Impact of Diabetes on Crash Risks of Truck-Permit Holders and Commercial Drivers

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OBJECTIVE —The U.S. and some Canadian government agencies have waived commercial license restrictions for some insulin-using diabetic drivers. However, the U.S. Federal Highway Administration is no longer giving waivers. Scientific evidence to support such regulations has been sparse. This article presents detailed analyses of crash risks for users and nonusers of insulin among diabetic truck-permit holders in Québec, Canada.

RESEARCH DESIGN AND METHODS — Diabetic truck-permit holders were group-matched by age to a random sample of healthy permit holders. Data on permits, medical conditions, and crashes involving 13,453 permit holder–years in 1987–1990 were extracted from the files of the public insurer for automobile injuries in Québec. Additional health status data were obtained from the provincial public health insurer. A telephone survey was conducted to collect data on driving patterns and exposure. Risk ratios were estimated using negative binomial regression models.

RESULTS — Risk ratios for crashes vary by category of diabetes. Permit holders for single-unit trucks (STs) who are diabetic without complications and not using insulin have an increased crash risk of 1.68 when compared with healthy permit holders of the same permit class. When controlling for risk exposure, commercial drivers with an ST permit and the same diabetic condition have an increased risk of 1.76. Insulin use is not associated with higher crash risk.

CONCLUSIONS — The increased crash risk for the group with uncomplicated diabetes not using insulin is a new finding. The lack of consistent increases in crash risks among diabetic commercial drivers with complications or who use insulin may be a "healthy worker effect" masking the real risk, because these licensees have a lower participation rate as professional drivers.

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For many years, the U.S. Federal Highway Administration (FHWA) prohibited individuals who use insulin from obtaining commercial vehicle driving licenses. However, it had temporarily permitted waivers of these restrictions for insulin-using drivers who met specified medical criteria (1). At present, the FHWA is no longer giving waivers. In Québec, Canada, starting in 1987, individuals with type 2 diabetes treated with insulin and, exceptionally, individuals with type 1 diabetes were permitted to drive trucks under certain conditions, but not buses, minibuses, or emergency vehicles (2).

The aim of this research is to provide a scientific basis for licensing agency regulations concerning medical impairments and fitness to drive commercial vehicles. The study analyzes the impact of diabetes on road safety among class 1–articulated truck (AT) and class 3–single-unit truck (ST) permit holders in Québec. Detailed analyses by diabetes treatment category (use of insulin) and presence or absence of complications are presented. Results of a previous databank on medical conditions can be found in other publications (3–7). For example, an odds ratio of 2.47 for the diabetic ST permit holders compared with the healthy individuals of the same permit class was estimated (3). The methods used in this article have allowed us to take into account the panel aspects of the data and, simultaneously, many explanatory variables. It was thus possible to isolate the medical condition from the other variables. In addition, a new databank with changes of medical conditions over time was used.

Diabetes, a common chronic disease, is of concern to licensing agencies because individuals with diabetes may experience periods of hypoglycemia when treated with insulin or sulfonylureas. Hypoglycemia can alter judgment and perception and can even lead to a loss of consciousness while driving. Existing studies on diabetes and crash risks show contradictory results. In some studies, diabetes increased the risk of passenger vehicle crashes (8–11); in others, there was either no effect (12) or even decreased risk (13,14). The study by Songer et al. (15) estimates an additional number of crashes as a result of severe hypoglycemia if drivers using insulin were allowed to drive commercial motor vehicles (CMVs) in interstate commerce. Waller (16) stressed the importance of separating the risks attributable to medical conditions from other causes. The present study is the first scientific evaluation of the relationship between crash risk and diabetes CMV drivers, taking into account individual driving exposure variables.

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Abbreviations: AT, articulated trucks; CMV, commercial motor vehicle; FHWA, Federal Highway Administration; RAMQ, Régie de l'Assurance Maladie du Québec; RR, risk ratio; SAAQ, Société de l'Assurance Automobile du Québec; ST, single-unit truck.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Sample of truck-permit holders, by health status and crash observation period, ≤66 years of age, Québec, Canada, 1987–1990*

Observation period	Health status: Good health	Diabetes and not using insulin: Without complications	Diabetes and not using insulin: With complications	Diabetes using insulin	Total diabetic group
1987	2,379	490	368	269	1,127
1988	2,295	458	392	277	1,127
1989	2,205	403	433	283	1,119
1990	2,079	374	469	279	1,122
Permit holder–years	8,958	1,725	1,662	1,108	4,495

Data are *n*.

RESEARCH DESIGN AND METHODS

Study design and study population

A cohort study design (17) was used in which diabetic and healthy nondiabetic truck drivers in Québec were followed to observe their crash rates. We linked personal driving records of Québec truck-permit holders with their health records and a survey on driving risk exposure. The 2 types of truck-driving permits were those for ATs (including tractor-trailers) and for STs. Data on permits (e.g., age, sex, and driving class), medical conditions, and crashes in the province of Québec for individuals were extracted from the administrative files of the Société de l'Assurance Automobile du Québec (SAAQ), the public insurer for injuries resulting from traffic crashes (compulsory no-fault system). The SAAQ is also responsible for road safety regulation and administration, hence it has access to driver records, including all crashes from police reports. Since 1989, every truck-permit holder has to submit medical reports from physicians and eye specialists to the SAAQ, the frequency of which is determined by type of permit and age. The SAAQ may designate a specialized physician for such reports. For validation, health status data were also obtained for 96.5% of the study subjects from the Régie de l'Assurance Maladie du Québec (RAMQ), the provincial public health insurer, which covers all Québec residents for medical and hospital services. Data were rendered anonymous by the SAAQ and RAMQ. At the time, to prevent the identification of an individual, access to data for epidemiological research was possible under strict confidentiality rules without having to obtain the individual's consent. Exposure to driving was measured through a 1990–1991 telephone survey of all truck-permit holders, which was carried out by a polling firm. The files from the SAAQ, the RAMQ, and the polling firm were linked using codes that respected confidentiality.

The survey asked about driving patterns, including kilometers driven per year, and proxies for exposure to crash risk, such as working radius, type of road, and time of the day, for the year before the interview. Crash experience was analyzed for all permit holders (without the risk-exposure variables mentioned above) and professional drivers (i.e., drivers with an AT or ST permit who drove a vehicle at work such as a truck, van, or car). For this second group, we used the risk exposure variables. In this article the terms "professional drivers" and "commercial drivers" are interchangeable.

The study population contained all diabetic AT and ST permit holders known in 1989 (medical file of the SAAQ). They were group-matched with a random sample of the same classes of permit holders in good health stratified by 5-year age-groups. Women and permit holders >65 years old (in 1989) were excluded because of their small numbers.

Health status was defined by combining the following: *1*) medical and treatment codes from the SAAQ, *2*) ICD-9 codes for diagnoses, and *3*) codes for medical acts from the RAMQ. The control population corresponds to permit holders coded by the SAAQ as having either good health or no medical evaluation and no health problems noted in RAMQ files. We recorded whether individuals with diabetes

Table 2—*Crash RRs and 95% CIs for all truck-permit holders, Québec, Canada, 1987–1990*

Explanatory variable	*n*	Mean	RR	95% CI
Observation period				
1987	3,506	0.14	1.12	0.98–1.29
1988	3,422	0.14	1.19*	1.04–1.36
1989	3,324	0.14	1.17*	1.02–1.34
1990	3,201	0.12	1.00	Reference category
Age (years)				
≤35	2,726	0.15	1.00	Reference category
36–45	3,640	0.14	0.89	0.76–1.03
46–55	4,406	0.12	0.73*	0.63–0.86
56–66	2,681	0.13	0.79*	0.66–0.95
Permit class				
AT	8,933	0.14	1.13	0.98–1.30
ST	4,520	0.13	1.00	Reference category
Health status				
Class AT				
Good health	5,813	0.14	1.00	Reference category
Diabetes without complications	1,253	0.15	1.14	0.94–1.38
Diabetes with complications	1,227	0.14	1.17	0.96–1.43
Diabetes treated with insulin	640	0.13	1.02	0.78–1.33
Class ST				
Good health	3,145	0.12	1.00	Reference category
Diabetes without complications	472	0.19	1.68*	1.27–2.24
Diabetes with complications	435	0.11	1.03	0.73–1.46
Diabetes treated with insulin	468	0.12	1.07	0.77–1.47

Data are *n*, means, RR, or CI. *Significantly different from 1.00 at 5%. Parameters of the beta distribution (*P*), $a = 121.66$ (0.209), $b = 1.50$ (<0.001). Permit holder-years, $n = 13{,}453$. Explanatory variables with the intercept, $n = 14$. Estimated intercept (*P*), 2.30 (0.007). Log-likelihood, −5,449.68.

were being treated by diet, oral hypoglycemic agents, or insulin. Comorbid conditions were also considered, resulting in 3 categories of diabetic drivers: *1*) insulin users (73% without comorbidity, 20% with visual, and 7% with cardiovascular problems), *2*) nonusers of insulin without complications (no comorbidity, 64% treated with oral agents), and *3*) nonusers with complications (hypertension, cardiovascular, or visual, 62% treated with oral agents). The sample sizes are presented in Table 1.

The major advantage of combining SAAQ and RAMQ data was to obtain the yearly evolution of health status from 1987 to 1990. This decision increased the reliability of health status information. We used permit holder–years as units of observation for analysis. A unit of observation was defined using crash records and attributes of a permit holder during 1 calendar year. Driving risk-exposure variables obtained for 1990 were taken as constant for the 4 years, provided driving experience was confirmed by the respondent. As a consequence, 3,506 individuals in 1987 (2,331 with AT and 1,175 with ST permits) could contribute up to 4 permit holder–years each. However, 3,201 individuals are present in 1990, the main reason being that from 1987 to 1990, 13% (300 of 2,379) of permit holder–years in good health changed health status, 24 individuals became diabetic, and the others changed to a medical condition that was excluded from this study (4% visual, 3% hypertension, and 5% cardiovascular problems) (5).

Statistical analyses and models

Mean yearly crash rates per driver with diabetes were compared with those in good health using age and both quantitative and qualitative measures of driving exposure as covariables. Medical status was introduced as a nested factor within permit class.

Negative binomial regression models for panels with entries and exits were estimated using the standard log-linear specification (18). The logarithm of the individual number of crashes in a year was regressed on a vector of explanatory variables for the *i*th individual. Crashes were considered as rare and independent events. Only 1.3% had >1 crash in a year, which justified the use of the Poisson process. The negative binomial models were used to account for individual heterogeneity unexplained by the available covariables; indeed, the Poisson model was rejected. The regression coefficients were tested with a Wald statistic to see whether

Table 3—*Crash RRs and 95% CIs for professional drivers, Québec, Canada, 1987–1990*

Explanatory variable	*n*	Mean	RR	95% CI
Observation period				
1987	904	0.15	0.97	0.76–1.23
1988	912	0.18	1.13	0.90–1.42
1989	903	0.14	0.91	0.72–1.16
1990	874	0.16	1.00	Reference category
Age (years)				
≤35	797	0.18	1.00	Reference category
36–45	1,041	0.14	0.83	0.64–1.09
46–55	1,233	0.15	0.85	0.65–1.11
56–66	522	0.18	1.06	0.77–1.45
Permit class				
AT	2,525	0.16	1.01	0.62–1.64
ST	1,068	0.16	1.00	Reference category
Health status				
Class AT				
Good health	1,736	0.17	1.00	Reference category
Diabetes without complications	369	0.13	0.81	0.58–1.14
Diabetes with complications	299	0.15	0.87	0.61–1.25
Diabetes treated with insulin	121	0.11	0.65	0.35–1.21
Class ST				
Good health	795	0.14	1.00	Reference category
Diabetes without complications	127	0.24	1.76*	1.06–2.91
Diabetes with complications	84	0.13	0.96	0.48–1.91
Diabetes treated with insulin	62	0.16	1.02	0.48–2.17
Distance driven				
Class AT				
≤20,000 km	935	0.11	1.00	Reference category
20,001–50,000 km	836	0.17	1.55*	1.16–2.08
50,001–100,000 km	447	0.20	1.87*	1.33–2.64
>100,000 km	307	0.21	1.94*	1.26–2.99
Class ST				
≤20,000 km	497	0.13	1.00	Reference category
20,001–50,000 km	380	0.17	1.19	0.79–1.79
>50,000 km	191	0.19	1.40	0.82–2.38
Owner of the truck				
Class AT				
Yes	774	0.16	1.08	0.85–1.38
No	1,751	0.17	1.00	Reference category
Class ST				
Yes	353	0.15	0.97	0.66–1.42
No	715	0.16	1.00	Reference category
Drive after 8 P.M.				
Class AT				
Yes	836	0.17	0.98	0.76–1.26
No	1,689	0.16	1.00	Reference category
Class ST				
Yes	295	0.16	1.10	0.74–1.64
No	773	0.15	1.00	Reference category
Working radius				
Class AT				
<50 km	1,186	0.13	1.00	Reference category
50–160 km	715	0.17	1.19	0.90–1.57
>160 km	624	0.19	1.18	0.83–1.69

(continued)

Table 3—*Continued*

Explanatory variable	*n*	Mean	RR	95% CI
Working radius *(continued)*				
Class ST				
<50 km	632	0.13	1.00	Reference category
50–160 km	324	0.19	1.62*	1.07–2.54
>160 km	112	0.17	1.36	0.71–2.60
Type of roads				
Class AT				
Highways	500	0.17	0.76	0.52–1.11
Country roads	540	0.10	0.57	0.40–0.82
City streets	735	0.17	1.00	Reference category
More than 1 type	750	0.18	0.90	0.67–1.22
Class ST				
Highways	96	0.15	0.60	0.30–1.21
Country roads	197	0.12	0.63	0.37–1.08
City streets	468	0.18	1.00	Reference category
More than 1 type	307	0.14	0.71	0.45–1.11

Data are *n*, means, RR, or CI. *Significantly different from 1.00 at 5%. Parameters of the beta distribution (*P*), $a = 114.20$ (0.355), $b = 2.56$ (0.001). Driver-years, $n = 3{,}593$. Explanatory variables with the intercept, $n = 33$. Estimated intercept (*P*), 1.80 (0.145). Log-likelihood, −1,613.03.

they differed significantly from zero (4,19). The risk ratio (RR) of the means for individuals belonging to a particular group versus a comparison group were estimated. This RR gives the marginal effect of belonging to the particular group in terms of relative crash risks, all other variables being equal.

Analyses for all truck-permit holders (Table 2) and professional drivers (Table 3) are now discussed. Those without driving exposure data (Table 2) contained only the observation period, age group, and health status as variables. The models with driving exposure data (Table 3) controlled for the distance driven, type of road, driving time, etc. Using total permit holders rather than professional drivers as denominators resulted in large underestimates of crash rates, but they were free of potential nonrespondent bias that may arise from confining analyses to respondents to the driving exposure survey. The response rates to the survey for person-years in good health and with diabetes, on available telephone numbers, were 80.9 and 81.3%, respectively. The rates and reasons for nonresponse were similar for both groups (refusal, 5%; no response within 5 calls, 10%). Given these similar and relatively high response rates for both diabetic and healthy drivers made nonrespondent bias very unlikely.

RESULTS — Table 2 presents crash RRs for all truck-permit holders without the use of any risk-exposure variable. As mentioned above, this model controlled for permit class, age, and observation period.

The medical conditions are nested within permit class to compare drivers with similar working conditions. For AT permits, the 3 groups with diabetes do not differ from the healthy group at the 5% significance level. For ST permits, the group with diabetes without complications represents an increased risk (RR = 1.68) when compared with those in good health.

When controlling for risk exposure (Table 3), the significant result holds for the same diabetic condition (RR = 1.76), and again the other groups with diabetes do not differ significantly from the healthy group. The introduction of the risk-exposure variables and the restriction to professional drivers reduced the sample size considerably. As a test for the stability of these results, we estimated the model of Table 2 with the 3,593 observations of Table 3. The RR for diabetes without complications within the ST permit class is identical (1.76) to that in Table 3. The complete results of this model are available from the authors. For the AT permit class, longer distances driven are associated with higher crash risks (RR = 1.55–1.94), although it is the working radius for the ST class (50–160 km, RR = 1.62) that matters. The group with the larger working radius is not significantly different probably because of the smaller number of observations.

It is of interest to note that the percentages of professional drivers vary considerably with the health status. Table 4 shows that there are fewer professional drivers in both permit classes among the licensees with diabetes with complications and those using insulin, whereas the fraction among those without complications is similar to the group in good health.

CONCLUSIONS — The increased crash risk for the permit holders and for the professional drivers with an ST permit and with uncomplicated diabetes not treated with insulin is a new and important finding. Among this group, 76% were treated with oral hypoglycemic agents, a percentage higher than that found for both license classes ST and AT combined (64%). Hypoglycemia resulting from insulin treatment is a well-known effect that is feared by both patients and physicians (20–22), yet it may also result from treatment with oral hypoglycemic agents (23,24). Ferner (24) reports that a Swiss survey found a case fatality rate for sulfonylurea-induced hypoglycemia of 4.3% among 116 admissions. The risk of sulfonylurea-induced hypoglycemia appears from the Swiss survey to be greater for some agents than for others. He stresses that the incidence of hypoglycemia induced by sul-

Table 4—*Number of respondent-years and percentages of professional driver-years by health status and permit class, ≤66 years of age, Québec, Canada, 1987–1990**

	AT permit			ST permit		
Health status	*N*	*n*	%	*N*	*n*	%
Good health	3,665	1,736	47.4	1,985	795	40.1
Diabetes						
Without complications	833	369	44.3	330	127	38.5
With complications	782	299	38.2	284	84	30.0
Using insulin	365	121	33.2	276	62	22.5

Data are *n* or %. *N*, number of respondent-years. *n*, number of professional driver-years used in Table 3. %, $100 \times n/N$. *Not every respondent answered all of the risk-exposure questions.

fonylureas is probably underestimated, although few reliable data are available. However, the U.K. Prospective Diabetes Study Group (25) reports that during a 6-year survey, 17% of those allocated to and taking sulfonylurea experienced hypoglycemic events, compared with 37% in those taking insulin and 0.9% in those allocated to diet therapy. The relative risk of sulfonylurea-induced hypoglycemia increases with age, particularly for the elderly (23). However, risk exposure also changes with age. Table 3 shows that age is not significant when controlling for risk exposure.

Our results lead to the following question: Why is the crash RR for licensees with an ST permit and diabetes without complications (for all truck-permit holders and for professional drivers) significantly higher than that where there are no significant increases for the diabetic AT permit holders and professional drivers?

It should be noted that the same results hold for the subset of injury crashes (i.e., at least 1 individual injured or a death). Laberge-Nadeau et al. (26) have shown that the injury crash rate for ST licensees with diabetes without complications is 3.6%, significantly higher than for the healthy licensees (1.8%). Again, there are no significant differences (at the 5% level) for the other diabetic groups with an ST license and none among the AT licensees.

Possible explanations include more stringent selection criteria with respect to medical conditions by the employers of AT drivers and different work environments and tasks (1). The selection effect would mean that employers hiring AT drivers used higher medical standards than when hiring ST drivers. For example, the medical restrictions for diabetic truck drivers are more severe in some Canadian provinces and for interstate travel in the U.S. (2). The work environment for ST drivers seems more stressful, particularly when driving on congested urban streets without adequate parking areas for deliveries, with rigid time constraints over a short period. ST drivers spend much more time handling materials than AT drivers, by a factor of 4 (27). Because our data do not contain any measures of glycemia at the time of a crash, it is not known to what extent the increased crash rates by drivers with uncomplicated diabetes were associated with hypoglycemia as a result of sulfonylureas. However, our results are sufficiently strong to warrant further investigation of the following questions: Is excess crash frequency associated with hypoglycemia? Do diabetic ST drivers follow an appropriate diet? Is their diabetes well controlled considering the physical effort required for their tasks? What kind of sulfonylurea are they taking?

The lack of consistent increases in crash risk among drivers treated with insulin does not in any way eliminate insulin as a potential risk factor for crashes. Although it is possible that the medical restrictions applied to insulin-using individuals (28) succeeded in keeping some higher-risk drivers from driving trucks, the small population of insulin-using individuals in our study limits the conclusions that can be drawn about the effects of insulin treatment. In a survey of 250 private car drivers with insulin-dependent diabetes, Frier et al. (29) found that 34.4% experienced severe or frequent hypoglycemia at the wheel, 13.6% had a crash, and for 5% hypoglycemia had been an important causal factor in the crash.

The nonsignificant results for the groups with diabetes with complications or with diabetes using insulin in Tables 2 and 3 suggest that there may be a self-selection effect (i.e., the crash risks might be underestimated for licensees with these medical conditions because the more severely affected individuals do not drive or restrict their driving, even though the regulations do not restrict them because they do have a valid AT or ST driver's permit). As Table 4 shows, there may also be a healthy worker effect, since the percentages of professional drivers among these groups are lower than for the licensees with diabetes without complications and the healthy licensees. Our findings of nonsignificant differences for the above-mentioned 2 groups should be regarded with caution and do not constitute, without further investigations, a basis for relaxing current medical restrictions for commercial drivers.

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