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Injury severity in police collision reports correlates poorly with requirement for hospital admission.

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ABSTRACT

Introduction: This study linked driver records with hospital records to investigate the correlation of injury data in police collision reports with need for hospital admission.
Methods: We studied hospital admissions and traffic collisions involving British Columbia residents between 2005 and 2015. Probabilistic linkage between driver licence and personal health number was successful for 95.5% of drivers. We first compared population level statistics on number of serious injuries following a motor vehicle crash according to police reports with the number hospital admissions for road trauma recorded in hospital records. Second, we determined how often drivers involved in police-reported crashes were admitted to hospital. Finally we studied drivers admitted to hospital for road trauma and determined how many of these collisions resulted in a police report, and when reports were available, how often police indicated no injury, minor injury, or major injury.
Results: There was poor agreement between police indication of injury severity and requirement for hospital admission. Population statistics from police reports counted only 70% as many road users with major injuries as there were hospital admissions for road trauma survivors. At the individual level, police indication of major injury had even worse correlation with requirement for hospital admission. Only half (56%) of drivers for whom police indicated "major injury" required admission to hospital and only 36% of drivers who required admission to hospital after a crash had a police report indicating major injury. Part of this discrepancy is because police attended only 65% of crashes of hospitalized drivers. However, even when police attended the crash of a hospitalized driver, the police report indicated a major injury only 55% of the time.
Implications: Our findings highlight a significant limitation of road trauma surveillance and traffic evaluations that rely on injury data from police collision reports. Recommendations for improvement are made.

1. Introduction

Road trauma is a major public health concern. Worldwide, almost 3500 people per day are killed in traffic collisions, and many more are seriously injured (Global Status Report on R, 2013). Vision Zero calls for annual reductions and eventual elimination of fatalities and serious injuries from road trauma (Tingvall and Haworth, 1999). Most experts believe that vision zero is best achieved through a safe systems approach that addresses four pillars of road safety: safe roads, safe vehicles, safe road users, and safe speeds (Howard et al., 2008). Some include post-crash discovery and medical response as a fifth pillar (Global Status Report on R, 2013).

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Accurate counts of the number of people killed or seriously injured (KSI) in traffic collisions are required to monitor progress towards vision zero goals. Factors contributing to serious crashes should be identified and analyzed from a safe systems approach, and appropriate changes made to prevent future events. When the targeted decrease in KSI crashes is not met, jurisdictions should identify the reasons and correct underlying problems. Traffic policy changes should be evaluated to measure their effect on KSI collisions. Policy that reduces the number of KSI collisions should be supported (Brubacher et al., 2014), and policy that increase KSI collisions should be revised (Brubacher et al., 2018).

In most developed countries, police are obligated to investigate any motor vehicle collision where someone was injured, and road trauma surveillance is based on police data. Police in these countries usually record injury severity: fatality, serious injury, and sometime slight injury. For fatal cases, defined as a death occurring within 30 days of the collision, police data is generally reconciled with medical data from hospital or coroner. For non-fatal injuries, however, the information on collision severity recorded by police is rarely reconciled with medical records (Derriks and Mak, 2007; Amoros et al., 2011). Hence, accurate statistics are available on road trauma fatalities but data on serious injury collisions relies on police assessment of injury severity and may be less reliable. The International Traffic Safety Data and Analysis Group (IRTAD) states that official statistics on serious traffic injuries in most countries are likely an underestimate as they are based on police reports which may miss cases of serious injury (Derriks and Mak, 2007; Amoros et al., 2011). IRTAD also notes that the pattern of serious injury crashes (i.e., road user role, contributory factors, geographic location, driver demographics) may differ from that of fatal crashes and require different countermeasures. For example, serious injury crashes involving vulnerable road users (pedestrians, cyclists) in urban areas are under-represented in police statistics when compared to hospital records, a pattern not seen for fatal crashes (Road Safety Annual Report, 2018, 2017). Another reason for accurate classification of serious injury crashes is that traffic evaluations often investigate changes in serious injuries crashes rather than fatal crashes as injuries are more common and provide greater statistical power.

According to annual *Canadian Vehicle Traffic Collision Statistics* reports prepared by Transport Canada, serious injuries "include persons admitted to hospital for treatment or observation" (Anonymous, 2017). Note that this definition excludes patients who are observed in the emergency department but not admitted to hospital inpatient wards. The counts of serious injuries in these reports are based on the assessment of injury severity by police as recorded in police collision reports (Anonymous, 2017). The objective of this manuscript is to use population level linkage between driver records and health records to compare police assessment of injury severity in collision reports with actual requirement for hospital admission.

2. Methods

2.1. Setting

British Columbia (BC), Canada's westernmost province, has a population of 4.6 million and covers a geographic area of almost a million square kilometers. For this project, population level hospital admission data (2005–2015) and police collision reports (2005–2015) from BC were linked at PopDataBC. Records were then deidentified, and accessed through the *secure research environment* (SRE) at PopDataBC. (PopulationdataBC) Population level statistics on number of serious traffic injuries derived from police reports were compared with those derived from hospital records. Next, injury severity recorded in police records was compared with actual need for hospital admission. This study was approved by our institutional research ethics board.

2.2. Hospital admissions

All hospital admissions in Canada (excluding patients treated and released from the emergency department) are recorded in the Discharge Abstract Database (DAD). DAD includes mechanism of injury but, in cases of road trauma, has no information on factors that contributed to the crash or where the crash occurred. In this study, we used admissions for road trauma as a measure of hospital utilization by road injury victims in BC. We defined "road trauma admissions" as those with International Classification of Diseases, 10th Revision, external cause of injury codes ranging from V02.1 (pedestrian injured in collision with 2- or 3-wheeled motor vehicle, traffic accident) through V89.9 (person injured in unspecified vehicle accident). We also included sequelae of transport accidents (Y85, Y850, Y859). E-codes for transport accidents that did not involve a motor vehicle (i.e., pedestrian x cyclist, cyclist x railway, cyclist x fixed object, etc.) were excluded as these cases are not captured in police collision reports in Canada. We also excluded injuries that occurred while getting into or out of a vehicle, events that occurred on industrial premises, events that did not involve a motorized vehicle, and events in which the only vehicle involved was a streetcar, railway vehicle, specialized agricultural vehicle, airplane, or watercraft. We included traffic injury involving snowmobiles and all-terrain vehicles (E-codes V86.0, V86.1, V86.2, V86.3) when they occurred on public roads.

2.3. Police collision reports

The traffic accident system (TAS) contains details of all police-reported crashes in BC, including date, time and location of crash, factors that police believe contributed to the crash (e.g., speeding, impaired driving), name and licence number of all drivers involved in the crash, road user role (e.g., driver, passenger, cyclist, pedestrian) and police assessment of injury severity (no injury, unknown injury, minor injury, major injury, fatality) for all persons involved in the collision. Major injuries in police reports are defined as those that required an overnight stay in hospital. Unfortunately, police in BC are provided with limited guidance on how to identify victims with minor injuries or no injury. Note that identifiers of road users other than drivers of a motorized vehicle are not routinely

captured in police collision reports so only drivers could be linked to hospital data. TAS is reconciled with coroners' data to ensure that it captures all fatal crashes (i.e., death within 30 days) occurring on public roads. Police attempt to attend all "major collisions" but police reporting of nonfatal crashes is discretionary.

2.4. Data linkage

Probabilistic linkage between driver licence (DL) and personal health number (PHN) was done at PopDataBC based on name, sex, and date of birth for all BC residents who had a driver license during the study period. Personal identifiers were replaced by a unique study ID number. De-identified data was stored and analyzed in the secure research environment at PopDataBC. Out of province residents were excluded.

2.5. Comparing police assessment of injury with health records

We used two approaches to compare injury data in police crash reports with hospital admissions occurring between January 2005 and December 2015. First we compared population level statistics on injuries for all road users (driver, passengers, pedestrians, and cyclists) derived from police crash reports (TAS) with road trauma admissions derived from hospital admission data (DAD). Police statistics included counts of road trauma survivors for whom the police report indicated "major injury". Hospital statistics counted trauma admissions where the mechanism of injury indicated road trauma using the E-codes listed previously. This population level analysis counted all road trauma victims regardless of whether they had a drivers licence or whether the driver licence and PHN could be linked.

Next, we studied BC residents who held a BC DL that was linked to a PHN and were operators of a motorized vehicle involved in a collision that was reported by police and/or were admitted to hospital for road trauma injuries where the E-code indicated that they were the driver. People involved in a collision as a passenger, cyclist, or pedestrian were excluded from this analysis since police reports do not reliably capture identifiers of non-drivers. For hospitalized drivers, we looked for corresponding collisions reported to police (i.e., within 3 days of the hospital admission) and recorded police indication of injury severity. Similarly, for drivers who sustained major injuries in a collision according to the police report, we looked for a corresponding hospital admission. In this way we were able to report how often police indicated a major injury for injured drivers who required a hospital admission, and how often a hospital admission was actually required for drivers who had major injuries according to the police report. Note that a driver could be counted more than once if they were involved in multiple separate collisions or hospital admissions for road trauma over the course of the study.

3. Results

There were 5,136,142 BCE residents who held a DL at some time during the study period and 4,906,925 (95.5%) of these were successfully linked to a PHN number.

3.1. Comparison of statistics generated from police versus hospital data

Between January 2005 and December 2015, DAD data captured 27,512 hospital admissions for road trauma (15,413 drivers, 4176 passengers, 1107 cyclists, and 3654 pedestrians). Of these hospital admissions, 3144 drivers, 901 passengers, 174 cyclists, and 687 pedestrians required care in an intensive care unit. During the same period there were 382,325 crashes recorded in TAS and police reported major injuries in 19,164 people: 10,977 drivers, 4285 passengers, 866 cyclists, and 3036 pedestrians. Thus the number of major road trauma injuries generated from TAS data was only 69.7% (19,164/27,512) of the actual number of hospital admissions for road trauma according to DAD data (Table 1).

3.2. Comparison of police assessment of injury severity with need for hospital admission

This analysis included 585,057 drivers involved in a collision reported to police and 15,413 people who were identified as drivers in hospital records and required admission for injuries sustained in a collision. Of the 585,057 drivers with a police report (regardless of police assessment of injury severity), 10,737 (1.8%) were admitted to hospital, and 2552 (0.4%) were admitted to the intensive care unit (ICU). Of the 10,737 drivers with a police report who were admitted to hospital, 10,060 were identified in DAD as drivers and 677 were identified in DAD as non-drivers.

According to police reports, 10,516 drivers had major injuries but only 5909 (56.2%) of these were actually admitted to hospital, including 1860 drivers (17.7%) who were admitted to the ICU. When police indicated that the driver had minor injuries (101,645 cases), 3365 (3.3%) were admitted to hospital, and 323 (0.3%) were admitted to the ICU. There were 440,120 drivers for whom the police report indicated no injury. Of these, 366 (0.1%) were admitted to hospital and 48 (< 0.1%) required ICU care. Of 30,903 drivers with unknown injury status per police report, 860 (2.8%) were admitted to hospital. There were 1873 drivers who were killed according to police reports. Of the fatally injured drivers, 237/1873 (12.7%) were admitted to hospital and 229/237 (96.6%) died in hospital (Table 2, Fig. 1).

Of the 15,413 people admitted to hospital for injuries sustained in a collision and identified in DAD as drivers, a police report was generated for only 10,060 (65.3%). Of these 10,060 drivers, the police report indicated no injury in 329 cases (3.3%), unknown

Table 1
Population level road trauma statistics (2005 to 2015). These numbers are derived from police-reported collisions and hospital admissions for road trauma for all BC residents regardless of whether driver's license was linked with personal health number. Cases requiring admission to an intensive care unit (ICU) are also indicated.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Police reported crashes												
Total crashes[a]	44,307	43,696	41,640	34,787	30,476	31,569	30,604	31,661	30,488	30,785	32,312	382,325
Major injury crashes	1794	1763	1754	1600	1504	1471	1274	1365	1256	1353	1410	16,544
Major injuries	2105	2052	2051	1884	1746	1692	1465	1527	1449	1588	1605	19,164
Drivers	1215	1158	1189	1063	1048	970	850	903	813	823	945	10,977
Drivers with PHN[b]	1169	1097	1132	1012	1012	932	815	866	783	787	911	10,516
Cyclists	93	72	62	79	67	86	73	85	72	95	82	866
Pedestrians	283	279	291	272	242	259	247	278	266	319	300	3036
Passengers	514	543	509	470	389	377	295	261	298	351	278	4285
Hospital Admissions (overnight)												
Any traffic injury[c]	3021	3048	2835	2725	2529	2402	2153	2223	2198	2231	2147	27,512
Required ICU admission	600	577	552	529	503	484	420	407	412	431	436	5351
Drivers	1654	1676	1571	1490	1474	1341	1203	1278	1242	1242	1242	15,413
Required ICU admission	329	345	313	292	294	295	256	233	262	262	263	3144
Cyclists	113	91	92	101	88	118	115	100	82	110	97	1107
Required ICU admission	17	11	15	18	15	19	14	15	11	21	18	174
Pedestrians	351	372	361	344	302	313	308	325	315	340	323	3654
Required ICU admission	74	63	75	62	67	56	51	66	55	54	64	687
Passengers	532	543	461	457	407	353	309	270	285	293	266	4176
Required ICU admission	123	107	102	111	86	75	68	61	50	62	56	901
Unspecified victims	371	366	350	333	258	277	218	250	274	246	219	3162
Required ICU admission	57	51	47	46	41	39	31	32	34	32	35	445

[a] Crashes occurring on the same day with the same driver were combined into a single crash event.
[b] Only drivers with a known PHN can be linked to the DAD.
[c] Admissions occurring within 3 days of one another or resulting from transfer to another hospital were combined into a single admission event.

injury status in 823 cases (8.2%), minor injuries in 3158 cases (31.4%), major injuries in 5530 (55.0%), and killed in 220 (2.2%). According to DAD data, 3144 drivers required an ICU admission. Of these drivers police reported the crash in 2393 (76.1%), indicated no injury in 43 (1.4%), unknown injury in 135 (4.3%), minor injuries in 304 (9.7%), major injuries in 1743 (55.4%), and killed in 168 (5.3%) (Table 3, Fig. 2).

4. Discussion

We found poor agreement between police indication of major injury, defined as requiring overnight stay in hospital, in collision reports, and actual requirement for overnight admission to a hospital ward. At the population level, the number of road trauma victims with major injuries derived from police reports was far less than the total number of road trauma victims who required hospital admission. In fact, there were 44% more hospital admissions for patients injured in road trauma (27,512) than cases where police indicated major injury (19,164). At the individual driver level, police indication of major injury had even worse correlation with actual requirement for hospital admission. Just over half (56.2%) of the drivers for whom police indicated “major injury” actually required admission to hospital. Conversely, just over a third (35.9%) of the drivers who required admission to hospital after a crash had a police report that indicated a major injury. Part of the explanation for this is that police attended under two thirds (65.3%) of crashes resulting in major injury to the driver. However, even when police attended the collision of a driver who required hospital admission (10,060 cases), the corresponding collision report indicated a major injury in barely half the cases (5530/10,060 = 55.0%) and the report listed no injury or unknown injury in 1152 (11.5%) of these cases.

There were also differences between the number of fatalities captured in DAD versus in TAS but this discrepancy likely reflects the fact that fatalities captured in DAD only include drivers who were admitted to hospital and died in hospital. Drivers declared dead at the scene prior to arrival to hospital or in the emergency department before being admitted to hospital would not be captured in DAD. Similarly, those who died following hospital discharge but within 30 days of the collision (in a long term care facility for example) would not be shown as died in hospital in DAD. In contrast, as TAS data is reconciled with coroner records, all of these fatalities would be captured in TAS.

It appears that under-reporting of serious road trauma in statistics derived from police collision reports is not unique to British Columbia. Publicly available Canadian statistics suggest that under-reporting of serious injuries is common in Canadian police reports. According to the Canadian Institute for Health Information (CIHI) there were 22,262 hospital admissions for traffic injuries in Canada between April 1, 2016 and March 31, 2017 (CIHI: Quick Stats, 2019). In contrast, Canadian Motor Vehicle Traffic Collisions Statistics reported by Statistics Canada (derived from police data) count only 10,760 serious road trauma injuries in 2016 and 9960 in 2017 (Canadian Motor Vehicle Tr, 2019). The International Traffic Safety Data and Analysis Group (IRTAD) concluded that police statistics from many countries underestimate the number of road users who were seriously injured in a crash (Derriks and Mak, 2007; Amoros et al., 2011). Yannis studied police and hospital records in 7 European countries and concluded that under-reporting of traffic

Table 2
Hospital admissions for motor vehicle drivers involved in a police-reported crash. This table shows requirement for hospital (and ICU) admission for drivers involved in a police reported crash according to police impression of injury severity. The table reports the total number of admissions with admission rate in parentheses.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Drivers in a police reported crash[a]	**68249**	**66756**	**63119**	**52603**	**46554**	**48821**	**46876**	**48389**	**46890**	**47126**	**49674**	**585057**
Admitted overnight	1193	1168	1135	1013	980	936	823	910	854	842	883	10737
(% of police reports)	(1.7%)	(1.7%)	(1.8%)	(1.9%)	(2.1%)	(1.9%)	(1.8%)	(1.9%)	(1.8%)	(1.8%)	(1.8%)	(1.8%)
(% of admitted)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
ICU stay required	266	280	269	247	231	246	197	195	206	204	211	2552
(% of police reports)	(0.4%)	(0.4%)	(0.4%)	(0.5%)	(0.5%)	(0.5%)	(0.4%)	(0.4%)	(0.4%)	(0.4%)	(0.4%)	(0.4%)
(% of admitted)	(22.3%)	(24.0%)	(23.7%)	(24.4%)	(23.6%)	(26.3%)	(23.9%)	(21.4%)	(24.1%)	(24.2%)	(23.9%)	(23.8%)
Drivers with no injury	**51860**	**51043**	**48079**	**39877**	**34733**	**36580**	**35552**	**36511**	**34798**	**34763**	**36324**	**440120**
Admitted overnight	51	63	48	35	22	16	24	37	25	27	18	366
(% of no injury)	(0.1%)	(0.1%)	(0.1%)	(0.1%)	(0.1%)	(0.0%)	(0.1%)	(0.1%)	(0.1%)	(0.1%)	(0.0%)	(0.1%)
(% of admitted)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
ICU stay required	7	14	5	5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	48
(% of no injury)	(0.0%)	(0.0%)	(0.0%)	(0.0%)								(0.0%)
(% of admitted)	(13.7%)	(22.2%)	(10.4%)	(14.3%)								(13.1%)
Drivers with minor injury	**10904**	**10862**	**10524**	**9051**	**8261**	**8800**	**7998**	**8677**	**8612**	**8702**	**9254**	**101645**
Admitted overnight	345	353	335	306	315	279	271	306	286	292	277	3365
(% of minor injury)	(3.2%)	(3.2%)	(3.2%)	(3.4%)	(3.8%)	(3.2%)	(3.4%)	(3.5%)	(3.3%)	(3.4%)	(3.0%)	(3.3%)
(% of admitted)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
ICU stay required	32	43	33	27	29	30	23	21	32	31	22	323
(% of minor injury)	(0.3%)	(0.4%)	(0.3%)	(0.3%)	(0.4%)	(0.3%)	(0.3%)	(0.2%)	(0.4%)	(0.4%)	(0.2%)	(0.3%)
(% of admitted)	(9.3%)	(12.2%)	(9.9%)	(8.8%)	(9.2%)	(10.8%)	(8.5%)	(6.9%)	(11.2%)	(10.6%)	(7.9%)	(9.6%)
Drivers with major injury	**1169**	**1097**	**1132**	**1012**	**1012**	**932**	**815**	**866**	**783**	**787**	**911**	**10516**
Admitted overnight	649	624	632	577	546	555	442	483	457	451	493	5909
(% of major injury)	(55.5%)	(56.9%)	(55.8%)	(57.0%)	(54.0%)	(59.5%)	(54.2%)	(55.8%)	(58.4%)	(57.3%)	(54.1%)	(56.2%)
(% of admitted)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
ICU stay required	191	189	198	193	170	185	138	144	152	146	154	1860
(% of major injury)	(16.3%)	(17.2%)	(17.5%)	(19.1%)	(16.8%)	(19.8%)	(16.9%)	(16.6%)	(19.4%)	(18.6%)	(16.9%)	(17.7%)
(% of admitted)	(29.4%)	(30.3%)	(31.3%)	(33.4%)	(31.1%)	(33.3%)	(31.2%)	(29.8%)	(33.3%)	(32.4%)	(31.2%)	(31.5%)

[a] . Includes 30,903 drivers with unknown injury status and 1873 drivers who were killed. Admissions rates for these injury types are not shown in the table.

injuries by police was common and that the likelihood of under-reporting varied between countries and also varied according to injury severity and road user type. Cyclist and pedestrian injuries were particularly unlikely to be captured in police reports (Yannis et al., 2014). Amoros compared statistics on road trauma injuries from police reports with road trauma hospitalizations in Rhone county, France and found that there were 2.2 times as many hospitalizations for road trauma as there were serious injuries in police reports (Amoros et al., 2008). Researchers in the Netherlands (1993–2008) used police and hospital data to estimate the total number of serious road trauma cases. They concluded that 85% of serious road injuries are recognizable as such in hospital data whereas police records include only 58% of serious road injuries from collisions involving a motorized vehicle and only 4% from collisions not involving a motorized vehicle such as single vehicle cyclist collisions (Reurings and Stipdonk, 2011). Another Dutch study concluded that prior to 2009, only 41% of serious injuries identified from hospital records could be linked to a casualty in police records and from 2010 onwards levels of reporting in police statistics was even lower (Weijermars et al., 2016). In Scotland, Jeffrey reported that 45% of hospital admissions for road trauma were not included in police statistics and that under-reporting was most common for crashes involving motorcyclists and pedal cyclists (Jeffrey et al., 2009). Abay compared police and emergency department data in one region of Denmark and found that police data included only 72% of serious road trauma injuries (Abay, 2015). Watson compared police data with health data in Queensland Australia and found that police collision data included only 54% of road trauma cases admitted to hospital and only 30% of road trauma cases who visited an Emergency Department (Watson et al., 2015).

As in our study, under-reporting of serious injuries in statistics derived from police data occurs when collisions do not come to police attention but is also due to misclassification of injury severity in police reports. A 2011 IRTAD report noted that in many countries, the police are obligated to go to the scene of a crash where there is at least one injured person and are then responsible for collecting information on the number of casualties, assessing the severity of injuries, and the overall severity of the crash. However,

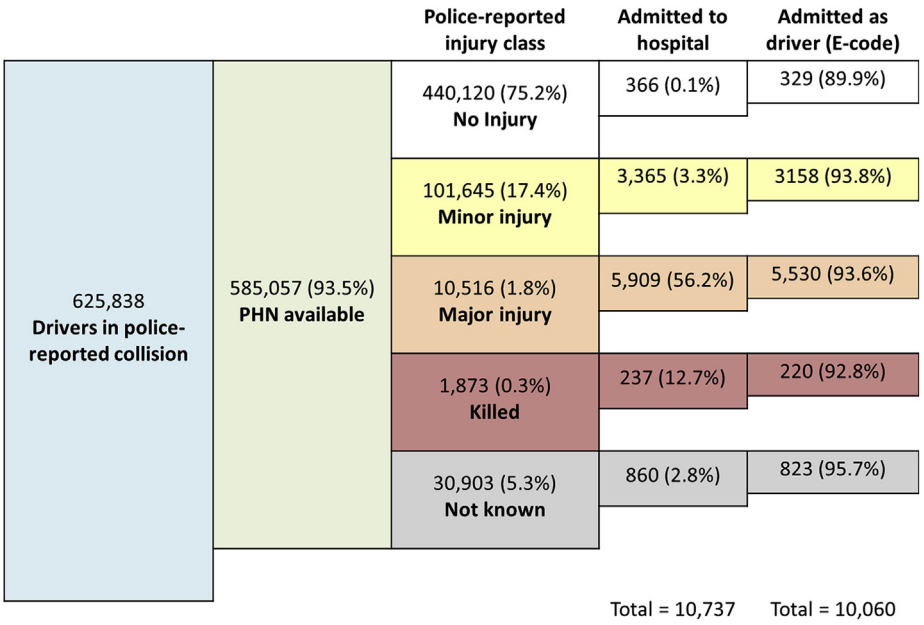

Fig. 1. This figure shows the count and percentage of drivers admitted to hospital according to police assessment of injury severity for drivers involved in a police-reported collision between 2005 and 2015.

the information on crash severity, as reported by the police, is rarely checked later with medical records, except when the injured person dies in hospital (Amoros et al., 2011). Imprialou (2017) reviewed the literature on crash data quality and noted that injury severity is often misclassified in police collision reports, with approximately one third of severe injuries overclassified in police reports and one third under-classified (Imprialou and Quddus, 2017). In France, Amoros reported poor agreement on injury severity assessment between police and hospital data (Kappa = 0.41) with police both under-estimating and over-estimating injury severity (Amoros et al., 2007). Yannis concluded that misclassification of injury severity in police reports played a considerable role in under-reporting of serious injuries in Europe (Yannis et al., 2014).

Misclassification of injury severity in police collision reports is problematic. Canadian and international statistics on the number of seriously injured road trauma survivors used in provincial, national, and international reports are based on police reports. Our findings suggest that these statistics are inaccurate, hindering efforts to monitor serious injury collisions and to identify contributory factors that lead to these devastating events. Inaccurate counts of serious road trauma injuries may also impact policy and infrastructure evaluations that use injury data from police reports. Ultimately this data gap would be expected to hinder development of effective prevention measures.

5. Recommendations

We found that under-reporting of serious injury crashes in police reports occurs both because police do not attend a large percentage of serious injury crashes, and due to misclassification of injury severity in police reports. These findings suggest ways to improve the accuracy of road trauma statistics.

First, police investigation of crashes should be expanded so that, at a minimum, a police report is generated for all collisions where someone is admitted to hospital. Accomplishing this could involve mandatory police attendance at all crashes where a potentially serious injury is identified during the original 911 call. Ambulance dispatchers make decisions on level of response based on factors such as airbag deployment, type of collision, evidence of serious injury (e.g., unconscious victim) elicited during the 911 call. These same factors could be used to dispatch police to the scene. Police attendance at serious injury crashes would also be improved if there were procedures whereby paramedics notify police whenever they identify road trauma survivors with potentially serious injuries. Similarly we suggest that all hospital admissions for road trauma should be reported to police, and police mandated to investigate all such collisions. Police investigation may be hampered if police are notified after the fact, but in most cases they could still obtain basic data such as approximate time and place of collision, and number of vehicles involved.

Second, we recommend that road trauma *injury* statistics use hospital data instead of police statistics. The simplest approach would be to report hospital road trauma admission statistics and police collision statistics separately (i.e., without linkage of individual records). In countries like Canada where hospital admission data is already collected (CIHI: Quick Stats, 2019), this approach could be implemented with little effort. Using hospital admission data to identify injuries that result in hospital admission would be straightforward. However, as criteria for hospital admission are not standardized, it would be more informative to report injury severity using a standardized injury severity score (e.g., AIS or MAIS) as is done in many European countries (Palmer, 2007; Ferreira et al., 2017; Weijermars et al., 2018). Since hospital admission data typically includes ICD9 or ICD10 diagnoses, injury severity can be

Table 3

Police reports for hospitalized drivers. This table shows the number and percent of police reports available for hospitalized drivers. The Table also shows how often police identified "no injury", "minor injuries", or "major injuries" in drivers who were admitted to hospital after a crash. Cases with "injury status unknown" on police reports are not listed. For privacy reasons, data is not shown for cells with fewer than 5 drivers.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
All drivers admitted to hospital	**1654**	**1676**	**1571**	**1490**	**1474**	**1341**	**1203**	**1278**	**1242**	**1242**	**1242**	**15413**
Crash resulted in a police report	1127	1102	1060	943	910	872	770	859	791	793	833	10060
(% of admitted)	(68.1%)	(65.8%)	(67.5%)	(63.3%)	(61.7%)	(65.0%)	(64.0%)	(67.2%)	(63.7%)	(63.8%)	(67.1%)	(65.3%)
(% of police reports)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
Police report indicates no injury	47	56	44	30	19	13	24	31	23	26	16	329
(% of admitted)	(2.8%)	(3.3%)	(2.8%)	(2.0%)	(1.3%)	(1.0%)	(2.0%)	(2.4%)	(1.9%)	(2.1%)	(1.3%)	(2.1%)
(% of police reports)	(4.2%)	(5.1%)	(4.2%)	(3.2%)	(2.1%)	(1.5%)	(3.1%)	(3.6%)	(2.9%)	(3.3%)	(1.9%)	(3.3%)
Police report indicates minor injury	331	337	311	290	288	259	249	289	258	279	267	3158
(% of admitted)	(20.0%)	(20.1%)	(19.8%)	(19.5%)	(19.5%)	(19.3%)	(20.7%)	(22.6%)	(20.8%)	(22.5%)	(21.5%)	(20.5%)
(% of police reports)	(29.4%)	(30.6%)	(29.3%)	(30.8%)	(31.6%)	(29.7%)	(32.3%)	(33.6%)	(32.6%)	(35.2%)	(32.1%)	(31.4%)
Police report indicates major injury	607	589	591	536	512	518	415	455	427	420	460	5530
(% of admitted)	(36.7%)	(35.1%)	(37.6%)	(36.0%)	(34.7%)	(38.6%)	(34.5%)	(35.6%)	(34.4%)	(33.8%)	(37.0%)	(35.9%)
(% of police reports)	(53.9%)	(53.4%)	(55.8%)	(56.8%)	(56.3%)	(59.4%)	(53.9%)	(53.0%)	(54.0%)	(53.0%)	(55.2%)	(55.0%)
Drivers requiring ICU admission	**329**	**345**	**313**	**292**	**294**	**295**	**256**	**233**	**262**	**262**	**263**	**3144**
Crash resulted in a police report	250	268	243	234	218	224	184	184	195	194	199	2393
(% of ICU)	(76.0%)	(77.7%)	(77.6%)	(80.1%)	(74.1%)	(75.9%)	(71.9%)	(79.0%)	(74.4%)	(74.0%)	(75.7%)	(76.1%)
(% of police reports)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
Police report indicates no injury	7	13	< 5	5	< 5	0	< 5	< 5	0	< 5	< 5	43
(% of ICU)	(2.1%)	(3.8%)		(1.7%)								(1.4%)
(% of police reports)	(2.8%)	(4.9%)		(2.1%)								(1.8%)
Police report indicates minor injury	31	43	28	26	28	27	22	18	29	31	21	304
(% of ICU)	(9.4%)	(12.5%)	(8.9%)	(8.9%)	(9.5%)	(9.2%)	(8.6%)	(7.7%)	(11.1%)	(11.8%)	(8.0%)	(9.7%)
(% of police reports)	(12.4%)	(16.0%)	(11.5%)	(11.1%)	(12.8%)	(12.1%)	(12.0%)	(9.8%)	(14.9%)	(16.0%)	(10.6%)	(12.7%)
Police report indicates major injury	177	181	181	182	160	169	128	136	146	137	146	1743
(% of ICU)	(53.8%)	(52.5%)	(57.8%)	(62.3%)	(54.4%)	(57.3%)	(50.0%)	(58.4%)	(55.7%)	(52.3%)	(55.5%)	(55.4%)
(% of police reports)	(70.8%)	(67.5%)	(74.5%)	(77.8%)	(73.4%)	(75.4%)	(69.6%)	(73.9%)	(74.9%)	(70.6%)	(73.4%)	(72.8%)

easily derived using open access software (Clark et al., 2018).

Third, we recommend that linkage of road trauma hospitalizations with corresponding police collision reports be used to generate annual traffic safety reports. With this linkage, health data would be used to classify injury severity and police collision reports would provide key details not available in health records such as crash location and factors that contributed to the crash. This approach would require careful planning to overcome technical and privacy issues. However, as our study demonstrates, these details are not insurmountable and we believe that the effort is justified given the enormous public health burden of road trauma. We recommend population level linkage of *individuals* based on driver license and personal health number as we report here. Ideally, all injured road users identified in a police collision report would then be linked to their corresponding health records. This would require that police obtain identifiers (DL, PHN, or name and birthdate) of all road users injured in a collision, not only drivers. If deterministic linkage of police collision reports to the medical records of individual road users is not possible (e.g., due to inability of police to obtain identifiers for all injured road users), we recommend probabilistic linkage of police collision reports with hospital records as others have done (Howard and Linder, 2014; Thygerson et al., 2011; Conderino et al., 2017). Note that accurate probabilistic linkage might require that health providers collect information on collision location as is done in STRADA (the Swedish Traffic Accident Data Acquisition) (Howard and Linder, 2014). Identifying collision location from reports of injured patients can be challenging for healthcare providers. However, when the GIS coordinates for ambulances dispatches are recorded, those coordinates can be used to approximate collision location for road trauma victims transported to hospital by ambulance (Brubacher et al., 2014, 2018).

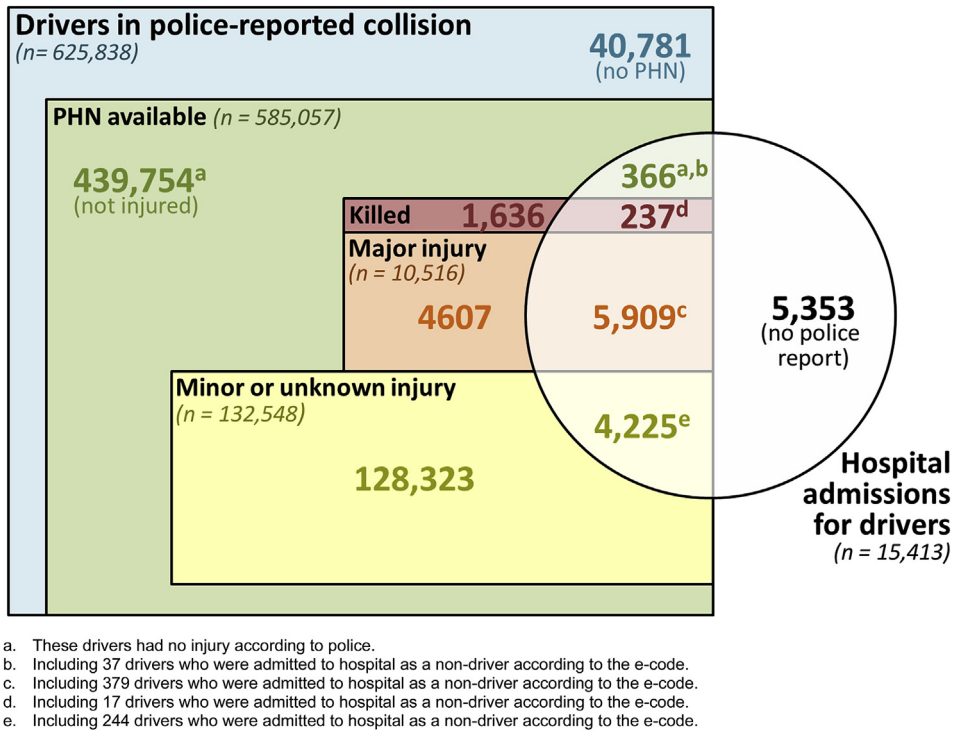

Fig. 2. This figure shows the overlap between police collision reports and hospital admissions for drivers who were either involved in a police-reported collision *or* admitted to hospital with an E-code indicating that they were a driver injured in a collision between 2005 and 2015.
a. These drivers had no injury according to police. b. Including 37 drivers who were admitted to hospital as a non-driver according to the e-code. c. Including 379 drivers who were admitted to hospital as a non-driver according to the e-code. d. Including 17 drivers who were admitted to hospital as a non-driver according to the e-code. e. Including 244 drivers who were admitted to hospital as a non-driver according to the e-code.

6. Limitations

As police reports do not currently capture DL or PHN of road users other than drivers, we were unable to compare police assessment of injury status with actual requirement for hospital admission for passengers, cyclists, or pedestrians involved in a crash. It is unlikely, however, that police ability to assess the injury status of drivers would be different than for other road users so this limitation does likely not affect our conclusions. We also recognize that DAD data has limitations because hospital data do not contain details regarding the circumstances of the collision. In particular, unlike police reports, DAD data does not allow linkage of multiple people injured in a single collision, and contains no information on the cause, location, or time of crash. Another limitation is that we were unable to verify the accuracy of the E-Codes used to identify road trauma admissions in DAD. It is possible that some of the E-Codes in DAD were incorrect and this could have affected our conclusions. Since traffic collisions are generally easy to identify, we believe that most misclassifications would involve road user role (for example an injured driver being coded as an injured passenger) but not an entirely different mechanism of injury (e.g., a fall being misclassified as road trauma). Indeed, of 10,737 drivers identified in police collision reports and admitted to hospital, 677 (6.3%) were coded as non-drivers in DAD. In these cases we have no way to verify the actual road user role, but we suspect that police reports provide more reliable information on road user role since police typically attend the collision scene and interview all road users involved.

7. Conclusions

There is poor agreement between police assessment of injury severity in collision reports and actual requirement for hospital admission. These findings highlight a significant limitation of road trauma surveillance and traffic evaluations that rely on injury severity data from police collision reports.

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Conflict of interest declaration

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