

ORIGINAL ARTICLE

Alcohol Consumption and the Incidence of Hypertension in a Mediterranean Cohort: The SUN Study

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Introduction and objectives. To assess prospectively the association between alcohol consumption, including alcoholic beverage preference and weekly pattern of consumption, and the risk of hypertension in a Mediterranean cohort.

Methods. We prospectively followed 9963 Spanish men and women initially without hypertension. Self-reported and validated data on diet and hypertension diagnoses were collected.

Results. During follow-up (median [interquartile range], 4.2 [2.5-6.1] years), 554 incident cases of hypertension were identified over a total of 43 562 person-years. The hazard ratio for hypertension among those who consumed alcohol on ≥ 5 days per week was 1.28 (95% confidence interval, 0.97-1.7) compared to abstainers. Among those who drank alcohol ≥ 5 days per week, the hazard ratio for hypertension associated with consuming ≥ 1 drink per day was 1.45 (95% confidence interval, 1.06-2) compared to abstainers. The consumption of beer or spirits, but not wine, was associated with an increased risk of hypertension. The hazard ratio associated with consuming >0.5 drinks of beer per day was 1.53 (95% confidence interval, 1.18-1.99) compared with abstainers. In contrast, there is a nonsignificant inverse association between red wine intake and the risk of hypertension.

Conclusions. In this Mediterranean population, the consumption of beer or spirits, but not wine, was associated with a higher risk of developing hypertension. However, the weekly pattern of alcohol consumption did not have a significant impact on the risk of hypertension.

Key words: Hypertension. Red wine. Alcohol consumption pattern. Prospective studies. Mediterranean diet.

Consumo de alcohol e incidencia de hipertensión en una cohorte mediterránea: el estudio SUN

Introducción y objetivos. Evaluar prospectivamente la asociación entre el consumo de alcohol, incluidas la bebida alcohólica preferida y la frecuencia semanal de consumo, y el riesgo de hipertensión en una cohorte mediterránea.

Métodos. Se siguió de manera prospectiva a 9.963 varones y mujeres españoles inicialmente libres de hipertensión. La información recogida sobre dieta y diagnóstico de hipertensión arterial fue la declarada por los pacientes y luego validada.

Resultados. Durante el seguimiento (mediana [intervalo intercuartílico], 4,2 [2,5-6,1] años) se identificaron 554 casos incidentes de hipertensión entre 43.562 personas-año. La *hazard ratio* (HR) de hipertensión para un consumo de alcohol ≥ 5 días por semana fue 1,28 (intervalo de confianza [IC] del 95%, 0,97-1,70) comparados con abstemios. Entre consumidores de alcohol al menos 5 días por semana, la HR de hipertensión para consumos ≥ 1 copa al día fue 1,45 (IC del 95%, 1,06-2) comparados con los abstemios. El consumo de cerveza y licores, pero no de vino, se asoció con mayor riesgo de hipertensión. La HR para el consumo diario de más de 0,5 copas de cerveza y licores, en comparación con los no bebedores, fue 1,53 (IC del 95%, 1,18-1,99). En cambio, la asociación entre el consumo de vino tinto y el riesgo de hipertensión fue inversa pero no significativa.

Conclusiones. En esta población mediterránea, el consumo de cerveza y licores, pero no de vino, se asoció con mayor riesgo de hipertensión. El patrón de consumo semanal de alcohol; sin embargo, no tuvo un impacto significativo en el riesgo de hipertensión.

Palabras clave: Hipertensión. Vino tinto. Patrón de consumo de alcohol. Estudios prospectivos. Dieta mediterránea.

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ABBREVIATIONS

BMI: body mass index
 IQR: interquartile range
 MET: metabolic equivalent
 MUFA: monounsaturated fatty acid
 PUFA: polyunsaturated fatty acid
 SFA: saturated fatty acid

INTRODUCTION

Questions concerning the balance between the medical risks and cardiovascular benefits of drinking alcohol remain unresolved. Although moderate alcohol intake has a protective effect on several cardiovascular disorders,¹⁻⁶ excessive alcohol consumption is one of the main risk factors for the development of hypertension, which is the second most important cause of disability-adjusted life-years lost worldwide⁷ and a well-known prevalent condition that contributes to significant adverse health outcomes, including premature death, heart attack, renal failure, and stroke.

The effect of the quantity of alcohol on hypertension according to the frequency of drinking is not clear and most studies which have examined the relationship between alcohol consumption and hypertension have had a cross-sectional design. Epidemiological data from prospective studies remain sparse and the results are contradictory. It has been suggested that the risk of hypertension associated with heavy drinking is independent of the specific beverage consumed.⁸ However, in a recent cohort study, significant increases in the risk of hypertension were observed only in the highest categories of beer, spirits, and white wine intake, but not red wine.⁹ Furthermore, the influence of the pattern of alcohol consumption—including the specific type of beverage—and the risk of hypertension has not been prospectively studied in a Mediterranean population, in which its role is easier to assess due to the higher consumption of wine and the consequent greater between-subjects variability in wine intake.

We evaluated the relationship between the type, quantity, and frequency of drinking and the incidence of hypertension in the *Seguimiento Universidad de Navarra* (SUN) study, a prospective Mediterranean cohort of university graduates in Spain.

METHODS**Study Population**

The SUN study is a dynamic prospective cohort study conducted in Spain with permanently

open recruitment and whose participants are all university graduates who are contacted and followed up using mailed questionnaires. A detailed description of the study methods has been published elsewhere.¹⁰ Briefly, beginning in December 1999, all graduates of the University of Navarra, registered nurses from some Spanish provinces, and university graduates from other colleges and associations received a mailed questionnaire and a letter of invitation to participate in the SUN study. A response to the initial questionnaire was considered as informed consent to participate in the study. The project protocol was approved by the Institutional Review Board of the University of Navarra.

After baseline assessment, participants received follow-up questionnaires every two years by mail that contained a wide variety of questions on diet, lifestyle, risk factors and medical conditions. Up to 5 additional mailings were sent to non-respondents.

By February 2008, the SUN study had enrolled 19 057 participants, aged between 20 and 90 years at baseline. Among them, 15 552 individuals were recruited before May 2005. The following participants were excluded: 1739 participants who had hypertension at baseline; 1544 who reported a baseline history of cardiovascular disease, cancer, or diabetes; 1563 who were below or above the pre-established limits for total energy intake at baseline (estimated daily energy intake <500 or >3500 kCal for women and <800 or >4000 kCal for men); and 332 who had missing values for any covariate. This left 11 279 participants available for follow-up; among them, 9963 responded to at least 1 follow-up questionnaire.

Dietary Assessment

Dietary habits at baseline were assessed using a semi-quantitative food-frequency questionnaire with 136 items, previously validated in Spain.¹¹ The questionnaire was based on typical portion sizes and had 9 options for the frequency of intake for each food item (ranging from never or almost never to ≥ 6 times per day) during the previous year. Alcohol beverage consumption was assessed in 5 of these items and there were 6 additional questions referring to the pattern of alcohol consumption. One question asked participants to respond to the following: “In a typical week, on how many days do you consume an alcoholic beverage of any type (wine, beer, or spirits), including alcoholic beverages consumed during the meal?” Trained dietitians updated the nutrient database using the latest available information that was included in the food-composition tables for Spain.^{12,13} Individuals

not reporting any consumption of alcohol were defined as non-current drinkers. Beverage (wine or beer and spirits) preference was assigned if $\geq 50\%$ of a participant's total alcohol intake was from that particular beverage.

Assessment of Other Covariates

The baseline questionnaire requested information on a wide array of sociodemographic factors (sex, age, university degree, marital and employment status), anthropometric measurements (weight, height), health-related habits (smoking status, physical activity), and clinical variables (use of medication, personal and family history of hypertension, coronary heart disease, cancer, and other diseases). Body mass index was defined as weight (in kilograms) divided by the square of height (in meters). The questionnaire assessed involvement and time spent by study participants in 17 different activities. We assigned a multiple of the resting metabolic rate (MET score) to each of these activities using previously published guidelines to quantify the average intensity of physical activity.¹⁴ The validity of self-reported weight, body mass index (BMI), and self-reported leisure-time physical activity in the SUN cohort has been previously reported.^{15,16}

Assessment of Hypertension

The baseline and follow-up questionnaires asked the participants if they had a medical diagnosis of hypertension, as well as the date of diagnosis. The baseline questionnaire also asked for information on the most recent systolic and diastolic blood pressure values. The follow-up questionnaire asked whether participants had measured their blood pressure in the period since the previous questionnaire.

Participants were considered to have hypertension at baseline if they reported a medical diagnosis of hypertension or systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg, or were receiving antihypertensive medication.¹⁷ Incident cases of hypertension were defined as those participants who did not have hypertension at baseline and reported a physician's diagnosis of hypertension in the follow-up questionnaire. The diagnosis of hypertension in this cohort has been validated in a previous study.¹⁸ Among participants reporting a diagnosis of hypertension, 82.3% (95% CI, 72.8-92.8) of cases were confirmed in a domiciliary visit where a physician (blinded to the information in the self-reported questionnaire) measured the participant's blood pressure twice, using

a standardized protocol. Among participants who did not report a diagnosis of hypertension, 85.4% (95% CI, 72.4-89.1) were confirmed as nonhypertensive during the domiciliary visit.¹⁸

Statistical Analysis

We estimated hazard ratios (HR) of hypertension and their 95% CI across categories of alcohol intake using Cox proportional hazards models. According to current guidelines for dealing with confounders,¹⁹ these were selected by taking into account the previously published literature on known causal risk factors for hypertension and avoided reliance on statistical approaches, such as criteria based on *P*-values, stepwise procedures or strategies that compare adjusted and unadjusted effect estimates for the hazard ratios, after introducing each single variable as an independent term in the model. It has been shown that the strategies mentioned may lead to bias.¹⁹ In addition to causal risk factors, we also adjusted for variables strongly associated with lifestyle, such as smoking, since they may be good correlates of causal factors.

We controlled for the following baseline factors: age (continuous variable), gender, total energy intake (quintiles), BMI (continuous), physical activity (quintiles), family history of hypertension (yes or no), hypercholesterolemia (yes or no), sodium intake (quintiles), potassium intake (quintiles), low-fat dairy products intake (quintiles), fruit consumption (quintiles), vegetable consumption (quintiles), olive oil consumption (quintiles), cereal fiber intake (quintiles), vegetable protein intake (quintiles), caffeine intake (quintiles), fish consumption (quintiles), and smoking (never, former, or current). We tested the assumption of proportional hazards by introducing an interaction between the explanatory variable and time into the Cox model.

Food and nutrient intake was adjusted for total energy intake using the residuals method, and separate regression models were run to obtain the residuals for women and men.²⁰ A standard drink was defined as 13.7 g of pure alcohol.²¹ In most analyses, unless otherwise stated, nondrinkers were considered as the reference category.

We conducted linear trend tests across increasing categories of drinking days per week by assigning the median value to each category and treating the resulting variable as a continuous one. Statistical interaction was assessed by likelihood ratio tests in which full models, including interaction terms, were compared with reduced models without interaction terms. All *P*-values are 2-tailed and statistical significance was set at $P < .05$. We used SPSS version 15.0 (SPSS, Chicago, IL, USA) for all analyses.

TABLE 1. Baseline Characteristics According to Alcoholic Drinks Consumption and Alcoholic Beverage Preference. The Sun Study, 1999-2005

	Alcoholic Drinks ^a Consumption Per Day			Alcoholic Beverage Preference ^b		
	0 (n=2190)	0.1-0.5 (n=4706)	>0.5 (n=3067)	Wine (n=2751)	Beer and Spirits (n=5022)	Noncurrent Drinkers (n=2190)
Age, mean (SD), y	35.5 (10.7)	35.1 (10.3)	38.5 (10.8)	40.2 (10.5)	34.4 (10.2)	35.5 (10.7)
Women, %	80.9	68.3	39.3	55.2	57.8	80.9
BMI, kg/m ²	22.6 (3.1)	22.9 (3.1)	24.0 (3.2)	23.6 (3.2)	23.1 (3.2)	22.6 (3.1)
Physical activity, MET-h/wk	23.6 (24.4)	23.4 (19.8)	26.5 (22)	24.4 (20.2)	24.8 (21.1)	23.6 (24.4)
Hypercholesterolemia, %	12.8	11.8	17.4	17.2	12.3	12.8
Family history of hypertension, %	48.1	48.8	48.6	52.2	46.8	48.1
Current smoker, %	16.0	23.9	29.2	19.7	29.4	16.0
Alcohol intake, g/d	0	2.7 (1.7)	16.0 (11.5)	9.2 (11.3)	7.2 (8.8)	0
Alcoholic beverage preference, %						
Wine	0	33.0	39.1			
Beer and spirits	0	67.0	60.9			
Daily intake						
Sodium intake, g/d	3.2 (2.1)	3.3 (2.2)	3.6 (2.2)	3.4 (2.3)	3.4 (2.1)	3.2 (2.1)
Potassium intake, g/d	4.7 (1.6)	4.7 (1.5)	4.7 (1.4)	4.8 (1.5)	4.6 (1.5)	4.7 (1.6)
Calcium intake, g/d	1.3 (0.5)	1.2 (0.5)	1.2 (0.4)	1.2 (0.5)	1.2 (0.5)	1.3 (0.5)
Magnesium intake, mg/d	406 (127)	408 (118)	416 (114)	418 (122)	407 (114)	406 (127)
Fruit consumption, servings/d	2.9 (2.2)	2.7 (2.1)	2.5 (1.9)	2.8 (2.1)	2.6 (2)	2.9 (2.2)
Vegetable consumption, servings/d	2.5 (1.5)	2.6 (1.4)	2.5 (1.4)	2.6 (1.5)	2.5 (1.4)	2.5 (1.5)
Fiber intake, g/d	27.1 (12.6)	26.9 (11.8)	25.9 (10.8)	27.6 (12)	25.9 (11)	27.1 (12.6)
Fiber from cereal, g/d	3.3 (3.1)	3.4 (2.9)	3.4 (2.8)	3.5 (3.1)	3.3 (2.7)	3.3 (3.1)
Caffeine intake, mg/d	37.5 (41)	44.2 (38.6)	51.8 (39.6)	46.7 (39.1)	47.5 (39.3)	37.5 (41)
Olive oil, g/d	18.2 (16)	18.5 (14.7)	18.8 (15)	19.2 (15.6)	18.3 (14.4)	18.2 (16)
Low-fat dairy product consumption, g/d	239.4 (271.1)	225.8 (250.2)	182.1 (220.7)	212 (239)	207 (240)	239.4 (271.1)
Fish consumption, g/d	92.3 (62.8)	93.2 (56.8)	98.9 (55.3)	99.5 (59.3)	93.2 (54.4)	92.3 (62.8)
Total energy intake, kCal/d	2308 (622)	2337 (592)	2485 (616)	2389 (616)	2399 (600)	2308 (622)
Energy intake, %						
Carbohydrates	44.6 (7.7)	43.7 (7.1)	41.9 (7.1)	43.1 (7.5)	42.9 (6.9)	44.6 (7.7)
Protein	18.4 (3.6)	18.2 (3.2)	17.3 (2.9)	17.9 (3.2)	17.8 (3)	18.4 (3.6)
Vegetable protein	5.4 (1.5)	5.3 (1.2)	5.1 (1.2)	5.3 (1.2)	5.2 (1.2)	5.4 (1.5)
Lipids	37.0 (7)	37.3 (6.4)	36.1 (6.2)	36.3 (6.5)	37.1 (6.2)	37 (7)
SFA	12.8 (3.5)	12.8 (3.1)	12.4 (3)	12.4 (3.1)	12.8 (3)	12.8 (3.5)
MUFA	15.7 (4)	16 (3.7)	15.6 (3.6)	15.7 (3.8)	15.8 (3.6)	15.7 (4)
PUFA	5.3 (1.8)	5.3 (1.6)	5.2 (1.4)	5.2 (1.5)	5.3 (1.6)	5.3 (1.8)

^aA standard drink was defined as any drink that contains about 13.7 g of pure alcohol.

^bThose classified as preferring wine or beer and spirits reported that ≥50% of their total alcohol intake was from that particular beverage. Non-current drinkers reported no consumption of alcoholic beverages.

Values are expressed as means (standard deviation) unless otherwise stated.

RESULTS

Baseline Characteristics and Average Alcohol Consumption

During 43 562 person-years of follow-up, 554 incident cases of hypertension were identified. The median follow-up was 4.2 years (interquartile range [IQR], 2.5-6.1). Table 1 presents the characteristics of the participants according to alcohol consumption and alcoholic beverage preference. The baseline characteristics of patients lost to follow-up did not substantially differ from those who completed follow-up (data not shown).

The median number of drinks consumed per day was 0.2 (IQR, 0.04-0.6). A total of 2190 participants (22%) reported no drinking at baseline. Non-current drinkers were more likely to be women and never smokers, whereas those with the heaviest alcohol consumption had a higher mean age, caffeine intake and fish consumption, and lower low-fat dairy product consumption. In this population, alcohol drinkers were more likely to drink beer and spirits rather than wine. Most other baseline characteristics were similar across drinking categories.

After multivariate adjustment, individuals drinking >2 alcoholic drinks per day had a higher

TABLE 2. Hazard Ratios (95% CI) of Hypertension According to Baseline Frequency and Quantity of Alcohol Among Sun Study Participants, 1999-2008

	Drinking Days Per Week				P (Trend)		
	0 ^a	1-2 d	3-4 d	≥5 d			
Number of cases	94	222	69	169			
Number of person-years	9569	23 298	4031	6664			
HR (95% CI) ^b	1	0.94 (0.74-1.20)	1.22 (0.88-1.68)	1.23 (0.94-1.61)	.02		
Multivariable HR (95% CI) ^c	1	0.97 (0.76-1.25)	1.18 (0.85-1.63)	1.28 (0.97-1.70)	.01		
Drinking days per week, drink/d	0	<1	≥1	<1	≥1	≥1	
Number of cases	94	210	12	51	18	74	95
Number of person-years	9569	22 188	1110	3019	1012	3345	3319
HR (95% CI) ^b	1	0.95 (0.74-1.21)	0.89 (0.49-1.64)	1.21 (0.85-1.71)	1.26 (0.75-2.11)	1.06 (0.77-1.46)	1.4 (1.03-1.89)
Multivariable HR (95% CI) ^c	1	0.98 (0.76-1.26)	0.95 (0.51-1.76)	1.22 (0.86-1.74)	1.10 (0.65-1.86)	1.13 (0.82-1.57)	1.45 (1.06-2.00)

HR indicates hazard ratio; CI, confidence interval.

^aReference category.

^bAdjusted for age and sex.

^cAdjusted for age, sex, total energy intake, BMI, physical activity, family history of hypertension, hypercholesterolemia, sodium intake, potassium intake, low-fat dairy products consumption, fruit consumption, vegetable consumption, olive oil consumption, cereal fiber intake, vegetable protein intake, caffeine consumption, fish consumption, and smoking.

risk of hypertension compared to nondrinkers (HR=1.55; 95% CI, 1.04-2.32).

Drinking Days Per Week, Drinks Per Day, and Risk of Hypertension

We evaluated the association of baseline drinking frequency and the quantity of alcohol consumed per drinking day with the risk of incident hypertension (Table 2).

In the multivariate-adjusted analysis, a greater number of drinking days was weakly associated with a higher risk of hypertension. Among those with an alcohol intake ≥5 days per week, the HR of hypertension was 1.28 (95% CI, 0.97-1.7) compared to nondrinkers. Participants who drank ≥5 days per week but who consumed less than 1 drink per day had an adjusted HR of 1.13 (95% CI, 0.82-1.57) compared to abstainers, whereas the HR was 1.45 (95% CI, 1.06-2) for those who drank ≥1 drink per day and who drank ≥5 days per week.

We also assessed the risk of hypertension according to drinking days per week across categories of weekly total alcohol intake (grams per week) (Table 3). Among those with the highest alcohol intake (>45 g/wk), >2 drinking days per week was associated with a higher risk of hypertension compared to those drinking on 1-2 days per week, although this association was not statistically significant (HR=1.33; 95% CI, 0.96-1.83). We did not observe a clear association between the number of drinking days per week and the risk of hypertension among individuals with lower total weekly alcohol intake.

We did not observe any significant interaction

between drinking days per week and age (continuous), sex, or BMI (continuous).

Alcoholic Beverage Preference, Type of Beverage, and Risk of Hypertension

Among alcohol drinkers, we assessed whether alcoholic beverage preference at baseline was associated with the risk of hypertension (Table 4). Individuals who preferred beer and spirits had a non-significant and slightly higher risk of hypertension compared with wine drinkers (HR=1.18; 95% CI, 0.97-1.44). We also analyzed the association between red wine consumption, the consumption of other types of wine, or the consumption of beer and spirits and the risk of hypertension (Table 5). The consumption of beer and spirits was associated with a higher risk of hypertension (HR=1.53; 95% CI, 1.18-1.99) for those with drinking ≥0.5 drinks per day versus those abstaining from beer and spirits. This association was not apparent for other alcoholic beverages. According to the point estimates for the hazard ratio, we observed a non-significant inverse relationship between red wine intake and the risk of hypertension. We did not observe any significant interaction between alcohol consumption according to type of beverage and age, sex, or BMI.

DISCUSSION

In this prospective Mediterranean cohort, overall alcohol consumption, but not drinking pattern (drinking days per week), was clearly associated with a risk of hypertension. On the other hand, we

TABLE 3. Hazard Ratios (95% CI) of Hypertension Among Drinkers According to Frequency of Alcohol Consumption and Total Quantity of Ethanol Consumed Per Week. The Sun Study, 1999-2008

Total Weekly Alcohol Intake, g/wk	Drinking, d/wk	
	≤2 d ^a	>2 d
0-30 g		
Number of cases	127	33
Number of person-years	14 641	1651
HR (95% CI) ^b	1	1.16 (0.77-1.74)
Multivariable 1 HR (95% CI) ^c	1	1.19 (0.78-1.81)
Multivariable 2 HR (95% CI) ^d	1	1.22 (0.80-1.87)
30-45 g		
Number of cases	37	18
Number of person-years	3016	1036
HR (95% CI)	1	0.85 (0.47-1.54)
Multivariable 1 HR (95% CI) ^c	1	0.81 (0.41-1.63)
Multivariable 2 HR (95% CI) ^d	1	0.76 (0.38-1.53)
>45 g		
Number of cases	58	187
Number of person-years	5641	8008
HR (95% CI)	1	1.40 (1.03-1.90)
Multivariable 1 HR (95% CI) ^c	1	1.40 (1.03-1.91)
Multivariable 2 HR (95% CI) ^d	1	1.33 (0.96-1.83)

HR indicates hazard ratio; CI, confidence interval.

^aReference category.

^bAdjusted for age and sex.

^cAdjusted for age, sex, total energy intake, BMI, physical activity, family history of hypertension, hypercholesterolemia, sodium intake, potassium intake, low-fat dairy product consumption, fruit consumption, vegetable consumption, olive oil consumption, cereal fiber intake, vegetable protein intake, caffeine consumption, fish consumption and smoking.

^dAdjusted for the covariates above plus alcohol consumption.

observed that individuals who preferred beer and spirits had a slightly higher risk of hypertension than those who preferred wine. In addition, consumption of alcohol in the form of beer and spirits, but not wine consumption, was associated with an increased risk of developing hypertension.

To our knowledge, this is the first long-term prospective study that has assessed the association between alcohol consumption (including drinking patterns during the week and type of alcoholic beverage) and the incidence of hypertension in a Mediterranean cohort. As expected, our results are consistent with the hypothesis that heavy drinking increases the risk of hypertension,²²⁻²⁴ and support the general recommendations on reducing alcohol consumption to prevent hypertension.²⁵

It has been suggested that the health effects of alcohol consumption may depend on the drinking pattern.²⁶ Our results do not support this hypothesis. Nonetheless, our findings are consistent with the conclusions of a study using a population-based sample in the United States that suggested that the average volume of alcohol consumed could play a more important role in the relationship between alcohol consumption and the risk of hypertension than the frequency of drinking.²⁷

Our results suggest a slightly lower risk of hypertension among red wine drinkers compared to abstainers, although the CI included the null value. This finding is consistent with the most popular theory in favor of the beneficial effect of wine, the so-called French paradox.^{28,29} However, this potential benefit of red wine on the development of hypertension has been questioned by a randomized controlled intervention study in 28 male drinkers showing a blood pressure increase caused by moderate alcohol consumption regardless of the source,³⁰ although this was a short-term trial and not directly comparable to the long-term effect assessed in large cohort studies. Further evidence has provided support for various mechanisms underlying the potential beneficial effects of wine, including the effects of the polyphenols found in red wine, especially resveratrol, which has been shown to inhibit angiotensin-II and increase nitric oxide synthesis and that partially explains the blood

TABLE 4. Hazard Ratios (HR) (95% CI) of Hypertension According Alcoholic Beverage Preference Taking as Reference Participants Not Drinkings. The Sun Study, 1999-2008

	Not Drinkings ^a (n=2190)	Wine (n=2751)	Beer and Spirits (n=5022)
Number of cases	94	189	271
Number of person-years	9569	12 032	21 961
HR (95% CI) ^b	1	1 (0.78-1.29)	1 (0.85-1.38)
Multivariable HR (95% CI) ^c	1	0.99 (0.77-1.29)	1.13 (0.88-1.45)

HR indicates hazard ratio; CI, confidence interval.

^aReference category.

^bAdjusted for age and sex.

^cAdjusted for age, sex, total energy intake, BMI, physical activity, family history of hypertension, hypercholesterolemia, sodium intake, potassium intake, low-fat dairy product consumption, fruit consumption, vegetable consumption, olive oil consumption, cereal fiber intake, vegetable protein intake, caffeine consumption, fish consumption, and smoking.

TABLE 5. Hazard Ratios (95% CI) for Hypertension According to Type of Alcoholic Beverage. The Sun Study, 1999-2008

	Drinks/d	No. Cases	HR (95% CI) ^a	Multivariable 1 HR (95% CI) ^b	Multivariable 2 HR (95% CI) ^c
Red wine	0 ^d	216	1	1	1
	0.1-0.5	233	1.04 (0.86-1.25)	1.01 (0.84-1.23)	1.00 (0.82-1.21)
	>0.5	105	0.98 (0.77-1.25)	0.94 (0.73-1.21)	0.89 (0.69-1.15)
<i>P</i> (trend)			.79	.59	.33
Other types of wine	0 ^d	383	1	1	1
	0.1-0.5	152	1.03 (0.85-1.25)	0.98 (0.81-1.19)	0.96 (0.79-1.17)
	>0.5	19	1.69 (1.06-2.68)	1.36 (0.84-2.21)	1.27 (0.78-2.07)
<i>P</i> (trend)			.03	.22	.35
Beer and spirits	0 ^d	148	1	1	1
	0.1-0.5	259	1.01 (0.82-1.24)	1.04 (0.84-1.28)	1.04 (0.84-1.28)
	>0.5	147	1.49 (1.17-1.90)	1.54 (1.19-1.99)	1.53 (1.18-1.99)
<i>P</i> (trend)			<.001	<.001	<.001

HR indicates hazard ratio; CI, confidence interval.

^aAdjusted for age and sex.

^bAdjusted for age, sex, total energy intake, BMI, physical activity, family history of hypertension, hypercholesterolemia, sodium intake, potassium intake, low-fat dairy product consumption, fruit consumption, vegetable consumption, olive oil consumption, cereal fiber intake, vegetable protein intake, caffeine consumption, fish consumption, and smoking.

^cMultivariable-adjusted Hazard Ratio further adjusted for consumption of alcohol from other sources.

^dReference category.

pressure reduction observed in some renal models of hypertension.³¹

Our results offer indirect support for the hypothesis that wine specifically has a beneficial effect compared to other alcoholic beverages in preventing cardiovascular disease and mortality.³⁴ In line with our results, a recent prospective cohort study has reported a significant increase in the risk of hypertension in relation to beer, spirits and white wine, whereas the consumption of red wine did not have a significant effect.⁹

Confounding by dietary habits and other lifestyle factors could explain the apparent health benefits of wine compared to other alcoholic beverages.³² Nevertheless, in our cohort there were similar dietary patterns between wine drinkers and the other groups.³³ Additionally, we controlled for potential dietary and non-dietary confounding factors in our analyses.

Our results offer indirect support to the hypothesis suggesting a specific beneficial effect of wine compared to other alcoholic beverages in the prevention of cardiovascular disease and mortality.³⁴ In line with our results, a recent prospective cohort study has reported a significant increase in the risk of hypertension that was only observed with beer, spirits and white wine, whereas the consumption of red wine did not produce any significant effect.⁹

Our study has several limitations. Dietary exposure can be misclassified despite the good correlation between food-frequency questionnaires and usual diet.³⁵ However, the validation study of

our dietary questionnaire demonstrated suitable validity and reliability.¹¹ Moreover, alcohol was the single nutrient showing the highest validity in the validation study of the food frequency questionnaire used.¹¹ As in all epidemiologic studies, reverse causation is a possible explanation of the results. However, it is unlikely that reverse causation bias explains our results given the prospective character of the SUN study. Additionally, individuals with diagnosed hypertension and those with prevalent cardiovascular disease at baseline were excluded from follow-up. Beside this, an important limitation of our study is the self-reported diagnosis of hypertension. Nevertheless, our outcome measure has been sufficiently validated elsewhere.¹⁸ Finally, the findings of this study should be interpreted with caution, since we cannot guarantee that residual confounding has been totally excluded, even though we performed the analyses adjusting for the main known risk factors for hypertension and several dietary factors. Further studies are warranted to strengthen these results, for example, in a more representative cohort of the general population, where lifestyle and dietary habits could be different and which would probably include wider variability in alcohol consumption.

CONCLUSIONS

These results suggest that there is an increased risk of hypertension associated with alcohol consumption, without the drinking pattern playing

any specific role. Finally, beer and spirits, but not red wine, have a specific, and deleterious, effect on the risk of developing hypertension.

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