

Medical Conditions and the Risk of Motor Vehicle Crashes in Men

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Objective: To determine whether men aged 45 to 70 years with any medical condition are at an increased risk of involvement as drivers in police-reported motor vehicle crashes.

Design: Case-control study.

Setting: Province-wide population-based sampling.

Participants: A total of 2504 drivers randomly selected from those involved as a driver in a motor vehicle crash (cases) and 2520 men not involved in a crash (controls) during a 6-month period.

Data Collection: The Société de l'assurance automobile du Québec (SAAQ) computerized files provided data on crashes, age, and medical conditions. A mailed questionnaire elicited information on usual mileage and driving conditions.

Results: Data from the SAAQ files were obtained for all 5024 drivers. The overall response rate to the mailed sur-

vey was 35.5% with no statistically significant differences in the distribution of characteristics between respondents and nonrespondents. There was no increase in crude (odds ratio, 0.99; 95% confidence interval, 0.85-1.17) or age-adjusted risk of crashes for men with a medical condition in the entire sample of subjects (N = 5024). Among respondents to the mailed questionnaire only, men with a medical condition showed no increased crude risk of crashes (odds ratio, 0.99; 95% confidence interval, 0.76-1.27); no difference was observed after adjustment for age, mileage driven, driver behaviors, and sociodemographic characteristics (odds ratio, 0.91; 95% confidence interval, 0.64-1.31).

Conclusions: Unlike previous studies, the risk estimate was derived from a population-based sample of drivers and adjusted for age, mileage driven, driver behaviors, and sociodemographic characteristics in multivariate analyses. The adjusted estimates failed to show an increased risk of motor vehicle crashes for drivers with a medical condition.

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DESPITE SEVERAL decades of studies, the association between having a chronic medical condition and being involved in motor vehicle crashes (crashes) remains controversial. Some studies have reported an increased risk, whereas others have found no risk or even a negative association for the same medical conditions.¹⁻¹⁶

In a recent review of the literature, we showed the lack of evidence between cardiovascular diseases (CVD) and crashes.¹ Following this, we documented a lack of association in a population-based, case-control study taking into account risk exposure.²

Most of the studies reporting on an association between a chronic medical condition and crashes focused on 1 or several selected conditions. After an initial period of interest in the 1960s and despite the lack of conclusive evidence, this topic of research was literally abandoned until recently.

Four groups of investigators have published the most important studies con-

ducted in the 1960s.³⁻⁶ Waller³ found that the observed rate of crashes per 1 million miles (1.6 million kilometers) for a cohort of patients with diabetes, epilepsy, CVD, and alcoholism was about twice that expected for the general population. He stated that drivers with a "good" attitude had lower rates of crashes than those with "bad" attitudes. However, no definition of "good" or "bad" is provided and was not taken into account in the analyses of risk of crash. In a later study of elderly drivers using similar methods, Waller⁷ found senility and CVD to be associated with higher risk of crashes per million miles driven in the past year.

Ysander⁴ studied for 10 years a cohort of drivers selected from all drivers in a Swedish region. Most chronic diseases were diabetes, CVD, renal disorders, and diseases of the sensory organs. Drivers with diabetes and CVD were shown to have about half the risk of crashes of healthy drivers. Half the study population was asked about their traffic exposure and reported similar levels; however, this was not accounted for in the analyses. In addition, 21% of the driv-

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SUBJECTS AND METHODS

METHODS

A detailed description of the study method has been published elsewhere.^{2,13} The proposed conceptual framework (**Figure**) has been described previously.^{2,13} In short, we hypothesized a direct positive effect of medical conditions on crashes and an indirect negative effect of medical conditions on crashes mediated by risk exposure (ie, mileage driven and driving conditions). Risk exposure would have a positive effect on crashes; however, there is a negative effect of medical conditions on risk exposure because drivers with illnesses drive less in less dangerous climatic conditions. Finally, the overall effect of disease on crashes is confounded by age, smoking status, and alcohol consumption, which may have positive direct effects both on disease and crashes.

DESIGN

A case-control design was chosen owing to the low probability of occurrence of events under study, availability of a computerized database, costs restriction, and logistics.

SUBJECTS

Eligibility Criteria

Male drivers licensed in Quebec for passenger car only and aged 45 to 70 years were all eligible for the study. The age group of 45 to 70 years was chosen for statistical power purposes; CVD and other medical conditions are more prevalent for that age group than for younger adults. Drivers licensed also for other vehicles (trucks, buses, and taxis) were excluded. Computerized files maintained by Société de l'assurance automobile du Québec (SAAQ) provided data for all drivers licensed in Quebec including driver category, data on medical conditions, and whether drivers had been involved in a police-reported crash. The SAAQ active files do not include individuals with a medical condition prohibiting a driving license such as legal blindness, CVD carrying a functional incapacity class IV, and specific conditions from metabolic musculoskeletal, neurologic, and mental systems. Eligible Quebec drivers for whom a register was active between January 1 and June 30, 1989, comprised our pool of subjects.

Sampling

Computer-generated random sampling was performed by the SAAQ from their computerized databases. The SAAQ provided a random sample of 2504 drivers involved in a crash between January 1 and June 30, 1989 (cases), and a random sample of 2520 drivers not involved in a crash during the same period (controls). The sample size was based on the prevalence of CVD since it was the primary objective of the study.² Given the 15% prevalence for a medical condition, there is a 0.80 power to detect an odds ratio (OR) of 1.25.

DATA SOURCES

In Quebec, drivers are responsible for reporting medical conditions that are entered into SAAQ computerized databases. The drivers' physicians complete forms containing *International Classification of Diseases, Ninth Revision (ICD-9)*¹⁷ codes, detailed information on patients' conditions, and laboratory test results. The SAAQ files also contain drivers' sociodemographic characteristics and their involvement in a crash reported to police authorities. There is no information on the proportion of crashes not reported to police authorities. However, we believe that, given current norms and requirements for insurance claims, all crashes that involved injuries are reported and a great proportion of crashes with significant property damage are reported and thus entered into SAAQ files.

A self-administered questionnaire mailed to all subjects collected data on (1) risk exposure, ie, mileage driven in the previous year and willingness to drive in different climatic conditions; (2) sociodemographic characteristics; and (3) driving behaviors, usual car maintenance habits, and lifestyles. In the questionnaire, purposefully, there was no mention of medical conditions or of involvement of the respondent in a crash. The SAAQ had allowed for only 1 mailing to be sent to selected individuals to avoid suspicions of breach of confidentiality from their users.

Questions on mileage driven asked the amount of usual weekly distances driven overall as well as for specific circumstances such as driving to and from work, driving while at work, other daily driving, short trips (<300-km round-trip), and long trips. The average total weekly mileage was comparable to the sum of the average weekly mileage for the 5 different driving circumstances with a Pearson correlation coefficient of 0.78 ($P = .01$). For the willingness to drive in various climatic conditions, we asked each subject to estimate separately, on a 5-point Likert scale, his willingness to drive at night, in the winter, during a heavy storm, during a light snowfall, during a snowstorm, on snowy roads, and on icy roads. Based on factor analysis results, these questions were grouped into 4 subscales pertaining to (1) conditions related to driving to and from work and at work, (2) daily driving, (3) short and long trips under less hazardous climatic conditions, and (4) short and long trips under severe climatic conditions. Reliability coefficients (Cronbach α) ranged from 0.79 to 0.93. A more detailed description of construction of scores is published elsewhere.¹³

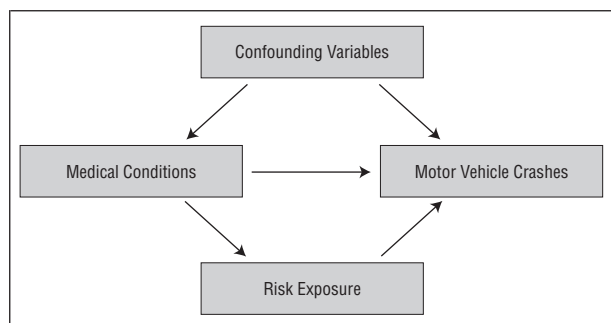
STATISTICAL ANALYSIS

SPSS software (SPSS Inc, Chicago, Ill) was used for all statistical analyses. The Pearson correlation coefficient, likelihood ratio χ^2 test, and Student t test were performed wherever appropriate. For overall medical condition as well as separately, crude and adjusted ORs and 95% confidence intervals (CIs) were estimated through multivariate stepwise hierarchical logistic regressions for the risk of crash. Covariates were allowed to be included at the .10 level of significance and excluded at the .20 level of significance. P values are relative to the relevant tests; in particular, in the stepwise logistic regression, likelihood ratio χ^2 tests were used.

ers with a medical condition did not drive during the study because they were ill.

The study by Grattan and Jeffcoate⁵ suggested that, in Britain, the proportion of crashes due to acute medi-

cal conditions is very small, if any (from 1.5-4 per 1000 crashes). Crancer and McMurray⁶ compared a cohort of almost 40 000 drivers with medical conditions with the entire population of 1.6 million drivers from Washing-



Conceptual framework of study.

ton State. Overall, 32.3% of drivers with a medical restriction had a crash compared with 29.0% of those who were healthy. Twenty years later, Songer et al⁸ reported a slight increased risk of crashes for drivers with type 1 diabetes mellitus when compared with their nondiabetic siblings. However, even if there was information on age, sex, and mileage driven, it is not clear which variables were taken into account in the multivariate analysis; moreover, cases were defined according to exposure (diabetes) and not according to outcome (crashes).

In 1991 Hansotia and Broste,⁹ in a study of a cohort of more than 30 000 Wisconsin drivers aged 16 to 90 years, found that those with diabetes and epilepsy had a 30% increase in risk of crashes per 1000 person-years. In the sample, 0.2% of diabetic subjects and 11.8% of epileptic subjects were still driving at the time of the study despite a recommendation from their physicians not to drive. There was no adjustment made for mileage driven or for driver behavior despite presence of the information as reported in their publication.

Other more recent articles have concentrated on studying elderly drivers and specific medical conditions such as Alzheimer disease and foot abnormalities.¹⁰⁻¹²

Therefore, an increased risk of crash for patients with a chronic medical condition has not been proved or disproved beyond doubt, certainly not while taking into account mileage driven and usual driving habits.

It would be legitimate to reexamine licensing guidelines and recommendations if chronic medical conditions are indeed associated with a higher risk of being involved in crashes. On the other hand, modern society is highly dependent on the use of passenger vehicles as a mode of mobility as an essential to a modern lifestyle. If drivers with a medical condition are at no additional risk, to impose or propose driving restrictions would seem unfair.

The objective of this study was to determine whether men with a chronic medical condition have an increased risk of being involved in a car crash.

RESULTS

The response rate to the mailed questionnaire was 35.5%. It varied with age group (33.2%-36.9%; $P = .05$), was lower for cases (crashes) than for controls (noncrashes) (31.6% and 39.4%, respectively; $P < .001$), and did not vary with the presence or absence of a medical condition. Nonrespondents did not differ significantly from respondents for the variables available in the SAAQ file and most rel-

Table 1. Prevalence of Medical Conditions by Selected Subsets of Study Population*

	Any Medical Condition (n = 749)	No Medical Condition (n = 4275)
Overall	14.9	85.1
Age group, y		
45-54	8.0	92.0
55-64	14.3	85.7
65-70	23.2	76.8
Response status		
Respondents	16.0	84.0
With MVC	15.9	84.1
No MVC	16.1	83.9
Nonrespondents	14.3	85.7
With MVC	14.4	85.6
No MVC	14.2	85.8
Type of accident		
No accident	14.9	85.1
Accident		
Material damages	14.7	85.3
Personal injuries	15.1	84.9

*Data are given as percentage. MVC indicates motor vehicle crash.

evant to the analysis (age, medical condition, and involvement in crashes).

At least 1 medical condition was reported by 14.9% of drivers (749/5024) (**Table 1**). The prevalence estimates of all medical conditions increased significantly with age ($P < .001$). The estimates did not vary significantly according to response status to the mailed questionnaire ($P = .10$), involvement in crash ($P = .97$), or the type of crash reported ($P = .39$).

For the entire sample of subjects ($N = 5024$), a crude OR of 0.99 (95% CI, 0.85-1.17) for involvement in a crash was associated with the presence of any medical condition (**Table 2**). The risk estimate for those answering the questionnaire was an OR of 0.99 (95% CI, 0.76-1.27).

There was no significant difference in yearly distance driven between drivers involved in a crash (12 000 km) and those not involved in a crash (12 700 km) ($P = .52$) (**Table 3**). Drivers with a medical condition drove significantly less (9300 km) than the drivers without one (13 000 km) ($P = .008$). Differences in distance driven were mostly for daily errands. Mean distances driven decreased significantly with age for all categories of driving purpose ($P < .001$). Finally, older drivers were more prone to restrict their driving in less favorable conditions.

Cigarette smoking and alcohol consumption were not statistically associated with crashes (**Table 4**). Healthy drivers were significantly more likely to report having ever smoked (29.0% vs 20.2%; $P = .002$) and drinking daily than drivers with a medical condition (21.3% vs 14.4%; $P = .03$).

No differences were found between cases (crashes) and controls (noncrashes) or between risk categories (presence of medical conditions) for mean scores for work-related driving, driving errands, or undertaking trips under specified unfavorable conditions (Table 4).

No differences between cases and controls or between medical condition groups were found for behaviors such as performing annual car checkups, wearing seat belts, drinking and driving, and preference for being a passenger or the driver (Table 4). Married drivers were less likely to be involved in a crash (79.2% vs 86.0%; $P = .01$). Drivers with any medical condition were less likely to work full-time (43% vs 66.1%; $P = .001$).

The multiple logistic regression models for the risk of crash included systematically the variables representing the dimensions considered in the conceptual framework. For the entire population, an age-adjusted OR of 1.00 (95% CI, 0.86-1.18) for crash was associated with the presence of any medical conditions. The age-adjusted OR did not differ when restricted to respondents only (OR, 0.99; 95% CI, 0.77-1.29). Further, the age-adjusted OR did not differ from the crude estimate computed previously.

For respondents to the questionnaire, further adjustments by the confounding variables available (smoking, alcohol consumption, mileage driven, and driving conditions) did not modify significantly the estimate (OR, 1.0; 95% CI, 0.78-1.31). The other covariates from the conceptual framework were then introduced in a stepwise fashion to the above models. Only marital status was

retained, providing an adjusted OR of 0.91 (95% CI, 0.64-1.31).

COMMENT

Our results are further analyses of a study that was initially designed to examine the association between CVD and crashes. Given that the sampling frame was a population-based random sample, external validity is not in question. Sample size was based on the prevalence of CVD and therefore may have affected the power to detect associations for conditions with a smaller prevalence. However, the CI ranges obtained in our calculations are narrow, suggesting that even with a larger sample size the magnitude of a potential association would likely have been of little clinical significance.

Unlike previous studies, this study controls through multivariate analysis of a conceptual model for confounders and other covariables. We controlled for mileage driven and various markers of drivers' behaviors such as use of seat belt, habits of car maintenance and repair, the willingness to drive in different climatic conditions, preference for being a passenger or a driver, and usual alcohol consumption habits. However, as is often the case, validity of the alcohol data can be questioned.

Even if another study¹⁶ reported a similar response rate, 35.5% is low by usual epidemiological standards. The SAAQ feared public suspicion of a breach of confidentiality if we proceeded with repeated mailings; only 1 mailing of the questionnaire was allowed despite previous agreements. The lower response rate from the men involved in crashes may reflect a greater reluctance to answer a questionnaire sent out with 2 letters, one from the investigators explaining the study but also one from the SAAQ in support of it. Neither the letter nor the questionnaire referred to crashes or medical conditions. However, the lack of difference between crude and age-adjusted ORs for the entire sample and for the respondents only reassured that no response bias was operating.

It is important to note that our study included only men aged 45 to 70 years. Therefore, results for women or younger men could be different because of a lower prevalence of medical conditions and because of possible differences in driving habits, mileage driven, and willingness to drive under less favorable conditions.

Table 2. Risk of Motor Vehicle Crash (MVC) for Drivers With a Medical Condition vs Drivers Without a Medical Condition*

Variables Controlled for	No.		OR (95% CI)
	MVC	No MVC	
For the entire sample			
Crude OR	2504	2520	0.99 (0.85-1.17)
Age-adjusted OR	2504	2520	1.00 (0.86-1.18)
For questionnaire respondents only			
Crude OR	791	993	0.99 (0.76-1.27)
Age-adjusted OR	791	993	0.99 (0.77-1.29)
Confounding variable-adjusted OR†	775	957	1.00 (0.78-1.31)
Above + other covariates‡	747	942	0.91 (0.64-1.31)

*OR indicates odds ratio; CI, confidence interval.

†The confounding variables controlled for included age, alcohol consumption, mileage driven during past year, and driving conditions.

‡The only other covariate to enter into the final model was marital status (at the .10 level).

Table 3. Mean Distances Driven* in the Previous Year According to Purpose of Driving by Crash Group and Health Status

Distances Driven	Cases			Controls		
	Any Condition (n = 126)	Healthy (n = 665)	Total (n = 791)	Any Condition (n = 160)	Healthy (n = 833)	Total (n = 993)
Mean distance driven in previous year, km	9200	12 600	12 000	9300	13 300	12 700
Mean distances driven in previous year, km						
To and from work	4000	6200	5900	3800	5900	5600
At work	6900	7200	7200	4400	6400	6200
Other daily driving	3800	4000	4000	4800	5400	5300
Short trips	2000	1800	1900	2000	1900	2000
Long trips	1800	1700	1700	1700	1700	1700

*Rounded to the nearest hundred.

Table 4. Drivers' Behaviors and Selected Characteristics by Crash Group and by Reported Cardiovascular Disease for Respondents to the Mailed Questionnaire*

Behaviors and Characteristics	MVC			No MVC		
	Any Condition (n = 81)	Healthy (n = 665)	Total (n = 791)	Any Condition (n = 112)	Healthy (n = 833)	Total (n = 933)
Smokes cigarettes	24.2	28.7	28.0	17.1	29.2	27.2
Drinks alcohol daily	14.4	21.3	20.2	6.5	21.9	19.4
Mean score for work-related driving	2.1	1.9	1.9	1.8	1.8	1.8
Mean score for driving errands	2.2	2.2	2.2	2.1	2.1	2.1
Mean score for undertaking trips	2.5	2.5	2.5	2.5	2.4	2.4
Performs at most 1 car checkup per year	22.3	23.9	23.6	22.9	25.9	25.5
Drives over speed limit	33.1	39.5	38.5	34.2	38.8	38.1
Does not always wear seat belt	18.7	17.2	17.5	17.3	17.1	17.1
Drives after drinking alcoholic beverages	50.8	59.1	58.0	44.2	54.6	53.1
Prefers being a passenger	10.4	10.8	10.7	12.7	9.5	10.0
Not married	18.2	21.3	20.8	18.1	15.6	14.0
Not working full-time	65.9	43.4	47.0	66.2	42.7	46.5

*Data are given as percentage except for mean scores. MVC indicates motor vehicle crash. Totals may vary because of missing information.

Our study included only crashes that were reported by the police. Is it possible that drivers with a medical condition are at a greater risk of crashes but that, because they had long modified their driving habits, these crashes would be less serious and would not require involvement of the police? Nevertheless, we found no difference in any result when comparing severity of crash: those resulting in injuries and those without injuries.

Unlike physicians in other provinces, Quebec physicians are not obliged to report patients they consider unfit for driving. Underreporting of medical conditions to the licensing bureau has been stated as common.¹⁸ Whether differential or nondifferential, the bias caused by underreporting would have reduced an estimate of a possible association between a medical condition and the risk of crash. Our sample size allowed an 80% power to detect a small OR (1.25), well below the epidemiologically significant threshold of an OR of 2.0 used to originally compute the study sample size. However, a physician medical report provides a better validity to the diagnosis than driver self-report.

One survey cannot pretend to answer a question such as the one addressed in this study. Therefore, we believe that a broader approach and future studies should be undertaken. Longitudinal studies with assessment of the individual's fitness to drive could be better suited. However, logistics, instruments, and costs may render such a study unrealistic. Therefore, further population-based case-control studies for specific populations should be undertaken. Extra care should be taken to ensure a good response rate and to use databases for states or regions where reporting of medical conditions is compulsory or where linkage with medical databases can be done.

In conclusion, Quebec male drivers who reported having chronic medical conditions carry no increased risk of being involved in motor vehicle crashes. Estimates of risk were controlled for the confounding effects of alcohol consumption; cigarette smoking; mileage driven in the past year; purposes and conditions of driving; driver's behaviors, such as car maintenance, adherence to the speed limit, and use of a seat belt; and driver's sociode-

mographic characteristics. Future studies should investigate other specific populations of drivers and should also examine specific medical conditions.

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