JAMA Internal Medicine | Original Investigation

Syncope and the Risk of Subsequent Motor Vehicle Crash
A Population-Based Retrospective Cohort Study

John A. Staples, MD, MPH; Shannon Erdelyi, MSc; Ketki Merchant, MSc, MBBS; Candace Yip, BSc; Mayesha Khan, MA; Donald A. Redelmeier, MD, MSHSR; Herbert Chan, PhD; Jeffrey R. Brubacher, MD

IMPORTANCE Medical driving restrictions are burdensome, yet syncope recurrence while driving can cause a motor vehicle crash (MVC). Few empirical data inform current driving restrictions after syncope.

OBJECTIVE To examine MVC risk among patients visiting the emergency department (ED) after first-episode syncope.

DESIGN, SETTING, AND PARTICIPANTS A population-based, retrospective observational cohort study of MVC risk after first-episode syncope was performed in British Columbia, Canada. Patients visiting any of 6 urban EDs for *syncope and collapse* were age- and sex-matched to 4 control patients visiting the same ED in the same month for a condition other than syncope. Patients' ED medical records were linked to administrative health records, driving history, and detailed crash reports. Crash-free survival among individuals with syncope was then compared with that among matched control patients. Data analyses were performed from May 2020 to March 2022.

EXPOSURES Initial ED visit for syncope.

MAIN OUTCOMES AND MEASURES Involvement as a driver in an MVC in the year following the index ED visit. Crashes were identified using insurance claim data and police crash reports.

RESULTS The study cohort included 43 589 patients (9223 patients with syncope and 34 366 controls; median [IQR] age, 54 [35-72] years; 22 360 [51.3%] women; 5033 [11.5%] rural residents). At baseline, crude MVC incidence rates among both the syncope and control groups were higher than among the general population (12.2, 13.2, and 8.2 crashes per 100 driver-years, respectively). In the year following index ED visit, 846 first crashes occurred in the syncope group and 3457 first crashes occurred in the control group, indicating no significant difference in subsequent MVC risk (9.2% vs 10.1%; adjusted hazard ratio [aHR], 0.93; 95% CI, 0.87-1.01; $P = .07$). Subsequent crash risk among patients with syncope was not significantly increased in the first 30 days after index ED visit (aHR, 1.07; 95% CI, 0.84-1.36; $P = .56$) or among subgroups at higher risk of adverse events after syncope (eg, age >65 years; cardiogenic syncope; Canadian Syncope Risk Score ≥1).

CONCLUSIONS AND RELEVANCE The findings of this population-based retrospective cohort study suggest that patients visiting the ED with first-episode syncope exhibit a subsequent crash risk no different than the average ED patient. More stringent driving restrictions after syncope may not be warranted.

JAMA Intern Med. doi:10.1001/jamainternmed.2022.2865
Published online August 1, 2022.

Editor's Note

Supplemental content

Author Affiliations: Department of Medicine, University of British Columbia, Vancouver, British Columbia, Canada (Staples, Merchant, Yip, Khan); Centre for Clinical Epidemiology & Evaluation, Vancouver, British Columbia, Canada (Staples, Brubacher); Department of Emergency Medicine, University of British Columbia, Vancouver, British Columbia, Canada (Erdelyi, Chan, Brubacher); Sunnybrook Research Institute, Toronto, Ontario, Canada (Redelmeier); Department of Medicine, University of Toronto, Toronto, Ontario, Canada (Redelmeier).

Corresponding Author: John A. Staples, MD, MPH, Department of Medicine, University of British Columbia, 828 West 10th Avenue, VGH Research Pavilion, Room 276, Vancouver, BC V5Z1M9, Canada (john.staples@ubc.ca).

Syncope is characterized by a sudden loss of consciousness and postural tone, manifestations which can incapacitate a driver and cause a motor vehicle crash (MVC).[1] The potential for syncope-related crash alarms clinicians and policy makers because syncope results in 1.3 million emergency department (ED) visits in the US annually,[2] it recurs in up to 9% of patients per year,[3] and up to 10% of patients referred to specialized syncope clinics report a prior episode of syncope while driving.[1,4] In response, many jurisdictions compel individuals at higher risk of syncope recurrence to temporarily cease driving (eTable 1 in the Supplement).[5-9]

Previous studies on the risk of MVC after syncope have produced conflicting findings.[10] Some studies indicate that syncope-related crashes are rare and suggest that burdensome driving restrictions are unwarranted.[11-15] Other studies imply that the risk of syncope-related crash is substantial and suggest that current driving restrictions are insufficient.[16-20] Most studies of syncope and MVC risk exhibit major methodologic limitations, including the lack of a control group,[11,12,16,18,19,21-25] reliance on self-reported crash data,[11,13,14,16,21-25] small sample size,[4,11-13,16,18,21,24,25] and poor generalizability to patients typically seen in routine clinical practice.[4,11,12,14,16,19,21-23,25] Road risks plausibly differ by syncope subtype (eg, vasovagal, orthostatic, cardiogenic), yet most larger studies based on administrative data are unable to distinguish between these groups.[17,19,20] As a consequence, clinical practice guidelines provide vague and inconsistent guidance on driving safety after syncope,[26-28] and syncope-related driving restrictions vary widely by jurisdiction.[5]

Physician warnings to patients who are potentially unfit to drive are associated with a reduction in subsequent road trauma, yet they also impose substantial social and financial burdens on the individuals advised or compelled to temporarily cease driving.[19] Recognizing that real-world data on crash risks after syncope may help clinicians, policy makers, and patients navigate fitness-to-drive decision-making, we conducted a population-based observational cohort study of crash risk after an emergency department (ED) visit for first-episode syncope.

Key Points

Question Is first-episode syncope associated with an increased risk of subsequent motor vehicle crash?

Findings This population-based retrospective observational cohort study examined 9223 patients who visited the emergency department (ED) for first-episode syncope and 34 366 matched control patients who visited the ED for a condition other than syncope. Researchers found that the risk of motor vehicle crash during the following year was similar in both groups.

Meaning In contrast to the results of previous studies, these findings suggest that more stringent driving restrictions after syncope may not be necessary.

Methods

The University of British Columbia Clinical Research Ethics Board approved the study and waived the requirement for individual consent. Data were deidentified before release to investigators. Results are presented in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.

Study Setting

During the study interval, British Columbia (BC), Canada, had 5 million residents, an annual vehicle mileage of 13 100 km per resident, an annual MVC incidence rate of 8.2 crashes per 100 driver-years, and an annual road fatality rate of 8.3 traffic deaths per 100 000 drivers.[29,30] The Insurance Corporation of British Columbia (ICBC) was the sole provider of mandatory basic automobile insurance for all vehicles registered in BC and the sole provider of driver licensing services for all 3.2 million drivers licensed in BC. Residents of BC accessed medical care using publicly funded universal health insurance.

Study Cohort

We drew the study cohort from a repository of administrative data on all visits to all EDs within the geographic boundaries of Vancouver Coastal Health, an administrative jurisdiction serving a contiguous urban region with more than 1 million residents.[31] The study cohort included individuals with 1 or more ED visits with a discharge diagnosis of syncope (Canadian Emergency Department Diagnosis Shortlist code R55, *syncope and collapse*) occurring between January 1, 2010, and December 31, 2015.[32-34] We included only an individual's first syncope visit to avoid oversampling of patients with recurrent syncope. We excluded individuals who (1) were 18 years of age or younger at index ED visit, (2) had a prior ED visit for syncope (January 1, 2007-December 31, 2009), or (3) had an index ED visit that resulted in hospitalization for more than 7 days. We matched each patient with syncope to 4 control patients with an index ED visit for a condition other than syncope (ie, *presenting complaint* was not *syncope/presyncope*; discharge diagnosis was not *syncope and collapse*). Matching was based on sex, age (±5 years), hospital site, and month of visit.

Medical Records

Two trained abstractors (K.M., C.Y.) reviewed all index ED visit medical records for all syncope patients and for a 5% random sample of controls (eMethods 1 in the Supplement). Based on these medical records, abstractors assessed the likelihood that syncope had occurred (definitely, very likely, possibly, unlikely, definitely did not occur), the likelihood that presyncope occurred, and the likely cause of syncope or presyncope. This method of assessment has shown excellent face validity.[33] We obtained selected laboratory data and all electrocardiogram (ECG) data from the index ED visit to facilitate calculation of the Canadian Syncope Risk Score and the San Francisco Syncope Rule.

Administrative Health Data

We linked the data abstracted from medical records to population-based administrative health data that have been used extensively in prior research (eMethods 2 in the Supplement).[35]

We obtained sex, age, and residential neighborhood from the Consolidation File; physician billing data from the Medical Services Plan; ED visit data from the National Ambulatory Care Reporting System; hospitalization data from the Discharge Abstract Database; community pharmacy prescription data from PharmaNet; neighborhood income quintile from the Income Band data set; and deaths from Vital Statistics data.

Baseline comorbidities were considered present when found within any of the 25 diagnosis fields for 1 or more hospitalizations or in any of the 5 diagnosis fields for 2 or more physician visits in a 5-year look-back interval, using diagnostic codes from the *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* (Discharge Abstract Database) and the *International Classification of Diseases, Ninth Revision, Clinical Modification* (Medical Services Plan). Additional details are available in eTable 2 in the Supplement. Baseline prescription medications were considered present when a prescription was dispensed in the 60 days leading up to the index ED visit date.

Driving Data

We obtained province-wide population-based driving history and MVC data from ICBC as in prior studies (eMethods 2 in the Supplement).[35] We used a previously established probabilistic linkage between driver license number and Personal Health Number based on name, sex, and birth date, with linkage rates of 95% or higher.[36] We established baseline driver history using a 5-year look-back interval, including the number of traffic contraventions for alcohol, speeding, or distracted driving; number of crashes as a driver; possession of vehicle insurance; license issuance, suspension, and expiration dates; and license type on index date. We obtained data on all police-reported crashes from the Traffic Accident System and used these data to identify fatal crashes. We obtained data from the ICBC Claims File to identify all crashes that involved a vehicle registered in BC and resulted in an insurance claim. We used the Claims File to identify total crashes and injury crashes because police attendance at nonfatal crashes in BC is discretionary. Both sources of crash data identify the driver of every vehicle involved in a recorded crash. Crashes occurring on the index date were assumed to be the cause of the index ED visit and were excluded from analysis.

Statistical Analysis

We used a cohort design to assess absolute and relative risks of crash after index ED visit (eFigure 1 in the Supplement). Our primary analysis used a Cox proportional hazards model to compare crash-free survival after index ED visit among patients with syncope and control patients. Individuals were followed from baseline (t_O = index ED visit discharge date, or hospital discharge date if admitted to hospital directly from index ED visit) and were right censored at t_O if unlicensed at t_O, and were otherwise right censored at the time of crash, death, subsequent license suspension or expiration, subsequent hospitalization for more than 30 days, completion of 1 year of follow-up, or study end (December 31, 2016). We adjusted regression models for matching characteristics and for factors known to be associated with MVC risk: age group and sex; year, season, and site of index ED visit; income quintile, urbanicity, and health authority of residential neighborhood; Charlson Comorbidity Index score of 2 or more; prior visits for substance misuse in the past 5 years; number of physician visits and overnight hospitalizations in the past year; number of prescription medications filled and fills for benzodiazepines and opioids in the past 60 days; full driver license instead of a learner or novice license at index date; years since granted full license; and crashes, total contraventions, impairment-related contraventions, and number of years with motor vehicle insurance in the past 5 years.

We repeated the main analysis for clinically important subgroups. We evaluated changes in risk after index ED visit using a piecewise Cox proportional hazards model with an interaction term between exposure and *time period from* t_O (0-30, 31-90, 91-180, and 181-360 days). We examined subsequent traffic contraventions as a driver and injuries as a nondriver (eg, passenger, pedestrian, cyclist) as surrogates for road exposure. Data were rarely missing (eMethods 2 in the Supplement). Data analyses were performed from May 2020 to March 2022 using R, version 4.0 (The R Foundation for Statistical Computing). Statistical tests were 2-tailed and P values < .05 were considered statistically significant.

Results

The final study cohort consisted of 43 589 individuals (9223 syncope patients and 34 366 age- and sex-matched controls; median [IQR] age, 54 [35-72] years; 22 360 [51.3%] women; 5033 [11.5%] rural residents). Race and ethnicity data were not collected. A participant flow diagram is presented in eFigure 2 in the Supplement. Among the cohort, 92% held an active driver license and 26% had a crash in the 5 years prior to index ED visit (**Table 1**). Compared with controls, patients with syncope had fewer hospitalizations and clinic visits in the year prior to index visit; were slightly more likely to have recent prescriptions for antihypertensives, atrioventricular nodal blocking agents, and diuretics; were less likely to have recent prescriptions for opioids, benzodiazepines, and QTc-prolonging agents; and were less likely to have prior traffic contraventions. Most patients in the syncope group were judged by medical record abstractors to have *definite or likely* syncope, with the most common causes being vasovagal and orthostatic (**Table 2**). Physicians documented having given driving advice to only 1.4% of patients in the syncope group.

In the year after index ED visit, there were 846 first crashes among patients with syncope and 3457 first crashes among controls, indicating that there was no significant difference in MVC risk between the groups (9.2% vs 10.1% crashed before a censoring event; first-crash incidence rate accounting for censoring, 12.3 vs 14.0 per 100 person-years; adjusted hazard ratio [aHR], 0.93; 95% CI, 0.87-1.01; P = .07; **Table 3**; **Figure 1**). Syncope patients were less likely to be censored by death (1.3% vs 2.6%) or hospitalization for more than 30 days (1.0% vs 1.4%). A similar proportion of syncope and control patients acquired 1 or more traffic contraventions in the year following index ED visit and subsequent hospitalization for traffic injury was rare

Table 1. Baseline Patient Characteristics

Characteristic	No. (%)			
	Syncope (n = 9223)	Syncope definite or likely (n = 5546)	Controls (n = 34 366)	*P* value [a]
Sex				
Female	4710 (51.1)	2809 (50.6)	17 650 (51.4)	.63
Male	4513 (48.9)	2737 (49.4)	16 716 (48.6)	
Age, median (IQR)	55 (35-72)	52 (32-70)	54 (35-70)	.09
Rural residence	1055 (11.4)	640 (11.5)	3978 (11.6)	.91
≥1 Hospitalization in prior year	1267 (13.7)	679 (12.2)	6198 (18.0)	<.001
≥7 Physician visits in prior year	6250 (67.8)	3549 (64.0)	24 953 (72.6)	<.001
Charlson comorbidity score ≥2	1926 (20.9)	1031 (18.6)	7694 (22.4)	.002
Selected comorbidities				
CVD	2166 (23.5)	1119 (20.2)	7121 (20.7)	<.001
Hypertension	3244 (35.2)	1768 (31.9)	10 997 (32.0)	<.001
Atrial fibrillation and flutter	465 (5.0)	227 (4.1)	1768 (5.1)	.71
Syncope	322 (3.5)	191 (3.4)	353 (1.0)	<.001
COPD	1013 (11.0)	546 (9.8)	4666 (13.6)	<.001
Psychiatric disorder	2797 (30.3)	1576 (28.4)	11 381 (33.1)	<.0001
Alcohol misuse	283 (3.1)	141 (2.5)	1458 (4.2)	<.001
Other substance misuse	294 (3.2)	160 (2.9)	1790 (5.2)	<.001
Prescription medications at baseline				
≤1	5886 (63.8)	3722 (67.1)	21 228 (61.8)	<.001
≥2	3337 (36.2)	1824 (32.9)	13 138 (38.2)	
Antihypertensives	3084 (33.4)	1709 (30.8)	10 369 (30.2)	<.001
ACEi or ARB	2051 (22.2)	1123 (20.2)	6366 (18.5)	<.001
β Blockers	1303 (14.1)	674 (12.2)	4315 (12.6)	<.001
Calcium channel blockers	971 (10.5)	521 (9.4)	3413 (9.9)	.09
Diuretics	1403 (15.2)	782 (14.1)	4609 (13.4)	<.001
Antiseizure drugs	512 (5.6)	271 (4.9)	1995 (5.8)	.37
Benzodiazepines	680 (7.4)	330 (6.0)	3137 (9.1)	<.001
Opioids	816 (8.8)	448 (8.1)	5022 (14.6)	<.001
QTc-prolonging drugs	1047 (11.4)	567 (10.2)	5401 (15.7)	<.001
Driving history (prior 5 y)				
Full license (vs learners/novice)	7760 (84.1)	4660 (84.0)	28 476 (82.9)	.008
Active license	8469 (91.8)	5142 (92.7)	31 210 (90.8)	.003
Active insurance	6169 (66.9)	3701 (66.7)	23 058 (67.1)	.71
Insurance, median (IQR), d	1132 (0-1825)	1126 (0-1825)	1043 (0-1825)	.04
≥1 Crash	2348 (25.5)	1408 (25.4)	9281 (27.0)	.003
≥1 Contravention	2417 (26.2)	1491 (26.9)	10 618 (30.9)	<.001
Alcohol-related	167 (1.8)	107 (1.9)	1041 (3.0)	<.001
Speed-related	1207 (13.1)	742 (13.4)	5084 (14.8)	<.001
Distraction-related	273 (3.0)	171 (3.1)	1155 (3.4)	.06

Abbreviations: ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular disease; QTc, corrected QT interval on electrocardiogram.

[a] *P* values for categorical data generated using a z test for 2 independent proportions, and for numeric data using the Mann-Whitney U test for 2 independent groups.

in both groups, suggesting no substantial difference in subsequent road exposure (eTable 3 in the Supplement).

The subgroup of individuals deemed by abstractors to have *definite or likely* syncope had a significantly lower likelihood of subsequent crash compared with controls (aHR, 0.89; 95% CI, 0.81-0.98; *P* = .02), as did the nested subset deemed to have *definite or likely* syncope of vasovagal cause (aHR, 0.86; 95% CI, 0.77-0.96; *P* = .005). Results of other subgroup analyses were generally consistent with the main analysis, even among individuals at higher risk of adverse events after syncope (eg, cardiogenic syncope; presence of cardiovascular disease; Canadian Syncope Risk Score ≥1; San Francisco Syncope Rule score ≥1; or hospitalization at index visit) and among individuals who might have been less able to limit driving (eg, working age, rural residence; **Figure 2**; eTables 4 and 5 in the Supplement). Among drivers with a commercial license, commercial vehicle crashes were no more common among the syncope group than among the control group (eTable 4 in the Supplement). Sudden driver incapacitation might provoke injurious or unexplained crashes, yet patients in the syncope group were no more likely be involved in subsequent casualty or single vehicle crashes (eTable 6 in the Supplement). The hazard of MVC was similar between syncope and control groups in all examined time intervals (eTable 7 and eFigure 3 in the Supplement). There was a modest decrease in crash risk for patients in both the syncope and control groups in the days immediately following index ED visit, perhaps because hospitalization or residual illness was associated with reduced road exposure (eFigure 4 in the Supplement).

Table 2. Clinical Details From Medical Record Review of Index ED Visit

Characteristic	No. (%)		
	Syncope (n = 9112)	Syncope definite or likely (n = 5546)	Controls (n = 1729)
Postural vital signs checked	1957 (21.5)	1237 (22.3)	18 (1.0)
ECG performed	8211 (90.1)	5084 (91.7)	447 (25.9)
Canadian Syncope Risk Score ≥1	1883 (20.7)	1011 (18.2)	NA
San Francisco Syncope Rule score ≥1	4867 (53.4)	2980 (53.7)	NA
Discharge diagnosis			
Syncope and collapse	9112 (100)	5546 (100)	NA
Other injury	NA	NA	295 (17.1)
Abdominal pain, unspecified	NA	NA	87 (5.0)
Chest pain, unspecified	NA	NA	82 (4.7)
Skin and soft tissue infection	NA	NA	69 (4.0)
Respiratory infection	NA	NA	51 (2.9)
ED discharge disposition			
Discharged	8249 (90.5)	4986 (89.9)	1518 (87.8)
Hospitalized	778 (8.5)	512 (9.2)	188 (10.9)
Other	85 (0.9)	48 (0.9)	23 (1.3)
Abstractor conclusions about syncope			
Definite	4775 (52.4)	4775 (86.1)	<5
Likely	771 (8.5)	771 (13.9)	6 (0.3)
Possible	322 (3.5)	NA	8 (0.5)
Unlikely	327 (3.6)	NA	21 (1.2)
No syncope	2793 (30.7)	NA	1660 (96.0)
Missing data	124 (1.4)	NA	31 (1.8)
Syncope causes			
Vasovagal	6148 (67.5)	4119 (74.3)	32 (1.9)
Orthostatic	1103 (12.1)	741 (13.4)	15 (0.9)
Cardiac	529 (5.8)	350 (6.3)	42 (2.4)
Other causes	372 (4.1)	289 (5.3)	<5
Nonsyncopal TLOC	212 (2.3)	46 (0.8)	18 (1.0)
No TLOC	480 (5.3)	NA	102 (5.9)
Missing data	268 (2.9)	<5	1516 (87.7)
Documented physician driving advice	131 (1.4)	91 (1.6)	NA

Abbreviations: CTAS, Canadian Triage and Acuity Scale; ECG, electrocardiogram; ED, emergency department; NA, not applicable; TLOC, transient loss of consciousness.

Medical record review was completed for 9112 of 9223 syncope-group patients (98.8%) and for 1729 of 34 366 control-group patients (5.0%). Abstractors were instructed to assign a syncope cause even when syncope was deemed to be unlikely or absent.

Compared with the general population of drivers in BC at the midpoint of the study interval, the crude baseline MVC incidence rate was significantly higher for patients with syncope (12.2 vs 8.2 crashes per 100 driver-years; incidence rate ratio, 1.48; 95% CI, 1.40-1.57; $P < .001$) as well as control patients (13.2 vs 8.2 crashes per 100 driver-years; incident rate ratio, 1.61; 95% CI, 1.57-1.66; $P < .001$).[30]

Discussion

In this population-based, multicenter, retrospective observational cohort study, we found that 9223 drivers visiting the ED for syncope exhibited a subsequent crash risk no different than that observed among matched controls visiting the ED for a condition other than syncope. We found no evidence of increased crash risk in the first month after index ED visit or among subgroups at higher risk of adverse events after syncope. Among the subgroup with *definite or likely* syncope of vasovagal cause, we observed a lower risk of subsequent crash than among controls. Crash risks among patients with syncope and among control patients exceeded those of the general population. Together, these data suggest that contemporary driving restrictions after first-episode syncope adequately address the risk of subsequent syncope-related crash.

Clinicians and policy makers should consider several key factors when interpreting these study results. First, relative crash rates after syncope may appear unexpectedly low because the baseline crash risk among controls was substantially higher than for the average driver in BC. Other ED patients are the most meaningful comparator for clinicians working in the ED, yet this design choice may be one reason for the contrast between our findings and those of other studies that used the general population as a reference group.[13,14,17] Second, individuals may have curtailed their road exposure (ie, miles or hours of driving per week) after syncope because they were instructed by a physician to temporarily cease driving, because they had independent concerns about syncope and driving, or because an underlying condition prompting syncope made driving unappealing (eg, severe hypovolemia from intractable vomiting).[37] Theoretically, a large decrease in road exposure may have masked a large increase in *crash risk while driving* (potentially from syncope-related incapacitation). However, we found that physicians rarely provided driving advice and that patients in

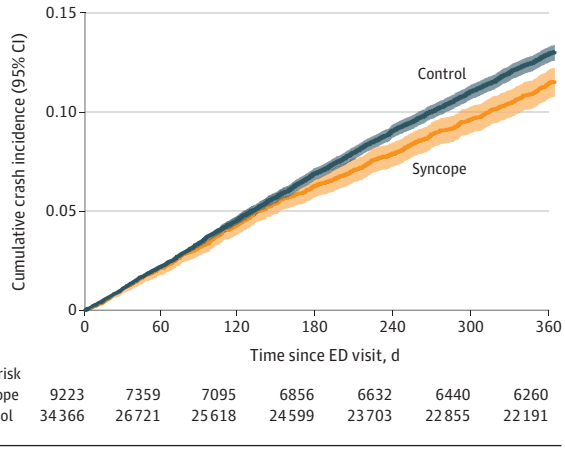
Table 3. First Event (Motor Vehicle Crash or Censoring Event) During the Year After Index ED Visit

Outcome	Syncope (n = 9223)	Syncope definite or likely (n = 5546)	Controls (n = 34 366)
Motor vehicle crashes			
All crashes (primary outcome)	846 (9.2)	498 (9.0)	3457 (10.1)
Casualty crashes (fatality or injury)	208 (2.3)	125 (2.3)	910 (2.6)
Fatal crashes	<5	0	<5
Property damage only	638 (6.9)	373 (6.7)	2547 (7.4)
Vehicles involved			
Single vehicle	192 (2.1)	110 (2.0)	729 (2.1)
Multiple vehicles	654 (7.1)	388 (7.0)	2728 (7.9)
Censoring events			
Death (all cause)	120 (1.3)	65 (1.2)	899 (2.6)
Hospitalized for >30 d	89 (1.0)	41 (0.7)	488 (1.4)
License suspended for >30 d	37 (0.4)	24 (0.4)	238 (0.7)
License expired for >30 d	1882 (20.4)	1030 (18.6)	7135 (20.8)
No crash or censoring event	6249 (67.8)	3888 (70.1)	22 149 (64.5)

Abbreviation: ED, emergency department.

Events occurring after the first crash or censoring event are excluded; without censoring is reported in eTable 3 in the Supplement. Driver license expiration was common during the study interval, but results of a sensitivity analysis that ignored it as a censoring event yielded similar results (eTable 6 in the Supplement).

Figure 1. Cumulative Motor Vehicle Crash Incidence



Cumulative crash incidence calculated using the Kaplan-Meier survival function to account for censoring events. ED indicates emergency department.

the syncope and control groups acquired a similar number of subsequent contraventions, arguing against a substantial curtailing of road exposure after syncope. Third, physicians might have appropriately identified and restricted driving only for the patients at the very highest risk of syncope recurrence. Overall, it seems implausible that the first 2 mechanisms are masking a clinically meaningful increase in crash risk after the typical ED visit for first-episode syncope; the third mechanism indicates physician screening for medically unfit drivers is working as intended.

A 2016 retrospective administrative database study by Numé and colleagues[17] found that 41 039 individuals visiting a hospital or an ED for syncope had twice the likelihood of subsequent crash injury relative to the general population. However, Numé and colleagues set their study in Denmark, where road travel is significantly safer than in Canada (5.6 vs 6.7 fatalities per billion vehicle-km)[38]; their syncope patients were older (median age, 66 vs 56 years) and far more likely to be hospitalized for syncope at the index visit (62% vs 11%); they compared syncope patients with the general population instead of with more crash-prone ED patients; their outcomes only included crash injuries resulting in hospital evaluation or death; and their outcomes included crashes occurring up to 48 hours before the index ED visit for syncope. These differences may explain why they found a statistically significant association between syncope and crash, and we did not.

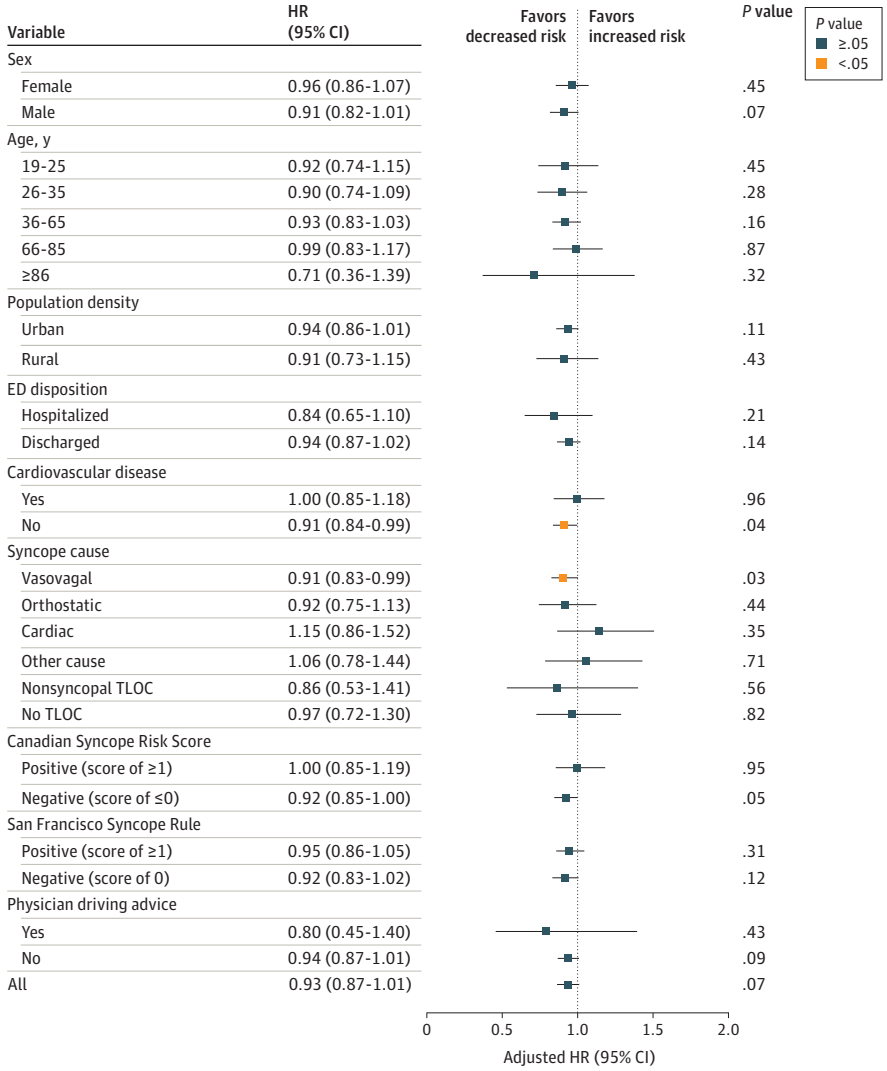
Our results also run counter to those of other studies. A study of 7750 drivers hospitalized for crash injury in Maryland (US) found that a prior diagnosis of syncope was associated with a 4-fold increase in police-determined crash culpability.[20] Another population-based study found that 25 422 individuals receiving a physician warning not to drive after "fainting or dizziness" had a baseline crash risk 3-fold higher than that of the general population.[19] Our findings may reassure clinicians and patients that the typical patient seen in the ED for first-episode syncope is at lower risk of crash than these earlier studies imply.

Strengths and Limitations

Our study had many strengths. We used a straightforward population-based cohort design that yielded both absolute and relative risks; we verified the diagnosis of syncope using medical record review; we relied on objective (rather than self-reported) real-world MVC data that distinguished drivers from passengers; we used granular health data, including outpatient prescription drug fills for all ages and a 5-year comorbidity look-back interval; we selected a control group highly relevant to clinicians in the ED; we accounted for competing risks, including license suspension and death, before analyzing the 4303 eligible first-crash outcomes; we examined high-risk subgroups; and our sensitivity analyses demonstrated results were robust to changes in study design.

Our study also had limitations. We identified syncope using standard diagnostic coding but did not include more specific diagnoses that have the potential to cause syncope (eg, ventricular tachycardia, cardiac arrest, pulmonary embolism, hypotension). Syncope diagnostic coding alone had only modest specificity for abstractor-confirmed syncope; reassuringly, individuals with *definite* or *likely* syncope exhibited results similar to the primary analysis. (eTable 1 in the Supplement).

Figure 2. Forest Plot Results for Selected Subgroup Analyses



Squares depict the adjusted HR point estimate; horizontal lines depict the 95% CIs. Results of the main analysis and the subgroup analyses for sex, age, residential neighborhood population density, and ED disposition compare all 9223 patients in the syncope group with all 34 366 patients in the control group. Subgroup analyses based on variables available only in medical record review (cardiovascular disease, syncope causes, Canadian Syncope Risk Score, San Francisco Syncope Rule score, physician driving advice) compare the 9112 patients who had a completed medical record review in the syncope group with 34 366 patients in the control group. ED indicates emergency department and TLOC indicates transient loss of consciousness.

Most patients in this study had first-episode vasovagal syncope and, thus, would not have been subjected to any warning or driving restriction. Moreover, the BC Motor Vehicle Act requires clinicians to report potentially unfit drivers only if they continue to drive after being warned. All participants held a driver license, but we lacked individual road exposure data. Surrogate measures of road exposure are likely insensitive to changes in driving habits. A substantial proportion of drivers were censored from the main analysis for license expiration; a sensitivity analysis that removed license expiration as a censoring event yielded results very similar to the main analysis. Patients in the control group may have had more road exposure or more unsafe driving behaviors at baseline that were not entirely accounted for despite adjustment for baseline crashes and traffic contraventions.

Conclusions

Medical driving restrictions affect employment and impair quality of life.[39] This population-based cohort study found that patients with first-episode syncope treated in the ED according to current clinical practice were no greater a threat to road safety than the average ED patient. These findings suggest that more stringent driving restrictions after syncope may not be warranted.

ARTICLE INFORMATION

Accepted for Publication: May 26, 2022.

Published Online: August 1, 2022. doi:10.1001/jamainternmed.2022.2865

Author Contributions: Ms Erdelyi had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: Staples, Erdelyi, Redelmeier, Chan, Brubacher.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Staples, Erdelyi, Merchant, Khan.
Critical revision of the manuscript for important intellectual content: All authors.

Statistical analysis: Staples, Erdelyi, Redelmeier.
Obtained funding: Staples, Erdelyi, Redelmeier, Chan, Brubacher.
Administrative, technical, or material support: Staples, Erdelyi, Merchant, Yip, Khan, Chan, Brubacher.
Supervision: Staples, Redelmeier, Brubacher.

Conflict of Interest Disclosures: Dr Staples reported support through a Mentored Clinician Scientist Award from the Vancouver Coastal Health Research Institute and a Health Professional Investigator Award from Michael Smith Health Research BC. Dr Brubacher reported support from Michael Smith Health Research BC and the British Columbia Emergency Medicine Network. No other disclosures were reported.

Funding/Support: This study was supported by a grant from the Canadian Institutes of Health Research (No. PJT-148849).

Role of the Funder/Sponsor: The Canadian Institutes of Health Research 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.

Disclaimer: All inferences, opinions, and conclusions drawn are those of the authors and do not reflect the opinions or policies of the Data Stewards.

REFERENCES

1. Sorajja D, Nesbitt GC, Hodge DO, et al. Syncope while driving: clinical characteristics, causes, and prognosis. *Circulation*. 2009;120(11):928-934. doi:10.1161/CIRCULATIONAHA.108.827626

2. Agency for Healthcare Research and Quality. HCUPnet: Healthcare Cost and Utilization Project. Accessed October 18, 2021. https://hcupnet.ahrq.gov/

3. Solbiati M, Casazza G, Dipaola F, et al. Syncope recurrence and mortality: a systematic review. *Europace*. 2015;17(2):300-308. doi:10.1093/europace/euu327

4. Li H, Weitzel M, Easley A, Barrington W, Windle J. Potential risk of vasovagal syncope for motor vehicle driving. *Am J Cardiol*. 2000;85(2):184-186. doi:10.1016/S0002-9149(99)00647-5

5. Margulescu AD, Anderson MH. A review of driving restrictions in patients at risk of syncope and cardiac arrhythmias associated with sudden incapacity: differing global approaches to regulation and risk. *Arrhythm Electrophysiol Rev*. 2019;8(2):90-98. doi:10.15420/aer.2019.13.2

6. Carr DB, Schwartzberg JG, Manning L, Sempek J. *Physician's Guide to Assessing and Counseling the Older Driver*. 2nd ed. National Highway Traffic Safety Administration; 2010.

7. Dobbs B. *Medical conditions and driving: a review of the scientific literature 1960-2000*. National Highway Traffic Safety Administration; 2005.

8. Canadian Medical Association. *CMA drivers guide: determining medical fitness to operate motor vehicles*. 9.1 ed. Canadian Medical Association; 2019.

9. Canadian Council of Motor Transport Administrators. *National Safety Code Standard 6: Determining Driver Fitness in Canada*. 13th ed. Canadian Council of Motor Transport Administrators; 2021.

10. Chee JN, Simpson C, Sheldon RS, et al. A systematic review of the risk of motor vehicle collision in patients with syncope. *Can J Cardiol*. 2021;37(1):151-161. doi:10.1016/j.cjca.2020.02.070

11. Bhatia A, Dhala A, Blanck Z, Deshpande S, Akhtar M, Sra AJ. Driving safety among patients with neurocardiogenic (vasovagal) syncope. *Pacing Clin Electrophysiol*. 1999;22(11):1576-1580. doi:10.1111/j.1540-8159.1999.tb00375.x

12. Folino AF, Migliore F, Porta A, Cerutti S, Iliceto S, Buja G. Syncope while driving: pathophysiological features and long-term follow-up. *Auton Neurosci*. 2012;166(1-2):60-65. doi:10.1016/j.autneu.2011.09.003

13. Koepsell TD, Wolf ME, McCloskey L, et al. Medical conditions and motor vehicle collision injuries in older adults. *J Am Geriatr Soc*. 1994;42(7):695-700. doi:10.1111/j.1532-5415.1994.tb06526.x

14. Tan VH, Ritchie D, Maxey C, Sheldon R; POST Investigators. Prospective assessment of the risk of vasovagal syncope during driving. *JACC Clin Electrophysiol*. 2016;2(2):203-208. doi:10.1016/j.jacep.2015.10.006

15. Lurie KG, Iskos D, Sakaguchi S, Fahy GJ, Benditt DG. Resumption of motor vehicle operation in vasovagal fainters. *Am J Cardiol*. 1999;83(4):604-606, A8. doi:10.1016/S0002-9149(98)00924-2

16. Martikainen KK, Seppä K, Viita PM, Rajala SA, Luukkaala TH, Keränen T. Outcome and consequences according to the type of transient loss of consciousness: 1-year follow-up study among primary health care patients. *J Neurol*. 2011;258(1):132-136. doi:10.1007/s00415-010-5687-0

17. Numé AK, Gislason G, Christiansen CB, et al. Syncope and motor vehicle crash risk: a Danish nationwide study. *JAMA Intern Med*. 2016;176(4):503-510. doi:10.1001/jamainternmed.2015.8606

18. Rehm CG, Ross SE. Syncope as etiology of road crashes involving elderly drivers. *Am Surg*. 1995;61(11):1006-1008.

19. Redelmeier DA, Yarnell CJ, Thiruchelvam D, Tibshirani RJ. Physicians' warnings for unfit drivers and the risk of trauma from road crashes. *N Engl J Med*. 2012;367(13):1228-1236. doi:10.1056/NEJMsa1114310

20. Dischinger PC, Ho SM, Kufera JA. Medical conditions and car crashes. *Annu Proc Assoc Adv Automot Med*. 2000;44:335-346.

21. Sheldon R, Koshman ML. Can patients with neuromediated syncope safely drive motor vehicles? *Am J Cardiol*. 1995;75(14):955-956. doi:10.1016/S0002-9149(99)80699-7

22. Akiyama T, Powell JL, Mitchell LB, Ehlert FA, Baessler C; Antiarrhythmics versus Implantable Defibrillators Investigators. Resumption of driving after life-threatening ventricular tachyarrhythmia. *N Engl J Med*. 2001;345(6):391-397. doi:10.1056/NEJM200108093450601

23. Trappe HJ, Wenzlaff P, Grellman G. Should patients with implantable cardioverter-defibrillators be allowed to drive? observations in 291 patients from a single center over an 11-year period. *J Interv Card Electrophysiol*. 1998;2(2):193-201. doi:10.1023/A:1009763818159

24. Silva M, Godinho A, Freitas J. Transient loss of consciousness assessment in a university hospital: from diagnosis to prognosis. *Porto Biomed J*. 2016;1(3):118-123. doi:10.1016/j.pbj.2016.07.001

25. Maas R, Ventura R, Kretzschmar C, Aydin A, Schuchert A. Syncope, driving recommendations, and clinical reality: survey of patients. *BMJ*. 2003;326(7379):21. doi:10.1136/bmj.326.7379.21

26. Shen WK, Sheldon RS, Benditt DG, et al; Writing Committee Members. 2017 ACC/AHA/HRS guideline for the evaluation and management of patients with syncope: Executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. *Heart Rhythm*. 2017;14(8):e218-e254. doi:10.1016/j.hrthm.2017.03.005

27. Brignole M, Moya A, de Lange FJ, et al; ESC Scientific Document Group. 2018 ESC guidelines for the diagnosis and management of syncope. *Eur Heart J*. 2018;39(21):1883-1948. doi:10.1093/eurheartj/ehy037

28. Sandhu RK, Raj SR, Thiruganasambandamoorthy V, et al; Primary Writing Committee; Secondary Writing Committee. Canadian Cardiovascular Society clinical practice update on the assessment and management of syncope. *Can J Cardiol*. 2020;36(8):1167-1177.. doi:10.1016/j.cjca.2019.12.023

29. Natural Resources Canada. 2008 Canadian Vehicle Survey Update Report. Accessed May 2, 2020. https://oee.nrcan.gc.ca/publications/statistics/cvs08/pdf/cvs08.pdf

30. Road Safety British Columbia. Motor Vehicle Related Crashes. Injuries and fatalities: 10-year statistics for British Columbia, 2009-2018. RoadSafetyBC; 2019. Accessed October 13, 2021. https://www2.gov.bc.ca/assets/gov/driving-and-transportation/driving/roadsafetybc/data/motor_vehicle_related_crashed_injuries_fatalities_10-year_statistics_for_british_columbia_2009-2018.pdf

31. Vancouver Coastal Health. Quick facts: VCH snapshot. Vancouver Coastal Health; 2015. Accessed October 5, 2021. http://www.vch.ca/Documents/VCH-fact-sheet.pdf)

32. Canadian Institute for Health Information. *The Canadian Emergency Department Diagnosis Shortlist (CED-DxS 2015)*. CIHI; 2017.

33. Staples JA, Vadeanu C, Gu B, Erdelyi S, Chan H, Brubacher JR. Syncope and presyncope as a presenting symptom or discharge diagnosis in the emergency department: an administrative data validation study. *Can J Cardiol*. 2017;33(12):1729-1732. doi:10.1016/j.cjca.2017.08.026

34. Ruwald MH, Hansen ML, Lamberts M, et al. Accuracy of the ICD-10 discharge diagnosis for syncope. *Europace*. 2013;15(4):595-600. doi:10.1093/europace/eus359

35. Staples JA, Erdelyi S, Moe J, Khan M, Chan H, Brubacher JR. Prescription opioid use among drivers in British Columbia, 1997-2016. *Inj Prev*. 2021;27(6):527-534. doi:10.1136/injuryprev-2020-043989

36. Brubacher JR, Chan H, Erdelyi S, Zed PJ, Staples JA, Etminan M. Medications and risk of motor vehicle collision responsibility in British Columbia, Canada: a population-based case-control study. *Lancet Public Health*. 2021;6(6):e374-e385. doi:10.1016/S2468-2667(21)00027-X

37. Ono T, Yuki K, Awano-Tanabe S, et al. Driving self-restriction and motor vehicle collision occurrence in glaucoma. *Optom Vis Sci*. 2015;92(3):357-364. doi:10.1097/OPX.0000000000000493

38. International Transport Forum. Road Safety Annual Report, 2018. Accessed June 23, 2022. https://www.itf-oecd.org/road-safety-annual-report-2018

39. van Dijk N, Sprangers MA, Colman N, Boer KR, Wieling W, Linzer M. Clinical factors associated with quality of life in patients with transient loss of consciousness. *J Cardiovasc Electrophysiol*. 2006;17(9):998-1003. doi:10.1111/j.1540-8167.2006.00533.x