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Speeding and impaired driving in fatal crashes – results from in-depth investigations

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Objective: *The aim of the study was to identify typical patterns of risk factors among speeding and impaired fatal crash involved car drivers, and to suggest countermeasures.* ***Method:*** *Results from in-depth investigations of 1501 fatal passenger car crashes that occurred in Norway in 2005-2015 and that involved 1949 passenger cars, are summarized. Relationships between speeding (excessive speed, EXC, or inappropriate speed, INAP), driving under the influence (DUI) of alcohol (ALC), drugs (DRUG) or both (MIX), and other driver, crash, vehicle, and road related variables were investigated.* ***Results:*** *Speeding and DUI drivers have in common that they, more often than others, are male, unbelted, unlicensed, driving old cars, and involved in single vehicle crashes under low-volume conditions (night-time, weekend, low volume roads). They are also less often fatigued, ill or suicidal. EXC and ALC drivers are on average younger and they generally show more high-risk behavior than INAP, DRUG, and MIX drivers. In pedestrian/cyclist crashes and crashes on slippery roads or in winter, INAP drivers are overrepresented, while EXC and DUI drivers are underrepresented. Among DRUG and MIX drivers there may be differences according to the type of substance.* ***Conclusions:*** *Those drivers who show most types of high-risk behavior, especially EXC and ALC drivers, are less likely to respond to measures relying on voluntary behavior changes, such as recommended speed, speed warnings, or classical enforcement, although such measures may be effective for INAP and some DRUG drivers. To change the behavior of EXC and ALC drivers, more restrictive measures are called for, such as non-overridable intelligent speed adaptation, vehicle impoundment or alcolock.*

Keywords: Fatality; In-depth investigation; Crash reconstruction; Speeding; DUI.

INTRODUCTION

Fatalities in crashes with passenger cars accounted for 78% of all road fatalities in Norway in 2005-2015. In about one third of all fatal crashes with passenger cars, a car driver has been speeding, and in at least every fifth fatal passenger car crash a car driver has been under the influence of alcohol or drugs (DUI). Both DUI and speeding are known to contribute to increased crash risk and severity (Elvik 2013).

Official crash statistics contain normally little or no (reliable) information about DUI or speed and are therefore not adequate for detailed investigations of driver related factors other than demographics (Vissers et al. 2018). In Norway, DUI (alcohol) disappeared from official crash statistics in 1997 and information about speed or drug driving has never been a part of it. In-depth studies provide far more information about driver related factors (Larsen & Kines 2002; Sagberg 2018).

In Norway, the Public Roads Administration has since 2005 conducted in-depth analyses of all fatal crashes in which information about speed and DUI (and many other variables) is collected. Based on these analyses, the present study aims to answer the following questions: What are typical crash, driver, vehicle, and road characteristics in speed and DUI related fatal car crashes? Are patterns of risk factors different between different groups of speeding and DUI drivers?

DUI and speeding have been found to be related to other types of high-risk behavior, such as non-wearing of seat-belts, being unlicensed, and reckless driving (Blows et al. 2005; Høye 2016). However, past studies have not always distinguished between different types of speeding or DUI (for example Sagberg 2018). The present study distinguishes between two types of speeding (excessive or inappropriate) and three types of DUI (driving under the influence of alcohol, other substances, or both).

METHOD

The present study is based on results from in-depth investigations of fatal crashes with passenger cars in Norway during 2005-2015 that were investigated by crash investigation teams (CITs) of the Norwegian Public Roads Administration. The CITs investigate all fatal crashes in Norway (crashes that lead to at least one fatality within 30 days, except for very few crashes where there is strong evidence for suicide). The investigations include crash-scene investigations, information from police examinations of involved persons and witnesses (often including friends and relatives), technical investigations, results from medical examinations, autopsies, and crash reconstructions. The present study uses information that is available from a database of the crash investigations.

Speeding is classified as excessive (EXC) or inappropriate (INAP). EXC refers to speed that normally would have led to license revocation (20 km/h above the limit at speed limits up to 60 km/h; 30 km/h above the limit at speed limits over 60 km/h). INAP refers to speed that has been too high under the current driving conditions (roughly speaking: other drivers in the same situation would probably also have had trouble keeping control over the car), without being EXC. Speed has been assessed for all drivers by the CIT, mostly based on physical evidence or crash reconstructions and in some cases based on accounts from witnesses (e.g. drivers of other vehicles who could report their own speed and an approximate relative speed). EXC is more clearly defined and most likely more reliable than that of INAP. Among those drivers among whom numerical speed estimates are available, more are classified as EXC (15%) than among those for whom no such estimates are available (9%), probably because speed is more often assessed when excessive speed is suspected than when it is not. Due to speed estimation or measurement errors, EXC may be misclassified in some cases (mostly EXC instead of INAP or vice versa), but it is unlikely that one or the other is systematically overestimated.

DUI is classified as alcohol only (ALC), other substances only (DRUG), or both (MIX). ALC comprises blood alcohol levels of .02 or above which is the current legal limit in Norway. DRUG comprises the presence of (legal/illegal) psychoactive substances that are assumed to have affected the driver. It has been assessed by the CIT, mostly based on blood samples/autopsies, and in a few cases based on witness accounts (e.g. friends/relative who had observed the driver drinking or taking medication before driving). Information about the type of substance was not available. Some DUI-drivers may have gone undetected as more than 30% of the fatally injured drivers were not investigated for alcohol or drug use by testing of blood samples (Valen et al. 2019).

The unit of analysis in the present study is a car or car driver. The majority of crash, driver, car, and road variables were dichotomized. Unadjusted bivariate relationships between speeding, DUI, and each of the other variables were calculated as odds ratios (OR). Additionally, adjusted ORs were calculated for most driver and car variables that can be regarded as crash predictors with either EXC, INAP, ALC, DRUG, or MIX as the dependent variable and driver and car related variables as covariates. All ORs were calculated with the logistic regression function in Stata (14.2). While most of the unadjusted ORs are based on all 1949 drivers, the adjusted ORs are based only on those drivers for whom information about all predictor variables in the logistic regression models is available.

RESULTS

Table 1 shows the numbers of crashes, involved passenger cars, involved crash partners (including other passenger cars), and fatalities in fatal crashes with passenger cars that occurred in Norway in 2005-2015 and that are included in the present study. In total, 1949 passenger cars, involved in 1501 crashes, were included in the analyses. Of all passenger car drivers, 30% had been speeding and 15% had been DUI.

Complete information about the proportions of drivers in each speed and DUI category among whom each of the crash, driver, car, and road factors has been present, is shown in Table A.1 in the appendix. Unadjusted ORs of these factors being present (vs. absent) among speeding (EXC/INAP vs. non-speeding) and DUI (ALC/DRUG/MIX vs. sober) drivers, are shown in table A.2 in the appendix. The adjusted ORs in Table 2 show the same relationships, based on logistic regression models with each of the other driver and car related factors in this table as predictor variables. Complete information from all models, including confidence intervals and Pseudo R^2, is shown in Table A.3 in the appendix. The results indicate that the predictor variables predict EXC and DUI better than INAP. The results described in the following are based on Table 2, unless mentioned otherwise.

Crashes

Crash type: Speeding and DUI crashes, especially EXC and ALC crashes, are more often than others single vehicle crashes. INAP crashes are more often than others collisions with vulnerable road users (pedestrians/cyclists). In most of these crashes, speed was coded as inappropriate in the current traffic situation (areas/situations with vulnerable road users), while speed in other INAP crashes was coded as inappropriate in relation to road geometry or driving conditions.

Fatalities: Speeding and DUI drivers have more often a fatality in the own car than other drivers. This is partly due to the high involvement in single vehicle crashes. In crashes with a crash partner, only speeding and MIX drivers have more often a fatality in the own car than non-speeding/sober drivers.

Time of crash: Nighttime and weekends are overrepresented in speeding and DUI crashes, especially in EXC, ALC, and MIX. Crashes in winter and on slippery roads are overrepresented among INAP crashes which is due to the definition of INAP. Winter and slippery roads are underrepresented in EXC and ALC crashes.

Drivers

Speed: Numerical speed estimates are available for 44% of drivers. According to these results, EXC drivers are on average much faster (115 km/h; N=128) than INAP drivers (77 km/h; N=162) and other drivers (46 km/h; N=575). Among EXC drivers, there is only a weak correlation between speed limit and estimated speed (r=.29), while the correlation is higher among INAP drivers (r=.35) and highest among non-speeding drivers (r=.49). Among INAP drivers, 31% were driving at least 10% above the speed limit, while all EXC drivers and 7% of non-speeding drivers were driving at least 10% above the speed limit.

DUI: Among DUI drivers, speed is highest among ALC drivers (106 km/h; N=66), followed by MIX (89 km/h; N=25) and DRUG (75; N=34). Among sober drivers, average speed is 71 km/h (N=740). In accordance with these results, there are strong relationships between speeding and DUI, especially between EXC and ALC.

Unlicensed driving and non-use of seat belts: Both unlicensed driving and non-use of seat belts are overrepresented among speeding and DUI drivers, especially among EXC and ALC drivers. For EXC and INAP, the adjusted effects of being unlicensed and unbelted are considerably smaller than the unadjusted effects and most of them are non-significant.

The proportion of unbelted drivers is in most groups of drivers higher among those who were fatally injured than among others (Table A.1, appendix). Among all fatal crash involved drivers, seat belt use is far lower than among non-crash involved car drivers in Norway (87% in urban areas and 92% in rural areas in 2000; ,95% in urban areas and 97% in rural areas in 2014; Statens vegvesen 2016).

Age and gender: Male and young drivers are overrepresented among speeding drivers (both EXC and INAP). Male drivers are also overrepresented among ACL drivers, but not among DRUG and MIX drivers. The relationships between the drivers' age and DUI differs between types of DUI and between the unadjusted and adjusted results. According to the adjusted ORs, young drivers are underrepresented among DRUG and MIX drivers, but not among ALC drivers.

Driver state (fatigue/illness/suicide): Among EXC drivers, fatigue/illness/suicide is underrepresented while fatigue/illness/suicide is not statistically significantly related to INAP or DUI (not shown in table 2; see table A.3 in the appendix). Fatigue, illness and suicide are combined because it is not always easy to distinguish between these three factors. They were assessed by the CIT, based on information from different sources (e.g. autopsies, witness accounts). In the absence of information, drivers were coded as not fatigued/ill/suicidal. These factors may therefore be underreported.

Vehicles

Old cars and cars without electronic stability control (ESC) are overrepresented in speeding and DUI crashes, except for MIX crashes according to the adjusted results. The adjusted effects of ESC are not statistically significant (not shown in table 2; see table A.3 in the appendix), probably because the cars age is statistically controlled for (more recent cars have far more often ESC than older cars).

Roads

Speed limit: 80 km/h is the standard speed limit on rural roads in Norway, but many rural roads have a speed limit of 70 km/h. Only few roads in Norway have speed limits above 80 km/h, and only 1.5% of the drivers in the present study crashed on roads with speed limits of 100 or 110 km/h. The results indicate that speeding and DUI are largely unrelated to speed limit; only ALC is overrepresented on roads with high speed limits and underrepresented on roads with low speed limits. Speeding and DUI are not related to whether or not roads are rural.

Traffic volume: The average traffic volume (AADT) has been lower on roads with INAP crashes than on roads with non-speeding driver crashes and lower on roads with ALC crashes than on roads with sober driver crashes (Table A.1, appendix). AADT is not statistically significantly different between EXC and non-speeding drivers or between DRUG or MIX and sober drivers. These results are based on analyses of variance with either EXC, INAP, ALC, DRUG, or MIX as dummy predictor variables and AADT as the dependent variable (calculated in Stata 14.2; see Table 3).

Curves: Curves are overrepresented in speeding and DUI crashes, except in DRUG crashes. The proportion of crashes that occurred in curves, is 71% among single vehicle crashes and 46% among other crashes.

DISCUSSION

The results of the present study show that there are strong relationships between speeding, DUI, and other risk factors among fatal crash involved passenger car drivers. However, there are several differences between subgroups of speeding and DUI drivers.

EXC and ALC are strongly related to each other and to being unbelted, unlicensed, male, and crashing in single vehicle crashes under low-volume conditions. Non-use of seat belts can be assumed to contribute to the high fatality risk of EXC and ALC drivers and it has been found to be related to increased crash risk (Høye 2016). The results from the present study indicate that both ALC (or other types of DUI) and EXC are among the factors that contribute to the high crash risk of unbelted drivers. Unlicensed driving has also been found to be related to high crash risk and to other types of high-risk behavior (Blows et al. 2005). Under low-volume conditions, drivers may be more tempted to speed because of the absence of other traffic; and drivers may (for the most part correctly) assume the risk of apprehension to be low. Additionally, there are probably more drinking situations at weekends and nights. Fatigue, illness and suicide crashes are underrepresented among EXC drivers. Fatigue and illness may deter drivers from speeding, while suicidal drivers mostly choose a specific crash scenario (Milner & De Leo 2012), rather than relying on high speed in itself.

Being unbelted, unlicensed, male, and crashing in single vehicle crashes under low-volume conditions are also overrepresented among INAP, DRUG, and MIX drivers, but to a lesser degree than among EXC and ALC drivers. Especially for INAP, the relationships to other variables are weaker. These results indicate that INAP, DRUG, and MIX occur among a wider range of different types of drivers and in more different types of situations. INAP drivers are also older and less often under the influence of alcohol (ALC and MIX) than EXC drivers.

Factors that are overrepresented in all types of speeding and DUI crashes are curves, older cars without ESC, and fatalities in the own car. The relationship between speeding, DUI and crashes in curves is most likely due to the larger effect of risky driver behavior in curves (Schneider et al. 2009). Older cars and cars without ESC have generally higher crash and injury risk and drivers of older cars (except for veteran cars) show on average more high-risk behavior than drivers of newer cars (Høye 2016).

A difference between speeding and DUI drivers is their age. Speeding drivers were on average far younger than DUI drivers. Young drivers were also in other studies found to have higher crash risk than most other drivers. Fondness for speed and DUI may explain a large part of the high risk (Hedlund & McCartt 2002). However, although ALC drivers in the present study have been younger than sober drivers, the age difference between ALC and sober drivers disappears when other driver related factors are statistically controlled for. DRUG and MIX drivers are on average older than sober drivers when other driver related factors are controlled for. The results for DRUG and MIX are difficult to generalize. There may be differences between different types of substances, especially between legal and illegal substances (Valen et al., 2019). Different substances are used by different groups of people at different occasions and with different goals (Patry et al. 2011). In studies of fatally injured drivers and motorcycle riders in Norway, those under the influence of prescription drugs were on average older than those under the influence of illegal drugs (Christophersen & Gjerde, 2013).

Another difference between speeding and DUI is their relationship to being unlicensed. Both speeding and DUI are related to being unlicensed. However, the relationship between speeding and being unlicensed becomes weak and non-significant with statistical control for other variables, while the relationship between DUI and being unlicensed remains strong and statistically significant. Thus, one may assume that the speeding behavior of unlicensed drivers not necessarily is due to inexperience or a lack of skills, but rather to a general inclination to high-risk behavior, such as DUI (Clarke et al. 2005).

A difference between EXC and INAP is that INAP more often occurs in crashes with vulnerable road users and far more often in winter and on slippery roads. One may suppose that such crashes are related to other factors (such as inattention or inexperience) than driving far above the speed limit which more often is a conscious violation (Ahie et al. 2015). The finding that winter and slippery roads are underrepresented in EXC and ALC crashes may indicate that these drivers to some degree take driving conditions into consideration (although they drop such considerations under more favorable driving conditions).

There may be more differences between different groups of speeding and DUI drivers according to the speed at which they crashed, the type of substance (other than alcohol) they were affected by, and their history of previous convictions (Ahie et al. 2015). However, these factors could not be investigated in the present study.

The results from the present study allow some conclusions about potentially effective measures against speed and DUI related fatal car crashes.

Because of the strong relationships between speeding and DUI, especially EXC and ALC, and being unlicensed and/or unbelted, addressing one of these behaviors is likely to be effective in identifying drivers showing one or more of the other behaviors as well. A challenge with drivers showing multiple types of high-risk behavior is that they for the most part not are very responsive to measures that rely on more or less voluntary behavior changes such as speed limits, information, license revocation, incentives, or fines (Høye 2016). More restrictive measures, such as vehicle impoundment (Rosenbloom & Eldror 2013), non-overridable intelligent speed adaptation (Agerholm et al. 2007), alcolock (Bjerre 2005), or seat-belt interlocks (Van Houten et al. 2014) may be more promising. In addition to classical enforcement, technological devices such as automatic number plate recognition or electronic license authentication may be promising measures for identifying unlicensed drivers and thereby also drivers who are likely to show other types of high-risk behavior (Sagberg 2018).

Among INAP drivers, most of the same risk factors are overrepresented as among EXC drivers. However, INAP drivers seem to be a more moderate and more heterogeneous group of drivers. Their failure to adjust speed is less likely to be due to a general inclination to take high risks and to disregard laws and common sense, and more likely to be due to other factors (for example inattention or misjudgments; Larsen & Kines 2002). Therefore, INAP drivers are more likely than EXC drivers to respond to measures that address unintentional driver errors and violations, such as speed limits, recommended speed, or in-vehicle speed warnings (Vlassenroot et al. 2007). For driver training, empirical evidence is mixed. For example, skid training may increase crash risk if drivers get over-confident in their driving skills (Katila et al. 2004).

The results from the present study indicate that speeding and DUI related crashes are overrepresented in curves and at sites and times with little traffic (low volume roads, nighttime, weekend). Consequently, a curvy low-volume road on a weekend night might be a promising site for targeted measures such as enforcement. Such sites and times will hardly allow large numbers of catches, but the ratio of apprehended to checked drivers is likely to be larger than at other times and sites. Curve improvements on low-volume roads may also be promising measures for reducing speed or the severity of crash consequences (e.g. curve warnings or roadside improvements; Peng et al. 2012). However, their cost-effectiveness will depend not only on the crash risk on such roads but also on the volumes (Montella et al. 2015). Moreover, in crashes involving DUI or judgement errors, their effectiveness may be limited.

A general measure that is likely to reduce fatal speeding and DUI related crashes is an increased renewal rate of the car fleet. Newer cars are not likely to lead to large changes of driver behavior, although for example seat belt reminders and speed warnings may have some effect (except among the most extreme high-risk drivers; Høye, 2016). However, they will provide more protection, especially to the occupants of the own car who are most at risk in crashes involving high speed and/or DUI (Kim et al. 2013).

The following conclusions can be drawn:

- Among speeding and DUI drivers, being unbelted, unlicensed, male, older cars, single vehicle crashes under low-volume conditions, and curves are overrepresented. However, typical risk profiles differ between different groups of speeding and DUI drivers.
- EXC and ALC drivers are on average younger and can be regarded as more extreme in their behavior than other drivers. Compared to INAP drivers, they are less often fatigued, ill, or suicidal, and they crash less often in winter or on slippery roads.
- Other speeding and DUI drivers, especially INAP, are a more moderate and more heterogeneous group than EXC and ALC drivers.
- DUI and EXC are among the factors that contribute to the high crash risk of unbelted and unlicenced drivers.
- INAP and some of the DRUG/MIX drivers are more likely to be responsive to non-restrictive measures than EXC and ALC drivers. For EXC and ALC drivers, restrictive measures are called for. All speeding and DUI drivers may benefit from targeted measures in curves and at site or times with low volumes, and from an increased renewal rate of the car fleet.

LIMITATIONS

Limitations of the present study refer mainly to the quality of the data. Information about speed and DUI is not always based on exact measurements and not all drivers have been tested for alcohol and drugs. The prevalence of DUI may be underestimated because not all drivers were tested. Valen et al. (2019) found a higher prevalence of DUI (31%) in a study that is based on about the same fatal crashes as the present study. However, includes only fatally injured drivers for whom test results were available. Thus, the lower prevalence of DUI in the present study is as expected, but it is still possible that DUI is underreported. Information about relevant other variables is relatively imprecise (especially inattention/illness/fatigue). The validity of the data could not be tested (for example, if EXC and INAP always are identified correctly). As in the study by Valen et al. (2019) drivers are included in the present study irrespective of their status as guilty or triggering part.

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TABLES

Table 1: Percentages of drivers speeding / not speeding or being intoxicated / sober in fatal crashes with passenger cars in Norway (2005-2015).

	EXC[1]	INAP[1]	Not speeding	ALC[1]	DRUG[1]	MIX[1]	Sober
Passenger cars (N=1949)	12 %	18 %	70 %	9 %	3 %	3 %	85 %
Passenger car fatalities (N=1297)	16 %	24 %	60 %	13 %	4 %	4 %	78 %
Total fatalities (N=2197)	11 %	19 %	70 %	9 %	3 %	3 %	85 %
Crashes (N=1501)	15 %	23 %	62 %	12 %	4 %	4 %	80 %
Crashes with crash partner (N=1471)	5 %	16 %	79 %	3 %	3 %	1 %	93 %
Crash partner fatalities (N=900)	5 %	11 %	84 %	2 %	2 %	1 %	95 %

[1] EXC: Excessive speed; INAP: Inappropriate speed; ALC: Under the influence of alcohol; DRUG: Under the influence of drugs; MIX: Under the influence of alcohol and drugs.

Table 2: Adjusted ORs with 95% confidence intervals (CI) from multiple logistic regression with row variables as predictors and speed or DUI as dependent variables; model characteristics (N and Pseudo R2) in the bottom rows.

	EXC[4] (vs. not speeding)	INAP[4] (vs. not speeding)	ALC[4] (vs. sober)	DRUG[4] (vs. sober)	MIX[4] (vs. sober)
EXC (vs. other)			8.041*	4.822*	6.117*
INAP (vs. other)			3.043*	2.088*	0.773
ALC (vs. other)	8.769*	2.866*			
DRUG (vs. other)	4.248*	1.974*			
MIX (vs. other)	5.745*	0.927			
Unlicensed driver (vs. licensed)	1.164	1.300	5.507*	17.952*	21.442*
Unbelted driver (vs. belted)	1.749*	1.342	3.546*	2.482*	7.059*
Male (vs. female)	4.499*	1.799*	2.267*	0.899	1.867
Young (< 25 years) (vs. older)	6.631*	2.214*	0.977	0.144*	0.377*
Tired/ill/suicidal (vs. other)	0.515*	0.725	0.776	0.917	0.804
Old car (>10 years) (vs. newer car)	2.174*	1.974*	1.810*	2.558*	1.042

[1] Only crashes with crash partner. **[2]** Friday 6pm to Saturday 6 am and Saturday 6pm to Sunday 6am. [3]Only fatally injured drivers. [4]EXC: Excessive speed; INAP: Inappropriate speed; ALC: Under the influence of alcohol; DRUG: Under the influence of drugs; MIX: Under the influence of alcohol and drugs.
* $p < .05$.

Table 3: Comparison of AADT between EXC/INAP and non-speeding drivers and between ALC/DRUG/MIX and sober drivers, results from ANOVA.

	F	df	p
EXC[1] (vs. not speeding)	0.81	1	0.369
INAP[1] (vs. not speeding)	21.92	1	0.000
ALC[1] (vs. sober)	7.39	1	0.007
DRUG[1] (vs. sober)	0.83	1	0.362
MIX[1] (vs. sober)	0.22	1	0.636

[1]EXC: Excessive speed; INAP: Inappropriate speed; ALC: Under the influence of alcohol; DRUG: Under the influence of drugs; MIX: Under the influence of alcohol and drugs.

APPENDIX: TABLES

Table A.1: Percentages of passenger cars in fatal crashes in three speed groups and four DUI groups among whom each of the crash, driver, car, and road characteristics were present.

		Speed			DUI			
	N	EXC[1] (N=226)	INAP[1] (N=354)	Not speeding (N=1369)	ALC[1] (N=177)	DRUG[1] (N=66)	MIX[1] (N=59)	Sober (N=1647)
Crash								
Single vehicle crash	1 949	65 %	32 %	14 %	74 %	42 %	66 %	15 %
Coll. with pedestrian/cyclist	1 949	4 %	17 %	12 %	8 %	8 %	3 %	12 %
Fatality in own car, total	1 949	86 %	75 %	52 %	89 %	77 %	90 %	55 %
Fatality in own car; crashes with partner	1 471	59 %	63 %	43 %	56 %	61 %	70 %	46 %
Fatally injured; crash with partner	1 471	49 %	42 %	58 %	47 %	39 %	50 %	57 %
Nighttime (6pm-6am)	1 949	70 %	39 %	29 %	76 %	48 %	75 %	29 %
Weekend (Sat.-Sun.)	1 949	59 %	32 %	25 %	60 %	29 %	47 %	26 %
Winter (November-March)	1 949	23 %	53 %	42 %	33 %	33 %	31 %	43 %
Slippery road	1 942	7 %	40 %	21 %	11 %	15 %	11 %	24 %
Driver								
EXC[1]	1 949	100 %	0 %	0 %	42 %	24 %	36 %	7 %
INAP[1]	1 949	0 %	100 %	0 %	29 %	26 %	19 %	17 %
ALC[1]	1 949	33 %	14 %	4 %	100 %	0 %	0 %	0 %
DRUG[1]	1 949	7 %	5 %	2 %	0 %	100 %	0 %	0 %
MIX[1]	1 949	9 %	3 %	2 %	0 %	0 %	100 %	0 %
Unlicensed driver	1 716	17 %	10 %	5 %	20 %	35 %	37 %	2 %
Unbelted driver, total	1 949	43 %	26 %	14 %	52 %	39 %	61 %	14 %
Unbelted driver, fatally injured	942	48 %	30 %	23 %	58 %	44 %	60 %	20 %
Age (years; mean)	1 926	26.9	37.7	46.4	31.5	37.7	30.4	44.0
Male	1 930	95 %	85 %	73 %	94 %	83 %	92 %	76 %
Young (< 25 years)	1 926	58 %	33 %	16 %	45 %	15 %	32 %	22 %
Tired/ill/suicidal	1 949	14 %	17 %	24 %	14 %	23 %	19 %	22 %
Car								
Old car (>10 years)	1 909	70 %	60 %	40 %	73 %	70 %	66 %	44 %
Electronic Stability Control	1 949	12 %	13 %	21 %	11 %	15 %	5 %	20 %
Road								
Speed limit 80-110	1 901	54 %	68 %	62 %	51 %	63 %	60 %	63 %
Speed limit 30-50	1 901	15 %	16 %	14 %	28 %	12 %	14 %	13 %
Rural area	1 949	85 %	85 %	84 %	84 %	86 %	86 %	84 %
Traffic volume (AADT[1])	1 753	5 986	4 286	6 534	4425	5333	6743	6237
Crash site curve	1 949	70 %	59 %	47 %	68 %	58 %	75 %	49 %

[1]EXC: Excessive speed; INAP: Inappropriate speed; ALC: Under the influence of alcohol; DRUG: Under the influence of drugs; MIX: Under the influence of alcohol and drugs; AADT: Annual Average Daily Traffic.

Table A.2: Unadjusted ORs with 95% confidence intervals (CI) from logistic regression with row variables as predictors and speed or DUI as dependent variables; statistically significant ORs in bold.

	EXC[4] (vs. not speeding)		INAP[4] (vs. not speeding)		ALC[4] (vs. sober)		DRUG[4] (vs. sober)		MIX[4] (vs. sober)	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Crash										
Single vehicle crash (vs. other)	**11.607**	(8.484; 15.88)	**2.982**	(2.273; 3.913)	**16.142**	(11.238; 23.185)	**4.176**	(2.517; 6.931)	**11.053**	(6.340; 19.268)
Coll. with pedestrian/cyclist (vs. other)	**0.281**	(0.136; 0.581)	**1.564**	(1.132; 2.161)	0.655	(0.378; 1.134)	0.580	(0.230; 1.46)	0.248	(0.060; 1.024)
Fatality in own car (vs. no fatality in own car)	**5.611**	(3.804; 8.276)	**2.840**	(2.181; 3.699)	**6.735**	(4.144; 10.947)	**2.754**	(1.536; 4.937)	**7.154**	(3.058; 16.735)
Fatality in own car (vs. no fatality in own car)[1]	**1.880**	(1.18; 2.996)	**2.180**	(1.631; 2.914)	1.471	(0.798; 2.71)	1.785	(0.924; 3.451)	**2.717**	(1.038; 7.111)
Fatally injured crash partner (vs. no crash partner fatality)[1]	0.684	(0.432; 1.082)	**0.527**	(0.396; 0.7)	0.686	(0.373; 1.26)	**0.514**	(0.266; 0.994)	0.789	(0.326; 1.907)
Nighttime (6pm-6am) (vs. daytime)	**5.770**	(4.243; 7.847)	**1.568**	(1.229; 2.001)	**7.621**	(5.319; 10.92)	**2.302**	(1.404; 3.773)	**7.174**	(3.954; 13.014)
Weekend (Sat.-Sun.) (vs. other day)	**4.345**	(3.245; 5.818)	**1.462**	(1.134; 1.885)	**4.173**	(3.03; 5.746)	1.130	(0.656; 1.947)	**2.524**	(1.497; 4.257)
Winter (November-March) (vs. summer)	**0.415**	(0.299; 0.576)	**1.591**	(1.258; 2.012)	**0.634**	(0.456; 0.88)	0.650	(0.386; 1.095)	0.571	(0.325; 1.002)
Slippery road (vs. not slippery)	**0.277**	(0.161; 0.476)	**2.580**	(2.009; 3.314)	**0.395**	(0.244; 0.637)	0.563	(0.284; 1.115)	**0.364**	(0.155; 0.855)
Driver										
EXC (vs. not speeding)					**15.555**	(10.398; 23.27)	**5.300**	(2.831; 9.919)	**8.501**	(4.659; 15.512)
INAP (vs. not speeding)					**4.483**	(2.982; 6.74)	**2.355**	(1.293; 4.288)	1.862	(0.913; 3.800)
ALC (vs. sober)	**15.555**	(10.398; 23.27)	**4.483**	(2.982; 6.74)						
DRUG (vs. sober)	**5.300**	(2.831; 9.919)	**2.355**	(1.293; 4.288)						
MIX (vs. sober)	**8.501**	(4.659; 15.512)	1.862	(0.913; 3.8)						
Unlicensed driver (vs. licensed)	**4.206**	(2.667; 6.633)	**2.421**	(1.545; 3.795)	**9.665**	(5.962; 15.669)	**20.638**	(11.284; 37.747)	**24.198**	(12.908; 45.365)
Unbelted driver (vs. belted)	**4.839**	(3.567; 6.565)	**2.252**	(1.698; 2.988)	**6.876**	(4.959; 9.534)	**4.129**	(2.471; 6.900)	**9.943**	(5.784; 17.094)
Unbelted driver (vs. belted)[3]	**3.124**	(2.164; 4.51)	**1.479**	(1.036; 2.112)	**5.328**	(3.628; 7.824)	**3.061**	(1.610; 5.822)	**5.752**	(3.026; 10.933)
Male (vs. female)	**6.146**	(3.393; 11.133)	**1.957**	(1.426; 2.686)	**4.658**	(2.504; 8.667)	1.543	(0.800; 2.978)	**3.334**	(1.324; 8.393)
Young (< 25 years) (vs. older)	**7.245**	(5.355; 9.801)	**2.647**	(2.031; 3.45)	**2.970**	(2.159; 4.084)	0.643	(0.325; 1.273)	1.710	(0.978; 2.99)
Tired/ill/suicidal (vs. other)	**0.526**	(0.354; 0.779)	**0.650**	(0.48; 0.882)	**0.572**	(0.369; 0.886)	1.022	(0.568; 1.839)	0.796	(0.409; 1.549)
Car										
Old car (>10 years) (vs. newer car)	**3.759**	(2.748; 5.142)	**2.293**	(1.803; 2.918)	**3.446**	(2.43; 4.888)	**3.069**	(1.779; 5.294)	**2.527**	(1.461; 4.371)
ESC (vs. no ESC)	**0.524**	(0.345; 0.794)	**0.567**	(0.406; 0.791)	**0.503**	(0.311; 0.813)	0.705	(0.356; 1.396)	**0.211**	(0.066; 0.680)
Road										
Speed limit 80-110 (vs. lower)	**0.742**	(0.558; 0.987)	**1.312**	(1.022; 1.684)	**0.601**	(0.438; 0.824)	1.003	(0.006; 1.676)	0.893	(0.523; 1.526)
Speed limit 30-50 (vs. higher)	1.094	(0.732; 1.634)	1.199	(0.866; 1.661)	**2.616**	(1.818; 3.764)	0.949	(0.446; 2.017)	1.081	(0.505; 2.313)
Rural area (vs. other)	1.056	(0.717; 1.557)	1.099	(0.794; 1.522)	0.974	(0.641; 1.482)	1.209	(0.591; 2.472)	1.217	(0.571; 2.594)
Crash site curve (vs. other)	**2.578**	(1.903; 3.491)	**1.618**	(1.276; 2.051)	**2.211**	(1.588; 3.079)	1.389	(0.844; 2.284)	**3.002**	(1.657; 5.436)

[1] Only crashes with crash partner. **[2]** Friday 6pm to Saturday 6 am and Saturday 6pm to Sunday 6am. [3]Only fatally injured drivers. [4]EXC: Excessive speed; INAP: Inappropriate speed; ALC: Under the influence of alcohol; DRUG: Under the influence of drugs; MIX: Under the influence of alcohol and drugs.

Table A.3: Adjusted ORs with 95% confidence intervals (CI) from multiple logistic regression with row variables as predictors and speed or DUI as dependent variables; statistically significant ORs in bold; model characteristics (N and Pseudo R2) in the bottom rows.

	EXC[4] (vs. not speeding)		INAP[4] (vs. not speeding)		ALC[4] (vs. sober)		DRUG[4] (vs. sober)		MIX[4] (vs. sober)	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Driver										
EXC (vs. other)					**8.041**	(4.840; 13.36)	**4.822**	(2.009; 11.571)	**6.117**	(2.703; 13.844)
INAP (vs. other)					**3.043**	(1.895; 4.888)	**2.088**	(1.051; 4.146)	0.773	(0.306; 1.954)
ALC (vs. other)	**8.769**	(5.213; 14.751)	**2.866**	(1.782; 4.61)						
DRUG (vs. other)	**4.248**	(1.895; 9.521)	**1.974**	(1.015; 3.842)						
MIX (vs. other)	**5.745**	(2.649; 12.46)	0.927	(0.386; 2.224)						
Unlicensed driver (vs. licensed)	1.164	(0.638; 2.123)	1.300	(0.757; 2.234)	**5.507**	(3.118; 9.728)	**17.952**	(8.957; 35.977)	**21.442**	(10.240; 44.898)
Unbelted driver (vs. belted)	**1.749**	(1.151; 2.657)	1.342	(0.957; 1.883)	**3.546**	(2.400; 5.240)	**2.482**	(1.314; 4.687)	**7.059**	(3.610; 13.804)
Male (vs. female)	**4.499**	(2.317; 8.738)	**1.799**	(1.284; 2.522)	**2.267**	(1.152; 4.464)	0.899	(0.435; 1.856)	1.867	(0.669; 5.209)
Young (< 25 years) (vs. older)	**6.631**	(4.536; 9.696)	**2.214**	(1.651; 2.969)	0.977	(0.640; 1.493)	**0.144**	(0.056; 0.368)	**0.377**	(0.168; 0.848)
Tired/ill/suicidal (vs. other)	**0.515**	(0.307; 0.862)	0.725	(0.522; 1.006)	0.776	(0.466; 1.294)	0.917	(0.458; 1.838)	0.804	(0.360; 1.799)
Car										
Old car (>10 years) (vs. newer car)	**2.174**	(1.427; 3.31)	**1.974**	(1.015; 3.842)	**1.810**	(1.154; 2.839)	**2.558**	(1.306; 5.013)	1.042	(0.516; 2.103)
ESC (vs. no ESC)	1.239	(0.701; 2.19)	0.927	(0.386; 2.224)	1.147	(0.633; 2.079)	1.560	(0.670; 3.633)	0.299	(0.082; 1.093)
Model characteristics										
N of observations	1364		1486		1579		1479		1472	
Pseudo R-square [5]	0.331		0.085		0.268		0.230		0.326	

[1] Only crashes with crash partner. [2] Friday 6pm to Saturday 6 am and Saturday 6pm to Sunday 6am. [3]Only fatally injured drivers. [4]EXC: Excessive speed; INAP: Inappropriate speed; ALC: Under the influence of alcohol; DRUG: Under the influence of drugs; MIX: Under the influence of alcohol and drugs. [5]Pseudo R-square indicates the proportion of variance in the dependent variable that is explained by the predictor variables.

APPENDIX: ADDITIONAL REFERENCES

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