HHS Public Access

Author manuscript

Nat Cardiovasc Res. Author manuscript; available in PMC 2023 November 30.

Published in final edited form as:

Nat Cardiovasc Res. 2022 January ; 1(1): 23–27. doi:10.1038/s44161-021-00003-7.

Population-Level Analyses of Alcohol Consumption as a Predictor of Acute Atrial Fibrillation Episodes

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Studying the short-term relationships between acute alcohol consumption and discrete atrial fibrillation (AF) episodes has proven difficult given the need for AF assessments shortly after acute and excessive drinking.[1–4] Here, we analyzed breathalyzer data and identified 8 recurrent and nationally-recognized events associated with increased alcohol consumption. Using these events as instrumental variables, we analyzed data from emergency department (ED) visits for AF in California. Using multivariable adjusted Poisson regression models to compare rates of AF and new-onset AF during and 6 days after instrumental variable events compared with all other days of the year, alcohol consumption inferred from these events was associated with a statistically significant increase in ED visits for AF and for new-onset AF. Our data suggest that acute alcohol consumption in the general population is associated with a higher risk of discrete AF episodes, as well as for new-onset (incident) AF.

Atrial fibrillation (AF) is the most common arrhythmia and is associated with substantial morbidity and mortality.[5–6] The importance of modifiable lifestyle factors that may meaningfully influence the risk of developing AF have recently become evident.[7] Alcohol, the most commonly consumed drug in the world, has emerged as an important risk factor for AF.[8–10] However, the great majority of research on the topic has revealed that

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Author Contributions

SA, CAG, CDF, GMM conceived and designed the study. SA, EV, GN, GMM performed data analysis and statistical analysis. SA, GMM wrote the first manuscript draft. Critical revision, editing, and approval of the final manuscript was done by all authors.

Competing Interests

The authors declare no competing interests.

chronic alcohol consumption serves as a predictor of new-onset AF,[8–10] with growing evidence that abstinence from alcohol can reduce the risk of incident AF[11] or reduce AF burden.[12] However, the initial reports suggesting a relationship between alcohol and AF pointed to temporally acute effects.[1–4] Indeed, AF patients report alcohol as the most common trigger of any given particular AF episode,[13–14] and we recently demonstrated acute electrophysiological changes in a human experiment expected to render the acutely alcohol-exposed atria more prone to fibrillate.[15] However, a study assessing 30 second ECG rhythm strips in participants with a mean breath alcohol concentration of 0.085% found that only 0.8% had an AF event.[16] Mechanistically, alcohol may increase the risk of AF by reducing atrial effective refractory periods (AERPs), particularly in the pulmonary veins.[15] Alcohol-related pro-arrhythmia may also result from fluctuations in autonomic tone, evidenced previously by an initial increased propensity to sinus tachycardia accompanied by diminished parasympathetic tone[16] or the enhanced vagal effects that often occur thereafter.[14] These limited investigations occurred in the context of paroxysmal AF, and there are no current studies of acute alcohol consumption as a precipitant of a first episode of incident AF.

Identifying modifiable exposures or behaviors that immediately influence whether an episode of AF will happen could prove invaluable to patients and help prevent much of the morbidity associated with the disease. Behavioral modification research has demonstrated that the consideration of immediate consequences may be a more powerful incentive to adhere to healthy behaviors compared to less compelling concerns regarding longer-term consequences.[17] Studying the relationships between acute alcohol consumption and individual AF episodes has historically proven difficult to conduct given the need for “real-time” data linking alcohol consumption and discrete episodes of AF.

Instrumental variable analyses represent one approach to studying such a relationship, where an instrumental variable is defined as a measurable phenomenon that is associated with the predictor of interest, but not with the outcome (except potentially by way of the predictor).[18] As conventional observational study designs are prone to bias from confounding, instrumental variable analyses represent a method to potentially circumvent this common limitation.[19]

We therefore sought to conduct an instrumental variable analysis to test the hypothesis that alcohol consumption is associated with an increased risk for an acute AF episode among the general population. We also sought to test a secondary hypothesis that acute alcohol consumption is associated with an increased risk for near-term episodes of AF that represent the initial onset of the disease.

Results

A total of 1,269,054 breath alcohol measurements were obtained from 36,158 individuals using the commercially available, Bluetooth-enabled breathalyzer device. These individuals resided in all 50 US states and 59 countries (18,833 resided in the US). Users obtained a median of 4.06 (IQR 1.25–10.60) measurements per year. The median blood alcohol concentration (BAC) was 0.04% (IQR 0.0–0.093%). A list of all candidate dates associated

with alcohol consumption initially identified from the breathalyzer data are listed in Extended Data Table 1. Candidate dates that immediately preceded or followed an instrumental variable event that were utilized in analyses included: Sundays before Martin Luther King (MLK) Day, July 5, December 24, and December 26. A total of 8 recurrent, nationally-recognized events associated with heightened alcohol consumption were identified (Extended Data Table 2). The number of participants with at least one breathalyzer use (for each event derived from the device-use selection method) and the median blood alcohol content levels (for each event derived from the blood alcohol content selection method) are shown in Figure 1.

In our validation analysis adjusted for calendar day of week and calendar month to corroborate the association between instrumental variable events and ED visits with evidence of excessive alcohol use, there were 2,640 additional events for alcohol-related ED visits per 100,000 person-years (95% CI 1,903–3,376, $p < 0.001$; Table 1) during and shortly after instrumental variable events.

During the study period, 1,196,236 number of emergency department visits for AF were observed, 1,502 resulting in hospitalization. After adjustment for calendar day of week and calendar month and accounting for the age, sex, and race/ ethnicity characteristics, there were more than 700 additional ED visits for AF per 100,000 person-years of the California general population during and shortly after instrumental variable-identified events associated with more alcohol (Table 2). After the same multivariable adjustment, statistically significantly more AF was observed during each of several individual events associated with more alcohol consumption alone (Table 2).

After the same multivariable adjustment, there were 1,757 additional visits for new-onset, incident AF ED visits per 100,000 person-years (95% CI 945–2,569, $p < 0.001$) during and shortly after instrumental variable events.

Individuals 65 years of age or older exhibited a statistically significantly higher rate of AF on instrumental variable days compared to younger individuals (47 per 100,000 person-years, $p = 0.047$. No significant interaction by gender was observed (3 additional AF events on instrumental variable events per 100,000 person-years for men compared to women, $p = 0.17$).In the negative control analyses, none of the instrumental variable events were associated with ED visits for SVT (**Table**).

Discussion

During recurrent, nationally-recognized events associated with more alcohol consumption empirically derived to serve as instrumental variables, we observed significantly more AF. A substantial increase in the first episode of AF for given individual patients during these instrumental variable events was also observed, suggesting that alcohol may acutely enhance the risk of an initial AF episode.

While there is evidence that chronic alcohol consumption is a predictor of an eventual diagnosis of AF,[8–10] investigations of acute alcohol consumption as a predictor of discrete AF episodes have been limited. Studies of chronic alcohol consumption and the risk of AF

have varied in terms of the magnitude of alcohol consumption evaluated, with evidence that AF risk rises with increasing levels of alcohol consumption.[8] Though initial reports describing the “Holiday Heart Syndrome” as an immediate relationship between alcohol and AF that points to temporally acute effects, these studies were based on small case series relying on self-report of alcohol consumption.[1–4] While recent evidence has provided mechanistic data to support biological plausibility of an acute relationship[20] and a recent contemporary report demonstrates that patients describe alcohol as the most common trigger of their AF episodes,[13] real-world effects in the general population have not previously been examined. Though a study confined to volunteers at Octoberfest (a festival in Munich) did not find a substantial association between elevated breath alcohol concentration and AF,[16] they only used 30 second ECG strips in just over 3,000 relatively young individuals and did not capture AF episodes that could have occurred in the hours or days which followed. In contrast, as the denominator of the current study was essentially the population of California, the nearly 40 million individuals available may have helped enhance power to detect such an association. In addition, the majority of research on the topic has relied on comparing self-reported alcohol consumption and incident AF and may be prone to substantial confounding (as those who drink more may differ in other important ways than those who do not). In contrast, this current instrumental variable analysis does not rely on self-report of alcohol consumption nor should it be vulnerable to confounding related to individual-level characteristics.

One potential criticism of the current study might be that we identified only particular calendar dates that routinely introduce some other unknown factor other than alcohol. Importantly, several of the events identified fall on dates that vary by year, such as the initiation of Daylight Saving Time, Super Bowl Sunday, and the FIFA World Cup. Of note, the events identified were not simply all major holidays, as demonstrated by the fact that occasions such as Halloween or Thanksgiving were not selected. Our empirically derived events are also independently supported by past literature on the subject: separate studies have shown that alcohol consumption is increased on New Year’s Day and Christmas Eve[21–22] and prior evidence suggests alcohol consumption increases on Super Bowl Sundays[23] and at sporting events in general.[24–26]

To further support the validity of the instrumental variables selected, we also found more alcohol-related ED visits during instrumental variable events. We recognize that we could have alternatively identified events associated with alcohol consumption directly from OSHPD instead of taking the multiple steps required to utilize the Bluetooth-enabled breathalyzers to identify instrumental variable events, but we believed that doing so would have introduced additional confounding related to healthcare utilization (e.g. those who utilized emergency services in OSHPD for alcohol-related issues may themselves be more likely in general to use emergency services for AF). We recognize that users of the commercially available breathalyzer device do not represent the general population, but that limitation should have reduced power to detect an association rather than increase the risk for false positive relationships in our analyses.

To address the possibility that there was something about the dates selected that simply increased symptoms of disease, prompted an ED visit, or more broadly increased arrhythmia

symptoms, we performed a negative control analysis using SVT as the outcome and failed to find any statistically relationships with our prespecified instrumental variable events.

Although it was interesting that older individuals experienced a relatively heightened risk of AF during instrumental variable events, no significant interactions of these effects were observed by gender. We also discovered significant relationships between the instrumental variables suggestive of heightened alcohol consumption and new-onset AF within a short timeframe. The observation that the magnitude of the heightened rate for new-onset AF during instrumental variable events compared to all other times (the rate differences observed) was greater than the rate differences all for all AF (the latter including recurrent AF) suggests that such initial alcohol-associated AF episodes might serve as motivating experiences to avoid excessive alcohol and therefore help curtail future AF events in at least some of those “new-onset” individuals. These data highlight the fact that the study cohort denominator in the current study was the general population, whereas previous research related to triggers of AF have focused on those already diagnosed with the disease.[13–14] In that case, it can be difficult if not impossible to disentangle instructions or information patients may receive as they learn about their AF—for example, even if no true alcohol-AF relationship exists, patients may erroneously connect a common behavior (such as drinking) with AF episodes if pre-existing beliefs in the healthcare system and previous literature support the existence of such a relationship.

Our study has several limitations. Although utilization of the instrumental variable approach was pursued to mitigate against conventional confounding, we acknowledge that, precisely because we inferred exposure to alcohol consumption based on several assumptions, we may have under-estimated the strength of true effects and rendered the analysis prone to false positives. For example, it is plausible that the general population of California that would seek care in EDs did not engage in the same drinking patterns as those using the Bluetooth-enabled breathalyzer devices as these populations likely differ by age, sex, race, and socioeconomic status. However, such differences would be expected to bias our results towards the null and should not result in spurious false positive relationships. Along similar lines, as there is no formal, exhaustive list of nationally recognized, recurrent events, it is likely we failed to identify some. Indeed, some of the events empirically derived are not recognized outside the US, which may have attenuated the magnitude of true underlying effects. We acknowledge that we were unable to distinguish between different types of alcoholic beverages (which may themselves have various health-effects) from either the breathalyzer data or the OSHPD database, and the drinking patterns of most Californians may differ from other populations in this regard. While instrumental variables reduce the effect of unmeasured confounding,[19] the dates associated with alcohol consumption may also be associated with other potential confounders which may themselves influence the risk for discrete episodes of atrial fibrillation, such as decreased sleep duration[27–29] (which may have played a role in the Daylight Saving Time event) and salt intake (which may be increased on holidays such as Christmas).[30–31] Though we believe that a period of 6 days following each instrumental variable event served as an adequate window of time to capture discrete AF episodes that occur in response to alcohol consumption, it is difficult to elucidate the ideal window of time to capture ED visits for AF following an inferred exposure to alcohol consumption. We leveraged the ability to follow individuals over time

and across multiple encounters including all outpatient surgeries, hospitalizations, and ED visits to define a given patient's first AF event as one that occurred only following at least one year of no evident healthcare utilization with an AF code, but recognize this likely misclassified some recurrent AF as an initial diagnosis. Finally, although instrumental variable analyses are often intended to help infer causality using observational data, it is important to emphasize that there may yet be unmeasured confounding unique to these analyses that acted as the true causal factor(s).

Thus, using empirically-derived recurrent events associated with heightened alcohol consumption as instrumental variables, these data suggest that a near-term increase in alcohol consumption is associated with a higher risk of an acute AF episode in the general population.

Methods

Study Design

The authors confirm that this research complies with all relevant ethical regulations. The study was approved by the University of California, San Francisco Institutional Review Board.

We retrieved time-specific and date-specific measurements for blood alcohol content (BAC) levels using data collected between January 1, 2014 to December 31, 2016 from all customers using a commercially available, Bluetooth-enabled breathalyzers (BACtrack, San Francisco, CA). There was missing data from these devices between the periods of August 5, 2014 to December 31, 2014 and January 1, 2016 to February 13, 2016. The accuracy of these devices is comparable to those used in law enforcement.[32–33]

We sought to empirically identify recurrent events associated with increased alcohol consumption. Because those events, once identified, would not otherwise be expected to have any inherent properties associated with AF apart from their relationship to the predictor of interest (increased alcohol consumption), the events were considered as instrumental variables for the purposes of these analyses.[18] We first identified candidate dates associated with alcohol consumption from the breathalyzers using either a "device-use" or "blood alcohol content" selection method. For the device-use selection method, we identified the dates within each year associated with the highest 5^{th} percentile of breathalyzer use. This process was repeated for each year of available data, and candidate dates were selected if they were identified in at least one calendar year. For the blood alcohol content selection method, we first determined the median BAC levels for each participant for each calendar date to account for repeated BAC measurements within individuals. We then identified dates within each calendar year associated with the highest 5th percentile of median BAC levels. This process was repeated for each calendar year of available data, and candidate dates were selected if they were identified in at least one calendar year. The candidate dates identified in either the device-use or blood alcohol content selection method were then individually screened to determine whether they occurred during recurrent, nationally-recognized events (such as national holidays, major televised events [such as sporting events], or publicly announced events, such as Daylight Saving Time) using a combination of search terms

entered into the Google (Mountain View, California) search engine for each candidate date. Dates immediately preceding or following such events were included and attributed to those events.

We abstracted the daily number of emergency department (ED) visits with a primary ICD-9 diagnostic code for AF (Extended Data Table 3) as well as the age, sex, and race/ ethnicity of patients visiting the emergency department with AF from the California's Office of Statewide Health Planning and Development (OSHPD) database between January 1, 2005 to December 30, 2015. We used 2019 California Census data distributed by age, sex, and race/ ethnicity to obtain population denominators of those demographic variables. The exact date of each healthcare encounter was included. Because patients with AF may not present immediately to the ED with an episode, we analyzed the number of AF visits occurring on dates of the instrumental variable events plus 6 days. Candidate dates immediately preceding or following instrumental variable events were attributed to the instrumental variable event and included as an additional day in the analyses (e.g., if July 4 and July 5 were both identified, we analyzed the number of AF occurring on July 4 plus *7* days to incorporate July 5).

We performed a secondary analysis comparing the rates of new-onset (incident) AF during instrumental variable events versus all other dates. We ascertained incident AF diagnoses by excluding all individuals exhibiting at least one visit for AF that occurred during the first year of available OSHPD data obtained from ED visits, all inpatient hospitalizations, and all outpatient procedures, and then analyzing only the first ED visit for AF that occurred for each patient.

To validate our instrumental variable, we compared the identified dates to rates of patient visits with ICD-9 diagnostic codes indicating excessive alcohol consumption (Extended Data Table 3).

We conducted effect-modification analyses to investigate possible interactions related to age (dichotomized as ≥ 65 years versus younger for those analyses) and gender. Finally, we performed negative control analyses by comparing the empirically-derived instrumental variable events to ED visits for supraventricular tachycardia (SVT) without AF (Extended Data Table 3).

Statistical Analysis

Normally distributed continuous variables are expressed as means ± SD and continuous variables with skewed distributions are expressed as medians and interquartile ranges (IQR). Poisson regression models were used to compare rates of the outcome of interest (alcohol use disorders for validation analyses, SVT for negative control analyses, and AF for the main analyses) that occurred during and shortly after (within 6 days of) recurrent, nationally-recognized events after adjusting for calendar day of week, and calendar month. We derived estimates for rate differences, which are characterized as differences in the number of outcome events per 100,000 person-years, stratifying for California general population-level age, sex, and race/ ethnicity. Models were adjusted for the day of week and

calendar month. Statistical analyses were performed using SAS, version 9.4 (SAS Institute Inc., Cary, NC). Two-tailed p-values < 0.05 were considered statistically significant.

Extended Data

Extended Data Table 1.

List of all candidate dates identified empirically from BACtrack prior to being categorized as recurrent, nationally-recognized events.

2014 (Device Use)	2015 (Device Use)	2016 (Device Use)	2014 (Quantitative)	2015 (Quantitative)	2016 (Quantitative)
*January 1	*January 1		*January 1	*January 1	
				January 11	
				January 17	
	*January 18			*January 18	
			*January 20	January 24	
	January 25		January 25	January 25	
	January 31				
			*February 2	*February 1	
				February 22	February 21
			March 2	March 14	March 6
			*March 9		*March 13
				March 21	March 19
				March 22	March 20
				March 29	March 26
			April 27	April 12	April 2
				April 26	April 10
					April 30
			May 4		
June 22				*June 21	
June 28					
	*July 4			*July 4	
*July 5	*July 5				
July 12				July 12	
*July 13					July 10
July 19					July 31
July 20					
July 26					
July 27					
August 2					
August 3					
		November 20			
	December 5	December 3			
	December 6	December 10			
	December 12	December 11			
	December 13	December 17			
	December 19	December 18			
	December 20				
	*December 24	*December 24			
	*December 25	*December 25			
	*December 26	*December 26			
	December 27	December 29			
		December 30			

"Device Use" refers to empiric method of identifying candidate dates on BACtrack with the highest 5th percentile of breathalyzer use. "Blood Alcohol Content" refers to empiric method of identifying candidate dates on BACtrack with

the highest 5th percentile of median BAC after accounting for repeated BAC measurements within each participant (see methods for additional details).

Bold rectangle boxes indicate candidate dates or nationally-recognized events that recurred across multiple years or across candidate date selection methods.

* Indicates candidate dates that were identified as recurrent, nationally-recognized events to be used in AF analyses.

AF indicates atrial fibrillation; and BAC, blood alcohol content.

Extended Data Table 2.

List of calendar years for which recurrent, nationally-recognized events were empirically identified through either device-use or blood alcohol content selection methods from BACtrack.

	2014 (Device-Use)	2015 (Device-Use)	2016 (Device-Use)	2014 (Blood Alcohol Content)	2015 (Blood Alcohol Content)	2016 (Blood Alcohol Content)
New Year's Day	✓	✓		✓	✓	
*Sunday Before MLK Day					✓	
*MLK Day				✓		
Super Bowl Sunday				✓	✓	
Initiation of Daylight Saving				✓		✓
Time						
Father's Day					✓	
*July 4		✓			✓	
*July 5	✓	✓				
FIFA World Cup	✓					
*December 24 (Christmas Eve)		✓	✓			
*December 25 (Christmas)		✓	✓			
*December 26		✓	✓			

"Device-Use" refers to empiric method of identifying candidate dates on BACtrack with the highest 5th percentile of breathalyzer use. "Blood Alcohol Content" refers to empiric method of identifying candidate dates on BACtrack with the highest 5th percentile of median BAC after accounting for repeated BAC measurements within each participant (see methods for additional details).

Dates immediately preceding or following recurrent, nationally-recognized events were described as one event in the results (see Methods section).

BAC indicates blood alcohol content; MLK, Martin Luther King; and FIFA, Fédération Internationale de Football Association.

Extended Data Table 3.

International Classification of Disease-9th Edition (ICD-9) code identification.

Diagnosis	ICD-9
Excessive Alcohol Use	291–291.81 Alcohol-induced mental disorders
	303: Alcohol dependance
	303.0–303.03: Acute alcohol intoxication in alcoholism
	303.9–303.93: Other and unspecified alcohol dependence

Diagnosis	ICD-9
	305.0: Nondependent alcohol abuse
Atrial Fibrillation	427.31: Atrial fibrillation
Paroxysmal Supraventricular Tachycardia	427.0: Paroxysmal supraventricular tachycardia (atrioventricular re-entrant tachycardia [AVRT], atrioventricular re-entrant nodal tachycardia [AVNRT], atrial tachycardia, junctional tachycardia)

Data Availability

Investigators interested in using OSHPD data can apply at https://oshpd.ca.gov/data-and-reports/request-data. This administrative data is publicly available through the established processes of the Office of Statewide Health Planning and Development.

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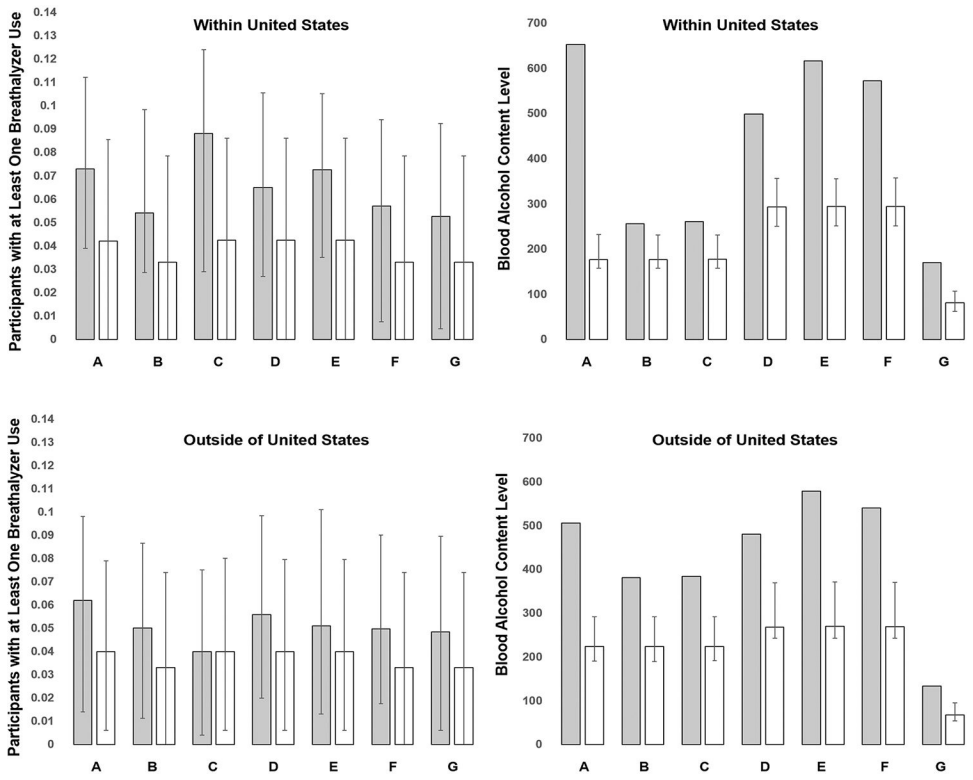

Figure 1. Number of participants with at least one breathalyzer use (left) and median blood alcohol content levels (right) of instrumental variable events between January 1, 2014 to December 31, 2016.

The Figure uses data derived from 1,269,054 breathalyzer measurements obtained from 36,158 individuals. The panel on the left (Panel A) represents a bar graph for instrumental variable events derived from the “device-use” method. The panel on the right (Panel B) represents a bar graph for instrumental variable events derived from the “blood alcohol content” method. For events selected from more than one year, the event on the year with either the highest number of participants with at least one breathalyzer use (Panel A) or highest median blood alcohol content levels (Panel B) are shown in this figure.

Grey bars represent the absolute number of participants with at least one breathalyzer use (Panel A) and median blood alcohol content levels (Panel B) for each event. White bars represent the median number of participants with at least one breathalyzer use on all other dates during the same year of an event and excluding that event (Panel A) and median blood alcohol content levels on all other dates during the same year of an event and excluding that event (Panel B). Y error bars represent 25th and 75th percentile participants with at least one breathalyzer use (Panel A) and blood alcohol content levels (Panel B).

Panel A:

I: January 1

II: July 4

III: July 5

IV: December 24

V: December 25

VI: December 26

VII: FIFA World Cup
Panel B:
I: January 1
II: Sunday Before Martin Luther King Day
III: Martin Luther King Day
IV: Super Bowl Sunday
V: Initiation of Daylight Saving Time
VI: July 4
VII: Father's Day
BAC indicates blood alcohol content; FIFA, Fédération Internationale de Football Association.

Table 1.

Rate differences per 100,000 person-years for validation analyses utilizing alcohol-related ED visits for both individual and aggregated instrumental variable events versus all other calendar dates.

	Rate differences	95% CI	P-values
January 1	9600	7451, 11750	<0.001
MLK Day	−85	−2214, 2044	0.94
Super Bowl Sunday	6314	4171, 8458	<0.001
Initiation of Daylight Saving Time	666	−1276, 2609	0.50
July 4	6425	4593, 8257	<0.001
Christmas	3587	1587, 5586	<0.001
FIFA World Cup	4415	950, 7880	0.013
Father's Day	−1591	−3563, 3801	0.11
Aggregated	2640	1903, 3376)	<0.001

Estimates were derived from a Poisson regression model after adjusting for calendar day of week, and calendar month. Two-tailed p-values < 0.05 were considered statistically significant.

CI indicates confidence intervals; IV, instrumental variable; MLK, Martin Luther King; and FIFA, Fédération Internationale de Football Association

Table 2.

Rate differences per 100,000 person-years for primary analyses utilizing ED visits for atrial fibrillation for both individual and aggregated instrumental variable events versus all other calendar dates.

	Rate differences	95% CI	P-values
January 1	4637	3054, 6221	<0.001
MLK Day	−1359	−2836, 118	0.07
Super Bowl Sunday	3111	1604, 4617	<0.001
Initiation of Daylight Saving Time	2186	800, 3572	0.002
July 4	−697	−2097, 704	0.33
Christmas	5362	3996, 6729	<0.001
FIFA World Cup	−1900	−4434, 6342	0.14
Father's Day	771	−677, 2219	0.30
Aggregated	719	189, 1249	0.008

Estimates were derived from a Poisson regression model after adjusting for calendar day of week, and calendar month. Two-tailed p-values < 0.05 were considered statistically significant.

CI indicates confidence intervals; IV, instrumental variable; MLK, Martin Luther King; and FIFA, Fédération Internationale de Football Association

Table 3.

Rate differences per 100,000 person-years for negative control analyses utilizing ED visits for SVT for both individual and aggregated instrumental variable events versus all other calendar dates.

	Rate differences	95% CI	P-values
January 1	1416	−4892, 7724	0.66
MLK Day	−419	−6840, 6001	0.90
Super Bowl Sunday	674	−5825, 7173	0.84
Initiation of Daylight Saving Time	−1716	−7857, 4426	0.58
July 4	−583	−6816, 5650	0.85
Christmas	458	−5630, 6546	0.88
FIFA World Cup	493	−10680, 11670	0.93
Father's Day	−96	−6531, 6338	0.98
Aggregated	466	−1854, 2786	0.69

Estimates were derived from a Poisson regression model after adjusting for calendar day of week, and calendar month. Two-tailed p-values < 0.05 were considered statistically significant.

CI indicates confidence intervals; IV, instrumental variable; MLK, Martin Luther King; and FIFA, Fédération Internationale de Football Association