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ANALYSIS AND COMPARATION OF EMERGENCIES IN THE ZLIN REGION

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Abstract

Every day, people are surrounded by emergencies that affect not only their health, lives, and property but also the environment. These events are a manifestation of the harmful effects of forces and phenomena, either on the environment or on the human activity itself. To improve the preparation not only of crisis management bodies and the protection of the population but also of the general public, it is necessary to carry out more detailed analyzes of threats and the impact of individual risks. The work aims to analyze emergencies in the selected local government and use methods of comparition, analysis, modeling, and qualitative risk analysis using their correlation to point out the most dangerous types of events and propose measures to reduce their impact.

Keywords: Analysis; Comparition; Emergencies; Zlin.

1. Introduction

Emergencies are events that threaten the health and lives of persons, property, animals, and the environment. Šin et al. 2017 divide emergencies into two categories:

- natural emergencies,
- anthropogenic emergencies.

These main categories are further divided into subcategories. Natural emergencies include:

- abiotic emergencies (origin in non-living nature),
- biotic emergencies (origin in living nature).

Anthropogenic emergencies include:

- man-made emergencies (originating in operational accidents and accidents connected with infrastructure),
- internal sociogenic emergencies (origin of national social, social, economic crisis),
- external sociogenic emergencies (origin of a military crisis),
- agrogenic emergencies (origin associated with agriculture and soil). [1]

The term emergency is also closely related to the term danger. Haddow, Bullock, and Coppola, 2020 define a hazard as “a resource that may or may not lead to an emergency or disaster. It is an event or physical condition that has the potential to cause death, injury, damage to property, infrastructure, and more.” [2]

The issue of emergencies is dealt for example in the article "The Comparative Analysis of Safety in the Czech Republic and in Abroad" by Vichova, K. et al., where the dangers for the Czech Republic are compared. In the article "Preparedness in Crisis Management", the authors Brumova, L. et al deal with the general concept of security in the Czech Republic and collect conceptual and strategic materials. The most basic material includes the Threat Analysis for the Czech Republic from 2015. This document analyzes the most serious threats to the Czech Republic and the result is the identification of 22 types of dangers with unacceptable risks. [3], [4], [5]

The biggest issue that all these articles deal with is the devastating effects of these events. It is necessary to deepen knowledge not only among the authorities of crisis management and population protection but also among the general public.

This work aims to point out the number of emergencies in the Zlin region when the municipality with the extended scope of Uherske Hradiste was chosen as an experimental model. To emphasize the importance, a qualitative risk analysis was created using their correlation, which points to the most serious risks.

2. Materials and methods

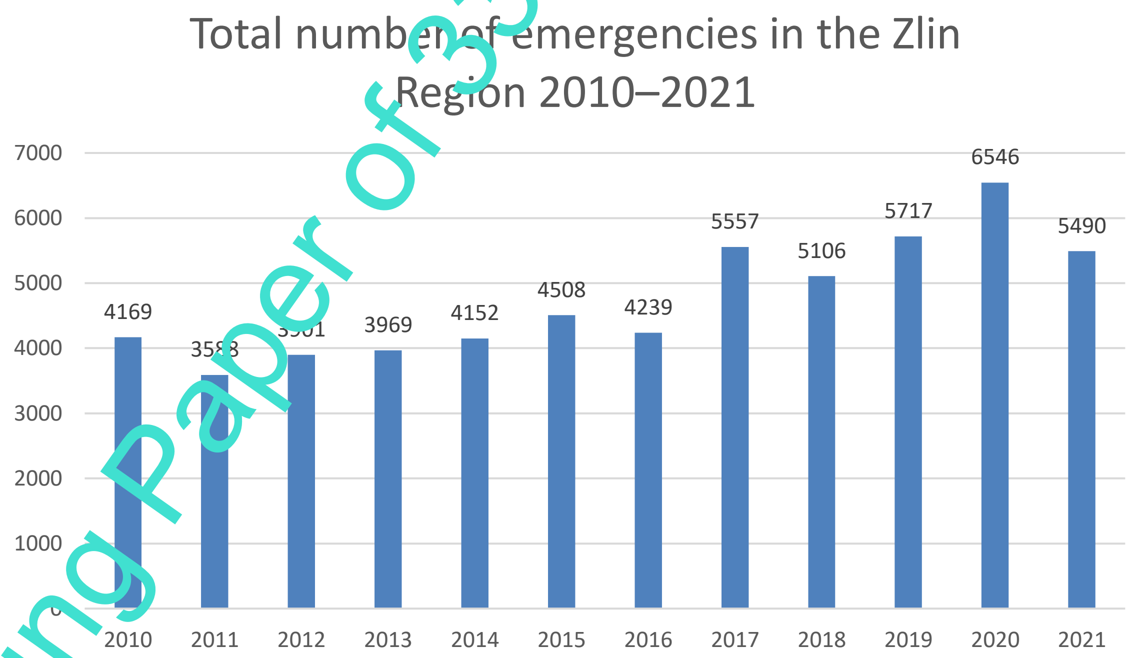
A total of four methods are used in this work. The first of them is the method of explanation, which is used to describe the theoretical basis of the work. Another method is the method of comparison, which is used to assess emergencies in the territory of the Zlin Region and the municipality with the extended jurisdiction of Uherske Hradiste. The third method is the modeling method, which is used to create map outputs in the QGIS software, thanks to which the dislocation of municipalities with extended jurisdiction in the Zlin Region is shown. Last but not least, the method of qualitative analysis of risks using their correlation is used for the evaluation and assessment of emergencies and the resulting graph of correlation.

The main goal of the work is the analysis of emergencies that were recorded in the Zlin Region in the Czech Republic and a closer analysis of the municipality with the extended scope of Uherske Hradiste, which falls into this region.

The Zlin region is located in the eastern part of the Czech Republic on the border with the Slovak Republic and covers an area of 3,964 km2. The total number of inhabitants is reported to be around 587,000 and it is divided into a total of thirteen administrative districts with extended jurisdiction. [6]

Fig. 1. Dislocation of municipalities with extended jurisdiction in the Zlin region

Statistical yearbooks of the Fire Rescue Service of the Czech Republic were used for the analysis of emergencies in this region, with the help of which the resulting event values were calculated. These calculations showed that a total of 56,942 emergencies occurred in the Zlin region from the period 2010–2021. In graph number 1, you can see the number of emergencies for individual years. [7]



Graph 1. Total number of emergencies in the Zlin Region 2010–2021

For a more detailed analysis, individual types of emergencies were selected and their total numbers in the region were calculated.

Between 2010 and 2021, a total of 56,942 emergencies were recorded in the Zlin Region. These events were divided into the following categories:

- Fires,
- Traffic accidents,
- Leakage of dangerous substances,
- Technical crashes,
- Radiation accident,
- Other emergencies,
- False alarms.

Graph number 1 shows the total number of emergencies in the Zlin Region for the period 2010–2021, and for comparition, the number of emergencies in the municipality with the extended scope of Uherske Hradiste, which was chosen for further analysis as a simplified model, is indicated. Individual emergencies are categorized according to the standards of the Fire and Rescue Service of the Czech Republic, just as they are listed in the statistical yearbooks. [7]

	Zlin region	The municipality with extended scope of UH
Emergencies	The number of emergencies	The number of emergencies
Fires	8 234	1 150
Traffic accidents	10 477	1 646
Leakage of dangerous substances	2 688	343
Technical accidents	33 446	6 613
Radiation accidents	2	0
Other emergencies	693	16
False alarms	4 134	706
Total amount	59 674	10 474

Table 1. Comparition of the number of emergencies between the Zlin region and the municipality with the extended jurisdiction of Uherske Hradiste

3. Results

To determine the most dangerous emergency events in the municipality with the extended jurisdiction of Uherske Hradiste, a qualitative risk analysis will be used using their correlation. The method is based on comparing individual events, where the values 0 and 1 are assigned according to the possibility of triggering another event or not.

Based on the comparition of the number of emergencies, the emergencies were further included in the qualitative risk analysis using their correlation. In the first step, table number 2 was created, the so-called risk correlation table, where 7 branches of emergencies were assigned. [8]

Risk	1.	2.	3.	4.	5.	6.	7.	Sum

1.	Fires	0	1	1	1	1	1	0	**5**
2.	Traffic accidents	1	0	1	1	0	1	0	**4**
3.	Leakage of dangerous substances	1	0	0	1	0	1	0	**3**
4.	Technical accidents	1	1	1	0	1	1	0	**5**
5.	Radiation accidents	0	0	0	0	0	1	0	**1**
6.	Other emergencies	1	1	1	1	0	0	0	**4**
7.	False alarms	0	0	0	0	0	0	0	**0**
	Total amount	**4**	**3**	**4**	**4**	**2**	**5**	**0**	

Table 2. Correlation of risks

After constructing the risk correlation table, the values 1 and 0 were assigned. If the risk Ri can cause the risk Rj, the value 1 is assigned. Otherwise, the value 0 was assigned.

Calculation of activity and passivity coefficients

For the assessment of emergencies in the municipality with the extended scope of Uherske Hradiste, it is necessary to calculate the coefficients of activity and passivity. Using these coefficients, the mathematical and graphical form of the method is then compiled.

- KARi – activity coefficient – is a percentage expression of the number of selected risks that are connected to the risk marked Ri. In case the risk Ri occurs,

so, these subsequent risks can be triggered.

- KPRi – passivity coefficient – is a percentage expression of the number of selected risks that are connected to the risk marked Ri and that can subsequently trigger the risk Ri.

To express the coefficients of activity and passivity, it is necessary to create several combinations. It is based on the formula that the number of risks is equal to x = 7, where the number of possible combinations is always x-1.

Calculation of the KARi activity coefficient for individual risks Ri:

$$K_{ARi} - \frac{\sum \quad Ri}{x - 1} * 100\ [\%]$$

1. $K_{ARi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{5}{7-1} * 100 = \frac{5}{6} * 100 = 83{,}33\ \%$
2. $K_{ARi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{7}{7-1} * 100 = \frac{4}{6} * 100 = 66{,}66\ \%$
3. $K_{ARi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{3}{7-1} * 100 = \frac{3}{6} * 100 = 50\ \%$
4. $K_{ARi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{5}{7-1} * 100 = \frac{5}{6} * 100 = 83{,}33\ \%$
5. $K_{ARi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{1}{7-1} * 100 = \frac{1}{6} * 100 = 16{,}66\ \%$
6. $K_{ARi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{4}{7-1} * 100 = \frac{4}{6} * 100 = 66{,}66\ \%$

7. $K_{ARi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{0}{7-1} * 100 = \frac{0}{6} * 100 = 0\ \%$

Calculation of passivity coefficients KPRi for individual risks Ri:

$$K_{PRi} - \frac{\sum \quad Ri}{x - 1} * 100\ [\%]$$

1. $K_{PRi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{4}{7-1} * 100 = \frac{4}{6} * 100 = 66{,}66\ \%$
2. $K_{PRi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{3}{7-1} * 100 = \frac{3}{6} * 100 = 50\ \%$
3. $K_{PRi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{4}{7-1} * 100 = \frac{4}{6} * 100 = 66{,}66\ \%$
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5. $K_{PRi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{2}{7-1} * 100 = \frac{2}{6} * 100 = 33{,}33\ \%$
6. $K_{PRi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{5}{7-1} * 100 = \frac{5}{6} * 100 = 83{,}33\ \%$
7. $K_{PRi} = \frac{\sum \quad Ri}{x-1} * 100\ [\%] = \frac{0}{7-1} * 100 = \frac{0}{6} * 100 = 0\ \%$

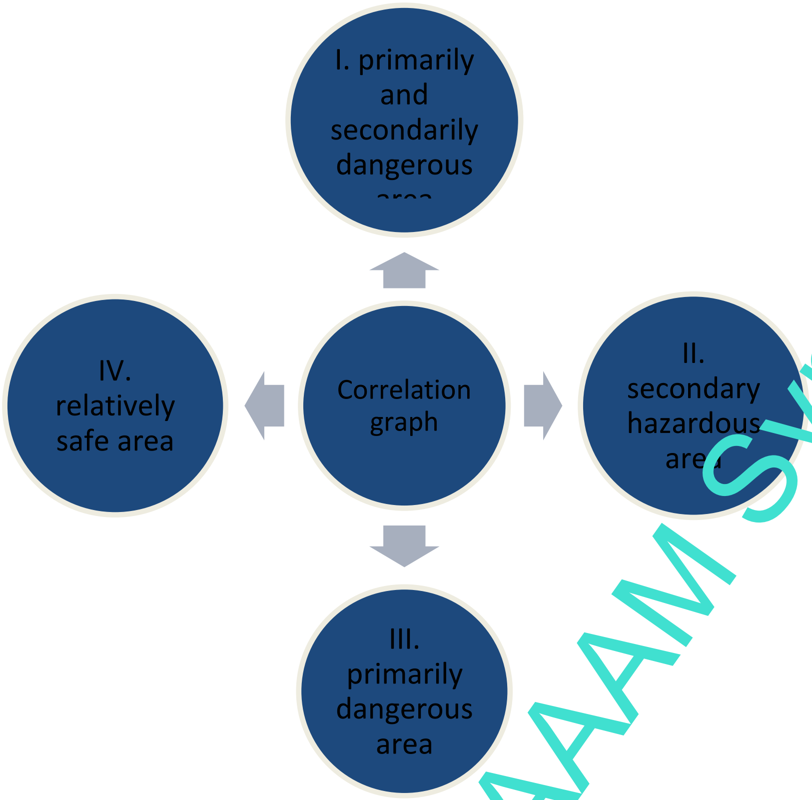
After calculating the coefficients of activity and passivity for individual risks, a table of coefficients of activity and passivity is drawn up, which makes it possible to more clearly create the axes of the resulting correlation graph.

Risk R_i	**1**	**2**	**3**	**4**	**5**	**6**	**7**
K_{ARi} [%]	83,33	66,66	50	83,33	16,66	66,66	0
K_{PRi} [%]	66,66	50	66,66	66,66	33,33	83,33	0

Table 2. Coefficients of activity and passivity

The resulting correlation graph

The task of creating a chart is to determine the significance of all risks and their correlation in a system. The graph is divided by two axes O_1 and O_2 into 4 categories, which are shown in graph No. 2.



Graph 2. Correlation graph areas

Area I. in the resulting graph covers 80% of the total area where the assessed risks are located. For axis O_1:

$$K_{Amax} - K_{Amin} = 100\ \%$$

In the case of the construction of the O_1 axis, if the 80% condition is met, it will be parallel with the y-axis at a distance of:

$$O_1 = K_{Amax} - \frac{K_{Amax} - K_{Amin}}{100} * 80$$

$$O_1 = 83,33 - \frac{83,33 - 0}{100} * 80 = 83,33 - 66,66 \doteq 17$$

Result for O1 = 17%.

For the O_2 axis, if 80% of the condition is met, the parallel to the x-axis is at a distance of:

$$O_2 = K_{Pmax} - \frac{K_{Pmax} - K_{Pmin}}{100} * 80$$

$$O_2 = 83,33 - \frac{83,33 - 0}{100} * 80 = 100 - 66,66 \doteq 17$$

Result for O2 = 17%.

Evaluation of the KARS method

After calculating the O_1 and O_2 axes, the values for defining the quadrants of the correlation graph were obtained. This graph can be seen in figure 1.

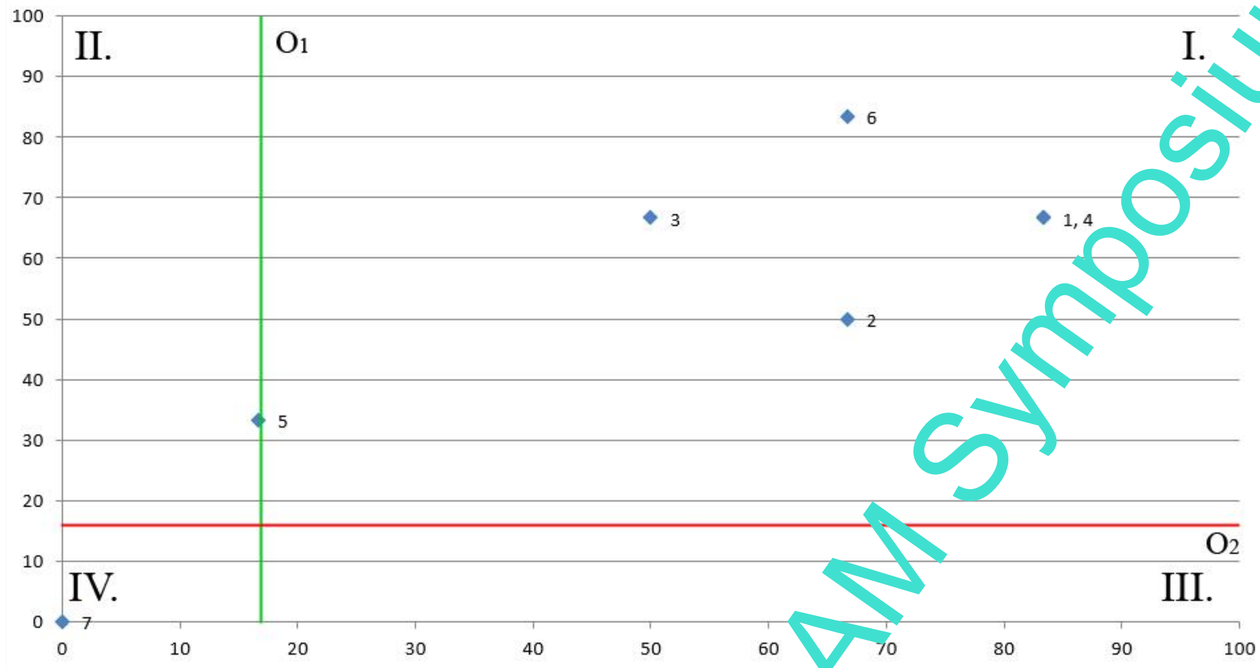
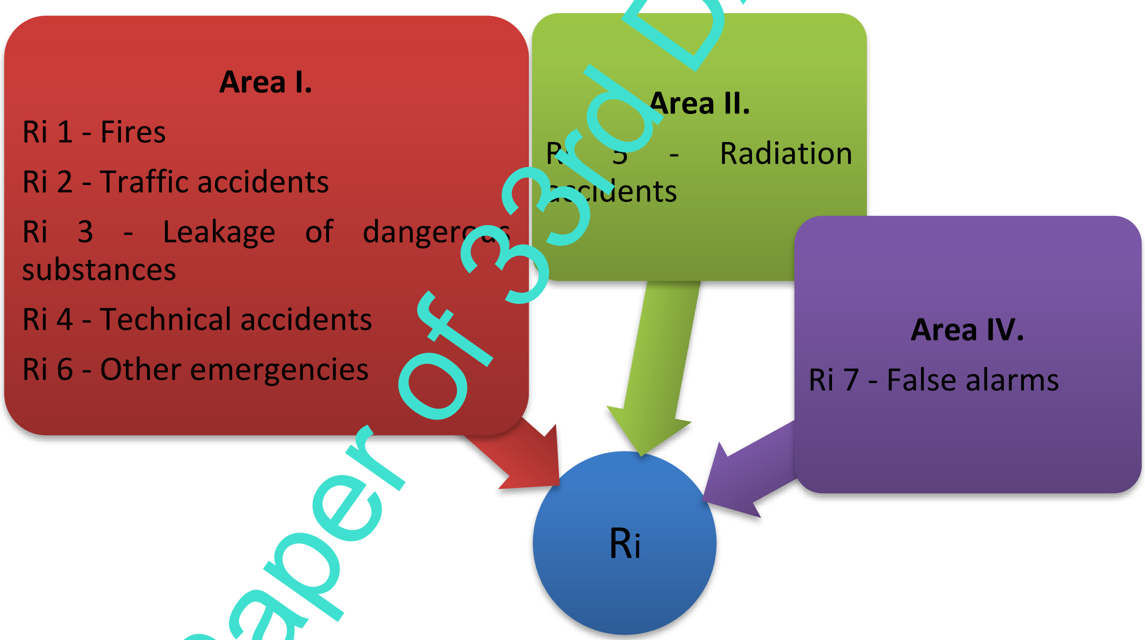


Fig. 2. Correlation of KARi and KPRi coefficients for Ri

It follows from the correlation graph that III. the quarter contains no risk. The most comprehensive is the area I. The others have one risk each. A more comprehensive list is described below.



Graph 3. Result areas and risks of the correlation graph

Area I. Primary and secondary dangerous risks:

A total of five emergencies were included between Area I. primary and secondary dangerous risks, that is 71% of the total number of emergencies defined in the analysis.

Ri 1 – fires – are emergencies that cause unwanted burning, resulting in the death or injury of persons or animals, and damage to property or the environment. Fires are generally among the most destructive emergencies, and an average of 68[illegible] fires occur annually in the Zlin region and 96 times in the municipality with the extended scope of the Uherske Hradiste.

Ri 2 – traffic accidents – emergencies in which activities related to the elimination of the consequences of a collision of means of transport take place. This includes road traffic accidents, mass road traffic accidents, railway traffic accidents, air traffic accidents, and other traffic accidents (traffic accidents on country and forest roads).

Ri 3 - spill NL - emergencies that lead to the release of dangerous chemical substances, including petroleum products and other substances.

Ri 4 – technical accidents – emergencies in which dangers or dangerous conditions are eliminated. Technical breakdowns, technical assistance, technological assistance, and other assistance can be distinguished.

Ri 6 - other emergencies - represent interventions for events such as epidemics or contagions caused by a dangerous disease. The number of these events increased mainly during the period of the COVID-19 disease and the declaration of a state of emergency in the Czech Republic.

Emergencies that occurred in this area are the most dangerous for the municipality with the extended scope of the Uherske Hradiste, and it is necessary to reduce their impact to a minimum. As a solution, an increased number of exercises of the components of the integrated rescue system is offered, which can make rescue and liquidation work more efficient. So-called standard activities are processed for this purpose. These activities contain the procedures and coordination of all components of the integrated rescue system and are thus an indispensable part of coping with emergencies.

Another measure is the increased awareness of the population about the nature of emergencies, information, and early warning using a unified warning and notification system.

Area II. Secondary dangerous risks:

Ri 5 – radiation accidents – emergencies in which radioactive substances or ionizing radiation are released. In the last 12 years, these events have occurred only 2 times, but in the analysis, the event came out among the most dangerous risks. Although these events do not occur as often and in number as other events that have been included in this area, they represent their place here due to the impact on the population and the possible emergence of a domino effect that would trigger other emergencies, see table no. 1.

Risks placed in this area are also a high risk for that area, but not as high a priority as the risks in the first area. In the case of radiation accidents, similar proposals are offered for the first area, i.e. a greater deepening of the knowledge of the population in the event of a radiation accident and the involvement of components of the integrated rescue system in more frequent exercises on the given issue.

Area IV. Relatively safe:

Ri 7 – false alarms – these are activities that are triggered due to reports of fire or other events that have not been confirmed. These false alarms cannot be estimated, so after an emergency call has been announced, the individual components of the EMS are obliged to arrive at the place of notification. Unfortunately, these false alarms have a growing tendency and people are not aware of the risks involved.

4. Discussion

Emergencies are an integral part of the lives of all people around the world. Thousands of incidents occur every day that require rescue and liquidation work. It is, therefore, necessary to pay increased attention to these events and to prepare not only the components of the integrated rescue system to deal with them but also the population itself.

The focus of the work was oriented to the analysis of emergencies in the Zlin region and, for a closer specification, to the municipality with the extended scope of Uherske Hradiste.

Data from the statistical yearbooks of the Fire and Rescue Service of the Czech Republic were used, with the help of which the total number of emergency incidents was calculated and compared within the territorial self-governing units, i.e. the Zlin Region and the municipality with the extended jurisdiction of Uherske Hradiste. To evaluate the seriousness of emergencies, a qualitative analysis of risks using their correlation was primarily used.

5. Conclusion

The presented article aimed to analyze and compare emergencies in the Zlin region with a focus on a smaller model, namely the municipality with the extended scope of Uherske Hradiste.

The work used the methods of explanation, comparition, modeling, and qualitative analysis of risks using their correlation. The first method of explanation is used to explain a process or phenomenon, and specifically, in this work, it was used to explain individual emergency events and their categorization that occur in the Zlin region and to explain the issue of the integrated rescue system.

The comparition method was used to compare emergencies both between the Zlin region and the municipality with the extended scope of Uherske Hradiste and also between themselves as such.

The third method used was the modeling method. This method represents a simplified picture of reality and was used in this work to create a map output that shows the territorial distribution of municipalities with extended jurisdiction in the Zlin region.

The fourth and last method is a qualitative analysis of risks using their correlation, which was used to compare individual emergencies and compile the resulting graph of correlation, which determined four basic areas and thus pointed to the most dangerous emergencies, and conversely also to the relatively safest ones.

The analysis showed that the most serious emergency events in the municipality with the extended scope of Uherske Hradiste are fires, traffic accidents, leaks of dangerous chemical substances, technical accidents, and other emergencies. It, therefore, reflects a fact that is also based on the calculation of individual data from the statistical yearbooks of the Fire Rescue Service of the Czech Republic.

To be prepared for these emergencies, exercises are carried out by the components of the integrated rescue system, which aim to prepare for emergencies and carry out rescue and liquidation work.

The limiting element of this work is the lack of published treatment of this area. Only a minimum of articles are devoted to the analysis of this area within the framework of emergencies. Future research will deal with deepening the area of exercises for the components of the integrated rescue system and streamlining rescue and liquidation work during emergencies in the Zlin Region.

6. Acknowledgments

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