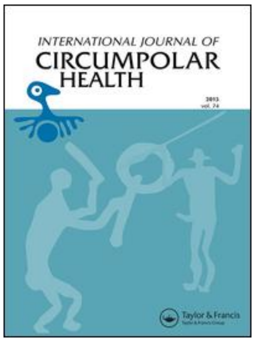


International Journal of Circumpolar Health

ISSN: (Print) 2242-3982 (Online) Journal homepage: https://www.tandfonline.com/loi/zich20

# Explaining reduction of pedestrian–motor vehicle crashes in Arkhangelsk, Russia, in 2005–2010

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# Explaining reduction of pedestrian–motor vehicle crashes in Arkhangelsk, Russia, in 2005–2010

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***Objective.*** To explain a reduction in pedestrian–motor vehicle crashes in Arkhangelsk, Russia, in 2005–2010.
***Study design.*** Retrospective ecological study.
***Methods.*** For 2005–2010, police data on pedestrian–motor vehicle crashes, traffic violations, and total motor vehicles (MVs) were combined with data on changes in national road traffic legislation and municipal road infrastructure. Negative binomial regression was used to investigate trends in monthly rates of pedestrian–motor vehicle crashes per total MVs and estimate changes in these rates per unit changes in the safety measures.
***Results.*** During the 6 years, the police registered 2,565 pedestrian–motor vehicle crashes: 1,597 (62%) outside crosswalks, 766 (30%) on non-signalized crosswalks, and 202 (8%) on signalized crosswalks. Crash rates outside crosswalks and on signalized crosswalks decreased on average by 1.1% per month, whereas the crash rate on non-signalized crosswalks remained unchanged. Numbers of signalized and non-signalized crosswalks increased by 14 and 19%, respectively. Also, 10% of non-signalized crosswalks were combined with speed humps, and 4% with light-reflecting vertical signs. Pedestrian penalties for traffic violations increased 4-fold. Driver penalties for ignoring prohibiting signal and failure to give way to pedestrian on non-signalized crosswalk increased 7- and 8-fold, respectively. The rate of total registered drivers' traffic violations per total MVs decreased on average by 0.3% per month. All studied infrastructure and legislative measures had inverse associations with the rate of crashes outside crosswalks. The rate of crashes on signalized crosswalks showed inverse associations with related monetary penalties.
***Conclusions.*** The introduction of infrastructure and legislative measures is the most probable explanation of the reduction of pedestrian–motor vehicle crashes in Arkhangelsk. The overall reduction is due to decreases in rates of crashes outside crosswalks and on signalized crosswalks. No change was observed in the rate of crashes on non-signalized crosswalks.

Keywords: *pedestrian*; *crash*; *infrastructure measures*; *legislative measures*; *law enforcement*; *Russia*

Received: 10 July 2012; Revised: 29 August 2012; Accepted: 3 September 2012; Published: 24 September 2012

Globally, road traffic crashes cause over 1.2 million deaths and up to 50 million non-fatal injuries per year (1). Over 400,000 global traffic fatalities are pedestrians, about 95% cases occurring in low- and middle-income countries (2). The Russian Federation ranks second highest on the road traffic mortality (25.2 per 100,000 population) in the WHO European region (1). The 2009–2011 annual numbers of traffic deaths and non-fatal injuries exceeded 26,000 and 250,000, respectively (3,4). Every third traffic crash in Russia involves a pedestrian (4). The global tendency is that pedestrians are at most risk in urban settings with high pedestrian and vehicle activity (5).

International publications show effectiveness of several pedestrian safety measures: infrastructure solutions, enhancement of road traffic legislation, law enforcement, education, media campaigns, and their combinations (6–17). Many of these measures were introduced in Russia during the last decade by implementation of the nationwide Road Safety Improvement Federal Target



Citation: Int J Circumpolar Health 2012, **71**: 19107 - http://dx.doi.org/10.3402/ijch.v71i0.19107
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Program 2006–2012 (18,19). The main nationwide pedestrian safety measures were increases in penalties for related traffic violations and traffic safety promotion activities in mass media and schools (18). Locally, pedestrian safety was addressed by infrastructure measures, for example, installation of traffic signals, speed humps, and light-reflecting traffic signs.

A previous study in Arkhangelsk, Russia, has shown that pedestrians constituted 54% of all traffic fatalities and 45% of non-fatal injuries during 2005–2010 (20). This study also identified reductions in pedestrian–motor vehicle crash rates per total motor vehicles (MVs) and total population during this period. The purpose of the present article is to explain the reduction by investigating its associations with national legislative measures, local infrastructure changes, and law enforcement measures.

## Materials and methods

### Study design and site

This retrospective ecological study was performed in Arkhangelsk – a Northwestern Russian city. The study period covered 6 years, from 1 January 2005 to 31 December 2010. During the period, Arkhangelsk population decreased by 0.6% (from 357,733 at baseline to 355,556 at end-point), whereas the total number of MVs increased by 37.3% (from 59,961 to 82,311, respectively), and the total length of the city road network remained constant (512 km) (20).

### Data sources

Data on pedestrian–motor vehicle crashes, called later *pedestrian crashes*, were obtained from the Arkhangelsk police database on fatal and non-fatal road traffic crashes. Description and reliability estimates of this source are presented elsewhere (20,21). The police also provided data on traffic violations and total number of MVs registered in the city. Data on infrastructure measures were obtained from the Arkhangelsk municipal department of road safety. Data on legislative measures were taken from national legislative acts. Data on total city population were obtained from the Ministry of Health of the Arkhangelsk region.

### Data description

Data on all pedestrian crashes and traffic violations registered by the police in Arkhangelsk in 2005–2010 were used. A pedestrian crash is defined by the police as an event on a road where a vehicle (motorized or animal-drawn) in motion collides with a pedestrian, resulting in an injury. Events where a pedestrian is hit by a vehicle in consequence of any other crash type, for example, vehicle collision or rollover, are accounted by the police in accordance with their origin and are not included in this study. For each pedestrian crash, the data included date (day, month, year), time (hour, minute), type of place (signalized crosswalk at junction/span, non-signalized crosswalk at junction/span, and junction/span with no crosswalk), related traffic violations, and health outcome for every involved pedestrian (fatal or non-fatal injury). For each traffic violation, the available data included date (day, month, and year), type of traffic violation (135 types), type of penalty (oral warning, monetary penalty, withdrawal of driving license, and imprisonment), and the amount of Russian rubles (RUB; 1 USD $\approx$ 30 RUB) for a monetary penalty.

Data on infrastructure measures included information on changes in characteristics and numbers of non-signalized and signalized crosswalks in Arkhangelsk in 2005–2010. Notably, all the crosswalks in Arkhangelsk are marked with vertical traffic signs. They are also marked with stripes, but stripes are commonly obliterated during November–March (winter months) and are renewed in June–August. Therefore, stripes are absent on many crosswalks during winter and spring months. The studied changes in characteristics of crosswalks included installation of traffic signals, speed humps, and light-reflecting vertical traffic signs (with fluorescent yellow–green outer frames) at non-signalized crosswalks. The new traffic signals and speed humps were installed on the "black spotted" non-signalized crosswalks where there had been 3 or more traffic crashes of any kind within a year. Traffic signals were preferred to speed humps at spots where improvements in the traffic regulations were clearly required. Replacement of regular vertical signs "pedestrian crossing" by new light-reflecting signs began from non-signalized crosswalks in the central part of Arkhangelsk in 2010. For all described infrastructure measures, addresses (street, closest building) and dates (month, year) were obtained. Due to administrative reasons (change of the responsible institution and loss of data in 2008), the same data variables on establishment of new non-signalized crosswalks and changes in their total number were available only for 2009–2010. New non-signalized crosswalks were established on pedestrian crash "black spots," at places where crosswalks were requested by the public, as well as within the continuous process of road renovation. Other introduced infrastructure measures (pedestrian barriers on sidewalks, refugee islands) were not considered in the study because of small numbers.

The legislative measures were nationwide increases in monetary penalties for common pedestrian-crash-related traffic violations: (a) driver failure to give way to pedestrian on non-signalized crosswalk; (b) ignoring prohibiting traffic signal by driver or pedestrian; (c) crossing outside crosswalk and walking on road by pedestrian. For a penalty raise, date (day, month, year) and size ("from–to") in RUB was obtained.

The data on the total number of MVs and total population in the city were available for 1 January of every year, starting 2005 to 2011.

### Data analyses

For investigation of time trends of monthly crash data and their associations with safety measures, the total number of pedestrian crashes was split into 3 categories: (a) outside crosswalks; (b) on non-signalized crosswalks; and (c) on signalized crosswalks. For the first category, the pedestrian primary fault was presumed, although the police could also document a driver fault. For the second category, the driver primary fault was always documented by the police. The category of crashes on signalized crosswalks was further split into crashes due to pedestrian violations and crashes due to driver violations, according to police documentation. To be used as denominators in rate calculations, the mid-month estimates of total MVs and total population in the city were calculated from annual data with the assumption of linear monthly changes in these variables within each year. Consequently, crashes of each category were aggregated into monthly counts, and monthly rates per 10,000 MVs were estimated.

The data on registered traffic violations were split into data on violations by drivers, pedestrians, and others. The monthly numbers of driver violations were transformed into monthly rates per 100 MVs, giving estimates of monthly percentage of drivers caught by the police on violations. Similarly, the monthly counts of pedestrian violations were transformed into monthly rates per 100 population, giving estimates of monthly percentage of total residents caught on violations as pedestrians. The two resulting rates were used in the analyses as proxy measures for intensity of police enforcement regarding drivers and pedestrians.

The data on infrastructure measures were treated as count variables. A value in each of these variables was a total of specified infrastructure units in the city in the corresponding month. The legislative measures were analyzed as categorical "before–after" variables.

To allow for over-dispersion in the data, negative binomial and zero-inflated negative binomial (ZINB) regressions (22) with a time regressor variable were applied to estimate trends and average percent changes (APCs) in the monthly occurrence of pedestrian crashes, with 95% confidence intervals (CI). Similar analyses were performed to estimate APCs in monthly occurrences of pedestrian crashes per unit changes in the safety measure variables. A Vuong test was used to select between the standard negative binomial and the ZINB model for each particular situation. Robust standard errors were calculated for all estimates to adjust for heterogeneity in the models. To account for changes in the traffic volume, the logarithm of the mid-month total MVs was included in all regression models as an offset variable. Therefore, the APCs reflect changes in pedestrian crash rates per total MVs. The seasonal variation was modeled using sine and cosine functions with a periodicity of 12 months (23). Multivariable analyses of the associations between safety measures and crash occurrence were not applicable due to multicollinearity. Therefore, all the presented associations are unadjusted for each other (crude). All analyses were performed using STATA v.12.0 (24).

### Ethical considerations

This study was approved on 23 March 2009 by the Ethical Committee of the Northern State Medical University, Arkhangelsk, Russia. None of the data variables in the study contained information allowing personal identification.

## Results

In total, the police registered 2,565 pedestrian crashes in Arkhangelsk during 2005–2010. This resulted in 117 pedestrian fatalities and 2,556 non-fatal pedestrian injuries. In addition, 97 pedestrians were non-fatally injured due to other types of crashes, which have not been considered in this study.

Pedestrian crashes occurred most often in October–December (34%). Most crashes occurred on Fridays (17%) while the least occurred on Sundays (11%). Within a day, most crashes occurred between 3:00 pm and 6:00 pm (23%). Out of the total, 77 (3%) pedestrian crashes involved drunk drivers or drivers who refused alcohol testing, 222 (9%) involved drunk pedestrians, and 456 (18%) were "hit-and-run" cases.

### Changes in pedestrian crash rates

There were registered 1,597 (62% of the total) pedestrian crashes outside crosswalks, 766 (30%) on non-signalized crosswalks, and 202 (8%) on signalized crosswalks (including 132 due to driver violations and 70 due to pedestrian violations). During the study period, the rate of pedestrian crashes outside crosswalks decreased on average by 1.1% per month (95% CI, from −1.4 to −0.8; $p<0.001$) (Fig. 1). The rate of pedestrian crashes on signalized crosswalks decreased on average by 1.1% per month (95% CI, from −1.8 to −0.4; $p=0.002$). The rate of pedestrian crashes on non-signalized crosswalks remained unchanged (APC = −0.2, 95% CI, from −0.6 to 0.2; $p=0.414$).

### Infrastructure changes

At baseline, the total number of signalized crosswalks in Arkhangelsk was 237. Within the study period, traffic signals were installed at 32 non-signalized crosswalks (increase of 14%; Fig. 2). In 2009–2010, 50 new non-signalized crosswalks were established while three of the existing non-signalized crosswalks were equipped with signals (increase of 19%). All the changes in numbers

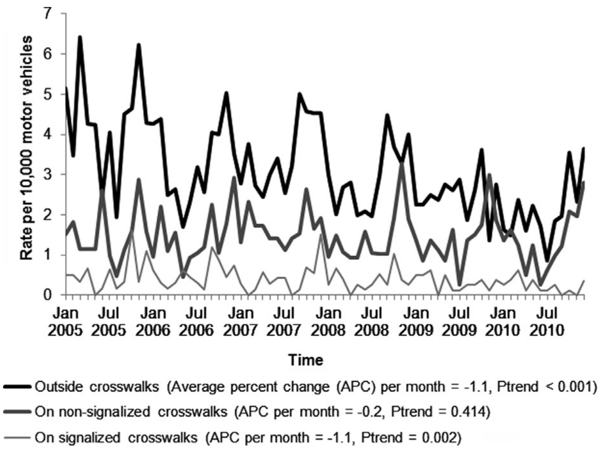


*Fig. 1.* Pedestrian–motor vehicle crashes by type in Arkhangelsk, Russia.

of crosswalks took place in periods from June to September.

There were no speed humps in Arkhangelsk at the baseline. During 2005–2010, 31 non-signalized crosswalks were equipped with speed humps, and one of them further changed into a signalized crosswalk, followed by removal of the earlier installed humps. Therefore, 30 (10%) non-signalized crosswalks in Arkhangelsk had speed humps at the end of the observation period. Thirty installations of speed humps occurred between May and September, and one in January. Twenty-six of the installed speed humps were monolith, seven of them de facto being elevated crosswalks. The rest had prefabricated demountable constructions.

Twelve non-signalized crosswalks were equipped with new light-reflecting signs instead of old ones in 2010 (4% of the total number). The replacements took place between February and July.

## Changes in road traffic legislation

Pedestrian penalties for traffic violations (ignoring prohibiting traffic signal, crossing outside crosswalk, and walking on the road) were hiked twice during the study period: (a) from 50 to 100 RUB on 7 July 2007 and (b) from 100 to 200 RUB on 23 May 2009. Driver penalty for ignoring prohibiting traffic signal increased from 100 to 700 RUB on 1 January 2008, and driver penalty for failure to give way to a pedestrian on non-signalized crosswalk increased from 100 to 800–1,000 RUB on 23 May 2009. Similarly, the average monetary penalties for these traffic violations increased in Arkhangelsk (Fig. 3).

## Traffic law enforcement

During the study period, the police registered 747,943 traffic violations. These included 659,476 (88%) violations by drivers, 85,625 (11%) by pedestrians, and 2,842 ( $<1\%$) by others (mainly administrative officials). Mean monthly rate of registered driver violations was 12.7 per 100 MVs, while the mean monthly rate of registered pedestrian violations was 0.3 per 100 residents. The rate of driver violations per 100 MVs decreased on average by 0.3% per month (95% CI, from $-0.4$ to $-0.3$; $p<0.001$) (Fig. 4). The rate of pedestrian violations per 100 population showed no change (APC $=0.1$, 95% CI, from $-0.2$ to 0.3; $p=0.648$) (Fig. 5).

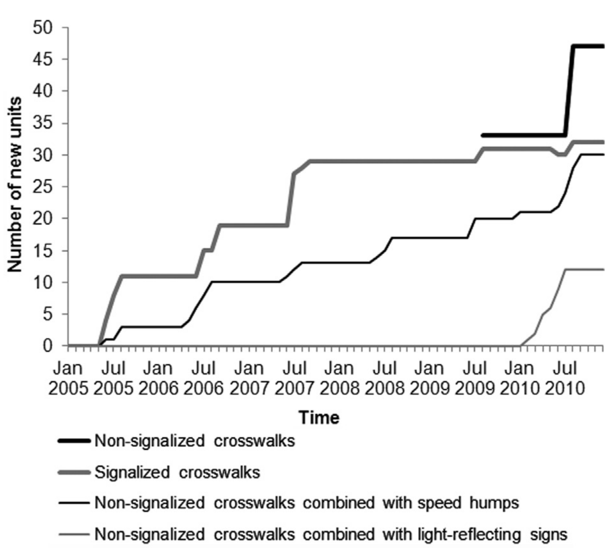


*Fig. 2.* Infrastructure–pedestrian safety measures in Arkhangelsk, Russia.

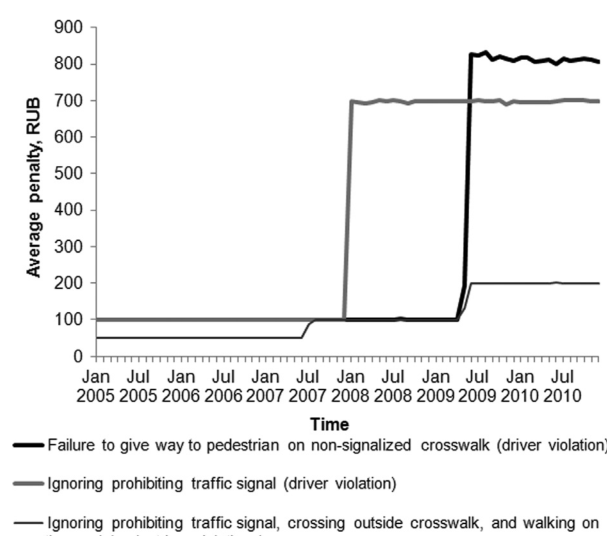


*Fig. 3.* Monetary penalties for traffic violations in Arkhangelsk, Russia.



Citation: Int J Circumpolar Health 2012, **71**: 19107 - http://dx.doi.org/10.3402/ijch.v71i0.19107

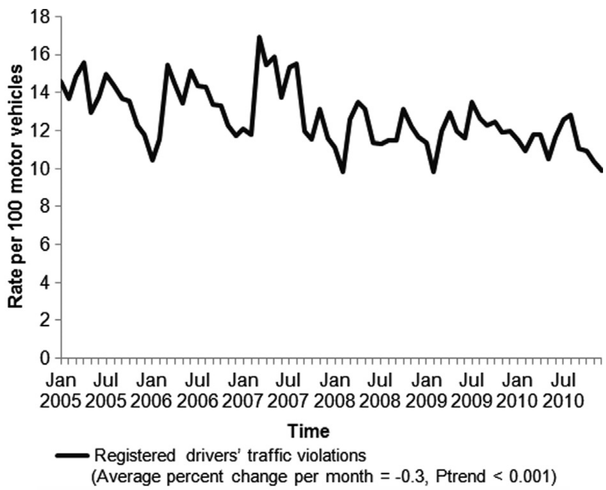


*Fig. 4.* Registered drivers' traffic violations in Arkhangelsk, Russia.

### *Associations of pedestrian safety measures with crash rates*

All infrastructure measures, with the exception of the introduction of new non-signalized crosswalks, and all legislative measures, showed significant inverse associations with the rate of pedestrian crashes outside crosswalks (Table I). The rate of pedestrian crashes outside crosswalks showed positive association with the rate of registered driver violations per 100 MVs (APC = 9.1, 95% CI, from 4.5 to 13.8; $p < 0.001$) and no association with the rate of registered pedestrian violations per 100 residents.

None of the studied pedestrian safety measures showed significant associations with the rate of pedestrian crashes on non-signalized crosswalks.

The monthly rate of pedestrian crashes on signalized crosswalks due to pedestrian violations showed a reduction along with the increase in pedestrian penalties for traffic violations. The reduction was more prominent (APC = −33.2, 95% CI, from −66.0 to −0.4; $p = 0.047$) after the first step of penalty increase. This rate also showed an average 2% reduction per one unit increase in total number of signalized crosswalks (95% CI, from −3.3 to −0.2; $p = 0.027$). The monthly rate of pedestrian crashes on signalized crosswalks due to driver violations showed an average reduction of 39% with a borderline significance (95% CI, from −79.3 to 1.8; $p = 0.061$) after the driver penalty for ignoring prohibiting traffic signal increased in January 2008. The rate of pedestrian violations per 100 residents and the rate of driver violations per 100 MVs showed no associations with related pedestrian crash rates on signalized crosswalks.

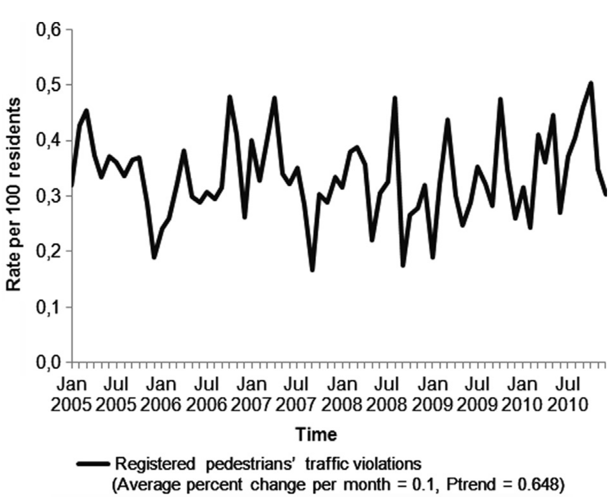


*Fig. 5.* Registered pedestrians' traffic violations in Arkhangelsk, Russia.

## Discussion

To our knowledge, this is the first study attempting to explain changes in rates of pedestrian crashes in the changing infrastructural and legal environment of a Russian city.

This study has explained the previously described overall reduction in pedestrian crashes (20) by a reduction in pedestrian crashes outside crosswalks and on signalized crosswalks. It has shown that the reductions in rates of these crashes were inversely associated with the implementation of a set of infrastructure and legislative pedestrian safety measures during 2005–2010.

The intensity of law enforcement on drivers decreased during the study period but was stable with regard to pedestrians. The reduction with regard to drivers may be explained by the absence of changes in the number and daily workload of the city police staff despite the increasing number of MVs. Unexpectedly, the proxy measures for the intensity of police enforcement showed significant and non-significant, but always positive, associations with the rates of pedestrian crashes of different types. According to the police, this can be explained by increases of the enforcement activities in the months with higher frequency of traffic crashes. Therefore, the causal association may be reverse: the crash rate may affect the intensity of law enforcement, and not vice versa. Nevertheless, the observed long-term reduction in the intensity of police law enforcement cannot be an explanation of the reduction in pedestrian crashes.

Three out of the total seven studied infrastructure and legislative measures targeted enhanced safety on non-signalized crosswalks: installation of speed humps, light-reflecting traffic signs, and an increase in driver penalty for failure to give way to a pedestrian on a non-signalized crosswalk. Similar measures were shown to be effective internationally (7–10, 14–16). Paradoxically, in our study they were not associated with pedestrian crashes on non-signalized crosswalks. At the same time, these 3 and the

*Table I.* Crude[a] estimates of average percent changes (APCs) in monthly rates[b] of pedestrian–motor vehicle crashes per one unit changes in pedestrian safety measures (Arkhangelsk, Russia, 2005–2010)

| | Pedestrian–motor vehicle crash types | | | |
|---|---|---|---|---|
| | | | On signalized crosswalks | |
| | Outside crosswalks, pedestrian primary fault presumed (n = 1,597) | On non-signalized crosswalks, driver primary fault presumed (n = 766) | Pedestrian fault documented (n = 132) | Driver fault documented (n = 70) |
| | APC (95% CI) | APC (95% CI) | APC (95% CI) | APC (95% CI) |
| Infrastructure measures (count variables) | | | | |
| Signalized crosswalks, total number | −2.1 (−2.7, −1.4) | n.a. | −1.8 (−3.3, −0.2) | −0.8 (−2.7, 1.1) |
| Non-signalized crosswalks, total number[c] | −0.6 (−1.3, 0.0) | 0.2 (−1.0, 1.4) | n.a. | n.a. |
| Number of non-signalized crosswalks with speed humps | −2.7 (−3.6, −1.9) | −0.4 (−1.5, 0.7) | n.a. | n.a. |
| Number of non-signalized crosswalks with light-reflecting vertical signs | −3.8 (−5.9, −1.6) | −0.9 (−3.3, 1.5) | n.a. | n.a. |
| Legislative measures (event variables) | | | | |
| Pedestrian penalty for a traffic violation raised | | | | |
| from 50 to 100 RUB in July 2007[d] | −21.1 (−33.7, −8.4) | −8.5 (−27.0, 10.0) | −33.2 (−66.0, −0.4) | n.a. |
| from 100 to 200 RUB in May 2009[e] | −31.1 (−47.4, −14.7) | −1.9 (−21.1, 17.3) | −21.1 (−55.6, 13.5) | n.a. |
| Driver penalty for ignoring prohibiting signal raised from 100 to 700 RUB in January 2008 | −39.6 (−52.0, −27.3) | n.a. | n.a. | −38.8 (−79.3, 1.8) |
| Driver penalty for failure to give way to pedestrian at non-signalized crosswalk raised from 100 to 800–1,000 RUB in May 2009 | −41.2 (−56.8, −25.6) | −7.1 (−25.7, 11.4) | n.a. | n.a. |
| Police law enforcement (rate variables) | | | | |
| Registered driver violations per 100 MVs | 9.1 (4.5, 13.8) | 3.2 (−1.6, 8.0) | n.a. | 7.1 (−4.0, 18.1) |
| Registered pedestrian violations per 100 population | 22.4 (−85.5, 130.5) | n.a. | 91.4 (−83.0, 265.8) | n.a. |

n.a.: not applicable.
[a]Unadjusted for each other.
[b]Rates are calculated per total number of registered motor vehicles.
[c]APCs estimated using data for January 2009–December 2010.
[d]APCs estimated using data for January 2005–April 2009.
[e]APCs estimated using data for July 2007–December 2010.

other 4 measures were strongly associated with pedestrian crashes outside crosswalks.

To solve this puzzle, one has to take into consideration the purposes of the set of introduced measures. Two of the measures aimed at preventing pedestrians from crossing roads in improper places and on prohibiting signals. They were: (a) the establishment of new crosswalks and (b) the increase in pedestrian penalties for traffic violations. Other measures promoted pedestrian priority on crosswalks: increases in driver penalties for not giving way to pedestrians on signalized and non-signalized crosswalks. Finally, a set of measures aimed at promoting pedestrian safety as well as their feeling of safety on crosswalks: installation of signals, speed humps, and light-reflecting vertical signs. The combination of these measures may have created a “carrot and stick effect,” both motivating and coercing pedestrians to use crosswalks. Therefore, a putative migration of pedestrians from outside crosswalks to crosswalks may have increased exposure at the latter. This inference is largely supported by the data: the numbers of crashes outside crosswalks decreased. It also explains the confusing absence of any associations of the safety measures installed at the non-signalized crosswalks with the related crash rate. These associations may be masked by the increase in number of crosswalks and the in-migrating pedestrian exposure. By the same reason, the observed associations between the safety measures targeting signalized crosswalks and crash rates on these crosswalks may be underestimated.

The phenomenon – a ''masked (or migrating) effect'' of measures to improve safety on crosswalks – may be observed in other circumstances. For example, Norway ranks second lowest in Europe on pedestrian fatality rate (6.7 per 100,000 population) and has the lowest rate of pedestrian fatalities outside crosswalks out of total pedestrian fatalities (45%), but the proportion of pedestrian fatalities on crosswalks is the highest (55%) (25). This explanation may be similar to our inferences: with high road infrastructure standards, high density of crosswalks, and pedestrian trust in and obedience to traffic rules, the crosswalks become the most likely places for rare pedestrian crashes to occur. An alternative explanation regarding both our study and the situation in Norway is that granting high priority to pedestrians on crosswalks may result in a false feeling of full safety there. This may provoke pedestrian carelessness of the danger of not being noticed by a driver, resulting in increased likelihood of a pedestrian crash at a crosswalk (7).

### Limitations

Absence of data on volume of pedestrian exposure in the city and its changes during the period is the major weakness of this study. For instance, one can argue that a reduction in pedestrian crashes can be explained by a decreasing number of pedestrians along with an increasing number of MVs and a relatively stable total population (26). However, this cannot bias our results substantially as is clear from simple calculations: (a) knowing the total population and the total MVs on the starting point of the study (approx. 60,000 and 358,000, respectively) and assuming that each MV carries on average 2 persons at a time, one can expect that the number of pedestrian residents could be up to 238,000; (b) the same estimate of the maximum number of pedestrian residents at the end of the period (ca. 356,000 population and 82,000 MVs) would be 192,000; (c) therefore, the rough estimate of the reduction in maximum pedestrian exposure is 20%, whereas the rates of pedestrian crashes outside crosswalks and on signalized crosswalks more than halved.

Consequently, the absence of data on changes in the distribution of pedestrian exposure leaves our conjectures about migration of pedestrian crash risks from outside crosswalks to crosswalks only partly confirmed by logical derivations from the observed crash trends but not by factual data on pedestrian behavior. Therefore, our guidance for further studies on pedestrian safety is that the data on volume and distribution of pedestrian exposure has to be collected for accurate assessment of risks and evaluation of interventions.

Lack of confounding control is another possible threat to the validity of the study. At least to some degree, the detected associations may be explained by the effects of a number of factors that may have been changing in the study period in line with implementation of the investigated pedestrian safety measures. These include: (a) an increase in general public awareness of the pedestrian safety due to ongoing educational and mass media campaigns; (b) an overall toughening of the traffic-related legislation; and (c) a reduction in the speed of motor transport due to increased traffic volume on the unchanged total length of municipal road networks. Control of some of these confounders was not performed because it was not possible to measure them, particularly in the retrospective. Moreover, control for these factors was likely to be impossible due to their potential collinearity in time with the investigated factors just in the same way as adjustment of the associations of investigated factors for each other was not possible due to the multicollinearity problem.

## Conclusion

Reduction of pedestrian crash rates in Arkhangelsk in 2005–2010 was associated with an increase of infrastructural interventions and legislative safety measures. The overall reduction in pedestrian crashes was due to a reduction in rates of crashes outside crosswalks and on signalized crosswalks. No change in the rate of crashes on non-signalized crosswalks was observed in spite of the measures to improve their safety. This may be due to an increase in their number and in-migration of pedestrian exposure from outside crosswalks.

## Acknowledgements

We thank SpareBank1 Nord-Norge and Department of Community Medicine, University of Tromsø, for financial support of the study. We also thank Alexey Maximov, Andrei Stolyarov, Marina Ermolina, Alexey Kuznetsov, and other officers of the Arkhangelsk road police for their help in data management and interpretation of the results.

## Conflict of interest and funding

The authors have not received any funding or benefits from industry or elsewhere to conduct this study, except for what is mentioned in the Acknowledgements. The authors declare no conflicts of interest.

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