



Original Investigation | Substance Use and Addiction

Associations Between Medical Conditions and Alcohol Consumption Levels in an Adult Primary Care Population

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Abstract

IMPORTANCE Excessive alcohol consumption is associated with increased incidence of several medical conditions, but few nonveteran, population-based studies have assessed levels of alcohol use across medical conditions.

OBJECTIVE To examine associations between medical conditions and alcohol consumption levels in a population-based sample of primary care patients using electronic health record data.

DESIGN, SETTING, AND PARTICIPANTS This cross-sectional study used separate multinomial logistic regression models to estimate adjusted associations between 26 medical conditions and alcohol consumption levels in a sample of 2 720 231 adult primary care patients screened for unhealthy drinking between January 1, 2014, and December 31, 2017, then only among those reporting alcohol use. The study was conducted at Kaiser Permanente Northern California, a large, integrated health care delivery system that incorporated alcohol screening into its adult primary care workflow. Data were analyzed from June 29, 2018, to February 7, 2020.

MAIN OUTCOMES AND MEASURES The main outcome was level of alcohol use, classified as no reported use, low-risk use, exceeding daily limits only, exceeding weekly limits only, or exceeding daily and weekly limits, per National Institute on Alcohol Abuse and Alcoholism guidelines. Other measures included sociodemographic, body mass index, smoking, inpatient and emergency department use, and a dichotomous indicator for the presence of 26 medical conditions in the year prior to the alcohol screening identified using *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* and *ICD-10-CM* diagnosis codes.

RESULTS Among the 2 720 231 included patients, 1 439 361 (52.9%) were female, 1 308 659 (48.1%) were white, and 883 276 (32.5%) were aged 18 to 34 years. Patients with any of the conditions (except injury or poisoning) had lower odds of drinking at low-risk and unhealthy levels relative to no reported use compared with those without the condition. Among 861 427 patients reporting alcohol use, patients with diabetes (odds ratio [OR], 1.11; 95% CI, 1.08-1.15), hypertension (OR, 1.11; 95% CI, 1.09-1.13), chronic obstructive pulmonary disease (COPD; OR, 1.16; 95% CI, 1.10-1.22), or injury or poisoning (OR, 1.06; 95% CI, 1.04-1.07) had higher odds of exceeding daily limits only; those with atrial fibrillation (OR, 1.12; 95% CI, 1.06-1.18), cancer (OR, 1.06; 95% CI, 1.03-1.10), COPD (OR, 1.15; 95% CI, 1.09-1.20), or hypertension (OR, 1.37; 95% CI, 1.34-1.40) had higher odds of exceeding weekly limits only; and those with COPD (OR, 1.15; 95% CI, 1.07-1.23), chronic liver disease (OR, 1.42; 95% CI, 1.32-1.53), or hypertension (OR, 1.48; 95% CI, 1.44-1.52) had higher odds of exceeding both daily and weekly limits.

CONCLUSIONS AND RELEVANCE Findings suggest that patients with certain medical conditions are more likely to have elevated levels of alcohol use. Health systems and clinicians may want to

(continued)

Key Points

Question What are the associations between medical conditions and alcohol drinking levels in primary care patients?

Findings In this cross-sectional study of more than 2.7 million adult primary care patients screened for unhealthy alcohol use, 269 379 patients (9.9%) reported unhealthy drinking habits, and patients with medical conditions were less likely to drink compared with those without. However, among those reporting alcohol use, patients with diabetes, hypertension, chronic obstructive pulmonary disease, atrial fibrillation, cancer, chronic liver disease, or injury or poisoning were more likely to report drinking above recommended guidelines.

Meaning Health systems and clinicians should take a more targeted approach to help patients with certain medical conditions reduce unhealthy alcohol consumption and health risks.

+ Invited Commentary

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Abstract (continued)

consider approaches to help targeted patient subgroups limit unhealthy alcohol use and reduce health risks.

JAMA Network Open. 2020;3(5):e204687. doi:10.1001/jamanetworkopen.2020.4687

Introduction

Excessive alcohol use is a serious and growing public health problem.¹ Annually, approximately 65 000 US deaths and approximately 4% of deaths and 5% of disease and injuries globally are attributable to alcohol use.² The population of excessive drinkers includes those with severe problems³ and those who exceed drinking guidelines but do not reach the severity of a disorder. US guidelines specify no more than 4 drinks per day or 14 per week for men aged 18 to 64 years and no more than 3 per day or 7 per week for women and men older than 65 years. In the US, at least 25% of adults⁴ and between 7% and 20% of adult primary care patients^{5,6} exceed guidelines.

Excessive drinking is associated with increased incidence of numerous medical conditions, including certain cancers,^{7,12} cardiovascular disease,¹³⁻¹⁵ cirrhosis and pancreatitis,¹⁶⁻¹⁹ and gastrointestinal disorders.²⁰ In older, predominantly male, white Veterans Health Administration samples, excessive drinking has been found to be associated with increased risk of gastrointestinal-related hospitalizations,^{20,21} postoperative complications,²² and poorer self-management of chronic diseases, such as diabetes²³ and hypertension.²⁴ A 2018 meta-analysis¹⁵ found that, even at moderate levels, alcohol use increases all-cause mortality and risk of death from several cardiovascular diseases and reduces life expectancy. Another study found that alcohol use uniformly increases blood pressure and stroke risk; even moderate drinking (2 drinks per day or less) increased the risk of stroke by about 15%.²⁵ But research has rarely assessed levels of alcohol consumption across medical conditions among primary care patients.

Kaiser Permanente Northern California (KPNC), a large, integrated health care delivery system, incorporated alcohol screening into its adult primary care workflow. Since implementation, more than 12 million alcohol screenings have been conducted in more than 150 clinics, with an 87% average screening rate. Using electronic health record (EHR) data collected during clinical care, we build on the growing literature on the health effects of alcohol use and examine alcohol consumption levels in a population-based sample of primary care patients with common chronic medical conditions. The findings help us better identify the associations between medical conditions and levels of alcohol use and may aid primary care clinicians in specific disease management strategies targeted at particularly vulnerable patients.

Methods

Setting

Kaiser Permanente Northern California's 4.3 million members constitute about one-third of northern California's population. They are insured through employer-based plans, Medicare, Medicaid, and health insurance exchanges and are representative of the US population with insurance: 53% women and 20% Asian persons, 7.5% black persons, and 17% Hispanic persons. The KPNC Institutional Review Board reviewed the study and granted a waiver of informed consent to examine EHR data. This report follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cross-sectional studies.

Systematic Alcohol Screening in Adult Primary Care

The KPNC alcohol screening, brief intervention, and referral to treatment (SBIRT) initiative was implemented in adult primary care in June 2013. Medical assistants screened all patients while

collecting vital sign measurements using EHR-embedded screening questions from the National Institute on Alcohol Abuse and Alcoholism (NIAAA) guide for primary care clinicians.²⁶ A modified single-item screening question, automatically tailored to patient age and sex, was used: "How many times in the past three months have you had 5 or more drinks in a day" for men aged 18 to 65 years or "4 or more drinks in a day" for women and men 66 years and older. This was followed by, "On average, how many days per week do you have an alcoholic drink?" and "On a typical drinking day, how many drinks do you have?"²⁶ These were used to calculate average drinks per week.

Study Sample

The study sample included 3 013 643 adult KPNC members 18 years and older screened between January 1, 2014, and December 31, 2017. The final analytical sample included 2 720 231 patients with complete data.

Alcohol Use

Individual alcohol consumption was identified at the first screening of the study period. Per NIAAA daily and weekly drinking guidelines, individuals were classified as having no use (reporting no alcohol use in the prior 90 days), low-risk use (exceeding neither daily nor weekly limits) and unhealthy use (exceeding either daily or weekly drinking limits). We further classified the unhealthy use group into mutually exclusive groups: exceeding daily limits (exceeding only daily limits), exceeding weekly limits (exceeding only weekly limits), or exceeding both limits (exceeding both daily and weekly limits).

Medical Conditions

The *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* and *ICD-10-CM* diagnosis codes in the year prior to the patient's alcohol screening were extracted from the EHR. We examined 20 common medical conditions,²⁷ some of which are among the most costly to treat in the US,^{28,29} including asthma, atherosclerosis, atrial fibrillation, chronic kidney disease, chronic liver disease, chronic obstructive pulmonary disease (COPD), coronary disease, diabetes, dementia, epilepsy, gastroesophageal reflux, heart failure, hyperlipidemia, hypertension, migraine, osteoarthritis, osteoporosis/osteopenia, Parkinson disease/syndrome, peptic ulcer, and rheumatoid arthritis. We also examined conditions associated with alcohol problems, including arthritis, cerebrovascular disease, chronic pain, HIV, and injury or poisoning.^{6,30,31} The KPNC cancer registry was used to identify patients with cancer.

Patient Characteristics

From the EHR, we extracted patients' sex, age, race/ethnicity, smoking status at screening, and the most recent body mass index (BMI) in the year prior to screening.³² To estimate socioeconomic status, which is associated with health status,³³ we used median household income by geocoding residential addresses to 2010 census blocks.^{34,35} We created a 3-group categorical variable for income based on tertiles of the overall distribution in the sample (low [\$60 841 or less], middle [\$60 842 to \$87 461], and high [\$87 462 or more]). To control for medical acuity, we counted inpatient and emergency department (ED) visits in the year prior to screening and created 3 categories (0, 1 to 2, or 3 or more visits). Patients with unknown household income ($n = 7223$), smoking status ($n = 184\,659$), and BMI ($n = 107\,471$) were excluded, providing a final analytical sample of 2 720 131 patients.

Statistical Analysis

We examined differences in alcohol consumption levels by medical conditions with χ^2 tests. We used multivariable multinomial logistic regression to estimate associations between conditions and levels of consumption, adjusting for sex, age, income, smoking status, BMI, and the number of inpatient and ED visits in the year prior. We fit separate multivariable models for each condition and conducted

the analyses in 2 steps. First, we estimated the odds of reporting low-risk use and unhealthy use relative to no use for those with the condition compared with those without the condition among the full sample ($n = 2\,720\,231$). Second, among patients reporting alcohol use ($n = 861\,427$), we estimated the odds of exceeding daily limits, weekly limits, and both limits relative to low-risk use for those with the condition compared with those without. In bivariate analyses, statistical significance was defined at a 2-tailed P value less than .05. In multivariable analyses, we used Bonferroni correction to lower the type I error rate for 2-tailed tests to a P value of .0004 or less ($P \leq [\alpha/n]$, where $\alpha = .05$ and n is number of comparisons [$n = 130$]).³⁶ All analyses were performed using SAS version 9.4 (SAS Institute).

Results

Sample Characteristics

Among the 2 720 231 patients in the final analytical sample, 1 439 361 (52.9%) were female, 1 308 659 (48.1%) were white, and 883 276 (32.5%) were aged 18 to 34 years (**Table 1**). Among the full sample, 1 858 804 (68.3%) reported no alcohol use in the prior 90 days, 592 048 (21.8%) reported low-risk use, 165 581 (6.1%) reported use that exceeded daily limits, 62 349 (2.3%) reported use that exceeded weekly limits, and 41 449 (1.5%) reported use that exceeded both limits. A greater proportion of patients with 3 or more inpatient and ED visits and Asian, Native Hawaiian, or Pacific Islander patients reported no use relative to other consumption levels. Patients reporting use that exceeded daily limits were more likely to be male and younger (aged 18 to 34 years), while patients reporting use that exceeded weekly limits were more likely to be female and older (65 years and older). A greater proportion of patients who smoked reported exceeding both limits relative to other consumption levels.

Prevalence of Alcohol Use by Medical Condition

The most prevalent conditions in the full sample of 2 720 231 patients were hypertension (626 153 patients [23.0%]), hyperlipidemia (601 782 patients [22.1%]), and injury or poisoning (427 398 patients [15.7%]) (**Table 2**). Patients with medical conditions were more likely to report no use, followed by low-risk use and unhealthy use. Among patients reporting unhealthy use, use exceeding daily limits was most prevalent among those with asthma, chronic liver disease, chronic pain, diabetes, epilepsy, gastroesophageal reflux, HIV, injury or poisoning, migraine, and peptic ulcer; use exceeding weekly limits was most prevalent among those with arthritis, atherosclerosis, atrial fibrillation, cancer, cerebrovascular disease, chronic kidney disease, COPD, coronary disease, dementia, heart failure, hypertension, osteoarthritis, osteoporosis/osteopenia, Parkinson disease/syndrome, and rheumatoid arthritis. Patients with hyperlipidemia had similar prevalence of exceeding daily and weekly limits, which were higher than exceeding both limits.

Adjusted Associations Between Medical Conditions and Alcohol Use Among the Full Sample

In the full sample of 2 720 231 patients, using multivariable multinomial logistic regression, we estimated the odds of reporting low-risk and unhealthy use relative to no use for patients with a medical condition compared with those without the condition. Among all conditions examined, except for hypertension and injuries or poisonings, patients with a medical condition had lower odds than those without the medical condition of low-risk and unhealthy use relative to no use (**Table 3**). For example, patients with Parkinson disease/syndrome were less likely compared with those without to report low-risk use (odds ratio [OR], 0.58; 95% CI, 0.53-0.63) and unhealthy use (OR, 0.38; 95% CI, 0.33-0.44) relative to no use. Compared with patients without, those with hypertension were less likely to report low-risk use (OR, 0.80; 95% CI, 0.79-0.80) but not unhealthy use (OR, 1.00; 95% CI, 0.99-1.02) relative to no use. In contrast, patients with an injury or poisoning

were more likely than those without to report low-risk use (OR, 1.02; 95% CI, 1.01-1.03) and unhealthy use (OR, 1.06; 95% CI, 1.05-1.07) relative to no use.

Adjusted Associations Between Medical Conditions and Alcohol Use Among Patients Who Reported Drinking

Associations between medical conditions and unhealthy use relative to low-risk use were examined among 861 427 patients who reported drinking. Compared with patients without these conditions, those with chronic liver disease, COPD, hypertension, and injury or poisoning were more likely to

Table 1. Demographic Characteristics of Adult Primary Care Patients Screened for Unhealthy Alcohol Use at Kaiser Permanente Northern California Between 2014 and 2017 by Alcohol Consumption Level

Characteristic	No. (%) ^a						P value ^c
	Total	Alcohol consumption level ^b					
		No use	Low-risk use	Exceeds daily limits	Exceeds weekly limits	Exceeds both limits	
Overall	2 720 231	1 858 804 (68.3)	592 048 (21.8)	165 581 (6.1)	62 349 (2.3)	41 449 (1.5)	NA
Sex							
Male	1 280 870 (47.1)	785 821 (42.3)	329 565 (55.7)	111 214 (67.2)	29 436 (47.2)	24 834 (59.9)	<.001
Female	1 439 361 (52.9)	1 072 983 (57.7)	262 483 (44.3)	54 367 (32.8)	32 913 (52.8)	16 615 (40.1)	
Age group, y							
18-34	883 276 (32.5)	593 012 (31.9)	178 422 (30.1)	87 297 (52.7)	10 868 (17.4)	13 677 (33.0)	<.001
35-49	705 906 (26.0)	474 246 (25.5)	161 571 (27.3)	46 697 (28.2)	12 299 (19.7)	11 093 (26.8)	
50-64	680 832 (25.0)	462 168 (24.9)	164 939 (27.9)	26 035 (15.7)	17 425 (27.9)	10 265 (24.8)	
≥65	450 217 (16.6)	329 378 (17.7)	87 116 (14.7)	5552 (3.4)	21 757 (34.9)	6414 (15.5)	
Race/ethnicity							
White	1 308 659 (48.1)	772 508 (41.6)	370 413 (62.6)	91 151 (55.0)	46 880 (75.2)	27 707 (66.8)	<.001
Asian, Native Hawaiian, or Pacific Islander	531 947 (19.6)	434 051 (23.4)	70 745 (11.9)	21 209 (12.8)	3211 (5.2)	2731 (6.6)	
African American	191 610 (7.0)	142 621 (7.7)	35 514 (6.0)	8822 (5.3)	2735 (4.4)	1918 (4.6)	
Latino/Hispanic	479 581 (17.6)	361 181 (19.4)	74 104 (12.5)	31 863 (19.2)	6008 (9.6)	6425 (15.5)	
Native American	14 061 (0.5)	10 228 (0.6)	2619 (0.4)	766 (0.5)	249 (0.4)	199 (0.5)	
Multiracial or unknown	194 373 (7.1)	138 215 (7.4)	38 653 (6.5)	11 770 (7.1)	3266 (5.2)	2469 (6.0)	
Household income							
Low (≤\$60 841)	910 784 (33.5)	652 820 (35.1)	171 354 (28.9)	52 690 (31.8)	19 401 (31.1)	14 519 (35.0)	<.001
Middle (\$60 842-\$87 461)	907 754 (33.4)	624 570 (33.6)	193 785 (32.7)	55 468 (33.5)	20 234 (32.5)	13 697 (33.0)	
High (≥\$87 462)	901 693 (33.1)	581 414 (31.3)	226 909 (38.3)	57 423 (34.7)	22 714 (36.4)	13 233 (31.9)	
BMI							
Underweight	42 799 (1.6)	34 039 (1.8)	6213 (1.0)	1398 (0.8)	768 (1.2)	381 (0.9)	<.001
Normal weight	883 471 (32.5)	594 660 (32.0)	203 838 (34.4)	51 340 (31.0)	21 260 (34.1)	12 373 (29.9)	
Overweight	920 909 (33.9)	602 622 (32.4)	218 945 (37.0)	60 648 (36.6)	23 356 (37.5)	15 338 (37.0)	
Obese	873 052 (32.1)	627 483 (33.8)	163 052 (27.5)	52 195 (31.5)	16 965 (27.2)	13 357 (32.2)	
Smoking status							
Never or former	2 450 387 (90.1)	1 701 786 (91.6)	530 281 (89.6)	137 620 (83.1)	50 941 (81.7)	29 759 (71.8)	<.001
Current	269 844 (9.9)	157 018 (8.4)	61 767 (10.4)	27 961 (16.9)	11 408 (18.3)	11 690 (28.2)	
No. of inpatient and ED visits							
0	2 277 944 (83.7)	1 522 084 (81.9)	520 274 (87.9)	146 127 (88.3)	53 839 (86.4)	35 620 (85.9)	<.001
1-2	388 030 (14.3)	290 267 (15.6)	66 456 (11.2)	18 147 (11.0)	7837 (12.6)	5323 (12.8)	
≥3	54 257 (2.0)	46 453 (2.5)	5318 (0.9)	1307 (0.8)	673 (1.1)	506 (1.2)	

Abbreviations: BMI, body mass index; ED, emergency department; NA, not applicable.

^a Column percentages are presented, which represent the proportion of patients within each demographic group in the overall sample and by alcohol consumption level. Percentages may not add up to 100% due to rounding error.

^b Patients were asked to estimate alcohol use in the past 3 months. Following the National Institute on Alcohol Abuse and Alcoholism drinking guidelines, we defined daily limits as more than 4 drinks per day for men aged 18 to 65 years or more than 3 drinks per day for women of any age and men 66 years or older and weekly limits as

more than 14 drinks per week for men aged 18 to 65 years or more than 7 drinks per week for women of any age and men 66 years or older. We classified patients as having no use (reporting no alcohol use), low-risk use (exceeding neither daily nor weekly limits), and unhealthy use (exceeding either daily or weekly limits). We further classified the unhealthy use group into the following mutually exclusive groups: exceeding daily limits, exceeding weekly limits, or exceeding both limits.

^c χ^2 tests were used to test for associations between demographic characteristics and alcohol consumption levels.

Table 2. Unadjusted Prevalence of Alcohol Consumption Levels by Medical Conditions Among Patients Screened at Kaiser Permanente Northern California From 2014 to 2017

Condition ^a	No. (%)						P value ^e
	Total ^b	Alcohol consumption level ^{c,d}					
		No reported use	Low-risk use	Exceeding daily limits	Exceeding weekly limits	Exceeding both limits	
Arthritis							
Yes	35 883 (1.3)	26 836 (74.8)	6598 (18.4)	902 (2.5)	1132 (3.2)	415 (1.2)	<.001
No	2 684 348 (98.7)	1 831 968 (68.2)	585 450 (21.8)	164 679 (6.1)	61 217 (2.3)	41 034 (1.5)	
Asthma							
Yes	256 681 (9.4)	186 479 (72.7)	48 691 (19.0)	12 933 (5.0)	5269 (2.1)	3309 (1.3)	<.001
No	2 463 550 (90.6)	1 672 325 (67.9)	543 357 (22.1)	152 648 (6.2)	57 080 (2.3)	38 140 (1.5)	
Atherosclerosis							
Yes	210 702 (7.7)	164 968 (78.3)	33 235 (15.8)	2988 (1.4)	7089 (3.4)	2422 (1.1)	<.001
No	2 509 529 (92.3)	1 693 836 (67.5)	558 813 (22.3)	162 593 (6.5)	55 260 (2.2)	39 027 (1.6)	
Atrial fibrillation							
Yes	48 873 (1.8)	36 990 (75.7)	8611 (17.6)	750 (1.5)	1885 (3.9)	637 (1.3)	<.001
No	2 671 358 (98.2)	1 821 814 (68.2)	583 437 (21.8)	164 831 (6.2)	60 464 (2.3)	40 812 (1.5)	
Cancer							
Yes	125 655 (4.6)	90 068 (71.7)	26 094 (20.8)	2866 (2.3)	4975 (4.0)	1652 (1.3)	<.001
No	2 594 576 (95.4)	1 768 736 (68.2)	565 954 (21.8)	162 715 (6.3)	57 374 (2.2)	39 797 (1.5)	
Cerebrovascular disease							
Yes	9732 (0.4)	8053 (82.7)	1239 (12.7)	126 (1.3)	231 (2.4)	83 (0.9)	<.001
No	2 710 499 (99.6)	1 850 751 (68.3)	590 809 (21.8)	165 455 (6.1)	62 118 (2.3)	41 366 (1.5)	
Chronic kidney disease							
Yes	131 355 (4.8)	108 504 (82.6)	17 176 (13.1)	1674 (1.3)	3084 (2.3)	917 (0.7)	<.001
No	2 588 876 (95.2)	1 750 300 (67.6)	574 872 (22.2)	163 907 (6.3)	59 265 (2.3)	40 532 (1.6)	
Chronic liver disease							
Yes	62 170 (2.3)	50 543 (81.3)	7892 (12.7)	1868 (3.0)	1042 (1.7)	825 (1.3)	<.001
No	2 658 061 (97.7)	1 808 261 (68.0)	584 156 (22.0)	163 713 (6.2)	61 307 (2.3)	40 624 (1.5)	
COPD							
Yes	69 159 (2.5)	53 021 (76.7)	10 744 (15.5)	1828 (2.6)	2499 (3.6)	1067 (1.5)	<.001
No	2 651 072 (97.5)	1 805 783 (68.1)	581 304 (21.9)	163 753 (6.2)	59 850 (2.3)	40 382 (1.5)	
Chronic pain							
Yes	150 977 (5.6)	115 136 (76.3)	25 556 (16.9)	5479 (3.6)	3136 (2.1)	1670 (1.1)	<.001
No	2 569 254 (94.4)	1 743 668 (67.9)	566 492 (22.0)	160 102 (6.2)	59 213 (2.3)	39 779 (1.5)	
Coronary disease							
Yes	88 732 (3.3)	68 735 (77.5)	14 681 (16.5)	1481 (1.7)	2874 (3.2)	961 (1.1)	<.001
No	2 631 499 (96.7)	1 790 069 (68.0)	577 367 (21.9)	164 100 (6.2)	59 475 (2.3)	40 488 (1.5)	
Dementia							
Yes	8890 (0.3)	8102 (91.1)	643 (7.2)	22 (0.2)	103 (1.2)	20 (0.2)	<.001
No	2 711 341 (99.7)	1 850 702 (68.3)	591 405 (21.8)	165 559 (6.1)	62 246 (2.3)	41 429 (1.5)	
Diabetes							
Yes	262 715 (9.7)	217 042 (82.6)	32 694 (12.4)	6513 (2.5)	4161 (1.6)	2305 (0.9)	<.001
No	2 457 516 (90.3)	1 641 762 (66.8)	559 354 (22.8)	159 068 (6.5)	58 188 (2.4)	39 144 (1.6)	
Epilepsy							
Yes	17 415 (0.6)	14 160 (81.3)	2250 (12.9)	530 (3.0)	295 (1.7)	180 (1.0)	<.001
No	2 702 816 (99.4)	1 844 644 (68.2)	589 798 (21.8)	165 051 (6.1)	62 054 (2.3)	41 269 (1.5)	
Gastroesophageal reflux							
Yes	301 844 (11.1)	225 862 (74.8)	53 827 (17.8)	10 290 (3.4)	8060 (2.7)	3805 (1.3)	<.001
No	2 418 387 (88.9)	1 632 942 (67.5)	538 221 (22.3)	155 291 (6.4)	54 289 (2.2)	37 644 (1.6)	
Heart failure							
Yes	34 721 (1.3)	29 492 (84.9)	3856 (11.1)	375 (1.1)	745 (2.1)	253 (0.7)	<.001
No	2 685 510 (98.7)	1 829 312 (68.1)	588 192 (21.9)	165 206 (6.2)	61 604 (2.3)	41 196 (1.5)	

(continued)

Table 2. Unadjusted Prevalence of Alcohol Consumption Levels by Medical Conditions Among Patients Screened at Kaiser Permanente Northern California From 2014 to 2017 (continued)

Condition ^a	No. (%)						P value ^e
	Total ^b	Alcohol consumption level ^{c,d}					
		No reported use	Low-risk use	Exceeding daily limits	Exceeding weekly limits	Exceeding both limits	
HIV							
Yes	6530 (0.2)	4217 (64.6)	1728 (26.5)	409 (6.3)	116 (1.8)	60 (0.9)	<.001
No	2 713 701 (99.8)	1 854 587 (68.3)	590 320 (21.8)	165 172 (6.1)	62 233 (2.3)	41 389 (1.5)	
Hyperlipidemia							
Yes	601 782 (22.1)	439 213 (73.0)	117 419 (19.5)	18 542 (3.1)	18 512 (3.1)	8096 (1.3)	<.001
No	2 118 449 (77.9)	1 419 591 (67.0)	474 629 (22.4)	147 039 (6.9)	43 837 (2.1)	33 353 (1.6)	
Hypertension							
Yes	626 153 (23.0)	461 131 (73.6)	114 291 (18.3)	19 370 (3.1)	21 159 (3.4)	10 202 (1.6)	<.001
No	2 094 078 (77.0)	1 397 673 (66.7)	477 757 (22.8)	146 211 (7.0)	41 190 (2.0)	31 247 (1.5)	
Injury or poisoning							
Yes	427 398 (15.7)	298 499 (69.8)	87 754 (20.5)	24 647 (5.8)	10 109 (2.4)	6389 (1.5)	<.001
No	2 292 833 (84.3)	1 560 305 (68.1)	504 294 (22.0)	140 934 (6.1)	52 240 (2.3)	35 060 (1.5)	
Migraine							
Yes	112 353 (4.1)	85 560 (76.2)	20 028 (17.8)	4198 (3.7)	1710 (1.5)	857 (0.8)	<.001
No	2 607 878 (95.9)	1 773 244 (68.0)	572 020 (21.9)	161 383 (6.2)	60 639 (2.3)	40 592 (1.6)	
Osteoarthritis							
Yes	279 772 (10.3)	205 306 (73.4)	54 738 (19.6)	7469 (2.7)	8797 (3.1)	3462 (1.2)	<.001
No	2 440 459 (89.7)	1 653 498 (67.8)	537 310 (22.0)	158 112 (6.5)	53 552 (2.2)	37 987 (1.6)	
Osteoporosis/osteopenia							
Yes	118 948 (4.4)	92 759 (78.0)	20 651 (17.4)	1259 (1.1)	3530 (3.0)	749 (0.6)	<.001
No	2 601 283 (95.6)	1 766 045 (67.9)	571 397 (22.0)	164 322 (6.3)	58 819 (2.3)	40 700 (1.6)	
Parkinson disease/syndrome							
Yes	5170 (0.2)	4247 (82.1)	745 (14.4)	31 (0.6)	120 (2.3)	27 (0.5)	<.001
No	2 715 061 (99.8)	1 854 557 (68.3)	591 303 (21.8)	165 550 (6.1)	62 229 (2.3)	41 422 (1.5)	
Peptic ulcer							
Yes	8612 (0.3)	6867 (79.7)	1226 (14.2)	229 (2.7)	194 (2.3)	96 (1.1)	<.001
No	2 711 619 (99.7)	1 851 937 (68.3)	590 822 (21.8)	165 352 (6.1)	62 155 (2.3)	41 353 (1.5)	
Rheumatoid arthritis							
Yes	16 933 (0.6)	13 455 (79.5)	2592 (15.3)	355 (2.1)	395 (2.3)	136 (0.8)	<.001
No	2 703 298 (99.4)	1 845 349 (68.3)	589 456 (21.8)	165 226 (6.1)	61 954 (2.3)	41 313 (1.5)	

Abbreviation: COPD, chronic obstructive pulmonary disease.

^a Medical conditions were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* and *International Statistical Classification of Diseases, Tenth Revision, Clinical Modification* codes in the electronic health record in the year prior to and including the date of the alcohol screening visit.

^b Percentages represent the proportions of patients with and without the medical condition in the overall sample. Percentages by column may not add up to 100% due to rounding error.

^c Patients were asked to estimate alcohol use in the past 3 months. Following the National Institute on Alcohol Abuse and Alcoholism drinking guidelines, we defined daily limits as more than 4 drinks per day (for men aged 18 to 65 years) or more than 3 drinks per day (for women of any age and men 66 years or older) and weekly limits as

more than 14 drinks per week (for men aged 18 to 65 years) or more than 7 drinks per week (for women of any age and men 66 years or older). We classified patients as having no use (reporting no alcohol use), low-risk use (exceeding neither daily nor weekly limits), and unhealthy use (exceeding either daily or weekly limits). We further classified the unhealthy use group into the following mutually exclusive groups: exceeding daily limits, exceeding weekly limits, or exceeding both limits.

^d Percentages represent the proportions of patients who reported drinking at each level by whether they have a medical condition. Percentages by row may not add up to 100% due to rounding error.

^e χ^2 tests were used to test for associations between demographic characteristics and alcohol consumption levels.

report unhealthy relative to low-risk use (Table 4). Patients with hypertension and COPD were more likely than those without to report use exceeding daily limits (hypertension: OR, 1.11; 95% CI, 1.09-1.13; COPD: OR, 1.16; 95% CI, 1.10-1.22), weekly limits (hypertension: OR, 1.37; 95% CI, 1.34-1.40; COPD: OR, 1.15; 95% CI, 1.09-1.20), and both limits (hypertension: OR, 1.48; 95% CI, 1.44-1.52; COPD: OR, 1.15; 95% CI, 1.07-1.23) relative to low-risk use. Patients with an injury or poisoning were more likely than those without to report use exceeding daily limits relative to low-risk use (OR, 1.06; 95%

CI, 1.04-1.07). Patients with chronic liver disease were more likely than those without to report use exceeding both limits, relative to low-risk use (OR, 1.42; 95% CI, 1.32-1.53).

In contrast, compared with those without the condition, patients with asthma, atherosclerosis, chronic kidney disease, chronic pain, coronary disease, dementia, HIV, migraine, osteoarthritis, osteoporosis/osteopenia, and Parkinson disease/syndrome were less likely to report unhealthy use relative to low-risk use. Patients with migraine and osteoporosis/osteopenia were less likely than patients without to report use exceeding daily limits (migraine: OR, 0.88; 95% CI, 0.85-0.91; osteoporosis/osteopenia: OR, 0.75; 95% CI, 0.70-0.79), weekly limits (migraine: OR, 0.72; 95% CI, 0.69-0.76; osteoporosis/osteopenia: OR, 0.64; 95% CI, 0.62-0.67), and both limits (migraine: OR, 0.63; 95% CI, 0.59-0.67; osteoporosis/osteopenia: OR, 0.50; 95% CI, 0.46-0.54) relative to low-risk use. Patients with coronary disease were less likely than those without to report use exceeding daily limits (OR, 0.86; 95% CI, 0.82-0.91) and both limits (OR, 0.85; 95% CI, 0.80-0.92) relative to low-risk use. Patients with the following conditions were less likely than those without to report use exceeding weekly limits and both limits relative to low-risk use: chronic kidney disease (weekly: OR, 0.87; 95% CI, 0.83-0.90; both: OR, 0.71; 95% CI, 0.66-0.76), chronic pain (weekly: OR, 0.90; 95% CI, 0.86-0.93; both: OR, 0.84; 95% CI, 0.80-0.88), and osteoarthritis (weekly: OR, 0.94; 95% CI, 0.92-0.97; both: OR, 0.88; 95% CI, 0.84-0.91). Patients with atherosclerosis (OR, 0.87; 95% CI, 0.84-0.91) and Parkinson disease/syndrome (OR, 0.44; 95% CI, 0.31-0.64) were less likely than those without to report use exceeding daily limits relative to low-risk use. Patients with asthma (OR, 0.93; 95% CI, 0.90-0.66) and dementia (OR, 0.67; 95% CI, 0.54-0.83) were less likely than those without to report use exceeding weekly limits relative to low-risk use. Patients with HIV were less

Table 3. Adjusted Associations of Medical Conditions With Reporting Low-Risk or Unhealthy Drinking Among the Full Sample of 2 720 231 Patients^a

Condition ^b	OR (95% CI) ^{c,d}	
	Low-risk use vs no use	Unhealthy use vs no use
Arthritis	0.91 (0.89-0.94) ^e	0.90 (0.86-0.94) ^e
Asthma	0.91 (0.90-0.92) ^e	0.89 (0.88-0.91) ^e
Atherosclerosis	0.70 (0.69-0.71) ^e	0.67 (0.66-0.69) ^e
Atrial fibrillation	0.82 (0.80-0.84) ^e	0.81 (0.78-0.84) ^e
Cancer	0.94 (0.93-0.96) ^e	0.93 (0.91-0.95) ^e
Cerebrovascular disease	0.74 (0.69-0.79) ^e	0.69 (0.62-0.76) ^e
Chronic kidney disease	0.57 (0.56-0.58) ^e	0.48 (0.47-0.49) ^e
Chronic liver disease	0.58 (0.57-0.60) ^e	0.67 (0.65-0.70) ^e
COPD	0.71 (0.70-0.73) ^e	0.83 (0.81-0.86) ^e
Chronic pain	0.71 (0.70-0.72) ^e	0.66 (0.64-0.67) ^e
Coronary disease	0.71 (0.69-0.72) ^e	0.64 (0.62-0.66) ^e
Dementia	0.32 (0.30-0.35) ^e	0.20 (0.17-0.24) ^e
Diabetes	0.52 (0.51-0.52) ^e	0.51 (0.50-0.52) ^e
Epilepsy	0.50 (0.48-0.53) ^e	0.49 (0.46-0.52) ^e
Gastroesophageal reflux	0.83 (0.82-0.84) ^e	0.83 (0.82-0.84) ^e
Heart failure	0.54 (0.52-0.56) ^e	0.49 (0.46-0.52) ^e
HIV	0.88 (0.83-0.93) ^e	0.67 (0.61-0.73) ^e
Hyperlipidemia	0.84 (0.83-0.84) ^e	0.84 (0.83-0.85) ^e
Hypertension	0.80 (0.79-0.80) ^e	1.00 (0.99-1.02)
Injury or poisoning	1.02 (1.01-1.03) ^e	1.06 (1.05-1.07) ^e
Migraine	0.82 (0.81-0.83) ^e	0.64 (0.63-0.66) ^e
Osteoarthritis	0.92 (0.91-0.93) ^e	0.87 (0.85-0.88) ^e
Osteoporosis/osteopenia	0.94 (0.93-0.96) ^e	0.72 (0.70-0.74) ^e
Parkinson disease/syndrome	0.58 (0.53-0.63) ^e	0.38 (0.33-0.44) ^e
Peptic ulcer	0.73 (0.68-0.78) ^e	0.76 (0.70-0.84) ^e
Rheumatoid arthritis	0.72 (0.69-0.76) ^e	0.66 (0.62-0.71) ^e

Abbreviations: COPD, chronic obstructive pulmonary disease; OR, odds ratio.

^a Separate multinomial logistic regression models for each medical condition were adjusted for sex, age, race/ethnicity, household income, body mass index, smoking status, and number of inpatient and emergency department visits in the year prior to the alcohol screening.

^b Medical conditions were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* and *International Statistical Classification of Diseases, Tenth Revision, Clinical Modification* codes in the electronic health record in the year prior to (and including) the date of the alcohol screening visit.

^c Low-risk alcohol use was defined as exceeding neither daily nor weekly limits and unhealthy use as exceeding either limit, according to the National Institute on Alcohol Abuse and Alcoholism drinking guidelines.

^d An OR less than 1 indicates that patients with the medical condition had lower odds than those without the condition of reporting low-risk or unhealthy use relative to no use (whereas an OR greater than 1 indicates higher odds), after controlling for covariates.

^e Bonferroni-corrected $P < .0004$.

likely than those without to report use exceeding both limits relative to low-risk use (OR, 0.45; 95% CI, 0.34-0.58).

Compared with patients without the condition, those with atrial fibrillation (OR, 0.80; 95% CI, 0.74-0.87) and cancer (OR, 0.91; 95% CI, 0.87-0.95) were less likely to report use exceeding daily limits but more likely to report use exceeding weekly limits relative to low-risk use (atrial fibrillation: OR, 1.12; 95% CI, 1.06-1.18; cancer: OR, 1.06; 95% CI, 1.03-1.10). In contrast, relative to low-risk use, patients with diabetes were more likely to report use exceeding daily limits (OR, 1.11; 95% CI, 1.08-1.15) but less likely to report use exceeding weekly limits (OR, 0.90; 95% CI, 0.86-0.93) compared with those without. There were no associations between cerebrovascular disease, epilepsy, gastroesophageal reflux, heart failure, hyperlipidemia, peptic ulcer, and rheumatoid arthritis and unhealthy alcohol use relative to low-risk use among patients reporting drinking.

Discussion

Using data collected in a systematic alcohol screening program, we examined associations between a variety of medical conditions and alcohol consumption levels among 2 720 231 adult primary care patients. With the exception of those with injury or poisoning diagnoses, often associated with acute alcohol intoxication in the literature,^{37,38} people with medical conditions were more likely to report no use compared with people without. This is consistent with previous studies that found no alcohol use was associated with poorer health, perhaps because people in ill health choose to quit drinking owing to the effects on their condition's symptoms or progression or medication contraindications—

Table 4. Adjusted Associations of Prevalent Medical Conditions With Reporting Unhealthy Alcohol Use Among 861 427 Patients Who Reported Alcohol Use^a

Condition ^b	OR (95% CI) ^{c,d}		
	Exceeding daily limits vs low-risk use	Exceeding weekly limits vs low-risk use	Exceeding both limits vs low-risk use
Arthritis	1.02 (0.95-1.09)	0.98 (0.92-1.05)	0.89 (0.80-0.98)
Asthma	1.03 (1.00-1.05)	0.93 (0.90-0.96) ^e	0.97 (0.93-1.00)
Atherosclerosis	0.87 (0.84-0.91) ^e	1.00 (0.97-1.03)	0.93 (0.88-0.97)
Atrial fibrillation	0.80 (0.74-0.87) ^e	1.12 (1.06-1.18) ^e	1.00 (0.92-1.09)
Cancer	0.91 (0.87-0.95) ^e	1.06 (1.03-1.10) ^e	0.92 (0.87-0.97)
Cerebrovascular disease	0.81 (0.67-0.97)	0.97 (0.84-1.12)	0.88 (0.70-1.10)
Chronic kidney disease	0.91 (0.87-0.96)	0.87 (0.83-0.90) ^e	0.71 (0.66-0.76) ^e
Chronic liver disease	1.07 (1.01-1.12)	1.09 (1.02-1.17)	1.42 (1.32-1.53) ^e
COPD	1.16 (1.10-1.22) ^e	1.15 (1.09-1.20) ^e	1.15 (1.07-1.23) ^e
Chronic pain	0.96 (0.94-0.99)	0.90 (0.86-0.93) ^e	0.84 (0.80-0.88) ^e
Coronary disease	0.86 (0.82-0.91) ^e	1.07 (1.03-1.12)	0.85 (0.80-0.92) ^e
Dementia	0.49 (0.32-0.76)	0.67 (0.54-0.83) ^e	0.45 (0.29-0.70)
Diabetes	1.11 (1.08-1.15) ^e	0.90 (0.86-0.93) ^e	0.96 (0.92-1.00)
Epilepsy	0.94 (0.85-1.04)	1.05 (0.93-1.19)	1.03 (0.89-1.21)
Gastroesophageal reflux	0.99 (0.97-1.01)	0.99 (0.97-1.02)	0.97 (0.94-1.01)
Heart failure	0.85 (0.76-0.95)	0.99 (0.91-1.07)	0.84 (0.73-0.95)
HIV	0.83 (0.74-0.93)	0.72 (0.60-0.87)	0.45 (0.34-0.58) ^e
Hyperlipidemia	1.02 (1.00-1.04)	1.01 (0.99-1.03)	0.99 (0.97-1.02)
Hypertension	1.11 (1.09-1.13) ^e	1.37 (1.34-1.40) ^e	1.48 (1.44-1.52) ^e
Injury or poisoning	1.06 (1.04-1.07) ^e	0.99 (0.97-1.02)	0.98 (0.95-1.01)
Migraine	0.88 (0.85-0.91) ^e	0.72 (0.69-0.76) ^e	0.63 (0.59-0.67) ^e
Osteoarthritis	0.96 (0.93-0.98)	0.94 (0.92-0.97) ^e	0.88 (0.84-0.91) ^e
Osteoporosis/osteopenia	0.75 (0.70-0.79) ^e	0.64 (0.62-0.67) ^e	0.50 (0.46-0.54) ^e
Parkinson disease/syndrome	0.44 (0.31-0.64) ^e	0.83 (0.69-1.01)	0.54 (0.37-0.80)
Peptic ulcer	1.10 (0.95-1.27)	0.98 (0.84-1.14)	1.03 (0.83-1.27)
Rheumatoid arthritis	0.94 (0.84-1.06)	0.92 (0.82-1.02)	0.77 (0.64-0.91)

Abbreviations: COPD, chronic obstructive pulmonary disease; OR, odds ratio.

^a Separate multinomial logistic regression models for each medical condition were adjusted for sex, age, race/ethnicity, household income, body mass index, smoking status, and number of inpatient and emergency department visits in the year prior to the alcohol screening.

^b Medical conditions were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* and *International Statistical Classification of Diseases, Tenth Revision, Clinical Modification* codes in the electronic health record in the year prior to (and including) the date of the alcohol screening visit.

^c Low-risk alcohol use was defined as exceeding neither daily nor weekly limits, and unhealthy use as exceeding either limit, according to the National Institute on Alcohol Abuse and Alcoholism drinking guidelines. We further classified the unhealthy use group into the following mutually exclusive groups: exceeding daily limits, exceeding weekly limits, or exceeding both limits.

^d An OR less than 1 indicates that patients with the medical condition had lower odds than those without the condition of reporting unhealthy use (exceeding daily, weekly, or both limits) relative to low-risk use (whereas an OR greater than 1 indicates higher odds), after controlling for covariates.

^e Bonferroni-corrected $P < .0004$.

so-called sick quitters—or because they were formerly heavy drinkers whose drinking may have been related to their poor health.³⁹⁻⁴²

However, among those reporting drinking, we found more complex associations. People with migraine or osteoporosis/osteopenia, for example, were less likely than those without to report unhealthy drinking than they were to drink within guidelines. Alcohol may exacerbate symptoms or they may use medications contraindicated with alcohol use. People with atrial fibrillation and cancer were less likely to exceed daily limits but more likely to exceed weekly limits compared with people without these conditions. These patients may be less able to tolerate the intoxicating effects of drinking 4 or more drinks at one time.

A few conditions, including COPD, hypertension, and chronic liver disease, were associated with unhealthy as opposed to low-risk drinking; patients with COPD and hypertension were more likely to exceed daily, weekly, and both limits, and those with chronic liver disease were more likely to exceed both daily and weekly limits. Patients with diabetes were more likely to report exceeding only daily limits but less likely to report exceeding only weekly limits than they were to report low-risk use. Our findings echo other studies demonstrating an association between these conditions and heavy drinking. While some studies have found light to moderate drinking to be associated with lower risk of type II diabetes,^{43,44} a 2015 meta-analysis⁴⁵ of data from almost 2 million individuals found this protective relationship only among women and only related to standard volume over time, not to a heavy episodic drinking pattern, such as the exceeding daily limits level we examined. There is also evidence on the association between excessive drinking and hypertension⁴⁶⁻⁴⁹ and on the benefits of reducing consumption. A 2017 meta-analysis⁵⁰ of data from 36 randomized clinical trials found that among people drinking 2 or more drinks per day, a reduction in alcohol consumption resulted in significant reductions in blood pressure. While several studies found an association between drinking and COPD and many patients with COPD have been or are heavy drinkers, smoking was often a confounder, and research is rarer on the independent association between excessive alcohol use and COPD controlling for smoking. A 2019 study of 44 000 Swedish men⁵¹ found that while light drinking was protective, the incidence of COPD increased significantly beginning at 14 or more drinks per week. Studies also found an association between unhealthy drinking and liver disease⁵² and liver disease outcomes,⁵³ especially for women.⁵⁴

All 4 conditions associated with higher rates of unhealthy drinking relative to low-risk drinking—COPD, hypertension, chronic liver disease, and diabetes—are common, costly, and prevalent among primary care populations. In all cases, heavy drinking can exacerbate symptoms, complicate treatment, and increase the risk of adverse outcomes, and reducing consumption may have beneficial effects.^{55,56} These findings underscore the clinical importance of linking unhealthy alcohol use to specific medical conditions. The mounting evidence of alcohol's adverse health effects have led to increased efforts to address harmful use in primary care settings.⁵⁷ Studies have documented the efficacy of approaches such as systematic alcohol SBIRT in reducing use.⁵⁸⁻⁶³ While many studies have focused on alcohol use outcomes, emerging research is examining how these interventions may affect health outcomes, such as blood pressure. Chi et al⁶⁴ found that a brief alcohol intervention delivered by a primary care physician was associated with reductions in blood pressure and improvements in blood pressure control among patients with hypertension. The physician SBIRT training in this system emphasized discussing alcohol consumption in the context of managing patients' presenting health concerns. We need further research on ways to identify and reduce excessive alcohol use among these higher-risk patients.

Limitations

Our study has several limitations. We cannot establish temporality of the associations observed between medical conditions and alcohol consumption levels, since patients were asked about consumption over the past 3 months at the screening, and the presence of medical conditions was determined for the year prior to (and including) the screening date. Future studies should aim to establish temporality to infer causality. We did not have lifetime drinking data for our sample and

could not differentiate between lifetime and current abstainers or determine if use levels reported at screenings represented lifetime use; the no use group likely included individuals who drank previously but quit, possibly related to serious medical conditions or to recovery from an alcohol use disorder. We found a high rate of no reported use, much higher than those in national surveys.⁶⁵ This primary care population may be older and sicker than those in community surveys or may be underreporting their drinking. We are also unable to determine clinically meaningful thresholds for the strength of associations we found. We used a conservative approach for adjusting for multiple comparisons, which could have dampened the significance of some associations we observed. Finally, while unadjusted ORs could potentially inform clinicians about drinking patterns among particularly vulnerable populations, we chose a more conservative approach, which adjusted for important sociodemographic, health, and utilization characteristics, to provide clinicians with information about medical conditions and drinking patterns independent of case-mix differences.

Conclusions

Patients with most medical conditions, compared with those without, were more likely to report no alcohol use than to drink at low-risk or high-risk levels. However, people with diabetes, hypertension, COPD, and chronic liver disease who reported drinking were more likely than those without to drink at unhealthy levels, potentially exacerbating their conditions and jeopardizing treatment regimens. Further research should identify how clinicians can tailor screening and interventions to help patients with certain chronic medical conditions to curtail excessive alcohol use and minimize health risks.

ARTICLE INFORMATION

Accepted for Publication: March 8, 2020.

Published: May 13, 2020. doi:10.1001/jamanetworkopen.2020.4687

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Obtained funding: Sterling, Weisner.

Administrative, technical, or material support: Sterling, Elson, Maxim.

Study supervision: Sterling.

Conflict of Interest Disclosures: Dr Sterling has received grants from the National Institute on Alcohol Abuse and Alcoholism during the conduct of the study. No other disclosures were reported.

Funding/Support: This study was supported by grant R01AA025902 from the National Institute on Alcohol Abuse and Alcoholism.

Role of the Funder/Sponsor: The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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