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The Relationship Between Speeding Behaviour (as Measured by Violation Convictions) and Crash Involvement

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While it seems rational to assume that crash involvement risk and outcome are influenced by the way one drives, nevertheless there is continuing controversy over the validity of certain categories of traffic law infractions as true measures of such behavior. Specifically, does the accumulation of tickets for speeding identify drivers as high risk for becoming culpably involved in speed-related crashes? Further, does a proclivity for exhibiting speeding behavior in the presence of police translate into a greater risk for involvement in high-severity collisions?

The research reported in this paper attempted to address these issues. Several years of crash and conviction data were utilized to examine (a) the risk of culpable crash involvement by severity of outcome during a 2-year period following 3 years of conviction record, and (b) the degree to which an increasing level of speeding convictions per driver relates to an increasing propensity for speed to be a factor in drivers' crash involvements. The results of the research identified a clear distinction between the conviction categories of "exceeding the speed limit" and "excessive speed" in terms of these accident-violation relationships. © *1997 National Safety Council and Elsevier Science Ltd.*

BACKGROUND

In previous research conducted by the Insurance Corporation of British Columbia (ICBC; Chen, Cooper & Pinili, 1995), the relative importance of various traffic offense convictions in predicting driver involvement in subsequent crashes was assessed. The purpose of the research was to suggest a more empirical basis for driver license adjudication programs and to investigate the increased predictive power of including culpable crash involvements in the conviction history record.

However, recent controversy surrounding the implementation of new traffic law enforcement programs in British Columbia—particularly with respect to the introduction of radar cameras—has produced a new focus on such research that places the results in a different, and unintended, context. Specifically, the fact that the logistic regression coefficients for the various "before" violations

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that best predicted "after-period" culpable crash involvements were not highly-ranked in the case of the two speeding conviction categories has led to a misplaced belief by some special interest groups that speed is therefore not an important element in crashes. Of course, the earlier ICBC research was not designed to assess the impact of speed in crash causation or severity. The effect of speed on highway crash involvement was long ago postulated by Soloman (1964) to be primarily a function of the speed variance. Such a finding was more recently confirmed by Lassarre (1986), who reported a larger effect of speed standard deviation than of mean speed change on the number of deaths on the French National Road system. Finch, Kompfner, Lockwood, and Maycock (1994), however, have suggested that a correlation between aggregate speed distribution variance and crash rate independent of that between mean speed and crash rate is difficult to confirm. In examining data from the United States and Europe, the authors did find a strong direct relationship between traffic speeds and crashes. But, regardless of the exact mechanism through which characteristics of the speed distribution may influence collision frequency, it cannot be argued that the speed at which a vehicle travels does not affect both stopping distance and severity of impact in a crash (Cooper, Zuo, & Pinili, 1992; Navin, 1995). Stopping sight distance is a quadratic function of the vehicle velocity (containing both v and v terms). A vehicle travelling at 114 km/h, on a 100 km/h design speed road, whose driver first observes an unavoidable obstruction at a distance of 205 metres will strike this object after emergency braking while still travelling at 50 km/h—a speed which Hoskin (1986), based on analysis of 1984 US Fatal Accident Reporting System (FARS) data, suggests may be associated with up to 24% fatality probability. Such a fatality risk most likely applies to unbelted occupants (the overall US belt-wearing level in 1984 was not high) but even for restrained front-seat occupants, collision speeds of 50 km/h would appear to be associated with about a 10% fatality probability (Miltner & Salwender, 1995). At 100 km/h initial speed, the above-mentioned vehicle would stop in time to avoid striking the obstacle. A 14% speed increase in this instance translates into an increase in the risk of death for vehicle occupants from 0% to between 10% and 24%. For severe crashes that resulted from vehicles running off freeways in the Los Angeles area, Kraus et al. (1993) found speed or loss-of-control to be the second most important factor after alcohol in establishing causation.

Probability of injury and extend of damage in crashes is a direct function of initial impact speed and specifically velocity change during the collision. According to Miltner and Salwender (1995), in affecting injury severity "the accident factors that are most significant are velocity and deformation depth" (p. 149). The probability of injury for both restrained and unrestrained drivers has been found to rise markedly with the speed zone in which the crash occurred (Rothe & Cooper, 1988), and the probability of death in car-to-car collisions has been presented as proportional to the fourth power of the velocity change (Joksch, 1993; Navin, 1995). In an in-depth investigation and reconstruction of head-on crash incidents in Germany, Miltner and Salwender (1995) found that the probability of a severe or fatal injury for belted front-seat occupants was about 30 times higher at 80 km/h impact speed than at 40 km/h. Shibata and Fukuda (1994) found fatality risk in automobile collisions to be 14 times higher at 50–80 km/h than at 30–50 km/h and over nine times higher at greater than 80 km/h than at 50–80 km/h. Similarly, Hoskin (1986), analyzing FARS data, showed that as the estimated speed at which fatal crashes occurred rose so did the proportion of all occupants who were killed. At speeds under 64 km/h, 24% of all involved occupants died; at 88–102 km/h about 37% of occupants died; and at speeds over 120 km/h fully 55% were fatally injured. Similar results in terms of serious injury risk have been presented by Bowie and Walz (1994) from an analysis of US National Crash Severity Study (NCSS) and National Accident Sampling System (NASS) data.

With such a well-established and, presumably, intuitive connection between speed and both vehicle control and crash severity, why do some drivers choose to drive fast? Perception of risk (or lack of it) is an obvious factor and there are many instances where the nature of the immediately-experienced roadway and the behavior of surrounding traffic seem at odds with the posted speed limit. Drivers negotiating horizontal curves, for example, may place a higher importance on such things as sight distance, pavement condition, and degree of curvature than on roadway signage when it comes to their speed selection (Kanellaidis, 1995). That this may often be an ineffective decision-making model is attested to by the fact

that speeding is the likely cause of twice the proportion of crashes on roadway curves as compared to that on straight sections (Bowie & Walz, 1994). Acting on cues from surrounding traffic is also a well-known phenomenon which seems to reflect an inherent understanding of the "U"-shaped crash involvement curve in relation to individual speed variation from that of other vehicles (Soloman, 1964). This so-called "contagion" hypothesis has been found to operate in both directions—individual vehicles can be influenced to drive either faster or slower—and generally means that driving behavior is influenced by a driver's comparison of his/her own behavior with some observable aspect of the behavior of nearby drivers (Connolly & Aberg, 1993).

Speed may be desirable for some in order to minimize travel time. Those who own radar detectors are more likely to speed, and accumulate more speeding convictions than non-owners, even though they use devices designed to prevent such apprehension (Cooper et al., 1992). But speed also has intrinsic value for some drivers who simply like the excitement (Kanellaidis, 1995). Young male drivers, for example, have often been described as having a predilection for "sensation seeking" and measures of this tendency have been related to self-reported speeding behavior (Clement & Jonah, 1984). Parker, Manstead, Stradling, and Reason (1992) found that younger (especially male) drivers displayed "less awareness of or concern with the negative outcomes of violations, especially speeding, and greater difficulty in resisting commission of the violations" (p. 129). And young male drivers are more likely than others to be involved in speed-related fatal crashes (Bowie & Walz, 1994). As one might expect, the self-reported reasons why people commit speed limit violations involve a fair amount of rationalization. Kanellaidis, Golias, and Zarifopoulos (1995), in interviewing drivers in Greece, found that reasons for speeding that reflected socially unacceptable behavior were overstated when respondents referred to others' driving and understated when they referred to their own actions.

So speed is an important factor in crash severity and a substantial proportion of drivers exceed prudent speeds. According to Freedman and Esterlitz (1990) about one-quarter of all drivers were exceeding the engineering design speed of rural US interstate highways following the speed limit increases of 1989. Is there a relationship among drivers' beliefs, behavior, and their risk of becoming involved in serious crashes especially when they are at fault?

Higher at-fault crash rates as well as higher levels of speeding convictions were found by Cooper et al. (1992) to characterize drivers who owned radar detectors. Kanellaidis et al. (1995) found that 83% of drivers who reported complying with highway speed limits all or most of the time also believed that speed limits could be effective in reducing crashes. This compared with only 47% of drivers reporting seldom or never complying who held the same belief in speed limit efficacy. There is also some evidence to suggest that committing violations is influenced by social expectations. Drivers previously involved in crashes have been found to have a greater expectation that "significant others" might expect them to commit violations than did those who were accident-free (Parker et al., 1992). In other words, those tending to be involved in crashes may not have the same perceived level of social unacceptance of unlawful acts as those who are not so involved. A later study by Parker, West, Stradling, and Manstead (1995) reported that surveyed drivers who admitted to regularly committing speeding infractions were significantly more likely to have been driving the striking vehicle in a self-reported car-to-car crash than were other surveyed drivers. That actual observed speeding behavior can similarly be associated with past crash involvement was observed by Wasielewski (1984), who examined the records of drivers whose speed on a two-lane roadway was measured using radar. He found higher speed to correlate significantly with a greater frequency of prior crashes and violation convictions. As with Parker et al. (1992), Wasielewski found higher speeds also to be characteristic of younger drivers.

A behavioral distinction on the basis of driver age was also uncovered by Rajalin (1994), who compared the records of drivers involved in fatal crashes with a randomly-selected control group of drivers; Rajalin also compared a sample of drivers stopped by the police for risky driving with a control sample from the same traffic stream. Rajalin found that for all age groups, those stopped by police for risky driving had substantially more prior speeding offenses than did their controls, and that fatal-crash-involved drivers had almost two times more speeding convictions per driver than the control drivers and over three times more

major behavioral offenses, such as drinking while intoxicated (DWI) and driving without a license. But the overrepresentation of prior speeding convictions in the crash-involved group was primarily associated with younger drivers (under 35 years of age). In addition, culpability in the crash was found to be the most important factor in relation to the total number of all prior offenses; those culpably involved averaged 1.30 offenses per driver while those involved, but not at fault, had a prior offense rate very similar to that of the controls (0.60 and 0.41, respectively). Rajalin concluded that: ". . . some drivers behave in a generally deviant manner and repeatedly violate traffic regulations. This kind of behavior has become a characteristic trait of these drivers, providing a basis on which some of them may be identified in traffic. This behavioral pattern also appears to precede fatal accidents, the participants in which, especially culpable ones, have substantially more recorded offenses than other drivers" (p. 561).

It is evident from the above discussion that serious speeding behavior (i.e., unsafe, risky, or excessive speed for prevailing driving conditions), if it exists as an identifiable pattern in an individual's driving record, should be indicative of an increased risk for culpable involvement in serious crashes. And, furthermore, that excessive speed itself is likely to be a leading factor in the causation of such crashes (Bowie & Walz, 1994). The research reported in this paper was designed to illustrate these associations through analysis of the records of British Columbia drivers.

METHOD

Re-analysis of the Driver Record Data Set Described in Chen et al. (1994)

The data used were the same as those described in the paper based on the earlier study. Driver record information covering the 5-year period 1985 to 1990 was combined with crash-related insurance claim data, which included assessments of culpability for the parties involved. Driver fault, or percent responsibility, is assessed in each claim-producing event by one or more insurance adjusters based on driver and witness statements, police reports where available, and the nature of the crash site (e.g., right-of-way). A crash involvement where the driver was assessed 50% or greater responsibility was defined as culpable for the purposes of this study.

The first 3 years of the record period were used as "before" data to predict culpable crash involvement in the final 2 years. However, instead of conducting a single logistic regression analysis involving at-fault association with one or more crashes of any severity, this time the dependent crash variable was separated into four different severity categories and four separate models were developed. These severity categories were: (a) one or more culpable non-casualty crash involvements; (b) one or more culpable injury crash involvements with associated claims costs of under $10,000; (c) one or more culpable injury crash involvements costing between $10,000 and $50,000; and finally, (d) one or more culpable injury crash or fatal crash involvements costing $50,000 or over.

The total number of drivers whose records were examined was 1,998,347, and these records produced 513,317 culpable crash involvements. Of these culpable crash involvements, 176,375 occurred during the final 2 years of record: 127,063 non-casualty; 29,229 casualty under $10,000; 15,597 casualty $10,000-$50,000; and 3,486 casualty over $50,000 plus fatal incidents. The definitions of conviction types are presented in Table 1. The conviction type STF represents excessive speed, defined as either 40 km/h or more over the speed limit, or excessive relative to road, traffic, visibility, or weather conditions.

A separate logistic regression model was constructed for each of the severity categories. Differences among independent variable estimates were tested using the standard normal Z distribution where:

$$Z = \frac{B_a - B_b}{\sqrt{(SE_a)^2 + (SE_b)^2}}$$

B: estimate
SE: standard error of estimate

The level of the test employed was $p < 0.05$ for which $Z = 1.96$.

Analysis of Driver Records in Association with Police Accident Data

Driver records for the period January 1, 1991 to December 31, 1994 were extracted and matched with police accident data for the same period obtained from the province's Motor Vehicle Branch (MVB). Since the driver records contained the dates of each crash involvement and

TABLE 1
CONVICTION GROUPS

Group	Conviction Type	Motor Vehicle Act Section	# of Drivers
CCC	Criminal code conviction	All types of criminal convictions (mainly DWI)	5,707
FTY	Failure to yield	M132 M134 M136	50,966
WDC	Without due care/consideration	M149 (A &B)	14,935
STF	Speed too fast/excessive speed	M149 (C) M152.1	13,915
LAN	Lane infractions	M154-M157 M159-M162 M165 M201	33,428
INT	Intersection infractions	M166-M172 M194	25,744
FYP	Failure to yield pedestrians etc.	M135 M176-M179 M181 M183	21,062
ESL	Exceed speed limit	M151 M152	526,556
MDS	Major disobey signal	M145 M148 M175 M186 M187 M195 M201 etc.	129,721
VDF	Vehicle not up to standard	M173 M174 M196 M216	10,455
MS	Minor disobey signal	M119 M130 M133 M139 M146 M153 M67	41,103
FTC	Follow too closely	M164	11,184
MA	Administrative infraction	M12 M64 M88 M92 M94 M192 M209 M217 M218 M23 M24 M30 etc.	151,019
RSS	24-hour roadside suspension	M214	30,058

conviction, it was possible to match each driver with the details (from the MVB police-reported accident databases) of each crash with which he/she had been associated. Further, since the police-reported accident data included details of any charges laid, it was possible to discount convictions that may have followed as a consequence of police attendance at the crash. Thus, in comparing crashes with convictions, only non-crash-related violations that could be assumed to reflect "regular" driving behavior were included.

For the analysis of this new data set, the focus was placed on specifically-identified speeding incidents, both violation convictions and crashes. In the case of violations, the categories identified were "exceeding the speed limit," "speed excessive for conditions," and "excessive speed," which is defined as exceeding the speed limit by 40 km/h or more. All of these categories are specifically linked to either posted speed limits or observable conditions and, thus, would likely reflect the intentional behavioral pattern referred to by Rajalin (1994). All other, non-speeding, violations were combined into another separate category. In the case of crashes, three categories were used: (a) all reported collision involvements, (b) all police-attended collision involvements, and (c) all police-attended collision involvements where the driver was assigned "unsafe speed" as a contributing factor by the reporting officer.

For each driver currently listed in the provincial drivers database as active, the numbers of occurrences of the above violation convictions and crash involvement types were enumerated. Drivers were then categorized as having either (a) no speeding convictions and 0, 1, 2, 3 or 4+ non-speeding convictions, (b) no excessive speeding convictions and 0, 1, 2, 3 or 4+ exceeding speed limit convictions and, finally, (c) 0, 1, 2, 3 or 4+ excessive speed (either excessive for conditions or 40 km/h or more over the speed limit) convictions. In each of these driver categories the rate of crashes per driver was calculated.

RESULTS

Tables 2 to 5 contain the results of the logistic regressions for each of the four crash severity categories. While the probability levels associated with three of the conviction types came out above the standard normally accepted for significance in one case each, the variables were left in the models in order to enable consistent comparison of relative importance of conviction type among the four outcome severities.

For low-severity culpable crash involvement prediction (non-casualty and injury under $10,000), the most important group of violations was primarily represented by right-of-way and traffic control infractions (FTY, MDS, and MS). Exceeding the speed limit (ESL) was in

TABLE 2
LOGISTIC REGRESSION RESULTS—CULPABLE NON-CASUALTY CRASH INVOLVEMENTS

Effect	Estimate	Standard Error	Chi-Square	Probability
INTERCEPT	-3.0124	0.00357	710223.9	0.0000
AFC	0.4452	0.00518	7385.13	0.0000
FTY	0.3427	0.0122	791.74	0.0000
MDS	0.3132	0.00701	1995.84	0.0000
CCC	0.2917	0.0393	55.09	0.0000
MS	0.2798	0.0146	365.55	0.0000
RSS	0.2318	0.0140	273.93	0.0000
INT	0.2308	0.0181	163.11	0.0000
LAN	0.2307	0.0153	227.10	0.0000
ESL	0.2091	0.00244	7337.16	0.0000
VDF	0.1875	0.0233	64.54	0.0000
STF	0.1258	0.0237	28.17	0.0000
MA	0.1059	0.00440	580.31	0.0000
FYP	0.1058	0.0218	23.48	0.0000
FTC	0.0841	0.0281	8.94	0.0028
WDC	0.0549	0.0227	5.85	0.0156

the middle of the hierarchy of estimates. Excessive speed (STF) appeared somewhat lower down in the list and, in fact, was significantly less correlated with non-casualty crashes than was ESL ($Z = 3.50$, $p = .0022$). While excessive speed and exceeding the speed limit were both highly significant predictors of subsequent minor culpable crash involvement, there were other types of violations (such as disobeying signals) that appeared to be better indicators of low-severity crash risk.

Even in the middle severity category of culpable crash involvements resulting in injury with cost between $10,000 and $50,000, excessive speed remained relatively low in terms of subsequent crash correlation, but was now not significantly different from ESL ($Z = 1.60$, $p = .1096$) in terms of its relation to crash risk. Primacy, in terms of crash predictive power, had been taken over by Criminal Code convictions (primarily DWI), with right-of-way and traffic control infractions being relegated to second level. Again, however, both ESL and STF were highly significant crash involvement predictors.

TABLE 3
LOGISTIC REGRESSION RESULTS—CULPABLE INJURY CRASH INVOLVEMENTS, UNDER $10,000

Effect	Estimate	Standard Error	Chi-Square	Probability
INTERCEPT	-4.5314	0.00714	402240.3	0.0000
AFC	0.3714	0.00906	1679.37	0.0000
FTY	0.3101	0.0214	209.12	0.0000
MDS	0.2969	0.0124	576.77	0.0000
MS	0.2769	0.0265	109.44	0.0000
RSS	0.2238	0.0243	84.72	0.0000
LAN	0.2210	0.0268	68.00	0.0000
FYP	0.2198	0.0389	31.93	0.0000
CCC	0.2126	0.0790	7.24	0.0071
ESL	0.2099	0.00434	2339.66	0.0000
FTC	0.1830	0.0491	13.89	0.0002
INT	0.1552	0.0329	22.24	0.0000
STF	0.1429	0.0417	11.74	0.0006
VDF	0.1120	0.0398	7.93	0.0049
WDC	0.0906	0.0398	5.17	0.0230
MA	0.0670	0.00732	83.61	0.0000

TABLE 4
LOGISTIC REGRESSION RESULTS—CULPABLE INJURY CRASH INVOLVEMENTS, $10,000-$50,000

Effect	Estimate	Standard Error	Chi-Square	Probability
INTERCEPT	-5.1758	0.00971	283975.1	0.0000
AFC	0.3711	0.0117	1003.45	0.0000
CCC	0.3942	0.0944	17.43	0.0000
FTY	0.3282	0.0278	139.57	0.0000
MS	0.2914	0.0346	70.83	0.0000
RSS	0.2902	0.0302	92.94	0.0000
MDS	0.2592	0.0165	246.05	0.0000
LAN	0.2357	0.0347	46.20	0.0000
ESL	0.2136	0.00567	1417.29	0.0000
FTC	0.1966	0.0642	9.39	0.0022
STF	0.1736	0.0536	10.48	0.0012
FYP	0.1681	0.0528	10.15	0.0014
INT	0.1647	0.0429	14.70	0.0001
MA	0.0730	0.00925	62.23	0.0000
WDC	0.0323	0.0533	0.37	0.5439
VDF	0.0196	0.0560	0.12	0.7264

With the final model, representing the most severe category of culpable crash involvements including fatalities, the trend for DWI offenses to assert their predictive importance continued. Criminal Code convictions were now clearly at the top and the 24-hour roadside suspension (for suspected alcohol consumption) continued to be in the top four, as did the FTY conviction. But excessive speed had now moved up to the next position after CCC (primarily DWI) as per Kraus et al. (1993), while violations such as disobeying signals, intersection and lane infractions were near the bottom of the rankings. Exceeding the speed limit (ESL) stayed firmly entrenched in the middle of the estimate hierarchy.

In fact, it is interesting to note that the estimates for ESL remained almost identical through all four crash severity categories, ranging between a low of 0.2091 and a high of 0.2136 ($Z = 0.73$, $p = .4654$). Meanwhile the estimates for STF began at 0.1258 for low-severity events and rose with each severity category to reach 0.3710 (the second highest estimate of all violations) for fatal and major injury

TABLE 5
LOGISTIC REGRESSION RESULTS—CULPABLE FATAL INJURY CRASH INVOLVEMENTS ≥$50,000

Effect	Estimate	Standard Error	Chi-Square	Probability
INTERCEPT	-6.6644	0.0202	108950.5	0.0000
AFC	0.3155	0.0239	173.82	0.0000
CCC	0.6363	0.1655	14.78	0.0001
STF	0.3710	0.0977	14.42	0.0001
FTY	0.3408	0.0560	37.05	0.0000
RSS	0.3150	0.0574	30.13	0.0000
WDC	0.2715	0.0941	8.32	0.0039
FTC	0.2503	0.1289	3.77	0.0521
FYP	0.2402	0.1063	5.10	0.0239
ESL	0.2101	0.0114	338.26	0.0000
VDF	0.2062	0.0901	5.24	0.0221
LAN	0.1859	0.0710	6.84	0.0089
MDS	0.1838	0.0356	26.63	0.0000
MS	0.1516	0.0760	3.98	0.0459
INT	0.1306	0.0902	2.10	0.1478
MA	0.0773	0.0175	19.60	0.0000

TABLE 6
CRASH RATES OF DRIVERS WITH TRAFFIC VIOLATION CONVICTIONS OVER A FOUR-YEAR PERIOD

Violation category and number of drivers	Number of Violations per Driver	Number of crashes per driver			Proportion of police-attended crashes that were speed-related
		All	Police-attended	Police attended and speed-related	
Non-speeding	(all drivers with speed convictions of any kind excluded from the data)				
2,375,565	0	0.10746	0.05861	0.00544	0.09280
127,783	1	0.18048	0.07512	0.00448	0.05969
18,477	2	0.27023	0.14234	0.01748	0.12281
4,441	3	0.31772	0.18892	0.02702	0.14303
3,402	4+	0.32305	0.22075	0.04203	0.19041
Exceeding Speed Limit	(only drivers with excessive speed convictions excluded from the data)				
154,103	0	0.19834	0.08967	0.00752	0.08387
567,663	1	0.17868	0.08005	0.00582	0.07264
175,605	2	0.32549	0.16111	0.01779	0.11042
71,754	3	0.43212	0.22141	0.02846	0.12853
62,736	4+	0.59921	0.32492	0.04976	0.15316
Excessive Speed	(all drivers included in the data)				
1,031,861	0	0.24979	0.12000	0.01235	0.10295
60,391	1	0.48938	0.26648	0.05464	0.20506
6,238	2	0.79897	0.44838	0.10083	0.22488
1,113	3	0.98742	0.59119	0.15633	0.26444
317	4+	1.14196	0.63722	0.19558	0.30693

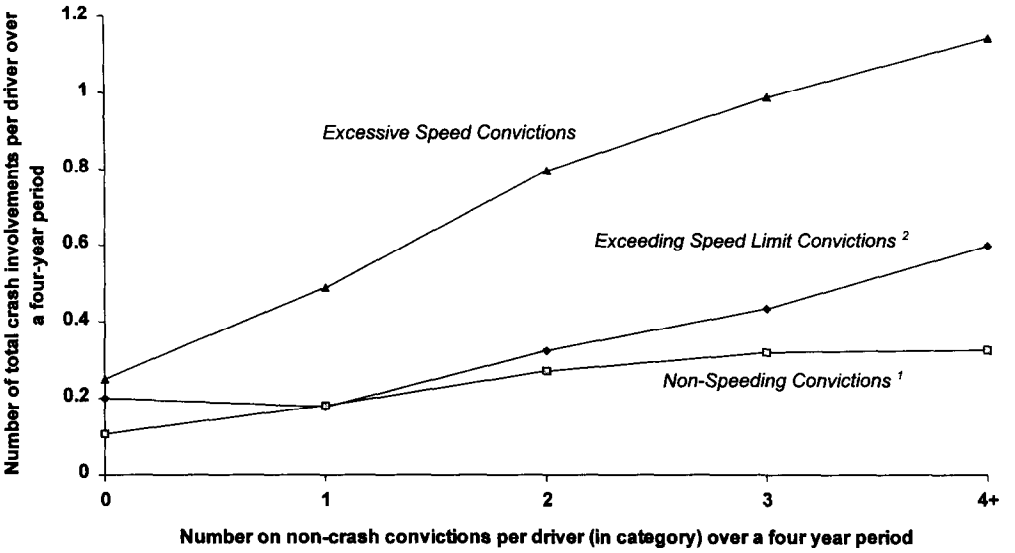
events. This rise in STF estimate level was statistically significant ($Z = 2.44$, $p = .0146$).

Having examined the predictive "power of speeding convictions in establishing subsequent crash risk by severity, the next stage of the research addressed the question of whether or not people's driving characteristics, as represented by violations committed, are reflected in the contributing factors to crashes in which they are involved. The data were reduced in such a way as to separate drivers (a) with no convictions of any kind, (b) those with convictions but none for speeding, (c) those with one speeding or other conviction, (d) two such convictions, (e) three such convictions, and (f) four or more such convictions. "Speeding" was defined in two separate ways, leading to two separate analyses. First, using the variables listed in Table 1, speeding was defined to include just ESL. Secondly, speed was defined so as to focus on STF (which in turn included both 40 km/h or more over the speed limit, and speed judged excessive for road or traffic conditions). Drivers with any speeding convictions were excluded from the first data set and drivers with excessive speed convictions were excluded from the second in order to create a hierarchy of "worst" speed behavior groups.

The crash data over the same time period were categorized in three ways: total crash involvements, police-attended crash involvements, and police-attended crash involvements in which the driver in question had been assigned by police the contributing factor of "unsafe speed." Then the total numbers of these crash involvements were enumerated for each of the six driver categories within each of the two speeding definitions, and also for drivers with various levels of non-speeding violations. These totals were expressed as a ratio of crashes per driver and can be found in Table 6.

From Table 6 it is clearly evident that the number of crash involvements per driver (crash rate) rises markedly with the number of speeding convictions obtained over the same period (Figure 1). This is so for both definitions of speeding and also for non-speeding convictions, but the effect is markedly greater for drivers having convictions for excessive speed. Further, the rise is proportionally greater when only unsafe speed crash involvements are used than when all crashes are included. But since unsafe speed crashes will generally follow the trend of all crashes, it is necessary also to examine the ratio of these two crash categories. That is, what proportion of these drivers' crashes are speed-related? When this was done (Table 6) it was found that the ratio was highest for speeding defined as "excessive" (STF). The increase in the

Figure 1
Crash Involvement Rates for Drivers with Accumulations of Different Conviction Types



1. drivers with no speeding convictions
2. drivers with no excessive speed convictions

proportion of police-attended crashes where the driver in question was assigned "unsafe speed," by the conviction category for both speeding and non-speeding definitions is shown in Figure 2.

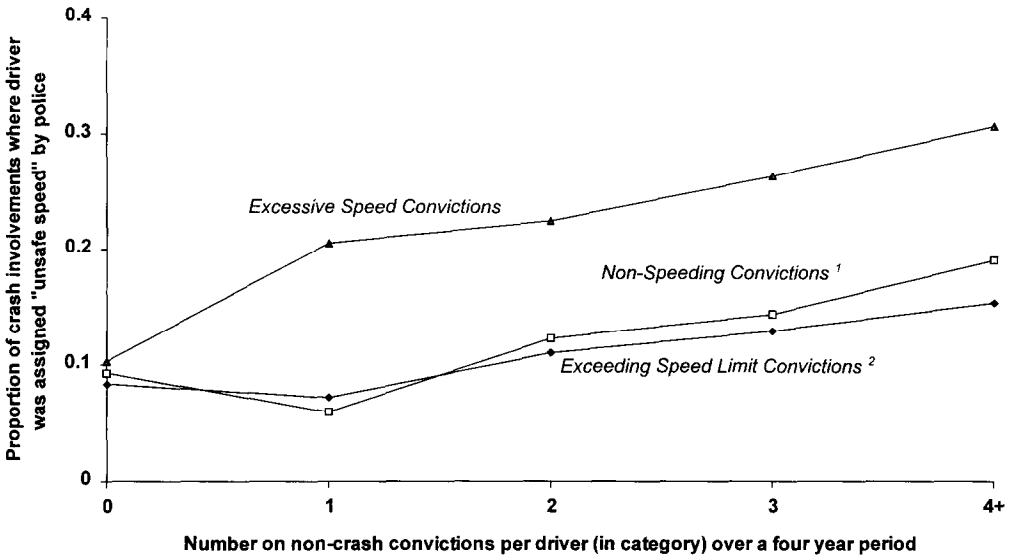
The results illustrated in Figures 1 and 2 represent statistically significant differences among the three violation-type groups. The total number of crashes per driver (0.25883) for those with no excessive speed convictions but with one or more convictions for exceeding the speed limit (N = 877,758 drivers) was significantly greater than the rate (0.19659) for those drivers (N = 154,103) with no speeding convictions of any kind but with one or more non-speeding convictions (χ^2 = 4,584, df = 1, $p <$ .01). Similarly, the total number of crashes per driver (0.52894) for those with one or more excessive speed convictions (N = 68,059 drivers) was significantly greater than that for drivers with one or more convictions for exceeding the speed limit and no excessive speed convictions (χ^2 = 9,364, df = 1, $p < .01$).

Also, the overall proportion of police-attended crashes ascribed to unsafe speed was significantly higher for the excessive-speed convicted drivers than for the exceeding-speed-limit convicted drivers (p_1 = 0.21064 and N_1 = *35,999 crashes versus* p_2 = 0.10310 and N_2 = 227,186 crashes; t = 58.8, $p < .01$). The same was true when comparing the exceeding-speed-limit convicted drivers with those having no speeding convictions, but one or more other moving violation convictions (p_3 = 0.07815 and N_3 = 30,295 crashes; t = 13.6, $p < .01$). In this case, the higher percentage of drivers with multiple convictions in the exceeding-speed-limit group gave it a greater overall proportion of crashes due to unsafe speed, even though at most points in Figure 2 the non-speeding conviction group was higher.

DISCUSSION

The results of the study showed that drivers with more speeding convictions (either for exceeding the speed limit or for excessive speed) had, over the same time period, both more total

Figure 2
Relationship Between Type and Number of Non-Crash Convictions, and the Proportion of Crash Involvements to Which Speed Reportedly Contributed



1. drivers with no speeding convictions
2. drivers with no excessive speed convictions

crash involvements and more "unsafe speed" involvements in crashes attended by police. Similarly, the presence of either of these two classes of speeding convictions was significantly related to the risk of culpable crash involvement during a subsequent period.

However, of these two classes of speeding conviction, only excessive speed became a more important culpable crash-involvement predictor as the severity of subsequent crash events increased. This class also had a much more pronounced relationship with the involvement in crashes specifically designated by police as being due to unsafe speed than did that of exceeding the speed limit.

The two hypotheses introduced at the end of the "Background" section of this paper have now been addressed. That is, serious speeding behavior (excessive speed), as a pattern derived from drivers' conviction records, was found to be indicative of increased risk for culpable involvement in serious crashes. Further, it was only the more serious speeding incidents (i.e., excessive speed as opposed to the much more common situation of simply exceeding the speed limit) that became more critical in predicting culpable crash involvement as the severity of these crashes increased. Also, such a history of excessive speed convictions was found to be associated with a high number of crashes in which a substantial proportion (up to 31% for those with four or more convictions) involved unsafe speed on the part of the driver with the history of speeding. This proportion compared with 15% for those with four or more exceeding-speed-limit convictions. But, to put both these numbers in perspective, only 9% of the police-attended crash involvements for drivers with no convictions of any kind were judged to be speed-related.

Another interesting observation was that having only speeding convictions of the exceeding-speed-limit type (and no excessive speed convictions) seemed to be associated with speed-related crash risk at a very similar level to that associated with having non-speeding convictions. This suggests that exceeding speed limit violations (which represent by far the most

frequent of all conviction types) on their own do not, at a level beyond that associated with other violations, represent behaviors that particularly predispose drivers to become involved in crashes in which their speed was judged to be a factor. As proposed by Parker et al. (1995), the tendency to commit any violations may be closely linked with faster driving. However, multiple excessive speed violations quite clearly characterize drivers who are more likely to be involved in unsafe-speed collisions.

Exceeding the speed limit by a relatively modest (i.e., not excessive) amount is a fairly common occurrence for many drivers. Recent measurements at various speed loop locations within British Columbia have indicated that 45% to 91% of drivers exceed the speed limit by less than 30 km/h and 40% to 56% exceed it by less than 15 km/h. About one-third of all the BC drivers during the 4 years of record examined likely had one or more convictions for such behavior. Certainly, those who got caught (and thus presumably committed violations), were more likely to be involved in crashes, and especially crashes where their speed was assessed as a factor. But their level of such crash involvement was not noticeably greater than was the case for drivers with one or more convictions for non-speeding violations. Also, this kind of violation behavior did not seem related to subsequent involvement in more severe crashes.

On the other hand, speeding of a more severe type—40 km/h or more over the limit or judged excessive for road or traffic conditions—was found to be much more strongly associated with both speed-related crash involvements and higher-severity consequences. A strong link between driving behavior and both crash causation and outcome can reasonably be postulated in the case of excessive speed. This is consistent with one of the suggestions from Parker et al. (1995) that the crucial factor in accident causation is not so much speed per se as a failure to adjust speed to prevailing conditions.

It is unfortunate that the conviction data did not provide any subdivision of the exceeding-speed-limit category by level of offense or by speed zone or land use within which the infraction was committed. For example, travelling 80 km/h in a 50 km/h residential area may be potentially far more serious than going 130 km/h in a 100 km/h highway zone. There are obviously a number of exceeding-speed-limit convictions that could be closer to the excessive speed category in terms of associated crash risk. The results of the research discussed here should not be taken to imply that exceeding the speed limit by less than 40 km/h is a benign activity; 40 km/h over the speed limit is simply the principal dividing line between two levels of speeding severity defined in the provincial Motor Vehicle Act, and is not necessarily the most appropriate differentiation level from an objective crash risk standpoint.

In addition, there are—as the logistic regression results indicated—violation types other than specifically speed-related that are more highly associated with crash involvement risk. Thirty-five percent of drivers with one or more excessive speed convictions also had one or more of these higher-risk convictions. Most revealing of all, the 2% of all drivers who had one or more convictions for excessive speed also accounted for fully 44% of all the Criminal Code convictions assessed during the 4-year record period.

Considering all drivers with one or more excessive speed convictions ($N = 68,059$), those 23,808 additionally having one or more of the higher crash-risk violations (coefficients greater than that for excessive speed in the results reported by Chen et al., 1995) had a higher crash rate per driver than the average for all those with one or more excessive speed convictions—0.77281 versus 0.52894 in terms of all crashes, 0.43905 versus 0.29019 in terms of police-attended crashes, and 0.09703 versus 0.06120 in terms of speed-related, police-attended crashes. But the proportion of police-attended crashes judged to be speed-related was very similar, at 22.1% and 21.1%, respectively. Only when the "other" convictions were for criminal and DWI-related offenses did the proportion increase markedly (to about 28%).

CONCLUSIONS

Generally speaking, drivers with more non-accident-related convictions for traffic law violations appear at greater risk of being culpably involved in crashes and also are more likely to be judged as contributing to the cause of the crash through travelling at an unsafe speed. But drivers with multiple convictions specifically for exceeding the speed limit would seem to be not notably more likely to be culpably involved in crashes or judged to have contributed to them

through unsafe speed than are those with multiple non-speeding violations.

Thus, the number of tickets accumulated by most drivers for exceeding the speed limit is likely not a primary measure of heightened risk for crash involvement due to speed. Other violation convictions produce the same, or an even more pronounced, effect. In addition to driving behavior, we may be seeing the influence of exposure here. That is, for infractions such as exceeding the speed limit that are heavily enforced by police and that are also commonly committed by drivers, the most important common link between being caught and being involved in crashes could simply be the amount one drives. And the behavioral link (i.e., speed in this case) between such violations and both crash frequency and severity may be relatively weak. Alternately, it is demonstrably the case that exceeding the speed limit is a characteristic offense for many drivers who also accumulate other moving violation convictions. Their attitudes and behaviors that put them at risk of speed-related crash involvement may be as much or more related to these other infraction tendencies as to speeding habits.

But "excessive" speeding, whether judged subjectively by a police officer or representing a measured extreme in relation to a posted limit, is an entirely different situation. Involvement in such activity is a predictor of increased risk of serious injury and fatal crashes. Drivers with four or more excessive speed convictions were found to have almost twice the overall crash rate of drivers whose most serious multiple speed-related offenses were for simply exceeding the posted limit. In addition, the proportion of crash involvements attributed to unsafe speed was twice as high. The implication is that efforts to reduce speed-related and severe crashes should focus on the excessive speeders—those at the high end of the speed distribution.

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