26	8
Never Smoked	1295	9	27	28	31	6
Total N	2981				p = < .0001	
Health Habit Score^a						
0, 1, 2	106	26	34	15	21	5
3	334	22	29	23	24	2
4	681	20	29	23	23	5
5	860	13	24	26	30	8
6	720	18	25	30	29	8
7	285	2	23	28	40	8
Total N	2986				p = < .0001	
Breakfast						
Almost Every Day	1720	7	24	29	33	7
Sometimes	661	17	29	25	24	6
Rarely or Never	602	29	31	19	19	3
Total N	2983				p = < .0001	
Physical Health Spectrum						
1. Severely disabled	295	15	24	23	33	6
2. Lesser disability	192	7	29	26	32	6
3. Two or more chronic conditions	348	13	23	26	31	8
4. One chronic condition	662	13	26	26	29	6
5. One symptom	575	17	26	25	26	7
6. Without complaints, medium/low energy	747	14	28	27	26	5
7. Without complaints, high energy	167	14	27	28	28	3
Total N	2986				N.S.	

^aSee text for description of Health Habit Score.

analyzed by demographic variables, as shown in Table 1. Classifying intakes by respondents' occupations** revealed that relatively fewer professionals and semiprofessionals than other occupational groups reported no intake or intakes of 50 mg or less. There were no significant differences in daily and occasional use of vitamin C pills among occupational groups (data not shown).

A greater proportion of females than males reported taking vitamin C pills daily (60 and 40 per cent, respectively, p < .0001). Males 16 to 44 years of age were more likely than females or other males to use neither vitamin C foods nor pills. There was a tendency among pill takers for persons aged 16 to 44 years to take vitamin C pills occasionally and persons 45 years and older to take them daily. Mexican-Americans were least likely of all ethnic groups to use vitamin C pills.

Mean vitamin C intakes compared for each ethnic group at each income level*** showed that White respondents had higher mean intakes at every income, while Blacks and Mexican-Americans were consistently below group means regardless of income.

**Occupation categories: professional, semi-professional, proprietors, managers, clerical, sales, foremen, craftsmen, operatives, service, laborers, students, unemployed.

***Levels of family income—high, adequate, marginal, inadequate—were based on total income and household size. e.g., for a family of 3-4, adequate income was considered to be \$8,000-14,999, marginal income was \$5,000-7,999, and income below \$5,000 was considered inadequate.

Vitamin C Use and Health Habits

The health habits investigated include eating breakfast, snacking, and smoking cigarettes. In addition, a health habit score from 0 to 7 was used, based on the respondents' answers to seven questions about personal habits and activi-

TABLE 4—Number and Per Cent of Respondents Who Used Vitamin C Pills Never, Occasionally and Regularly, by Physical Health Spectrum (PHS)

PHS	All N	Use of Vitamin C Pills		
		Never %	Occasional %	Regular %
1. Severely Disabled	513	49.7	16.2	34.1
2. Lesser Disability				
3. 2 Chronic Conditions	1627	49.0	21.1	29.9
4. 1 Chronic Condition				
5. 1 Symptom(s)				
6. Without Complaints, Medium/Low Energy	933	52.7	22.8	24.5
7. Without Complaints, High Energy				
TOTAL	3073			p = < .0001

TABLE 5—Mean Days Indoors and in Bed, Due to Illness at Five Levels of Vitamin C Intake from All Sources Used Daily

	Respondents with Regular Vitamin C Intake (mg)						
	N =	ALL 2952	0 ^a 407	1-50 772	51-100 767	101-1000 829	> 1000 177
Mean Days Indoors		9.3	7.2	7.3	10.4	10.3	13.1
Mean Days in Bed		4.7	3.1	3.4	5.0	5.9	8.0

p = < .001 KRUSKAL-WALLIS TEST

a) Zero intake includes respondents with no *daily* intake of vitamin C from pills or specified food.

ties.‡ These variables were analyzed at five levels of vitamin C intake (see Table 3). Eating breakfast had a positive association with use of vitamin C pills. Higher (better) health habit scores were associated with higher mean daily vitamin C from food and also were strongly related to use of vitamin C pills. Eating between meals was the only health habit variable not significantly related to any level of C intake or to its source.

Vitamin C Use and Health Status

The physical health spectrum (PHS), established in the HPL as the principal measure of physical health status, is an index based on symptoms, chronic conditions, energy level, and degree of disability reported by respondents. It ranges from PHS 1 (severely disabled) to PHS 7 (without complaints, high energy). The PHS has been described in detail earlier.³⁴ Respondents at the low end of the PHS, especially those with multiple chronic conditions, had the highest mean daily intake of vitamin C, while those at the upper end of the PHS had the lowest mean daily intake. Persons in poor physical health were more likely than others to take vitamin C pills daily, while those in better health were more likely to take the pills occasionally (Table 4). Thus, poor physical health was associated with higher intake of vitamin C, and vice versa. While this association was highly significant, the differences were small, and the correlation coefficient was only .05, indicating that intake of vitamin C was influenced by many factors other than state of health.

PHS and health habit scores were positively but not highly correlated ($r = 0.16$). Individuals with PHS scores of 1-4 showed a consistent sharp increase in mean vitamin C intake as the number of their health promoting habits increased, while persons with PHS scores of 6 and 7 did not show an increase in vitamin C intake as the number of health promoting habits increased.

Two other indicators of health status—days indoors due to illness and days in bed—were examined relative to vitamin C use. Tables 5 and 6 show the strong positive association between intake of vitamin C (from all sources and from pills) and number of days indoors and days in bed.

Individuals whose vitamin C intake was more than 1000 or 2000 mg daily comprised only 8 per cent of all respondents. They are described in Table 7 by demographic characteristics.

Comparison of these two high intake groups with each other and with all others in the survey population reveals similarities as well as differences in health habits and PHS scores, as shown in Table 8. The most notable difference is that there was a smaller proportion of high vitamin C users

‡Consumption of alcohol, cigarette smoking, relative weight, eating breakfast, snacking, hours of sleep, physical activity.

TABLE 6—Mean Days Indoors and in Bed, Due to Illness by Frequency of Vitamin C Pill Use

	Respondents' Use of Vitamin C Pills			
	N =	Never 1526	Occasional 874	Daily 634
Mean Days Indoors		7.9	9.4	12.8
Mean Days in Bed		3.9	5.2	6.9

p = < .001 KRUSKAL-WALLIS TEST

with health habit scores below 5 and more with scores above 5 when compared to the rest of the survey population. On the other hand, PHS scores of high vitamin C users tended toward the lower range of 1-4, and very few high users had PHS score 7.

Discussion

At a time when the public was almost besieged with messages extolling the health benefits of large daily doses of vitamin C, only 8 per cent of 3,119 survey respondents reported having adopted that practice with intakes greater than 1000 mg per day. Vitamin C supplements were reported in regular use by less than one-third of the respondents.

The initial phase of the Health and Nutrition Examination Survey (HANES I)³⁵ began in 1971 and ended in 1974, the same year as the Health and Ways of Living Study. Its more than 20,000 respondents were part of a nationwide probability sample and could, presumably, have been exposed to media messages promoting high doses of vitamin C.‡‡ Approximately 32 per cent of 10,000 adults (age 18-75) in the HANES population said they took some kind of vitamin or mineral supplement, 21 per cent reported taking such supplements "regularly," and 11 per cent "irregularly." Only 1 per cent of the supplements were solely vitamin C, but 26 per cent of respondents took a combination supplement which *might* have contained vitamin C.‡‡‡ It appears that Alameda County respondents were heavier users of vitamin C supplements than were HANES respondents.

The survey questions were based on kinds and amounts of food sufficient to meet the Recommended Dietary Allowance for vitamin C according to the Food and Nutrition Board, National Research Council:³⁶ 45 mg daily for adults at the time of the survey, 60 mg at present.³⁷ Two servings of fruit or vegetables and one small glass of a specified juice could supply approximately that amount and provide other nutrients and fiber as well. The study results show that 78 per cent of respondents reported meeting the 1974 RDA for vitamin C, all but 6 per cent from food only, and that 60 per cent would have met the present RDA, all but 20 per cent from food only.

‡‡Freeman Co., publisher of Pauling's *Vitamin C and the Common Cold*, (1970), sold in excess of 207,000 copies, with peak sales in 1972. The book qualifies as a "medium" seller rather than a best seller. In contrast, vitamin C in supplement form was and still is a best seller, according to sales information from a major pharmaceutical company. The sharpest rise in sales occurred in 1970, 1971, and 1972. With 1969 as the base year, index 100, changes in index of sales were of the following magnitude: 1970-104; 1971-146; 1972-204. A pharmaceutical company spokesman attributes this rise to Pauling's book. Sales leveled off in 1973-1976. A moderate increase occurred from 1976 to 1981, but sales fell off in 1981.

‡‡‡Unpublished data, First Health and Nutrition Examination Survey, 1971-74.

TABLE 7—Demographic Characteristics of Respondents with High Daily Intake of Vitamin C

RESPONDENTS	1001–2000 mg	> 2000 mg
	N = 177 %	N = 57 %
Sex	6	2
Female	53	63
Male	47	37
Race		
White, Non-Hispanic	85	98
Black	8	0
Age (years)		
16–24	10	18
25–34	36	23
35–54	28	39
55–74	24	17
≥75	2	3
Education (years)*		
Grade School	3	7
Some High School	6	11
High School Graduate	27	28
College	39	28
Post Graduate	25	26
Income		
Inadequate	14	14
Marginal	9	7
Adequate	30	33
High	48	46
Employment		
Professional and Semi Professional**	32	37
Managerial; Clerical;** Sales Foremen/Craftsmen;** Operatives; Service; Laborers**	39	40
	30	23

*25 (11%) of 234 High Intake Respondents were students at time of survey.
**Largest Proportions

Fourteen per cent of respondents appeared to have no regular source of vitamin C. This group includes persons who reported that they did not have at least two servings of fruit or vegetables almost every day, had none of the specified juices on an average day, and did not take vitamin C pills each day. Because of possible underreporting, 14 per cent is probably too high an estimate of persons who had inadequate vitamin C. However, there is cause for concern if any segment of the population lacks a regular source of vitamin C sufficient to meet nutritional needs.

Underreporting of vitamin C use was very likely for several reasons:

- 1) vitamin C rich foods other than those specified on the questionnaire might have been part of usual diets of some respondents. For example, chili peppers, a rich source of vitamin C,³³ are eaten routinely by Mexican-Americans in sufficient amount to meet or exceed the National Research Council RDA.^{36,37} They are used as a condiment and are not generally considered to be a vegetable. Hence their use would not be reflected in questionnaire responses;

- 2) no definition was given for a serving;

- 3) the term *occasionally* was not defined. Respondents might have taken vitamin C pills several times a week, a month, or a year.

Underestimation of vitamin C intake in some cases was also likely because no quantitative value was assigned to less than two servings of vegetables and fruit eaten *almost every day* or *sometimes*.

As in any dietary survey, overreporting was likewise a possibility and thus a potential source of error.

Cigarette smoking was inversely related to vitamin C

TABLE 8—Comparison of High Vitamin C Intake Groups with All Other Respondents, By Health Habits and PHS Scores

	Daily Intake of Vitamin C		
	≤ 1000 mg	1001–2000 mg	> 2000 mg
	N = 2885 %	N = 177 %	N = 57 %
Health Habit Score			
0–2	4	4	0
3–4	34	24	23
5	29	30	28
6–7	34	42	49
Cigarettes			
Smokes	35	27	32
Used to Smoke	21	32	28
Never Smoked	44	42	40
Breakfast			
Almost Daily	57	67	72
Sometimes	22	22	21
Rarely or Never	21	11	7
Vegetables			
Almost Daily	68	80	84
Sometimes	25	19	11
Rarely or Never	7	2	5
PHS Score			
1–2	16	17	21
3–4	34	39	39
5	19	21	14
6	25	20	26
7	5	3	0

intake. Evidence that smoking interferes with utilization of vitamin C^{38,39} appears to place the smoker in double jeopardy with regard to vitamin C nutrition. The association of life-style with nutrient intake has been demonstrated in research with teenagers⁴⁰ and adults.⁴¹ Findings in this study are consistent with those in earlier studies.

Analysis of the survey data to determine a possible effect of health habits and health status on vitamin C intake revealed three general categories of respondents:

- sick people with few or no health promoting habits, who had vitamin C daily but not in large amounts;
- sick people with many good health habits, who had very high intakes of vitamin C daily; and
- healthy people with a range of health habits, who had vitamin C daily but not in large amounts.

Our findings suggest that some persons who used vitamin C pills daily may have done so as part of a health promoting life-style, and that occasional pill users might have taken vitamin C pills when they felt they were getting sick. Whether vitamin C was used as self-medication or was medically prescribed for prevention or therapy is not clear from these data.

The purpose and methods of this study precluded obtaining any new information about specific health effects of doses of vitamin C greater or less than the Recommended Dietary Allowance. However, considerable light was shed on patterns of vitamin C use in a free-living population and on characteristics of those who are likely to consume either large doses or inadequate amounts of vitamin C. Whether the large users had been influenced by the media or had been reached via other transmittal routes of folk medicine remains unknown.

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APPENDIX

Questions about Vitamin C Pills and Food

1. Do you take vitamin pills or other supplements?
 - NO YES, REGULARLY
 - YES, OCCASIONALLY
 How many of these per day do you take? _____
 Do these pills (or other supplements) contain vitamin C?
 NO YES
 How many milligrams of vitamin C in each?
 CIRCLE ONE: 50 mg 100 mg 250 mg 500 mg
2. On an average day, about how many of these do you drink?

Coffee	_____ cups
	number
Tea	_____ cups
	number
Milk	_____ glasses
	number
Water	_____ glasses
	number
Soda (pop)	_____ cans or bottles
	number
Orange, tomato or grapefruit juice	_____ small glasses
	number
3. How often do you eat at least two servings of fruit or vegetables in a day? (Include juices and all types of raw or cooked fruits and vegetables.)
 - ALMOST EVERY DAY SOMETIMES
 - RARELY OR NEVER

Determination of Vitamin C Intake

Total vitamin C intake was determined by computing the sum of the following:

- *Vitamin C from pills*—For regular users of pills, this was computed from the number of pills and the milligrams of vitamin C per pill reported on the questionnaire. For respondents who indicated they were *occasional* users or *never* took vitamin supplements, the amount of vitamin C from pills was considered to be zero.

- *Vitamin C from juices**—This was determined from the number of small glasses of orange, tomato, or grapefruit juice the respondent reported consuming. A small glass was assumed to hold 4 ounces, and a value of 40 mg of vitamin C was assigned for each glass.³³

- *Vitamin C from fruit or vegetables**—A value of 50 mgs³³ was assigned if the respondent indicated he/she ate at least two servings *almost every day*. If the respondent reported that he/she ate at least two servings *sometimes*, or *rarely or never*, the vitamin C value was considered to be zero.

*The authors recognize the errors inherent in this crude method of estimating vitamin C intake from food. However, in analysis of vitamin C intakes greater than 1000 mg, errors in food sources are not important since it is unlikely that this amount of vitamin C would be provided by food alone except in unusual cases.

Vitamin C intakes below 400 mg might be provided by a combination of food and pills, or by food or pills only. Intakes of 400 mg and higher might be supplied by a combination of food and pills, or by pills only.