Method for Assessing Risk of Road Accidents in Transportation of School Children

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Abstract. The rationale behind the problem being investigated is explained by the remaining high level of the accident rates with the participation of vehicles carrying groups of children, including school buses, in the Russian Federation over the period of several years. The article is aimed at the identification of new approaches to improve the safety of transportation of schoolchildren in accordance with the Concept of children transportation by buses and the plan for its implementation. The leading approach to solve the problem under consideration is the prediction of accidents in the schoolchildren transportation. The article presents the results of the accident rate analysis with the participation of school buses in the Russian Federation for five years. Besides, a system to monitor the transportation of schoolchildren is proposed; the system will allow analyzing and forecasting traffic accidents which involve buses carrying groups of children, including school buses. In addition, the article presents a methodology for assessing the risk of road accidents during the transportation of schoolchildren.

1. Introduction

In 2006-2008 years there was launched a program of school buses purchasing for rural educational institutions within the framework of "Education" national priority project. Its purpose was to provide Russian students with guaranteed free transportation to the place of training and return back home. All supplied school buses has been transferred into ownership of the constituent of the Russian Federation, which independently distribute them among the educational institutions [1].

Undoubtedly, this made it possible to make education more accessible for many categories of citizens. But the transfer of buses to general education institutions assigned almost the whole process of organizing and ensuring the safety of transportation to them. At the same time, most of the functions assigned general education institutions cannot realize due to the lack of an industrial and technical base, professional staff and sufficient funding. In this regard, most of the tasks are solved by the teaching staff, which entails a number of problems the consequences of which are as follows [2]:

- numerous violations of transport legislation in the transportation of schoolchildren;
- high accident rates with the participation of school buses.
2. The problem of schoolchildren safety transportation in the Russian Federation

Over the period of five years, starting from 2012 to 2016 years, 68 road accidents involving school buses had occurred in our country (Figure 1) [3-6].

![Figure 1. School buses accident rate for 2012-2016 years.](image)

As the diagram shows, the number of schoolchildren affected in road accidents declines annually. It has decreased more than threefold in these five years. At the same time, the number of road accidents, including those caused by drivers of school buses, almost does not change.

Accident analysis showed that 37% of the whole 68 accidents that occurred over the five years were caused by school bus drivers, because of a malfunction of vehicles or violation of rules for the organized children groups bus transportation. Bus drivers made two runs on schoolchildren pedestrians. In addition, the cases of driving a school bus under the alcohol intoxication were revealed.

School buses carry children to the places of study and back home. If it is necessary to transport children on long-distance routes, for example, to sports or entertainment events, transportations are arranged using the buses of passenger motor transport enterprises. In this regard, we conduct the analysis of accidents, which involve buses transporting the groups of children (Figure 2) [3-6].

![Figure 2. Indicators of accident rate for the buses transporting groups of children from 2012 to 2016 years.](image)

As can be seen from the diagram, every year dozens of children are injured in road accidents, being passengers of buses. All indicators significantly increased in 2016 year compared to 2015: the number of accidents increased by 70 percent, the number of dead children increased by 357 percent, the number of injured children increased by 105 percent.
A number of Russian researchers’ investigations are devoted to the problems in the field of arrangement and safety transportation of schoolchildren.

Based on the analysis of domestic schoolchildren transportation system the team of authors [7] concludes that it does not exist as such. The authors draw attention to the fact that there is still no concept of "school transportation" approved at the legislative level in Russia. The other works of these researchers [8, 9] discuss the problems associated with the safety of student transportation, as well as organizational, technological and economic problems in addition to legislative questions.

Considering the conditions of student transportation in the Russian Federation, Pashutina N A [10, 11] highlights the design features of vehicles for student transportation and the state of the bus fleet. Special attention is paid to the statutory regulation of activities in the field of school transportation.

Rather detailed analysis of the existing problems in the field of rural school transportation is given in the work of Anokhin S A [12]. The author draws attention to the lack of material and technical base for carrying out maintenance and repair of buses, as well as long time spent travelling by bus after school.

The authoring team [13, 14] envisages an increase of schoolchildren safety transportation as one of the directions for reducing child road traffic injuries.

The presented analyses of the accident rate with the participation of school buses and the regarding scientific works allow talking about the rationale of the schoolchildren safety transportation issue.

3. Monitoring and risk assessment of road accidents in the transportation of schoolchildren

The Concept for the organization of children group transportation by buses and its Implementation Plan [15] adopted in 2016 are aimed at solving some of the existing problems in the field of school transportation safety. As one of the priority measures aimed at improving the activity of transporting organized groups of children by buses, the Concept provides the continuous monitoring of traffic conditions along the bus routes, while transporting the organized children groups, including school transportation. One of three activities of the Concept Implementation Plan is the arrangement and conduction of monitoring the organized transporting of children groups by buses, including school buses, using GLONASS information and navigation system in the regions of the Russian Federation.

In this regard, it is proposed to develop and implement an integrated system of monitoring the safety of schoolchildren transportation and road accident risk at the regional level.

Analytics platform, holding the analysis of input data, occupies the central place in the monitoring system. The core of this platform is a database that acts as a storage and source of information for processing and presenting information to users.

The information is feasible to be arranged in three blocks of indicators in schoolchildren transportation monitoring system (Figure 3).

![Figure 3. Input data in monitoring system.](image-url)
Based on the information collected, the monitoring system will allow performing not only standard procedures for comparing, processing and analyzing information, but also conducting complex special calculations of analytical and prognostic nature.

The safety of pupil transportation depends on all the components of the "driver-vehicle-road-environment" system, as well as their interaction [16-18]. The proposed method allows assessing the risk of road accidents in three components of the system: the driver, the bus and the road. Environmental conditions are not taken into account in this case.

To identify dangerous sections of highways we propose to use the method of analyzing the frequency of road accidents and the method of accident rates in analytics system.

To estimate the probability of a traffic accident during transportation of schoolchildren, the following procedure has been developed. The probability of possible traffic accident is estimated for each bus involved in the transportation of students and belonging to the educational institution.

Relative frequency $\alpha_1$ of traffic accidents involving buses, where drivers has the same age $x_1$ and driving experience $x_2$, as the driver of the estimated bus; and the relative frequency $\alpha_2$ of the traffic accidents involving buses, which age $x_3$ is the same as the age of estimated bus; the values are determined by the formulas (1) and (2):

$$\alpha_1 = \frac{S_{x_1x_2}}{S_a} \quad (1)$$

$$\alpha_2 = \frac{S_{x_1x_2}}{S_a} \quad (2)$$

where $S_{x_1x_2}$ is a quantity of traffic accidents involving the buses with the drivers of age $x_1$ and driving experience $x_2$; $S_a$ is a total amount of bus traffic accidents for the investigated period; $S_{x_1x_2}$ is a quantity of traffic accidents involving buses aged $x_2$.

Relative frequency of road accidents for the buses with the vehicle age and driver characteristics same as for the estimated bus, is determined by the formula (3):

$$y^* = \alpha_1 \cdot \alpha_2 \quad (3)$$

Analytics system calculates final accident rate for each regional road, based on the partial accident rates, which are determined in accordance with the Recommendations on road safety [19]. Total accident rate is calculated for the road sections, where children are transported, and a segment of final accident rate values $[b_1;b_2]$ is determined for the road sections of the given bus.

Relative frequency of road accidents on the road sections with such total accident rates is determined by the formula (4):

$$\beta = \frac{S_r}{S_t} \quad (4)$$

where $\beta$ is a relative frequency of traffic accidents on the road sections with final accident rate value $[b_1;b_2]$; $S_r$ is a quantity of traffic accidents on these sections; $S_t$ is a total amount of the traffic accidents for the investigated period.

Relative frequency of traffic accidents for a given bus, calculated according to formula (3), is adjusted with regard to the road conditions of the school transportation route and is determined by the formula (5):

$$p = y^* \cdot \beta \quad (5)$$
Using this technique, you can assess the probability of a traffic accident involving a vehicle transporting the students. If the probability of an accident is greater than 0.2, preventive measures should be taken.

4. Conclusion

Increasing the safety of school transportation is one of the directions for reducing child road traffic injuries. Whereas, the reducing the traffic accidents with children ranks among the tasks of the Federal Target Program "Improving road safety in 2013-2020" [20]. Thus, the authors' studies are aimed at solving national challenges of the Russian Federation.

The method proposed in the article corresponds to the Implementation Plan of the Concept for the Arrangement of Children Group Transportation by Buses and can be used to forecast and prevent road accidents in the transportation of schoolchildren in the regions of the Russian Federation.

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