Developing the Safer Road Investment Plan – Examples from selected Slavonian counties in Croatia

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Abstract

This paper presents the results of the detailed road safety assessments conducted according to the iRAP Star Rating methodology, on the primary rural road network consisting of 40 road sections, 753 kilometres in length, present in two Slavonian counties within Republic of Croatia. The results of this assessments are used to select and prioritise the most cost-effective road countermeasures that are both economically feasible and have significant potential for preventing the fatal and serious injury road traffic accidents on rural roads in the period of next 20 years. In this paper, the authors present and discuss the results obtained based on the performed road safety assessments and developed Safer Road Investment Plan (SRIP) for primary rural network in selected Slavonian counties and give conclusions and specific guidance relevant for road safety professionals and other stakeholders involved in planning, designing, and maintaining different categories of rural roads.

Keywords

Road safety assessment; rural roads; road crash analysis; road design characteristics; road countermeasures prioritisation.

Introduction

The results of numerous road safety analysis performed in various countries over the world indicate that although rural roads have low traffic volumes, they account for most of the road related deaths and serious injuries (Howard and Mclnerney, 2010; Gaca and Kiec, 2016; Yasanthi et al., 2021; Cavanagh and Sinclair, 2021; Khedher and Yun, 2022; Das et al., 2022). One of the main reasons behind higher number of road crashes with fatal and serious injury outcomes on rural roads are higher operating speeds of vehicles in traffic stream and the presence of various hazardous roadside objects along rural roads. Rural roads are also characterised by large variations in relevant road design elements due to which drivers need constantly to adapt the speed of their vehicles in order to maintain safe driving in various traffic circumstances. The road crashes that occur in rural areas are typically scattered over the network, so in order to get better understanding of the causation factors that have the most significant impacts on the probability of road traffic accident occurrence and its severity on rural roads, it is necessary to perform a correlation analysis between relevant traffic stream, road design, road environment and road crash characteristics.

In the scope of this paper, the results of detailed road safety assessments conducted according to the iRAP Star Rating methodology, on the primary rural road network consisting of 40 road sections, 753 kilometres in length, present in two Slavonian counties within Republic of Croatia are presented (Ševrović et al., 2021). In the scope of performed road safety assessments, a detailed correlation analysis was performed between existing road design, traffic stream and road environment features and relevant characteristics related to road crashes that have occurred on the assessed rural road network in the period between years 2015 and 2019. Based on the performed analysis, the most cost-

effective road countermeasures for preventing the fatal and serious injury road traffic accidents on observed rural roads in the period of next 20 years have been proposed.

Methodology of research

Road safety assessments of primary rural road network present in two Slavonian counties within Republic of Croatia were conducted according to the iRAP Star Rating protocol, throughout following methodological steps:

1. Conducting video inspections of observed road network;
2. Uploading the road network geometry data and georeferenced video files into webGIS system
3. Coding the road attributes related to relevant road infrastructure, road environment and traffic flow characteristics for 10-meter road segments of observed roads, performed in accredited coding tool application.
4. Data conversion process in PreProcessor Tool, based on which 10-meter road segments were converted into 100-meter segments, compatible for upload in iRAP ViDA software
5. Crash data analysis
6. Statistical analysis of Star Rating Results
7. Development of Safer Road Investment Plan (SRIP) for the observed road network

Road Survey

Road surveys were conducted in April and May 2021, according to iRAP standards (iRAP, 2021a) by accredited survey vehicle (iRAP, 2022a) equipped with inspection cameras and high-precision satellite positioning devices. The survey vehicle has recorded the videos at speeds up to the 110 km/h, in single front/back camera mode, with resolution of 1920x1080 at 30fps. The video surveys were georeferenced using a satellite positioning devices of SPS accuracy. Georeferencing interval was 10 Hz, interval length varying regarding to vehicle speed, between 0,04m at 5km/h and 1,2m at the speed of 110 km/h respective to position accuracy. It was ensured that georeferencing of video frames is frame accurate, and that the positioning accuracy exceeds less than 10m accuracy requirement in more than 90% of the time.

Data coding

In the first phase of the data coding process, road network data, containing the road centerlines of all observed road sections and georeferenced video files, recorded during road survey were imported together in iRAP accredited FPZ webGIS system prior to creating coding projects. Each road centerline was then segmented on 10-meter road segments and linked with the corresponding video files. Individual coding projects were than created and prepared for the coding process. The coding was done through the FPZ Coding Tool application on 10-meter road segments, by clicking on the appropriate attribute icons on the toolbars. Coding Tool application allows entering about 160 different attributes about the geometric, constructional, and technical characteristics of the road network and the existing characteristics and structure of traffic flow, specified according to the iRAP methodology (iRAP, 2022b). Upon finalisation of coding process, the coding data was converted into 100-meter segments and uploaded into iRAP ViDA software (iRAP, 2021b) for further statistical analysis.

Crash Data Analysis

Crash data analysis was performed based on the available data on the total number of road traffic accidents that have occurred on the observed roads within Vukovar-Srijem and Osijek-Baranja counties in the period between years 2015 and 2019, and data on the number of fatalities and serious injuries related to these accidents. Relevant crash data was gathered from the Ministry of Interior official road

crash database and published Road Safety Bulletins in the period between years 2015 and 2019. Gathered crash data was filtered, processed and analyzed in JMP 11 statistical software.

Star Rating Process

The Star Rating system (iRAP 2021c) uses the typical international practice of recognizing the best performing category as 5-star and the worst as 1-star (5 stars scale), so that a 5-star road means that the probability of a crash occurrence, which may lead to death or serious injury, is very low. The final output of the Star Rating process are the Star Rating Maps, in which the "n" road sections are shown with different colour, depending on their Star award. Based on the coded and supporting data, the ViDA online software was used to produce Star Rating of the observed road network. The star rating is based on individual relative risk for four user groups, including vehicle occupants, passengers, motorcyclists and bicyclists.

Safer Road Investment Plan (SRIP)

One of the basic outputs of the iRAP Star Rating methodology is the Safer Roads Investment Plan (SRIP) that considers more than 90 proven road improvement options to generate affordable and economically sound road improvements that will save lives (iRAP 2021c; iRAP 2022c). These road improvement options range from low-cost countermeasures such as improved road markings and pedestrian crossings to high-cost countermeasures such as intersection upgrades and road duplication. The SRIP table shows the list of the most cost-effective improvements that can reduce the crash risk for all road user types.

Discussion of the results

Based on the statistical analysis of the coded data it was determined that 63% of the observed road network is in rural/open area and the remaining 37 percent in the urban environment. Almost all (95%) of observed roads are single carriageways, with one traffic lane per direction. Opposite traffic flows on these roads are mainly separated only by centerline. Remaining 5% of roads are undivided roads with two traffic lanes in each direction of travel. Close to two-thirds (64%) of the observed roads have speed limit of 80 km/h or more, around 22% of roads have speed limit of 50 km/h, while the remaining roads have speed limits of 30 or 40 km/h. Most of the observed roads (82%) consist of straight and gently curving sections. Moderate, sharp and very sharp curves are recorded on the remaining 18% of the observed road segments.

Results of the conducted crash data analysis show that during the observed time period, a total of 202 fatal road crashes, 1.184 serious injury crashes, 4.179 slight injury crashes and 10.726 road crashes with material damage only have occurred on roads present within Vukovar-Srijem and Osijek-Baranja counties. Distribution of road crashes by type shows that the most common types of road traffic accidents include a run-of road crashes (26.3% of road crashes), rear-end collisions (15.7%), side collisions (15.5%) and head-on collisions (13.33%). The primary causes of this crashes include inappropriate speeding (30.1% of road crashes), illegal vehicle movements on roadway (14.7%), not obeying the right of way (10.9%), illegal overtaking (6.2%) and by driving at insufficient distance (6%).

The percentage of high risk (1-star) road sections in the vehicle occupants' category is 42.02%, and there is also similar proportion (41.70%) of roads rated with 2-stars. On the other hand, there are only 15% of 3-star road segments, while remaining 1.21% of road segments are rated with 4-stars. The rating for motorcyclists is even worse, with more than half of the road network length (55.77%) belonging to the 1-star high-risk category and 38.60% of road segments rated with 2-stars, while only 5.63% of road segments have been awarded with 3-stars. It was also determined that the rated road sections for the vulnerable road users were awarded with poor rating on significant percentage of observed road network. For pedestrians 61.90% of roads were rated with 1-star, 19.67% of road

segments with 2-stars and only 18.42% with 3-stars or more. In the bicyclists' category, the percentage of 1-star and 2-star roads is 35.76% and 47.70%, respectively. Most of the remaining road segments (13.59%) are rated with 3-stars for bicyclists, while only 2.95% of road segments have been awarded with 4-stars or more.

High levels of risk on the observed roads are primarily a result of the large number hazardous locations which significantly increase the possibility of fatal and serious injury crashes. Deep drainage ditches, signs, posts or poles and trees wider than 10 cm in diameter, high embankment slopes and unprotected road safety barrier ends alongside the road are identified as main types of dangerous objects which contribute to overall high risk rate. Based on the detailed analysis of relative contributions of different types of crash risks on the resulting Star Rating Scores, produced for individual 100-meter road segments it was found that on the most of observed road segments, drivers are primarily exposed to the risk of running-of the road, head-on collisions and side collisions at intersections.

According to the developed Safer Road Investment Plan (SRIP), a total of 236 road fatalities and serious injuries can be prevented on the observed road network over next 20 years, if all proposed countermeasures are implemented. The cost of these countermeasures adds up to approx. 9,992,939 €. The cost of each countermeasure was compared to the value of life and serious injuries that could be saved, and the Benefit to Cost Ratio (BCR) was calculated for each countermeasure proposed. The minimum BCR value for the countermeasures to be included on the final list of SRIP plan was set to 3. The total program BCR of the entire investment plan is 5. Predominant proposed countermeasures that are expected to produce the maximum effect are: Implementation of central hatching (painted medians), implementing or upgrading the roadside barriers, clearing roadside hazards, sideslope improvements and shoulder sealing on both sides of the road, implementation of traffic calming measures and facilitation of shoulder rumble strips.

Based on the estimated Star Rating Scores that can be achieved if all proposed countermeasures are implemented, it can be concluded that the proposed SRIP plan would most significantly improve the safety for vehicle occupants and motorcyclists. For vehicle occupants, the number of 1-Star (very high-risk) roads would be reduced by 21.57% (from 42.92% to 21.35%), while the number of 2-Star roads would be increased by 7.85% (from 41.70% to 49.55%), respectively. On the other hand, the percentage of road network sections awarded with 3-star and 4-stars would be increased to 26.82% and 2.28%, respectively. Relatively significant improvements can also be achieved in motorcyclists safety. If all proposed countermeasures are implemented, the percentage of road network sections rated with 2-stars and 3-stars for motorcyclist would be increased by 13.68% and 6.56%, respectively, while the percentage of road network sections allocated into high (1-star) risk category would be reduced by 20.4%. Road safety improvements that can be achieved for pedestrians and bicyclists are much lower. However, this can be explained by the fact that SRIP plan does not include countermeasures that specifically target non-motorised road users, since they were considered as ineffective in rural areas with almost no pedestrians and bicyclists.

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