HHS Public Access

Author manuscript

Inj Prev. Author manuscript; available in PMC 2017 July 11.

Published in final edited form as:

Inj Prev. 2015 April ; 21(2): 84–90. doi:10.1136/injuryprev-2014-041266.

Epidemiology of pedestrian–MVCs by road type in Cluj, Romania

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Abstract

Objective—Pedestrian–motor vehicle (PMV) crash rates in Romania are among the highest in all of Europe. The purpose of this study was to examine the characteristics of pedestrian–MVCs in Cluj County, Romania, on the two major types of roadways: national or local.

Methods—Cluj County police crash report data from 2010 were used to identify pedestrian, driver and crash characteristics of pedestrian–MVCs. Crashes with available location data were geocoded and road type (national or local) for each crash was determined. Distributions of crash characteristics were examined by road type and multivariable logistic regression models were built to determine predictors of crash road type.

Results—Crashes occurring on national roads involved more teenagers and adults, while those on local roads involved more young children (0–12) and older adults (65+) ($p<0.01$). Crashes on national roads were more likely to have marked pedestrian crossings and shoulders compared with local crashes. Pedestrian–MVCs that involved a moving violation by the motorist were more likely to occur on national roadways (adjusted OR=1.93, 95% CI 1.07 to 3.49).

Conclusions—Pedestrian–MVCs pose a considerable health burden in Romania. Results from this study suggest that factors leading to PMV crashes on national roads are more likely to involve driver-related causes compared with local roads. Intervention priorities to reduce pedestrian crashes on national roads should be directed towards driver behaviour on national roads. Further examination of driver and pedestrian behaviours related to crash risk on both national and local roads, such as distraction and speeding, is warranted.

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Contributors

CH: conception and design, acquisition of data, analysis and interpretation of data and in writing the final version of the manuscript for publication. CP-A: conception and design, analysis and interpretation of data and in writing the final version of the manuscript for publication. DR: acquisition of data, interpretation of data and writing of the final version of the manuscript for publication.

Competing interests None.

Ethics approval

The ethics approval for this paper was provided by the University of Iowa Institutional Review Board.

Provenance and peer review Not commissioned; internally peer reviewed.

BACKGROUND

Fatality rates from pedestrian–MVCs in low-income and middle-income countries are, on average, twice that of high-income countries.[1] Romania, a middle-income country, has a pedestrian fatality rate of 40.4 per million population, which was the highest in the European Union (EU)-24 and over the past decade has consistently remained among the highest along with Lithuania, Poland and Greece.[23] In comparison, Luxembourg (2.0) and the Netherlands (3.8) have the EU's lowest pedestrian fatality rates per million population.[2]

Roadway infrastructure in Romania is changing rapidly and may be associated with pedestrian injury rates. Romania joined the EU in 2007 and has since received funds from agencies such as the European Fund for Regional Development and the European Investment Bank to build and rehabilitate the nation's roadways.[4] The World Economic Forum ranked Romanian roadway quality 134th out of 139 countries in 2010.[5] Roadway improvement efforts have focused on high-speed national roads that facilitate transportation through and between cities, while infrastructure improvement for local roads has lagged.[67] The emphasis for roadway improvements led to increasing transportation access and speed, and safety has not been a high priority.[8] Moreover, the roadway infrastructure development has not kept up with the rising numbers of vehicles, which increased from 4.2 million registered motor vehicles in 2007 to more than 5.5 million in 2012.[9] National roads often bisect urban and rural population centres, but little is known about how pedestrians interact with these high-speed, high-volume roads.

Specific causes and contributing factors for the high pedestrian fatalities associated with driver and pedestrian behaviour in Romania have not been identified. Illegal pedestrian behaviour is likely to contribute. In 2010, 10 452 citations for illegal pedestrian crossings were issued, which was nearly double the 5575 given in 2009. It is unclear, however, whether these numbers increased due to better enforcement or changes in pedestrian behaviour. According to the Romanian National Police Reports, the top causes of all traffic crashes are excessive speed (18.4%), followed by jaywalking (17.5%) and failure-to-yield to pedestrians (8.9%).[9] In Cluj County, containing Cluj-Napoca, the second largest city in Romania and an educational and cultural hub, the number of severe RTCs has averaged 366 per year since 2008, with a high of 387 in 2013, according to police reports.[10]

The objective of this study was to identify factors related to crashes on national versus local roads, with the hypothesis that driver, pedestrian and crash contributing causes vary by road type. Specifically, we hypothesised that crashes on national roads would involve more driver-related causes, such as speed and failure to yield the right-of-way to the pedestrian, while crashes on local roads would involve more pedestrian-related causes such as jaywalking and pedestrian distraction. Therefore, we examined two main contributing causes available from police crash records: moving violations by the motor vehicle and improper road interactions by pedestrians (including jaywalking or children running into the roadway).

METHODS

This study was conducted in Cluj County, located in the northwest region of Romania. The county has a population of 691 100, approximately half of whom live in the capital city of Cluj-Napoca, Romania's second largest city.[11] The county has four other mid-sized cities and more than 50 small towns. It serves as a major thoroughfare for inter-country and cross-country traffic, and more than a third of the roadways are through mountainous regions. This county was chosen because the study authors have an ongoing collaboration through an National Institutes of Health-funded Fogarty Training grant.

This study uses the 2010 RTC data collected through police reports in Cluj County, Romania, during which 832 total traffic crashes were reported to the police. Crash reports that identified a pedestrian as a party in the reported collision were used, and associated information about the pedestrian, the motor vehicle driver and environment were collected from the police data. Of the 832 crashes, 318 (38%) involved a pedestrian. Of these, 13 involved two pedestrians and one driver, and 299 involved one pedestrian and one driver. Six crashes that involved one pedestrian and two drivers were excluded from this study because actions of the vehicles or which driver's car hit the pedestrian could not be determined. All driver and pedestrian characteristics were extracted directly from data documented in the police reports. These variables included age, gender, alcohol tests, pedestrian action (eg, crossing the road), medical condition, driver seat belt use, years driver licence held and vehicle category.

Cluj Traffic Police reports did not use global positioning system (GPS) technology to geocode crash location in 2010, therefore crash locations were approximated by the research team using the nearest road post mile marker for rural locations and street intersection or an electricity pole (numbered and positioned near the road) for urban locations extracted from the police reports. None of these data were able to be linked to existing street network files, therefore crash locations were geo-coded on-site from May to November, 2011, using mile marker, intersection or electricity pole information and a handheld GPS device. Crash location data were ascertained for 204 (65.4%) of the eligible crashes and these crashes involved 217 pedestrians. Geocoded crashes were compared with those that could not be mapped to identify any systematic differences. The presence of a shoulder was the only variable that differed between geocoded and non-geocoded crashes that was a significant factor in the final model, with more shoulders present in the geocoded sample (48.3% vs 61.8%).

Road type was the main outcome of this study, categorised as local or national. Roadway classifications were based on the national regulations on route classification developed and administered by the Romanian Ministry of Transport (Government Ordinance OG no. 43/1997 regarding routes classification, last modified by OG no. 7/2010). Roadway classes are marked with specific colours and signage so that drivers are aware of the road types.

For this study, national roads were defined as heavily travelled roads designated as transportation and commercial motorways (road class categories Autostrăzi (A), European (E), and Drumuri Naţionale (DN)). E routes, for example, are national European routes and

are designed to accommodate both domestic travel and international traffic travelling through the country. Local roads were defined as county or community roads designated for local transportation (road class categories Drumuri Judeţene (DJ) and Drumuri Comunale (DC)). Romania has its own roadway classifications, which differ from those of other places in Europe, thus cannot be directly compared. However, this classification system generally follows the same hierarchy that is familiar worldwide (with varying nomenclature) of freeways, arterials, collectors and local roads.

The main independent variables included child-related cause, moving violations by motor vehicles and jaywalking/other pedestrian risky actions. Child-related causes included any action by a child that contributed to the cause of the pedestrian–MVC (eg, darting out into the street). A child was defined as under the age of 18. Moving violations by motor vehicles included imprudent (reckless) driving (n=2), irregular overtaking (n=3), not looking when reversing (n=4), failure-to-yield to pedestrians (n=85), inappropriate speed to road conditions (n=6), irregular speed (n=1), driving the wrong direction in lane (n=1) and infringement of traffic signs/signals/lights (n=8). Pedestrian actions leading to the crash included the following: jaywalking/irregular crossing (n=106), pedestrian standing in roadway (n=13) and other violations committed by pedestrian (n=1). These variables were not mutually exclusive, meaning a pedestrian–motor vehicle (PMV) crash could have involved more than one cause (eg, moving violation and child-related cause). Specifically, Cluj police records allow for the specification of main and secondary causes. Due to the subjective nature of police reports, we did not take into account whether causes were listed as main or secondary. For this same reason, we did not adjust for crashes that listed multiple causes because the goal was to determine the individual contribution of each factor.

Analysis

Frequencies and distributions of person and crash variables by road type were examined and multicollinearity of variables was assessed. Univariate and multivariable logistic regression models were used to examine the association of three main independent variables: child-related causes, moving violation by motor vehicle and jaywalking or other pedestrian action, with road type. These predictors were derived from main or secondary crash causes and each was examined separately.

A limited number of variables were available in the police data. Based on studies from other countries, we identified covariates using an a priori approach and using the variables that were available in the data. Covariates included in the regression models were pedestrian age and presence of a shoulder on the roadway. Presence of a marked pedestrian crossing was also included in the child-related model, but not included in the moving violation and jaywalking models due to high correlation between variables (moving violation×pedestrian crossing: $r=0.79$, $p<0.01$; jaywalking×pedestrian crossing: $r=-0.81$, $p<0.01$). We also examined the interactions of the main predictors of these models with pedestrian crossings, and they were not significant. All analyses for this paper were generated using SAS software, V.9.3.

Ethics approval for this study was obtained from the Institutional Review Board at the University of Iowa. Data usage was approved via a collaboration protocol between the

Department of Traffic Police, Cluj Police Inspectorate, and the Center for Health Policy and Public Health, Institute for Social Research at College of Political, Administrative and Communication Sciences, Babeş-Bolyai University.

RESULTS

Figure 1 shows the distribution of mapped pedestrian–MVCs by road type (national road or local road) in Cluj County, Romania. The distribution of crashes was fairly equal for national (53.4%) and local (46.1%) roads, but these distributions do not account for pedestrian exposure and should not be interpreted as prevalence measures. In areas outside of the city of Cluj-Napoca, 69 (58.5%) of the crashes were on national roads, and these were distributed throughout the national roads across the county. Within the city of Cluj-Napoca, 48 (48.5%) pedestrian crashes were on national roads and 51 (51.5%) on local roads.

Pedestrian and driver characteristics

Table 1 shows the distribution of pedestrian and driver characteristics stratified by road type. Crashes occurring on national roads involved larger proportions of older children (13–17) and adults (18–64) than local roads, while local roads had more crashes with young children (0–12) and older adults (65+; $p<0.01$). National roads had a higher proportion of crashes in which the pedestrian was crossing the road, but this was not statistically significant ($p=0.09$). Pedestrian gender, positive alcohol tests (driver or pedestrian), pedestrian medical condition, driver age, driver gender, driver seat belt use and number of years the driver had held a licence did not vary significantly by crash location (national vs local road). Trucks and buses were significantly more frequent on national roads, while tractors and two-wheeled vehicles were significantly more frequent on local roads.

Crash characteristics

Table 2 shows the distribution of crash characteristics by road type. A larger proportion of pedestrian–MVCs that occurred on national roadways had a shoulder ($p<0.01$) and a marked pedestrian crossing ($p=0.03$) compared with those occurring on local roads. Crash causes (primary or secondary) also varied by road type, with moving violations by motor vehicles being cited more often on national roads ($p=0.01$) and child-related imprudence ($p=0.01$) and jaywalking ($p=0.03$) occurring more often on local roads. Lighting, time of day, weekday, month and roadway geometry (intersection or non-intersection) did not vary significantly by road type (national or local).

Predictors of crash location (local vs national road)

Crashes that involved a moving violation by the motorist were nearly twice as likely (adjusted OR=1.93, 95% CI 1.07 to 3.49) to occur on national roadways as compared with crashes that did not have a motorist moving violation (table 3). Crashes involving child-related causes (OR=0.19, 95% CI 0.05 to 0.81) or jaywalking or other pedestrian action (OR=0.54, 95% CI 0.31 to 0.93) were significantly less likely to occur on national roadways in univariate analyses compared with crashes without those causes, but these did not remain statistically significant in adjusted models (table 3).

DISCUSSION

PMV crashes pose a considerable public health burden in Romania, as well as throughout the EU.[12] As the EU has grown, roadway infrastructure in member countries, and in many of the middle-income members of the EU, the majority of new roadways are built through EU funds. This study examined the characteristics of PMV crashes by road type (local or national road). One major limitation of this study is that relative incidence of PMV crashes by roadway could not be examined because pedestrian exposure information was not available. Pedestrian volume is likely to be far higher on local roads, suggesting that per pedestrian or per pedestrian mile travelled, incidence rates might be far higher on national roads.

Our results reveal important differences in the characteristics of crashes on the two types of roads. PMV crashes on national roads were more likely to involve motor vehicle violations. These roads have higher speeds, requiring greater stopping distances. Drivers may be less attentive to pedestrians on national roads. Crashes involving pedestrian errors (eg, child darting into road, jaywalking) more frequently occurred on local roads, mostly attributed to young children (0–12) and older adults (65 +). This finding is consistent with previous European reports that children younger than 10 years of age and adults older than 65 years have the highest percentage of pedestrian fatalities in Europe.[1314] Also, a study of emergency department visits using data from a large children's hospital in Cluj found that one of the top injury mechanisms for non-fatal childhood injuries was bicycling/pedestrian activities (16%) and this was especially high among the 5-year-old to 14-year-old age group (24.2%).[15]

Results from the current study are consistent with established risk factors for PMV crashes and general risk factors for traffic fatalities in Europe. According to the European Transport Safety Council, the top three risk factors for traffic fatalities in EU countries are speeding, non-use of seat belts and drunk driving.[16] A study of the 'Southern, Eastern, and Central (SEC) European Belt', which did not include Romania but did include many countries with similar pedestrian crash rates and roadway infrastructure (eg, Poland and Slovakia), suggests that pedestrian roadway safety problems are largely due to lack of law enforcement and poor infrastructure as well as a lack of roadway hierarchy systems (giving highest priority to pedestrians, bicycles and public transit).[17]

Distraction, among both drivers and pedestrians, is increasingly recognised as a risk factor for traffic crashes.[1819] Although information on distraction was not available in these data, Romanians are known for their frequent use of cellphones and other portable technologies and thus Romania is likely not immune from this rising worldwide epidemic. In 2011, 26.2 million mobile phone users were registered by the Romanian National Authority for Management and Regulation in Communication,[20] Romania registered more mobile phone users than its actual population (the 2011 Census reported a population of approximately 20 million).[21] Romanian police reports do not code driver or pedestrian distraction, although using a cellphone while driving, including talking on the phone and texting, is a penalty in the Romanian Road Traffic Code. Previous research has demonstrated that distracted pedestrians are more likely to be hit by a vehicle compared with undistracted pedestrians, as

shown by studies done in virtual pedestrian environments.[22,23] Modifying the police reporting system to collect data on distraction would represent an opportunity to have more accurate data on risk factors and behaviours of road users in Romania. Moreover, it would provide evidence for road safety enforcement and prevention strategies.

The European Commission statements of policy orientations on road safety 2011 through 2020 highlight the need to address safety of vulnerable road users.[24] Roads that are not designed to accommodate vulnerable populations result in higher burden of injuries for those particular populations. Some preventive strategies include increasing pedestrians' visibility when crossing or travelling along the street and reducing pedestrian exposure to road traffic by designing roadways to accommodate them (eg, creating more sidewalks in rural areas). However, solutions that can be incorporated into the roadway environment are likely to have more impact in reducing pedestrian crashes. A particularity of Romanian road infrastructure in need of immediate attention is national roads that cross urban and rural settlements. National roads in Romania include European routes, which have been expanded in recent years throughout the country, largely a result of funding from the EU.[4] Although road network expansion has enabled better connectivity for motorists to travel both within Romania and within the EU, many of these national roadways bisect small towns and villages and present as obstacles for pedestrians. Nearly 60% of all roads in Romania fit under this category.[25] Pedestrians are also often exposed to high-speed traffic on these roadways due to motorist failure to reduce their speeds to legal limits as they pass through towns and small cities.[10]

Poor roadway pedestrian accommodations, combined with behavioural aspects (eg, distraction and lack of adequate enforcement), contribute to Romania having one of the highest pedestrian injury and fatality rates in Europe.

Limitations

The sample size of this study was limited due to missing crash location information for approximately one-third of the PMV crashes. Although crashes did not have any systematic differences based on whether location information was available, the extent of representation of this sample is not known. Police crash reports are well recognised for under-representing all crash events, and disproportionately represent crashes with more severe injuries. Thus, the sample analysed is not likely to be fully representative of the spectrum of crash injury severity. Information about pedestrian exposure to local and national roads and frequency of risky behaviours was not available, and thus we could not determine the increase in odds for pedestrians by roadway. However, previous PMV research has shown that most PMV crashes occur in urban areas because there is more pedestrian exposure to motor vehicle traffic in those areas.[26]

This study was limited to the data available in the Cluj County crash database, which was police-reported, meaning it is possible that some of the included variables may be biased (eg, causes) and inconsistencies may have been introduced. The results from this study encourage further investigation of crash factors, including exposure data for motor vehicles and pedestrians and behavioural characteristics, such as speeding by motorists and

distraction by both motorists and pedestrians, and details on the infrastructure (eg, presence of sidewalks).

Conclusions

Pedestrian safety has not been identified as a priority in new roadway infrastructures developed through the EU. This study suggests that motorists are more likely to be at fault for pedestrian collisions on national roads, and that pedestrian crashes on national roads are over-represented compared with local roads. Accommodations to improve pedestrian safety on national roads should be examined as the national roadway infrastructure continues to grow in Romania. Conversely, pedestrian-contributed factors were prevalent on local roads. A further examination of specific pedestrian and driver behaviours would be beneficial and enable the development of interventions targeted to reduce risk factors leading to PMV crashes.

Acknowledgments

The manuscript used data provided by the Department of Traffic Police, Cluj Police Inspectorate, as part of a collaboration protocol signed with the Center for Health Policy and Public Health, Institute for Social Research, College of Political, Administrative and Communication Sciences, Babeş-Bolyai University, to support road traffic research in Cluj County. The authors gratefully acknowledge all members of the Department of Traffic Police who contributed to the project documentation used in this manuscript.

Funding

Partial funding was provided by the NIH-Fogarty Funded University of Iowa Trauma Training Program (D43 TW007261) and the CDC/NCIPC-funded University of Iowa Injury Prevention Research Center (R49 CE002108).

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What is already known on the subject

Pedestrian–MVC rates in Romania are among the highest in Eastern Europe.

What this study adds

- Pedestrian–MVCs are a problem on both local and national roadways in Romania, but have different contributing factors.
- Pedestrian–MVCs in Cluj County, Romania, that involve moving violations by the motor vehicle are more likely to occur on national roadways than local roadways.
- When pedestrian actions were recorded as a contributing cause to the crash, such as jaywalking and child actions, the roadway of the collision was more frequently a local road.

School buses crash

Two Tennessee school buses were travelling in opposite directions when the driver of one carrying children made a sudden left turn and crashed into the other bus, killing three and injuring three others.

Hockey fights: popular but dangerous

A reporter for The Hockey News makes the excellent point that although fighting in professional ice hockey may not be banned because it is so popular among some fans, it can and should be reduced because of the growing evidence of resulting brain damage. Three 509% is what was reported died within 4 months in 2011.

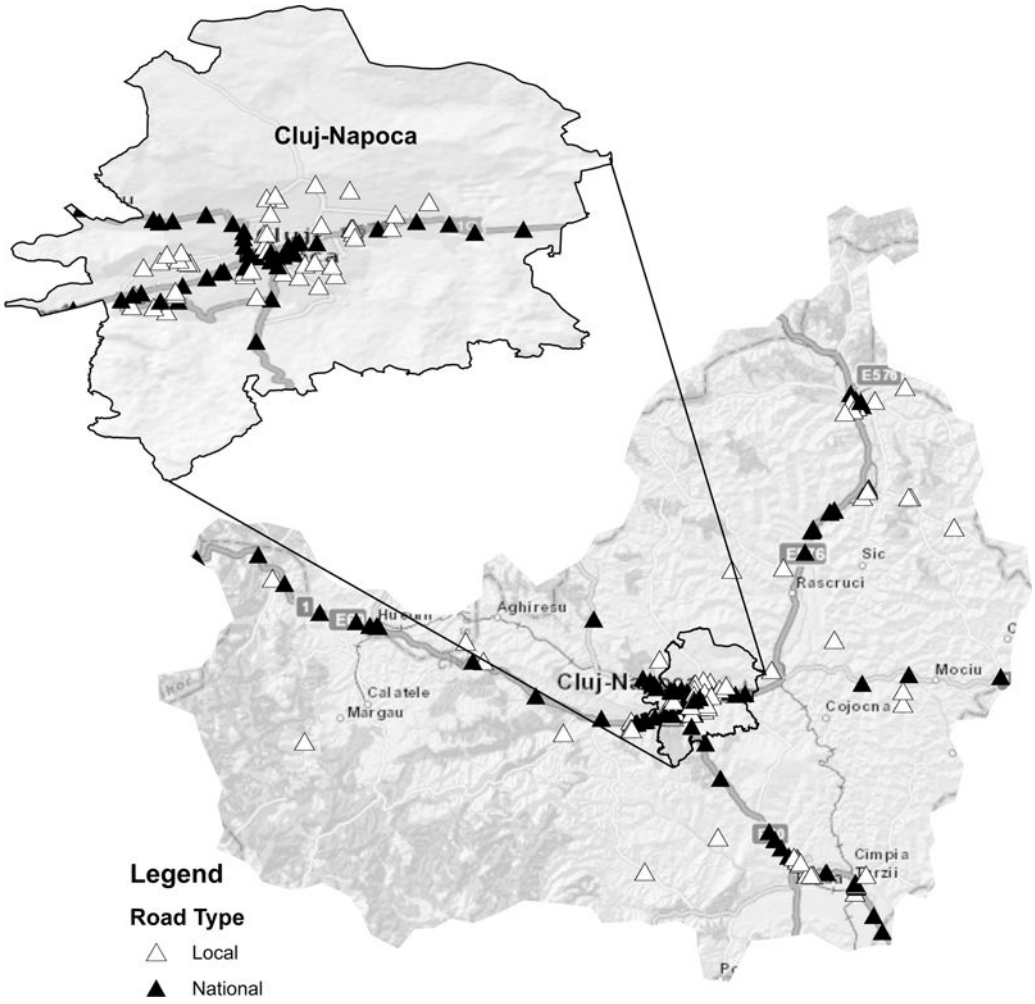

Figure 1.
Pedestrian–MVCs by road type in Cluj County, Romania, 2010.

Inj Prev. Author manuscript; available in PMC 2017 July 11.

Table 1

Pedestrian and driver characteristics of pedestrian–MVCs in Cluj County, Romania, by road type, 2010

	Local roads (N=100)		National roads (N=117)		
Characteristic	**N**	**Per cent**	**N**	**Per cent**	**p Value**
Pedestrians (N=217)					
Age					<0.01
0–12	25	25.0	10	8.6	
13–17	6	6.0	14	12.0	
18–44	26	26.0	48	41.0	
45–64	17	17.0	24	20.5	
65–93	26	26.0	21	18.0	
Gender					0.74
Male	45	45.0	50	42.7	
Female	55	55.0	67	57.3	
Alcohol test positive					0.97
Yes	5	5.0	6	5.1	
No	95	95.0	111	94.9	
Action					0.09
Crossing the road	84	85.7	105	92.9	
Walking or waiting on road or sidewalk	14	14.3	8	7.1	
Medical condition					0.22
Slightly injured	60	60.0	61	52.1	
Severely injured	32	32.0	38	32.5	
Dead	8	8.0	18	15.4	
Drivers (N=203)	(N=93)		(N=110)		
Age					0.47
13–17	1	1.1	0	0.0	
18–44	71	76.3	83	75.5	
45–64	20	21.5	23	20.9	
65+	1	1.1	4	3.6	
Gender					0.38

Characteristic	Local roads (N=100) N	Local roads (N=100) Per cent	National roads (N=117) N	National roads (N=117) Per cent	p Value
Male	80	86.0	99	90.0	
Female	13	14.0	11	10.0	
Seat belt used					0.89
Yes	84	90.3	100	90.9	
No	9	9.7	10	9.1	
Alcohol test positive					0.12
Yes	4	4.3	1	0.9	
No	89	95.7	109	99.1	
Number years driver has held licence *					0.76
5 years or less	61	71.8	73	68.2	
6–10 years	20	23.5	30	28.0	
10+ years	4	4.7	4	3.7	
Vehicle category					0.01
Car	75	80.7	93	84.6	
Truck/bus	3	3.2	9	8.2	
Van	7	7.5	8	7.3	
Tractor/moped/scooter/motorcycle/bicycle	8	8.6	0	0.0	

* Numbers do not add to total due to missing data.

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Table 2

Crash characteristics of pedestrian–MVCs in Cluj County, Romania, by road type, 2010

Crash (N=217)	Local roads (N=100)		National roads (N=117)		p Value
Lighting					0.17
Daylight/sunny or functional street lighting	79	79.0	83	70.9	
Cloudy, dawn, twilight, broken or no street lighting	21	21.0	34	29.1	
Time of day					0.51
10:00 pm to 5:59 am	2	2.0	7	6.0	
6:00 am to 9:59 am	14	14.0	17	14.5	
10:00 am to 2:59 pm	31	31.0	32	27.4	
3:00 pm to 9:59 pm	53	53.0	61	52.1	
Weekday					0.59
Sunday	5	5.0	8	6.8	
Monday	22	22.0	18	15.4	
Tuesday	10	10.0	19	16.2	
Wednesday	13	13.0	21	18.0	
Thursday	13	13.0	15	12.8	
Friday	19	19.0	18	15.4	
Saturday	18	18.0	18	15.4	
Month					0.90
December–February	31	31.0	32	27.4	
March–May	27	27.0	31	26.5	
June–August	15	15.0	21	18.0	
September–November	27	27.0	33	28.2	
Roadway features					
Shoulder					<0.01
Yes	51	51.0	83	70.9	
No	49	49.0	34	29.1	
Roadway geometry					0.65
Intersection	14	14.0	19	16.2	
Non-intersection	86	86.0	98	83.8	

Crash (N=217)	Local roads (N=100)		National roads (N=117)		p Value
Marked pedestrian crossing					0.03
Yes	28	28.0	49	41.9	
No	72	72.0	68	58.1	
Primary or secondary causes					
Moving violation by motor vehicle					0.01
Yes	37	37.0	65	55.6	
No	63	63.0	52	44.4	
Child-related					0.01
Yes	13	13.0	3	2.6	
No	18	18.0	21	18.0	
Not applicable (ped was not a child)	69	69.0	93	79.5	
Jaywalking or other pedestrian action					0.03
Yes	63	63.0	56	47.9	
No	37	37.0	61	52.1	

Table 3

Predictors of pedestrian–MVC locations, national road versus local road, Cluj County, Romania, 2010

	Model 1—child-related cause (N=55)		Model 2—moving violation (N=217)		Model 3—jaywalking or other pedestrian action (N=217)	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Characteristic Pedestrian age						
0–12	0.23	0.06 to 0.97	0.36	0.13 to 0.97	0.35	0.13 to 0.95
13–18	ref	ref	2.22	0.67 to 7.38	2.19	0.66 to 7.22
19–44			1.47	0.64 to 3.37	1.49	0.66 to 3.40
45–64			ref	ref	ref	ref
65–93			0.65	0.27 to 1.56	0.64	0.27 to 1.54
Shoulder						
Yes	0.31	0.08 to 1.22	2.80	1.52 to 5.17	2.72	1.49 to 4.99
No	ref	ref	ref	ref	ref	ref
Marked pedestrian crossing						
Yes	0.21	0.05 to 0.99				
No	ref	ref				
Child-related cause						
Yes	0.44	0.08 to 2.51				
No	ref	ref				
Moving violation by motor vehicle						
Yes			1.93	1.07 to 3.49		
No			ref	ref		
Jaywalking or other pedestrian action						
Yes					0.61	0.34 to 1.11
No					ref	ref

Model 1 Adj R^2=0.38, model 2 Adj R^2=0.18, model 3 Adj R^2=0.17. (1) Outcome=national road versus local road. (2) Pedestrian crossing was not included in models 2 or 3 because it is highly correlated with both moving violation and jaywalking.

Shaded area indicates those variables are not in those models.