Do eating habits differ according to alcohol consumption? Results of a study of the French cohort of the European Prospective Investigation into Cancer and Nutrition (E3N-EPIC)[1–4]

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ABSTRACT

Background: The potential of dietary habits to confound the association between alcohol consumption and health needs further study.

Objective: We examined whether eating habits differed according to alcohol consumption in a large cohort of French women.

Design: This was a cross-sectional study of the French cohort of the European Prospective Investigation into Cancer and Nutrition (E3N-EPIC). The cohort was established in 1990 and includes 100 000 women born between 1925 and 1950. Dietary data were obtained between 1993 and 1995 by using self-administered food-frequency questionnaires. About 73 000 questionnaires were analyzed, and women were placed into 7 categories of alcohol consumption.

Results: After adjustment for energy derived from alcohol, increasing alcohol consumption was associated with a higher total energy intake, a higher percentage of energy intake as protein and lipids, and higher intakes of cholesterol, fatty acids, retinol, iron, and vitamin E. Conversely, energy provided by carbohydrates decreased with increasing alcohol consumption, as did β-carotene intake. Increasing alcohol consumption was associated with higher consumption of animal products, cheese, potatoes, oil, bread, and breakfast cereals and with lower consumption of vegetables and dairy products.

Conclusion: In this population of middle-aged, highly educated French women, marked differences in dietary patterns and nutrient intakes were found according to alcohol consumption. Part of the detrimental effect of alcohol on health may be due to the less healthy dietary habits of drinkers. This points to a confounding role of eating habits and nutrient intakes in the relation between alcohol and health. *Am J Clin Nutr* 2001;74:322–7.

KEY WORDS Alcohol intake, dietary patterns, alcoholic beverages, cohort study, nutrients, energy, E3N-EPIC, European Prospective Investigation into Cancer and Nutrition, food-frequency questionnaire, women, France

INTRODUCTION

The consequences of alcohol consumption on health have been extensively studied (1, 2). In the French population aged 35–64 y, the total number of deaths attributable to alcohol in 1990 was 17 353 (13 573 men and 3780 women), corresponding to 17.4% of overall mortality. Among these deaths, 4709 were due to cancer, 1862 to mental disorders, 6196 to gastrointestinal diseases, 404 to cardiovascular disease, 2469 to unintentional injuries, 1603 to intentional injuries, 49 to respiratory diseases, and 61 to other alcohol-related diseases (3).

Moderate alcohol consumption (1 or 2 drinks daily) can beneficially affect life expectancy (4, 5), notably through a protective effect on coronary artery disease, mediated by an increase in HDL concentrations, independently of the type of alcoholic beverage consumed (6). For cancer, there is convincing evidence that a high alcohol intake is a strong risk factor for malignancies of the mouth, pharynx, larynx, esophagus, and liver (7). However, moderate consumption of wine was related to a lower risk of cancer death in a recent study (8).

Probably the most important confounding factor in epidemiologic studies, at least with respect to coronary artery disease and cancer, is cigarette smoking, which in many studies is correlated with alcohol consumption (9–11). The potential confounding role of dietary habits, both good and bad, is unclear, but is in obvious need of further study. To determine whether eating habits differ significantly according to the level of alcohol consumption, and whether the dietary correlates of alcohol consumption offer health benefits or disadvantages according to the level of alcohol consumption, we analyzed data from participants in the French cohort (Etude Epidémiologique de Femmes de la Mutuelle Générale de l'Education Nationale) of the European Prospective Investigation into Cancer and Nutrition (E3N-EPIC) (12).

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TABLE 1
Characteristics of the 72 904 women according to alcohol consumption[1]

	Alcohol consumption (g ethanol/d)						
	0 (n = 9207)	>0 to 2 (n = 12 852)	>2 to 4 (n = 8276)	>4 to 8 (n = 11 735)	>8 to 16 (n = 14 170)	>16 to 32 (n = 11 595)	>32 (n = 5069)
Percentage of subjects (%)	12.6	17.6	11.4	16.1	19.4	15.9	7.0
Age at the time of the questionnaire (y)	52.97 ± 6.92[2]	52.54 ± 6.77	52.06 ± 6.52	52.04 ± 6.58	52.34 ± 6.72	52.43 ± 6.61	52.00 ± 6.41
Weight (kg)	59.52 ± 10.38	59.64 ± 9.70	59.82 ± 9.31	59.95 ± 8.89	59.83 ± 8.76	60.19 ± 8.75	61.30 ± 9.36
Height (cm)	161.33 ± 5.81	161.33 ± 5.71	161.70 ± 5.62	161.85 ± 5.62	161.88 ± 5.62	162.09 ± 5.61	162.38 ± 9.36
BMI (kg/m^2)	22.85 ± 3.73	22.88 ± 3.42	22.86 ± 3.27	22.57 ± 3.08	22.82 ± 3.06	22.89 ± 3.03	23.23 ± 3.31
Age at menopause (y)	49.21 ± 6.59	49.32 ± 5.80	49.43 ± 6.03	49.18 ± 5.55	49.37 ± 5.94	49.35 ± 5.78	49.09 ± 6.31
Percentage at the lowest education level (%)	14.16	13.95	11.23	10.78	10.73	10.58	9.79
Current smoker (%)	6.4	6.7	8.9	10.4	13.0	16.8	25.8

[1] P for trend < 0.0001 for all characteristics (chi-square test or ANOVA).
[2] $\bar{x}$ ± SD.

SUBJECTS AND METHODS

E3N-EPIC was designed to study risk factors for cancer at the sites occurring most frequently in women (13). The cohort includes 100 000 women aged 40–65 y at baseline (in 1990) who are covered by the French national teachers' health insurer. The main risk factors studied were eating habits, hormone treatments, and reproductive factors. Other factors were smoking, morphology, personal medical history, and regular use of medicinal drugs. Biological samples are banked for biomarker studies. Participants are followed prospectively, with the use of self-administered questionnaires, about every 24 mo.

The dietary questionnaire analyzed in the present study was sent to the participants between June 1993 and July 1995. It comprised 2 parts and was sent with a booklet of photos to facilitate the estimation of portion sizes. The first part included questions on the consumption (frequency and quantity) of 66 food groups. The second part included qualitative questions. Overall, the questionnaire covered the daily consumption of 238 food items.

Both the questionnaire and the illustrated booklet were validated previously (14, 15). The validity of the self-administered questionnaire was tested in a sample of 115 women. In that assessment, the answers recorded on the questionnaire at the beginning of the validation study were compared with the mean responses on twelve 24-h dietary recalls assessed monthly on the different days of the week. The highest correlation coefficient (0.71) was for alcoholic beverages (14).

After the questionnaires were mailed to 95 644 women and 2 reminders were mailed to nonresponders, 77 580 questionnaires were collected. A total of 4676 subjects were excluded. Exclusion criteria were absence of consent for external health follow-up by the health insurer in case of dropout (n = 1010), double answers (n = 18), miscoded answers (n = 2075), missing values for all dietary items on an entire page (n = 143) or for a whole meal in the dietary questionnaire (n = 1339), and daily energy intake <2092 kJ (500 kcal) (n = 91). Statistical analyses focused on the remaining 72 904 questionnaires. Extreme values (for 1.6% of the subjects), ie, those differing from the mean by 4 SDs, were replaced by the mean.

The following alcoholic beverages were listed in the questionnaire: wine, beer, cider, fortified wines and aperitifs (port, vermouth and muscat, punch, and kir), and spirits (anis seed liquors, whisky, gin, and vodka). Alcohol consumption was translated into daily amounts of ethanol, assuming that 100 mL of a beverage containing 10% alcohol (roughly equivalent to one glass of wine) contains 8 g ethanol. Subjects were placed into 7 categories according to their daily alcohol consumption: nondrinkers, >0 to 2 g, >2 to 4 g, >4 to 8 g, >8 to 16 g, >16 to 32 g, and >32 g (heavy drinkers).

Statistical analyses were performed by using SAS statistical software (version 8.00 for WINDOWS NT; SAS Institute Inc, Cary, NC). Analysis of variance (GLM, Tukey option, Bonferroni option) was used to compare certain general characteristics of the study population with alcohol consumption and to identify foods for which consumption differed between categories of alcohol consumption, taking into account multiple testing. Only the most discriminatory dietary variables were analyzed. The null hypothesis, ie, that there was no significant difference in food consumption between alcohol categories, was rejected at a P value <0.05. Foods were first classified according to the value of the F statistic and then a principal components analysis (PRINCOMP) was applied to the variables identified as discriminatory. Relations between nutrient intake and alcohol consumption were tested by using linear or quadratic tests for categorized alcohol consumption or ethanol intake (REG). Daily food items were categorized as over- or underconsumed by comparing the mean value for each category of alcohol consumption with the mean value calculated for all participants.

RESULTS

The main characteristics of the study population are presented in **Table 1**.

Alcohol consumption

The mean (±SD) amount of ethanol consumed was 10.5 ± 13.4 g/d. The median value was 5.8 g/d, indicating that the alcohol consumption distribution was highly skewed to the right. A total of 9207 women (12.6%) were nondrinkers, and 5069 (7.0%) drank >32 g ethanol daily. Drinking habits are analyzed in **Table 2** according to beverage type. Wine was the most commonly consumed alcoholic beverage (61.5% of all alcohol consumption). Light drinkers (those who consumed 0–2 g ethanol/d) drank similar amounts of wine and fortified wines. In all categories of alcohol consumption, beer and spirits accounted for ≈4–10% of total alcohol intake.

TABLE 2
Amount of alcoholic beverages consumed by drinkers[1]

	Alcohol consumption (g ethanol/d)						
	>0 to 2 (n = 12 852)	>2 to 4 (n = 8276)	>4 to 8 (n = 11 735)	>8 to 16 (n = 14 170)	>16 to 32 (n = 11 595)	>32 (n = 5069)	All drinkers (n = 63 697)
				mL (%)			
Wine	5.1 (38.2)	20.8 (56.0)	46.5 (63.5)	100.3 (69.9)	205.3 (73.6)	431.9 (73.2)	106.4 (61.5)
Beer	0.9 (3.8)	3.1 (4.1)	7.4 (5.0)	16.6 (5.7)	33.4 (6.0)	79.1 (6.8)	18.0 (5.1)
Cider	1.5 (7.2)	3.5 (4.3)	5.0 (3.0)	7.4 (2.3)	11.1 (1.8)	14.5 (1.1)	6.5 (3.5)
Fortified wines	3.0 (43.9)	6.5 (27.2)	9.7 (0.3)	13.7 (4.7)	19.9 (10.9)	35.7 (9.3)	12.8 (22.1)
Spirits	0.2 (6.9)	0.7 (8.5)	1.4 (8.1)	2.5 (7.5)	4.9 (7.7)	13.5 (9.6)	2.7 (7.2)

[1] Percentage contribution to daily alcohol consumption in parentheses.

Dietary factors

Food items were analyzed according to alcohol consumption and were further grouped to explore dietary patterns. The principal components analysis identified some food items that were associated with increasing alcohol consumption. Intakes of cheese, processed meat, seafood, vegetable oil, poultry, coffee, potatoes, eggs, and lamb were positively correlated with alcohol consumption, whereas intakes of soup, yogurts, vegetables, and fruit were negatively correlated with alcohol consumption. The average consumption of certain food items for which daily consumption differed most significantly between categories of drinkers are shown in **Figure 1**.

Nutrient intake

Mean absolute energy intakes are shown in **Table 3**. Energy intake, adjusted for body mass index (BMI) and age, increased significantly with alcohol consumption (regression coefficient for ethanol = 48.63 kJ/g). Energy intake was 29.5% higher (2390 kJ) in heavy drinkers than in nondrinkers. When energy from alcohol was excluded (regression coefficient for ethanol = 19.35 kJ/g), energy intake was still 12.4% higher in heavy drinkers than in nondrinkers.

Further analyses were carried out after subtracting the energy derived from ethanol. Contributions of macronutrients to food-derived energy intake, after adjustment for BMI and age, were significantly different among categories of drinkers (Table 3). The percentage of energy from carbohydrates fell as alcohol consumption increased (regression coefficient for ethanol = –0.10%/g), whereas the percentage of energy from lipids increased (regression coefficient for ethanol = 0.06%/g). A relation was also observed between the percentage of energy from protein and ethanol, with an increase in the percentage of energy from protein of 5.65% between nondrinkers and heavy drinkers (regression coefficient for ethanol = 0.02%/g), although values were similar among women who consumed from 0 to 16 g ethanol/d.

Intakes of selected micronutrients were also computed (**Table 4**). Consumption of polyunsaturated fatty acids, saturated fatty acids, and monounsaturated fatty acids was 22.0%, 22.4%, and 35.9% higher, respectively, in heavy drinkers than in nondrinkers. Cholesterol intake was 31.6% higher in heavy

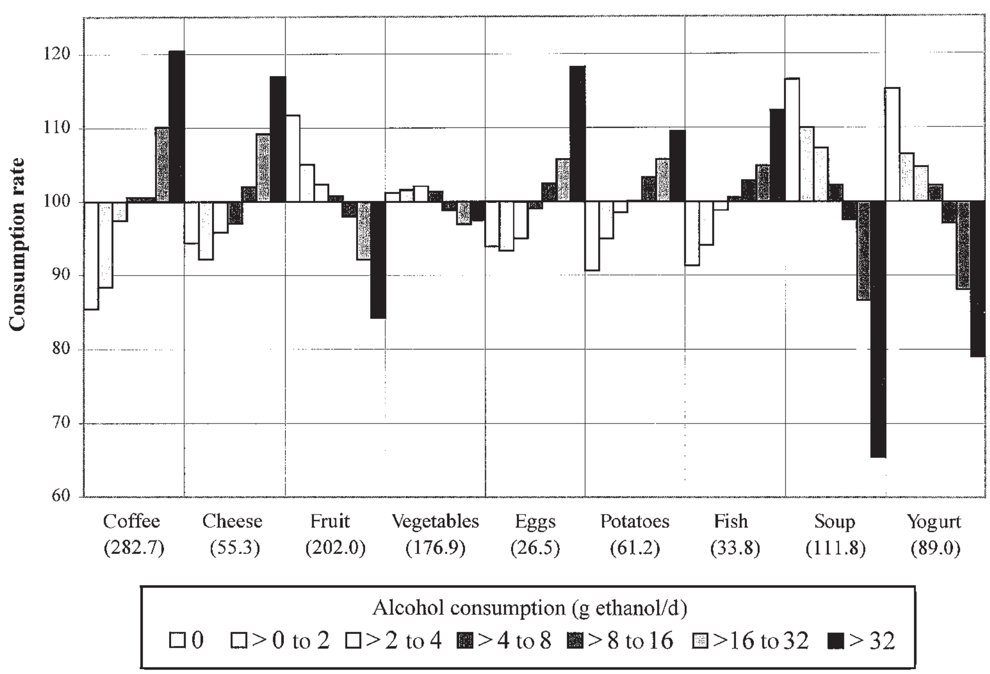

FIGURE 1. Consumption of selected food items (population mean in parentheses; arbitrary mean = 100) according to alcohol consumption in 72 904 French women.

TABLE 3
Total energy intake, food-derived energy intake, and macronutrient contributions to food-derived energy intake of 72 904 women according to alcohol consumption[1]

	Alcohol consumption (g ethanol/d)						
	0 (n = 9207)	>0 to 2 (n = 12 852)	>2 to 4 (n = 8276)	>4 to 8 (n = 11 735)	>8 to 16 (n = 14 170)	>16 to 32 (n = 11 595)	>32 (n = 5069)
Total energy (MJ/d)	8.12 ± 2.67	8.25 ± 2.49	8.59 ± 2.48	8.78 ± 2.45	9.14 ± 2.48	9.58 ± 2.58	10.51 ± 2.98
Food-derived energy (MJ/d)	8.12 ± 2.67	8.22 ± 2.49	8.50 ± 2.48	8.61 ± 2.45	8.81 ± 2.48	8.92 ± 2.57	9.13 ± 2.91
Carbohydrates (% of energy)	45.3 ± 7.8	44.3 ± 7.0	43.5 ± 6.9	43.2 ± 6.6	42.5 ± 6.7	41.5 ± 6.8	39.7 ± 7.1
Lipids (% of energy)	34.4 ± 7.4	35.6 ± 6.7	36.3 ± 6.5	36.6 ± 6.2	37.0 ± 6.4	37.6 ± 6.3	38.4 ± 6.5
Protein (% of energy)	17.7 ± 3.5	17.6 ± 3.2	17.6 ± 3.1	17.6 ± 3.0	17.7 ± 2.9	18.0 ± 3.0	18.7 ± 3.3

[1] $\bar{x}$ ± SD. P for trend <0.0001 for all variables. Regression coefficients are given in the text.

drinkers than in nondrinkers. Intakes of retinol, vitamin E, and iron increased with alcohol consumption, whereas intake of β-carotene decreased. Intakes of vitamin C and fiber had a bell-shaped relation with alcohol consumption, whereas calcium intake had a U-shaped relation.

Smoking

A strong positive relation was observed between categories of tobacco use and alcohol consumption (chi-square test: $P <$ 0.0001). Among nondrinkers, 75.6% of women had never smoked. In contrast, only 6.4% of women who smoked were nondrinkers. Smokers were 4 times as frequent among heavy drinkers as among nondrinkers.

DISCUSSION

In this study of middle-aged, well-educated French women, significant differences in nutrient intake and food consumption were found according to the degree of alcohol consumption. In particular, total energy intake increased with alcohol consumption, even after adjustment for the energy provided by alcohol. The distribution of energy sources was also uneven: energy from lipids and protein increased with alcohol consumption, whereas the contribution of carbohydrates to total energy decreased. Drinkers also consumed more animal-derived foods than did nondrinkers.

Few studies (16–19) have investigated differences in food and nutrient intakes according to drinking habits in women, and the results of such studies are discordant. Mannisto et al (18) found a decrease in total energy intake with increasing alcohol consumption, whereas 3 studies (16, 17, 19) reported an increase in total energy intake, but the results of these studies diverged when energy from ethanol was excluded. Like us, Toniolo et al (16) found an increase in nonalcohol energy intake with increasing alcohol consumption. Veenstra et al (17) reported drinkers and nondrinkers to have similar nonalcohol energy intakes. Mannisto et al (18) found lower nonalcohol energy intakes in heavy drinkers than in nondrinkers, and Colditz et al (19) observed a U-shaped distribution of energy intake according to alcohol consumption. There is general agreement on the existence of a negative relation between BMI and alcohol consumption in women (20, 21). Colditz et al (19) found a U-shaped distribution of BMI, with an increase in BMI in heavy drinkers (>50 g ethanol/d). Our results differ in that BMI, even after adjustment for nonalcohol energy intake, increased with increasing alcohol consumption. Yet, our population also differs in its distributions of both BMI and alcohol consumption.

Some studies of both sexes showed that the contributions of fat and protein to nonalcohol energy intake are greater in heavy drinkers than in nondrinkers, whereas the contribution of carbohydrates is lower (22, 23). However, these findings were less convincing for women than for men, possibly because of the wider range of alcohol consumption among men.

Few studies have shown significant differences in micronutrient intakes according to alcohol consumption, but

TABLE 4
Micronutrient intakes of 72 904 women according to alcohol consumption[1]

	Alcohol consumption (g ethanol/d)							
	0 (n = 9207)	>0 to 2 (n = 12 852)	>2 to 4 (n = 8276)	>4 to 8 (n = 11 735)	>8 to 16 (n = 14 170)	>16 to 32 (n = 11 595)	>32 (n = 5069)	P for trend
PUFA (g/d)	10.9 ± 6.2	11.6 ± 6.0	12.0 ± 5.9	12.2 ± 5.8	12.5 ± 5.9	12.8 ± 5.9	13.3 ± 6.7	<0.0001[2]
SFA (g/d)	30.8 ± 15.7	31.9 ± 14.8	33.8 ± 15.1	34.3 ± 14.6	35.6 ± 15.0	36.4 ± 15.2	37.7 ± 16.8	<0.0001[2]
MUFA (g/d)	22.0 ± 10.9	23.1 ± 9.8	24.7 ± 9.8	25.4 ± 9.9	26.6 ± 10.2	27.8 ± 10.6	29.9 ± 12.3	<0.0001[2]
Cholesterol (mg/d)	367.3 ± 190.4	378.8 ± 175.2	396.8 ± 168.3	408.3 ± 168.9	424.8 ± 177.2	442.3 ± 182.4	483.4 ± 220.9	<0.0001[2]
Retinol (μg/d)	845.5 ± 995.2	862.9 ± 891.3	923.0 ± 945.6	922.1 ± 917.8	971.1 ± 936.7	996.5 ± 975.8	1086.5 ± 1111.4	<0.0001[2]
Iron (mg/d)	12.2 ± 3.9	12.3 ± 3.7	12.9 ± 3.6	13.3 ± 3.6	14.0 ± 3.6	15.1 ± 3.8	17.5 ± 4.7	<0.0001[2]
β-Carotene (μg/d)	8242.0 ± 4519.2	8062.9 ± 4210.2	7999.1 ± 4141.4	7908.5 ± 4074.3	7723.7 ± 4019.6	7494.8 ± 4088.6	7172.2 ± 4371.7	<0.0001[2]
Vitamin E (mg/d)	10.7 ± 5.5	11.2 ± 5.3	11.4 ± 5.2	11.5 ± 5.0	11.6 ± 5.1	11.6 ± 5.1	11.8 ± 5.5	<0.0001[2]
Vitamin C (mg/d)	137.2 ± 77.7	135.6 ± 71.2	138.0 ± 68.2	139.2 ± 68.80	137.1 ± 69.1	133.1 ± 72.3	129.3 ± 77.7	<0.0001[3]
Fiber (g/d)	20.4 ± 7.9	20.6 ± 7.0	20.3 ± 7.3	20.8 ± 7.0	20.7 ± 7.0	20.5 ± 7.1	20.1 ± 7.7	<0.0001[3]
Calcium (mg/d)	1033.1 ± 508.4	998.6 ± 466.2	1020.2 ± 457.1	1015.61 ± 446.2	1027.0 ± 468.8	1036.1 ± 470.2	1054.6 ± 521.3	<0.0001[3]

[1] $\bar{x}$ ± SD. PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids.
[2] For linear trend with ethanol intake as a continuous variable.
[3] For quadratic trend with ethanol intake as a continuous variable.

between-person variability was shown to be low. D'Avanzo et al (23) showed that retinol and iron intakes increase with alcohol consumption, whereas fiber consumption decreases. Toniolo et al (16) found no relation between alcohol consumption and intakes of cholesterol, retinol, and vitamin E, but found a negative association with intakes of vitamin C, fiber, and β-carotene. We also found that female nondrinkers had significantly higher β-carotene intakes than did drinkers.

Mannisto et al (18) reported results similar to ours for meat, cheese, oil, egg, fish, cereal, fruit, and milk consumption, but found higher vegetable and lower coffee consumption with increasing alcohol intake. Toniolo et al (16) also found a decrease in fruit and dairy product consumption with increasing alcohol intake, but no association with meat, poultry, fish, egg, vegetable, pasta, or rice consumption. Tjønneland et al (24) compared the dietary habits of wine drinkers, drinkers of other alcoholic beverages, and nondrinkers. Relative to other alcoholic beverages, wine was associated with healthier eating habits (consumption of fruit, fish, vegetables, and salad and use of olive oil for cooking).

The confounding effect of diet on the relation between alcohol consumption and health has also been studied. Lower vegetable and fruit consumption were found to be related to the risk of cardiovascular disease (25, 26), and folate deficiency was linked to an increased breast cancer risk among alcohol drinkers (27, 28). Substantial alcohol consumption, associated with low folate and methionine intakes, was found to be related to an increased risk of colon cancer (29, 30). These studies illustrate the importance of controlling for dietary intake when analyzing the relation between health and alcohol. Indeed, part of the detrimental effect of alcohol on health may be due to unhealthy dietary habits. However, diet is unlikely to explain all the effects of alcohol on health, particularly the beneficial effect of moderate drinking, because moderate drinkers did not have healthier diets than nondrinkers in our study.

The validity of reported alcohol consumption is questionable, and it is thus important to stress that the dietary assessment methods used here have been validated. In most validation studies, correlation coefficients for ethanol intake, as measured by the questionnaire and the reference method, were higher than for other dietary items (31, 32).

To rule out a possible selection bias due to the fact that dietary questionnaires were sent only to women who had answered the 2 previous questionnaires, a first analysis was performed on a random subsample of the E3N-EPIC population who had answered a 24-h recall interview aimed at calibrating dietary data within the EPIC cohorts (33). Of the 4084 women who participated in the calibration study, 120 had not answered the dietary questionnaire. No significant differences in nutrient intake or food consumption were found between respondents and nonrespondents to the dietary questionnaire. Further comparisons showed that respondents tended to be more physically active than were nonrespondents.

In terms of recommended nutrient intakes for the French population (34), the E3N-EPIC participants had relatively healthy eating habits: energy contributions from lipids, protein, and carbohydrates were close to recommended values, although iron intake was low and vitamin A intake was high. A comparison of our results with the results of a dietary survey (35) conducted in northern France showed that, on average, the E3N-EPIC population consumed more carbohydrates and less fat (measured by their contribution to total energy intake) than did the survey population, but similar amounts of protein. Regional dietary variations may account for some of these differences.

The representative nature of the E3N-EPIC population is questionable because 88% of the women had completed secondary school, and alcohol consumption is known to increase with educational level (23, 36, 37). A study conducted in 1993 of a random sample of 602 French women aged 18–75 y showed that 36.7% of those aged 45–54 y and 30.7% of those aged 55–64 y never consumed alcohol, compared with 11.7% and 13.8%, respectively, in our population. However, average consumption was similar, at ≈1.5 glasses/d (37). Although the distribution of ethanol intake in our population differs from that in the general French population, the size of our sample made it possible to analyze subgroups of drinkers.

In conclusion, our findings suggest that part of the detrimental effect of alcohol on health may be due to the unhealthy dietary habits of drinkers. Because most nutrients showed a dose-response gradient across alcohol consumption categories, our results do not support the hypothesis that the beneficial effect of moderate alcohol consumption on overall mortality is related to a healthier diet among drinkers than among nondrinkers.

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