SPECIAL ARTICLE

Physicians' Warnings for Unfit Drivers and the Risk of Trauma from Road Crashes

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ABSTRACT

BACKGROUND

Physicians' warnings to patients who are potentially unfit to drive are a medical intervention intended to prevent trauma from motor vehicle crashes. We assessed the association between medical warnings and the risk of subsequent road crashes.

METHODS

We identified consecutive patients who received a medical warning in Ontario, Canada, between April 1, 2006, and December 31, 2009, from a physician who judged them to be potentially unfit to drive. We excluded patients who were younger than 18 years of age, who were not residents of Ontario, or who lacked valid health-card numbers under universal health insurance. We analyzed emergency department visits for road crashes during a baseline interval before the warning and a subsequent interval after the warning.

RESULTS

A total of 100,075 patients received a medical warning from a total of 6098 physicians. During the 3-year baseline interval, there were 1430 road crashes in which the patient was a driver and presented to the emergency department, as compared with 273 road crashes during the 1-year subsequent interval, representing a reduction of approximately 45% in the annual rate of crashes per 1000 patients after the warning (4.76 vs. 2.73, $P<0.001$). The lower rate was observed across patients with diverse characteristics. No significant change was observed in subsequent crashes in which patients were pedestrians or passengers. Medical warnings were associated with an increase in subsequent emergency department visits for depression and a decrease in return visits to the responsible physician.

CONCLUSIONS

Physicians' warnings to patients who are potentially unfit to drive may contribute to a decrease in subsequent trauma from road crashes, yet they may also exacerbate mood disorders and compromise the doctor–patient relationship. (Funded by the Canada Research Chairs program and others.)

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PHYSICIANS' WARNINGS TO PATIENTS WHO are potentially unfit to drive are a medical intervention intended to prevent trauma from motor vehicle crashes. Advocates point out the similarity to physicians' warnings with regard to communicable infections, arguing that formal warnings are needed because dangerous driving imposes risks on others.[1] However, formal warnings may reduce the patient's quality of life, jeopardize doctor–patient relationships, burden family members, and generate bureaucratic hassles.[2] Many small studies offer conflicting conclusions on the effectiveness of physicians' warnings to patients who are potentially unfit to drive.[3-6] Different regions, therefore, have different policies for medical warnings to drivers.[7]

Medical warnings for unfit drivers in Ontario, Canada, were introduced in 1968 as an affirmative duty for physicians.[8] The policy requires physicians to report any patient who is "suffering from a condition that may make it dangerous for the person to operate a motor vehicle."[9] Subsequent data, however, showed low rates of adherence by physicians.[10,11] In 2006, Ontario introduced a financial incentive ($36.25) for physicians to provide warnings to patients who are potentially unfit to drive.[12,13] The new program offered an opportunity to test the effectiveness of medical warnings in reducing a patient's risk of a road crash.

METHODS

STUDY SETTING AND OVERSIGHT

In 2008 (the midpoint of the study), Ontario had a population of 12,932,297 persons (of whom 9,042,286 were licensed drivers) and a total of 229,196 crashes resulting in death, disability, or property damage.[14] Of these crashes, 17,929 involved an emergency department visit by the driver, for an overall annual rate of about 1.98 events per 1000 drivers. Patients had free access to outpatient, emergency, and hospital care under universal health insurance and could be tracked forward and backward in time through validated population-based databases.

The study was approved by the research ethics board of Sunnybrook Health Sciences Centre, including a waived requirement for individual consent.

PROGRAM FOR MEDICAL WARNINGS

Medical warnings in Ontario were a joint program of the Ontario Ministry of Transportation, the Ontario Ministry of Health and Long-Term Care, and the Ontario Medical Association. As with programs of the American Medical Association, the intent was to encourage physicians to identify, report, caution, counsel, and find creative solutions for patients considered to be potentially medically unfit to drive.[15,16] One element was a checklist of common diagnoses for the physician to complete.[17] The program, which was supported by an official driver-improvement office,[18] provided simplified documentation of the physician's warning (including the billing fee for the associated physician's service[12]) and resulted in suspension of the driver's license in about 10 to 30% of cases.[8,19]

IDENTIFICATION OF PATIENTS

We identified consecutive patients who had received a medical warning from a physician between April 1, 2006, and December 31, 2009. This period encompassed all available data for the first 4 years of the program and provided a minimum of 1 year of follow-up for all patients. We excluded children (age <18 years), persons living outside Ontario, and those who lacked a valid health-card number (85 patients). For patients with more than one warning, we included only the first warning in the analysis. Time zero for each patient was defined as the day of the first warning and also served to differentiate the first phase of the program (encompassing patients who were first warned in 2006 or 2007) from the second phase of the program (encompassing patients who were first warned in 2008 or 2009).

CHARACTERISTICS OF PATIENTS

Data on the patient's age at the time of the warning were obtained from the population registry for Ontario, as were data on sex and place of residence (classified as urban or rural). We used validated linked identifiers to ascertain hospitalizations, emergency department visits, and outpatient visits for the full year before the warning.[20] Diagnoses were ascertained on the basis of physicians' records in comprehensive billing data because the indication for each warning was not available.[21] The databases did not contain information on

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driving records, distance traveled, functional status, use of medications, driver testing, roadway infractions, past suspensions, or subsequent licensing decisions.

MOTOR VEHICLE CRASHES

For each patient, we identified road crashes that involved the patient as the driver and that resulted in an emergency department visit by the patient to any Ontario hospital, representing all data available before and after the patient received the warning. We focused on visits for injuries due to crashes, according to the diagnostic codes of the *International Classification of Diseases, 10th Revision* (V20 through V69).[22] We included emergency department visits involving crashes in which the patient was the driver of the motor vehicle and excluded emergency department visits involving crashes in which the patient was a passenger or pedestrian. Secondary analyses examined the excluded emergency department visits as well as time (time of day, day of week, and season of year), the type of vehicle (car, truck, or other), the type of crash (involving a single vehicle or multiple vehicles), and the severity of the driver's injury (arrival at the hospital by ambulance or other means and triage urgency).[12]

SELF-MATCHING CROSSOVER DESIGN

We used an analytic design in which each patient served as his or her own control because a randomized, blinded trial of warnings would not have been ethical or practical. As in case-crossover designs, self-matching eliminates confounding due to genetics, personality, education, and other stable characteristics (measured or unmeasured).[23] As in time-series analyses, an extended observational interval before and after the intervention addressed regression to the mean, protopathic bias, and other temporal confounders.[24] A limitation of our design is that acute changes in health may increase the person's risk of trauma (owing to impairments associated with illness) or decrease the risk (owing to reduced driving because of illness).

TYPE OF PREVENTION

The type of prevention was classified on the basis of whether the patient had an emergency department visit in the year immediately before the warning, hereafter termed the antecedent interval. Patients who had no emergency department visits for a road crash during the antecedent interval were considered to have received a preemptive warning, whereas patients who had an emergency department visit for a road crash during the antecedent interval were considered to have received a responsive warning. The purpose was to assess the effectiveness of prevention that either precedes or follows a major event.[25] Separation of the antecedent interval from the baseline interval also helped reduce artifacts related to selection bias, reverse causality, and other distortions in before-and-after comparisons.

MEDICAL DIAGNOSES IN PATIENTS

We examined the diagnoses that led to warnings by analyzing the entire antecedent interval for each patient. A list of the 20 most common diagnoses was compiled on the basis of billing data that provided diagnostic codes for all visits during the year.[26] A patient with a stroke and a heart attack, for example, was classified as having received both diagnoses (see the Supplementary Appendix, available with the full text of this article at NEJM.org). The purpose was to examine common medical diagnoses that may have prompted the medical warning. We also collected data for exploratory purposes on the general degree of morbidity (numbers of outpatient clinic visits, emergency department visits, and hospital admissions) and the characteristics of the physician responsible for the warning (age, sex, years in practice, and specialization).

POTENTIAL ADVERSE EFFECTS

Further analyses assessed the robustness of the study findings, checked for potential survivor bias, and tested for unintended consequences.[27] The first set of analyses examined emergency department visits by persons involved in road crashes as pedestrians or as passengers. The second set of analyses examined emergency department visits related to depression (selected as a diagnosis that was frequent in the community, recorded in databases, clinically important, and potentially exacerbated by driving restrictions). The final set of analyses examined the possibility of a breakdown in the doctor–patient relationship by investigating discontinuities in outpatient care for any reason during the year before and the year after the warning.

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STATISTICAL ANALYSIS

The primary analysis evaluated emergency department visits by drivers in road crashes and compared the baseline interval with the subsequent interval. Statistical testing was performed with the use of McNemar's test, adapted to evaluate departures from a ratio of 3:1 (because each patient provided 3 years of baseline observation and 1 year of subsequent observation).[28] Statistical estimates were also confirmed with the use of time-series analyses and longitudinal generalized estimating equations (see the Supplementary Appendix). Prespecified subgroup analyses examined patients in the first phase separately (to provide an extended interval after the warning) and patients in the second phase separately (to provide an extended baseline before the warning). The year of recruitment and all other patient characteristics were subjected to post hoc subgroup analyses to check the robustness of the findings.

RESULTS

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS

A total of 100,075 patients received a medical warning from a total of 6098 physicians (Table 1). The proportion of all licensed drivers who received warnings increased from 0.46% (41,300 patients) in the first phase of the program to 0.65% (58,775 patients) in the second phase. The typical patient was a 60-year-old man living in an urban location who had multiple outpatient clinic visits during the year before the warning. Most patients (95%) had received at least 1 of the 20 most common diagnoses (e.g., alcoholism, epilepsy, and dementia), and 21% had received at least 5 of the diagnoses. The distribution of baseline characteristics was generally stable over time.

ROAD CRASHES

During the 3-year baseline interval, patients who subsequently received a warning were involved as drivers in 1430 road crashes that resulted in an emergency department visit by the patient. This baseline number was equivalent to a rate of 4.76 events per 1000 persons annually, which is about twice the rate in the general population, and remained relatively stable over time (Fig. 1). During the year after receipt of a warning, patients were involved as drivers in 273 road crashes that resulted in an emergency department visit. This subsequent number was equivalent to a rate of 2.73 events per 1000 persons annually, which is still higher than the rate in the general popula-

Table 1. Characteristics of the Patients.

Characteristic	First Phase, 2006–2007 (N=41,300)	Second Phase, 2008–2009 (N=58,775)
	number (percent)	
Demographic characteristics		
Age		
<30 yr	3,981 (10)	5,571 (9)
30–44 yr	6,798 (16)	8,340 (14)
45–59 yr	9,606 (23)	12,863 (22)
60–74 yr	9,059 (22)	12,761 (22)
≥75 yr	11,856 (29)	19,240 (33)
Sex		
Male	24,098 (58)	32,927 (56)
Female	17,202 (42)	25,848 (44)
Place of residence		
Urban	37,353 (90)	53,864 (92)
Rural	3,947 (10)	4,911 (8)
Selected medical diagnoses*		
Alcoholism	4,115 (10)	5,046 (9)
Epilepsy	4,550 (11)	5,975 (10)
Dementia	5,427 (13)	8,601 (15)
Sleep disorder	6,223 (15)	7,279 (12)
Fainting or dizziness	10,536 (26)	14,886 (25)
Stroke	4,388 (11)	6,947 (12)
Diabetes	7,423 (18)	10,691 (18)
Depression without psychosis	3,354 (8)	4,153 (7)
Type of prevention		
Preemptive warning†	40,497 (98)	57,790 (98)
Responsive warning‡	803 (2)	985 (2)
Total medical care§		
≥7 Outpatient clinic visits	32,756 (79)	45,775 (78)
≥1 Emergency department visit	23,873 (58)	34,804 (59)
≥1 Hospital admission	11,833 (29)	16,880 (29)

* Patients may have had multiple diagnoses. Diagnoses were identified from physician billing data for the year before the warning. For a list of the 20 most common diagnoses, see Tables S5 and S6 in the Supplementary Appendix.
† Preemptive warning denotes no road crash resulting in an emergency department visit during the antecedent interval.
‡ Responsive warning denotes one or more road crashes resulting in an emergency department visit during the antecedent interval.
§ Visits and admissions were identified from physician billing data for the year before the warning.

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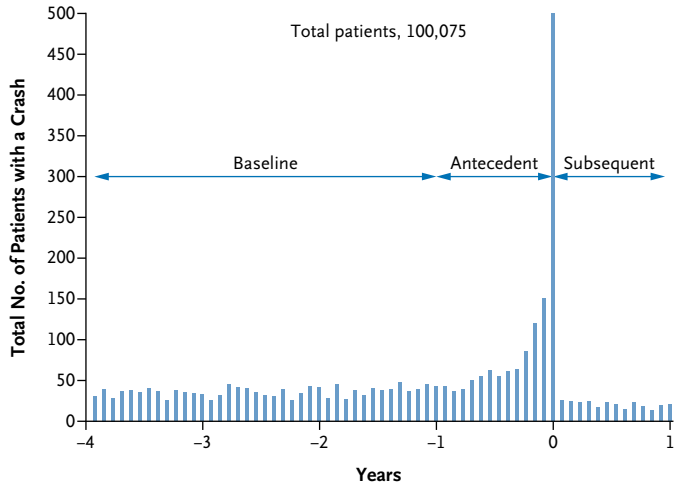

Figure 1. Patients Who Were Drivers in Motor Vehicle Crashes.
Each patient was followed for 5 years. The x axis is divided into segments of 28 days, with time zero defined as the day of the medical warning to the patient. The y axis shows the total count of road crashes involving patients as drivers and resulting in emergency department visits by the patients for each time point. The analysis included all data, so one patient might have had more than one crash. Results showed stable counts during the 3-year baseline interval, rising counts during the 1-year antecedent interval, and a reduction in counts during the 1-year subsequent interval (after the warning).

tion, and was relatively stable over time. The observed reduction in road crashes in the year after the warning was equivalent to a 45% relative reduction in risk (95% confidence interval [CI], 36 to 52; P<0.001).

PATIENT CHARACTERISTICS

The relative reduction in crashes in the year after the warning was consistent among patients with different characteristics, was observed in all demographic subgroups (Table 2), and persisted among patients whose physicians had diverse characteristics (Table S2 in the Supplementary Appendix). The reduction varied according to the diagnosis (Table 2). Among patients with at least 5 of the 20 most common diagnoses, the reduction in the annual crash risk was 52% (5.89 events per 1000 patients annually during the baseline interval, vs. 2.80 events per 1000 patients annually during the subsequent interval; P<0.001). The overall reduction was mostly accounted for by patients who received preemptive warnings (those with no crashes during the year immediately before the warning). The reduction was equally large in each phase of the program and was sustained among patients with extended years of baseline or follow-up (Fig. 2).

CRASH CHARACTERISTICS

The relative reduction in road crashes in the year after the warning spanned events with diverse characteristics. The reduction was apparent for crashes during different times of the day, week, and year (Table 3); for single-vehicle and multiple-vehicle crashes; for cars and trucks (but not miscellaneous vehicles, for which licensing is often not mandatory or is mandatory but not enforced); and for cases in which the patient arrived by ambulance and those classified as high triage urgency. No subgroup had findings that were inconsistent with this reduction, and the comparisons of risk before and after the warning were significant for all subgroups with at least 400 total events.

ADDITIONAL OUTCOMES

The observed reduction in risk did not extend to emergency department visits for which the patient was not a driver in a road crash. The rate of emergency department visits for which the patient was a pedestrian was 1.30 events per 1000 patients annually during the baseline interval and 1.29 events per 1000 during the subsequent interval (relative reduction, 0%; 95% CI, –24 to 19). The rate of emergency department visits in which the patient was a passenger was 3.08 events per 1000 patients annually during the baseline interval and 3.04 events per 1000 during the subsequent interval (relative reduction, 3%; 95% CI, –11 to 15). Emergency department visits for depression increased from 19.15 events per 1000 patients annually during the baseline interval to 23.91 events during the subsequent interval (relative increase, 27%; 95% CI, 17 to 37).

CONTINUITY OF THE DOCTOR—PATIENT RELATIONSHIP

There were fewer patient visits to the responsible physician in the year after the warning (215,973 total visits) than in the year before the warning (281,971 total visits). A total of 28,851 patients (29%) had a reduction in visits, including 10,259 (10%) with 0 visits in the subsequent year despite 2 or more visits in the prior year. A total of 18,312 patients (18%) had an increase in visits, including 5054 (5%) with 0 visits in the prior year yet 2 or more visits in the subsequent year. The remaining 52,912 patients (53%) had the same number of visits during each of the 2 years. We found no major overall reduction in care, as assessed by total visits to all physicians (2,423,434 visits in the year

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Table 2. Risk of a Crash during the Baseline Interval and the Subsequent Interval, According to Patient Characteristics.

Characteristic	Total No. of Events	Event Rate*		Relative Risk (95% CI)
		Baseline	Subsequent	
Demographic characteristics				
Age				
<30 yr	270	7.71	5.13	0.63 (0.46–0.88)
30–44 yr	440	8.06	4.89	0.58 (0.44–0.75)
45–59 yr	445	5.55	3.16	0.56 (0.43–0.74)
60–74 yr	272	3.39	2.29	0.66 (0.49–0.91)
≥75 yr	276	2.65	0.93	0.34 (0.23–0.51)
Sex				
Male	1034	4.97	3.23	0.62 (0.53–0.74)
Female	669	4.49	2.07	0.45 (0.36–0.57)
Place of residence				
Urban	1503	4.59	2.70	0.57 (0.49–0.66)
Rural	200	6.54	3.06	0.44 (0.29–0.69)
Selected medical diagnoses				
Alcoholism	244	7.24	4.91	0.64 (0.46–0.91)
Epilepsy	221	5.92	3.23	0.53 (0.36–0.78)
Dementia	135	2.92	0.86	0.31 (0.18–0.58)
Sleep disorder	299	6.10	3.85	0.62 (0.46–0.85)
Fainting or dizziness	526	5.91	2.95	0.49 (0.38–0.64)
Stroke	132	3.50	1.15	0.32 (0.19–0.60)
Diabetes	293	4.49	2.71	0.59 (0.43–0.82)
Depression without psychosis	224	8.75	3.60	0.38 (0.25–0.60)
Type of prevention				
Preemptive warning	1615	4.62	2.56	0.54 (0.47–0.63)
Responsive warning	88	12.49	11.74	0.75 (0.44–1.34)
Total medical care				
≥7 Outpatient clinic visits	1419	5.10	2.76	0.52 (0.45–0.61)
≤6 Outpatient clinic visits	284	3.53	2.60	0.70 (0.52–0.96)
≥1 Emergency department visit	1128	5.38	3.08	0.55 (0.47–0.65)
No emergency department visits	575	3.89	2.22	0.56 (0.45–0.71)
≥1 Hospital admission	466	4.59	2.47	0.53 (0.41–0.69)
No hospital admissions	1237	4.83	2.83	0.56 (0.48–0.66)

* Event rates were calculated per 1000 patients annually during the corresponding interval.

before the warning and 2,396,957 in the year after the warning).

DISCUSSION

We found that physicians' warnings to potentially unfit drivers were associated with a reduction in the subsequent risk of road crashes requiring emergency department visits by the patients. The reduction in risk was immediate, substantial, and sustained, and it was not attributable to population shifts, confounding by differences in patient characteristics, concurrent temporal trends, or a significant change in events in which the patients were involved as passengers or pedestrians. Together, these data suggest that warning patients who are medically unfit to drive may reduce the risk of road crashes.

Patients often overestimate their driving skills, believe that statistical data do not apply to them, and fail to take protective actions to reduce trauma from road crashes.[29-31] Our findings thus

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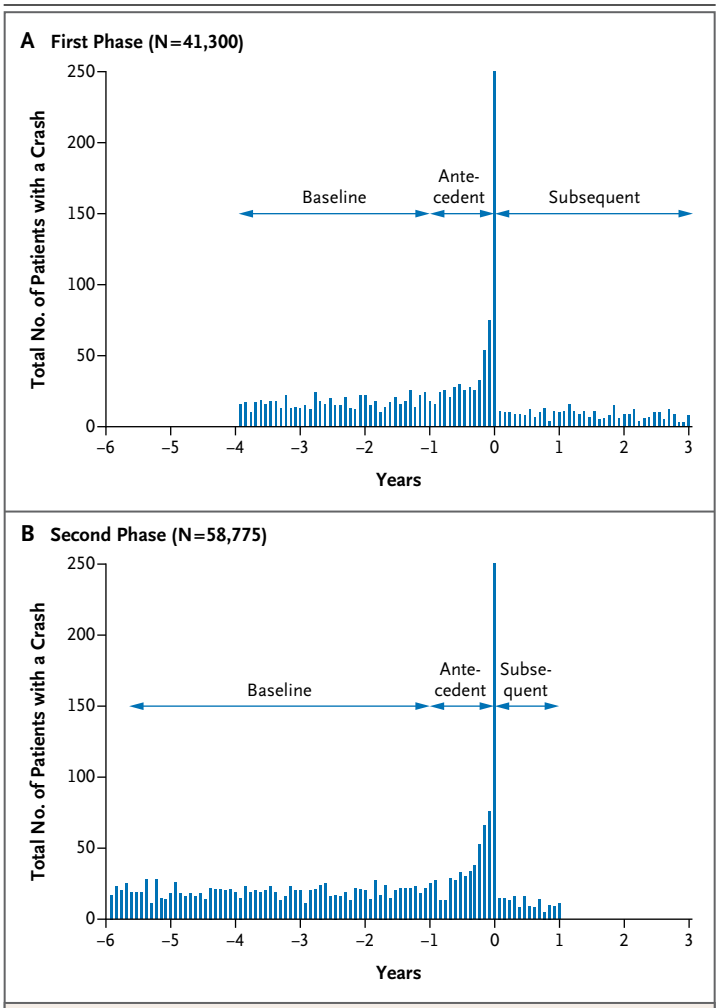

Figure 2. Analysis of Separate Patient Cohorts.

Crashes during 9 potential years are shown. Panel A shows data for patients enrolled during the first phase (2006 and 2007), and Panel B shows data for patients enrolled during the second phase (2008 and 2009). The x axis is divided into segments of 28 days, with time zero defined as the day of the medical warning to the patient. The y axis shows the total count of road crashes involving patients as drivers and resulting in emergency department visits by the patient for each time point. The baseline interval lasted 3 years for the first phase and 5 years for the second phase, the antecedent interval lasted 1 year for both the first phase and the second phase, and the subsequent interval lasted 3 years for the first phase and 1 year for the second phase. The analysis included all data, so one patient might have had more than one crash. Results showed a reduction in crash rates from the baseline interval to the subsequent interval among patients in both the first phase and the second phase.

pose an ethical conflict for clinicians who seek to optimize patients' health yet respect their preferences. The data also suggest that physicians' warnings to unfit drivers are associated with a significant increase in depression, can compromise the doctor–patient relationship, and still do not reduce the patient's risk to the level of risk in the general population. Consequently, clinical judgment is needed in deciding which patients are most likely to benefit from a warning.[32] The danger of excessive warnings is heightened wherever a government both pays for medical care and regulates road traffic.

Interrupted longitudinal analysis is the strongest quasi-experimental method for evaluating interventions if the baseline risk is stable, observed for a long time, and followed by an abrupt change (Fig. 2). Alternative interpretations are still possible because self-imposed restrictions by the driver, warnings by family members, or mechanical problems with the vehicle could also lead to a reduction in crashes. Another possible explanation is that changes in the patient's behavior are caused by changes in the patient's symptoms rather than by the physician's warning — that is, the warning simply validates a decision that the patient has already made. However, these interpretations would not explain why diagnoses associated with relatively high baseline risks were not always associated with relatively large risk reductions after the warning (Table 2).

A related limitation was our inability to assess disease severity, patients' preferences, doctor–patient dialogues, and subsequent exposures. The data indicate that some driving continues because road crashes involving patients as drivers still occur at rates above the population norm after receipt of a warning. In addition, we found no offsetting increases in road crashes involving patients as passengers or pedestrians, which might have reflected substitutes for driving. Odometer data or self-report surveys would provide interesting information but were not available and can be unreliable in assessing driving risks.[33,34] The mechanism of risk reduction could include a combination of altered driving behaviors such as traveling shorter distances, driving with greater care, and being more vigilant in avoiding major hazards.[35]

The results of this study suggest that medical warnings may help to prevent trauma from road crashes. The data also suggest that incentives for physicians to offer such warnings increase their frequency. The main risk of such practices is that, taken to the extreme, they could result in lost

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Table 3. Risk of a Crash during the Baseline Interval and the Subsequent Interval, According to Crash Characteristics.

Characteristic	Total No. of Events	Event Rate*		Relative Risk (95% CI)
		Baseline	Subsequent	
Time of day†				
Morning	381	1.10	0.50	0.45 (0.34–0.61)
Afternoon	957	2.66	1.57	0.58 (0.49–0.69)
Night	365	1.00	0.66	0.64 (0.49–0.84)
Day of week				
Weekday	1235	3.47	1.93	0.54 (0.47–0.64)
Weekend	468	1.29	0.80	0.62 (0.49–0.79)
Season of year				
Spring	356	0.94	0.73	0.77 (0.60–1.01)
Summer	485	1.38	0.70	0.50 (0.39–0.65)
Autumn	460	1.33	0.61	0.45 (0.35–0.60)
Winter	402	1.11	0.69	0.61 (0.47–0.80)
No. of vehicles involved				
>1	1501	4.22	2.34	0.54 (0.46–0.62)
1	202	0.54	0.39	0.75 (0.53–1.07)
Driver's vehicle				
Car	1433	4.02	2.26	0.55 (0.47–0.64)
Truck‡	118	0.36	0.11	0.33 (0.19–0.64)
Other§	152	0.39	0.36	0.95 (0.66–1.41)
Arrived by ambulance				
Yes	989	2.72	1.72	0.63 (0.53–0.74)
No	714	2.04	1.01	0.48 (0.38–0.60)
Triage urgency¶				
High	1197	3.28	2.11	0.63 (0.55–0.74)
Low	506	1.48	0.62	0.40 (0.31–0.53)
Hospital admission				
Yes	176	0.47	0.34	0.72 (0.50–1.06)
No	1527	4.29	2.39	0.54 (0.47–0.62)
Full cohort	1703	4.76	2.73	0.55 (0.48–0.64)

* Event rates were calculated per 1000 patients annually during the corresponding interval.
† Morning was defined as 4 a.m. to 11:59 a.m., afternoon as noon to 7:59 p.m., and night as 8 p.m. to 3:59 a.m. (8 hours each).
‡ This category includes heavy transportation vehicles.
§ Other vehicles included tractors, snowmobiles, and all-terrain vehicles.
¶ High urgency denotes the need for resuscitation, emergency care, or urgent care, and low urgency denotes all other triage levels.

freedoms for patients who might be inherently safe drivers.[36,37] Ontario is the first North American region to enact such payments, and analyses in other regions would be worthwhile. In addition, more research is needed on graded licensure (an approach analogous to policies for young drivers that allow driving only in favorable circumstances).[38] In the interim, the data suggest that practicing physicians may be able to help prevent serious trauma from road crashes.

The views expressed in this article are those of the authors and do not necessarily represent the official views of the Ontario Ministry of Health and Long-Term Care.

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