# SOCIAL ACTIVITY IN THE CONTEXT OF EMERGENCY SITUATIONS: A COMPREHENSIVE ANALYSIS OF SOCIAL MEDIA DATA

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**Abstract**

*This study explores the potential of social media data for analyzing and predicting public behavior during emergency situations. A comprehensive methodology was developed, encompassing three key stages: automated data collection from social networks, mathematical processing using algorithms like Isolation Forest, and dependency analysis correlating user activity with meteorological and calendar factors. Over 89,000 records were collected in Yekaterinburg, revealing distinct patterns in categories such as "Fire" and "Road Accidents." For instance, fire-related discussions spiked during holidays due to open flame use, while road accidents peaked during seasonal transitions. Weather conditions like temperature and precipitation significantly influenced activity levels. The findings confirm that social media activity serves as a reliable indicator of real threats and public concern, offering valuable insights for ES management. This research lays the groundwork for advanced tools to enhance urban resilience and public safety.*

**Keywords:** Social media, Data analysis, Crisis communication, Risk management

## I. Introduction

In previous works by the authors [1-3], a methodology was developed for collecting and analyzing data from social networks to study the social consequences of large-scale urban infrastructure accidents. This approach is based on the systematic collection of user-generated content that reflects both the objective picture of incidents and subjective public reactions, enabling a comprehensive entropy analysis of emergency situations (ES) development and their impact on the population.

The choice of social networks as the primary data source is justified by their role as communication hubs during emergencies. Users actively share information about ongoing events, ranging from personal observations to evacuation instructions, transforming traditional forms of crisis communication. Social networks serve as key channels for both receiving and disseminating information, especially when traditional communications are overloaded or unavailable. Users aim to help by participating in search-and-rescue operations, providing information, and organizing interactions [4].

Weather conditions also significantly influence social media usage. A large-scale study in the USA, covering 3.5 billion posts on Facebook and Twitter from 2009 to 2016, found that cold weather (below −5°C) and precipitation (1.5–2 cm) increase user activity by 35%, which significantly exceeds traditional load peaks, such as during New Year's Eve [5]. This underscores the importance of analyzing weather factors when studying user behavior on social media.

Particular scientific and practical interest lies in crisis communication models during emergencies. Research [6] showed that during Hurricane Sandy, social media users demonstrated clear patterns of information behavior at different stages of the disaster: warning (publishing forecasts and warnings), immediate response to the natural disaster (information on the current situation and urgent needs), and recovery (messages about assistance and support). Additionally, information about the geographic location of disaster epicenters and actual local needs was actively disseminated. Analyzing such communication patterns can be used for prompt intervention by emergency services and coordination of rescue operations.

During emergencies, people experience heightened informational anxiety. The theory of uncertainty avoidance and terror-management theory explain why users turn to verified sources and seek information that reduces anxiety and restores mental stability [7]. According to the uncertainty avoidance theory, users prefer content from authoritative sources (e.g., official accounts or experts), as it is perceived as more reliable and helps reduce anxiety levels. Terror-management theory emphasizes that when confronted with threats related to death or serious consequences, people choose information consistent with their cultural values and worldview to protect psychological well-being. This explains why, in stressful situations, users interact less with posts containing informal language (e.g., netspeak) or requiring additional cognitive or emotional effort [7].

Research also confirms a correlation between social media activity and the intensity of external events. For example, Fang et al. used the temporal evolution of social media activity to track the process of a rainstorm in Wuhan in 2016 and showed that changes in activity correlate with the intensity of rainfall [8]. Automatic tools capable of quickly identifying the type, scale, location, and consequences of disasters are essential for ensuring public safety and managing ES [9].

The aim of this study is to comprehensively collect, process, and analyze data on ES in Yekaterinburg using statistical analysis and visualization methods to identify relationships between meteorological parameters, user social activity, and the occurrence of various categories of ES.

## II. Data Collection

The first stage of the research involved automated data collection from the social network VKontakte. A program was developed to search for groups related to Yekaterinburg and analyze publications containing keywords related to various ES categories. These included fires, floods, road accidents, conflicts, and other events.

For each category, keywords were defined for filtering publications. For instance, for the "Fire" category, terms like "fire," "flame," "burning," etc., were used. Publications were analyzed for matches with these words and then saved in an SQLite database. Metadata such as date, time, text, number of likes, comments, and reposts were recorded for each entry.

The data collection process began by searching for groups related to the keyword "Yekaterinburg." For each group found, the program checked its accessibility (open or closed) and collected publications. Subsequently, a multi-level content analysis was conducted: analyzing main publications, gathering comments on publications, and collecting sub-comments.

Special attention was given to collecting user interaction metrics (likes, comments, reposts for each content unit—publication, comment, sub-comment). Collected data were stored in the SQLite database. The database structure is presented in Table 1. Using separate tables for each category allowed efficient data organization and simplified subsequent analysis. The program also ensured protection against duplicate entries upon repeated runs.

**Table 1:** *Parameters of the FullEKB_days Database*

| Name | Data type | Description |
|---|---|---|
| | | ***Main Identifiers*** |
| Date | Date | Event or publication date |
| ID | Text | Unique identifier of the record (publication/comment) |
| | | ***Engagement Metrics*** |
| Number of Publications | Integer | Number of publications per day for a specific category |
| MatchedKeywords | Text | Keywords matching the record |
| Likes, Comments, Reposts | Integer | Number of likes, comments, reposts |
| Sentiment | Text | Final sentiment: positive, neutral, negative |
| | | ***Meteorological Parameters*** |
| Po | Float | Atmospheric pressure (hPa) |
| U | Integer | Relative humidity (%) |
| Ff | Integer | Average wind speed at 10–12 m height (m/s) |
| VV | Integer | Visibility, horizontal range (km) |
| DD | Text | Wind direction (e.g., N, NE, SSW, etc.) |
| Ff3 | Integer | Maximum wind gust (m/s) |
| Tn | Float | Minimum air temperature (°C) |
| Tx | Float | Maximum air temperature (°C) |
| RRR | Float | Amount of precipitation (mm) |
| E | Text | Soil surface condition without snow (e.g., dry, wet) |
| Tg | Float | Minimum soil surface temperature at night (°C) |
| E_prime | Integer | Soil condition with ice/snow (e.g., cover density) |
| Sss | Text | Snow cover height (cm) |
| N | Text | Cloudiness: 0–10 (scale) or descriptions (clear, overcast) |
| W1 | Text | Weather event during the interval (e.g., rain, snow) |
| | | ***Calendar Features*** |
| IsHoliday | Boolean | Holiday indicator: 1 – holiday, 0 – not |
| IsWeekend | Boolean | Weekend indicator: 1 – weekend, 0 – weekday |

## III. Results

Over the year (June 2024 – June 2025), more than 89,000 records were collected. Figure 1 shows the dynamics of activity in the categories "Fire," "Road Accident," "Water Outage," and "Ecological Crisis." The x-axis represents the date, and the y-axis represents the number of comments.

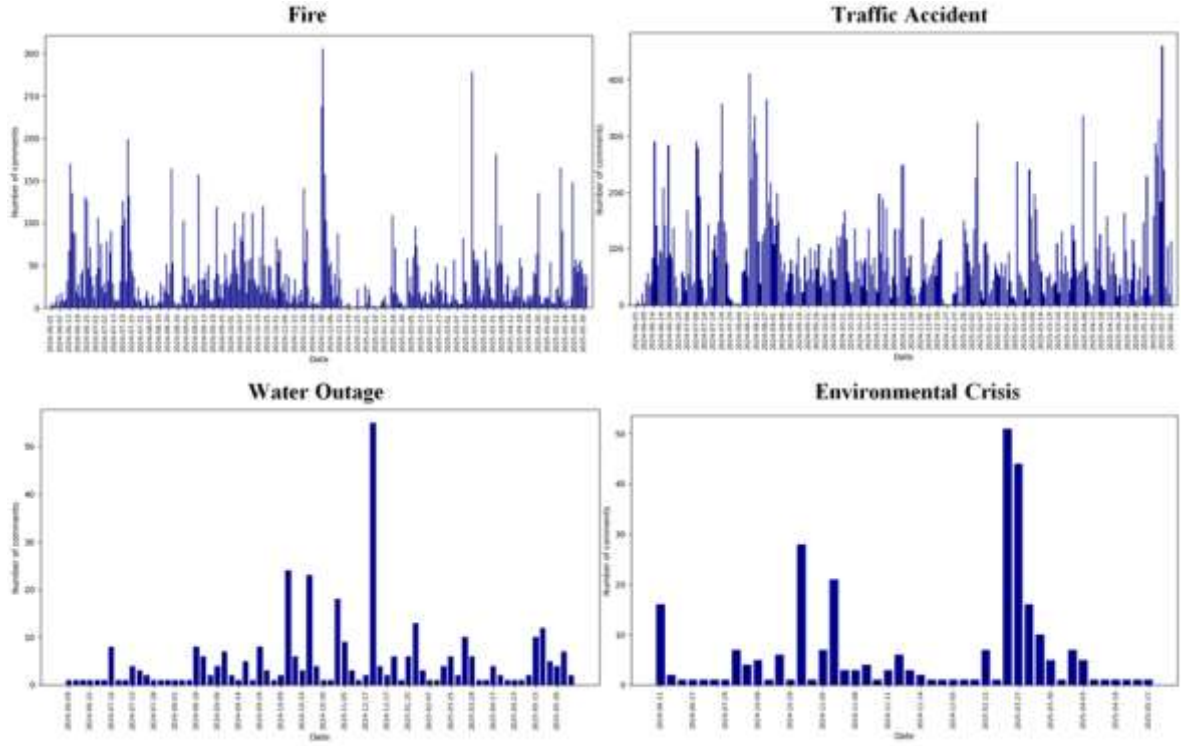


**Figure 1:** *Graphs of Yekaterinburg Residents' Activity in Some Categories*

During the study period (June 2024 to June 2025), periodic spikes in comment activity were observed. The most significant peak in the "Fire" category occurred on November 30 – December 1, 2024, during a major fire in the industrial zone of the Koltsovo district of Yekaterinburg. A polystyrene production workshop burned over 1,500 square meters, with the roof collapsing over 400 square meters. Black toxic smoke was visible across parts of Yekaterinburg and beyond, and reports from eyewitnesses about a preceding explosion caused widespread public resonance, explaining the record number of comments (over 300).

1. The "Fire" category demonstrates high and sensitive public reaction: activity spikes clearly correlate with large-scale incidents threatening life and health. This indicates high informational anxiety and the need for timely information, making this category critically important for early warning and risk management systems.

2. The "Road Accident" category is characterized by frequent but less intense spikes, indicating high everyday engagement in road safety. Activity here is less dependent on single events and more reflective of the overall vulnerability of the transport system, requiring constant monitoring and prevention.

3. The "Water Outage" and "Ecological Crisis" categories show low and episodic activity. This may indicate either low frequency of such events or their low visibility to the public—requiring further research to identify causes and possible underappreciated risks.

4. The overall picture confirms the hypothesis: social activity on social media is a reliable indicator of the real level of threat and degree of public concern. It reflects not only informational interest but also real socio-economic consequences of ES, making it a valuable tool for ES management authorities.

## IV. Mathematical Data Processing: Analysis and Visualization

*Anomaly Detection*

The Isolation Forest algorithm was applied to detect anomalies in the data. It works by constructing multiple decision trees that partition the data into subsets. Anomalous points are identified faster as they are "isolated" early in the partitioning process. The algorithm was applied to time series data, where each point represented the number of comments over a specific time interval. Anomalies were identified as points significantly differing from the overall distribution.
Isolation Forest performs well with large volumes of data and does not require preliminary normalization, is easy to interpret, and is robust to random fluctuations in the data.

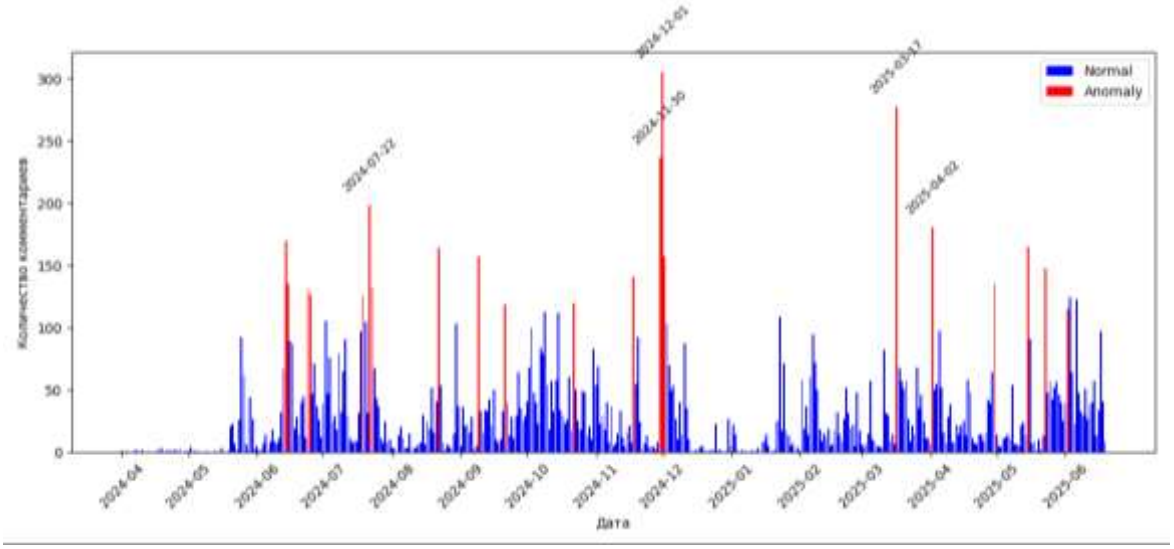


**Figure 2:** *Anomalies in the Data*

On the graph (Figure 4), red dots indicate anomalous periods of activity. Significant anomalies:

- July 22, 2024: Spike in activity related to the cancellation of fire restrictions.
- November 30, 2024: High peak of activity linked to a major fire in the Koltsovo area.
- March 17, 2025: Another significant spike in activity due to the evacuation of UGI students following a bomb threat and alarm activation.

*Correlation with Weather Conditions*

The third stage of the research aimed to analyze dependencies between external factors (e.g., temperature, precipitation, holidays) and user activity levels on social media. The forecasting methodology included several sequential steps:

1. Data Preparation:
    - Conversion of textual representations of numerical values (e.g., "no precipitation" → 0).
    - Missing value filling with 0. Missing elements indicate absence of an event (e.g., precipitation) or lack of publication.
    - Integration of contextual data, such as holidays and weekends, using the holidays library. This aspect is crucial as social activity varies significantly depending on the day of the week and presence of holidays.
2. Visualization of Dependencies: Construction of graphs to analyze correlations between weather data, holidays, and the number of publications.

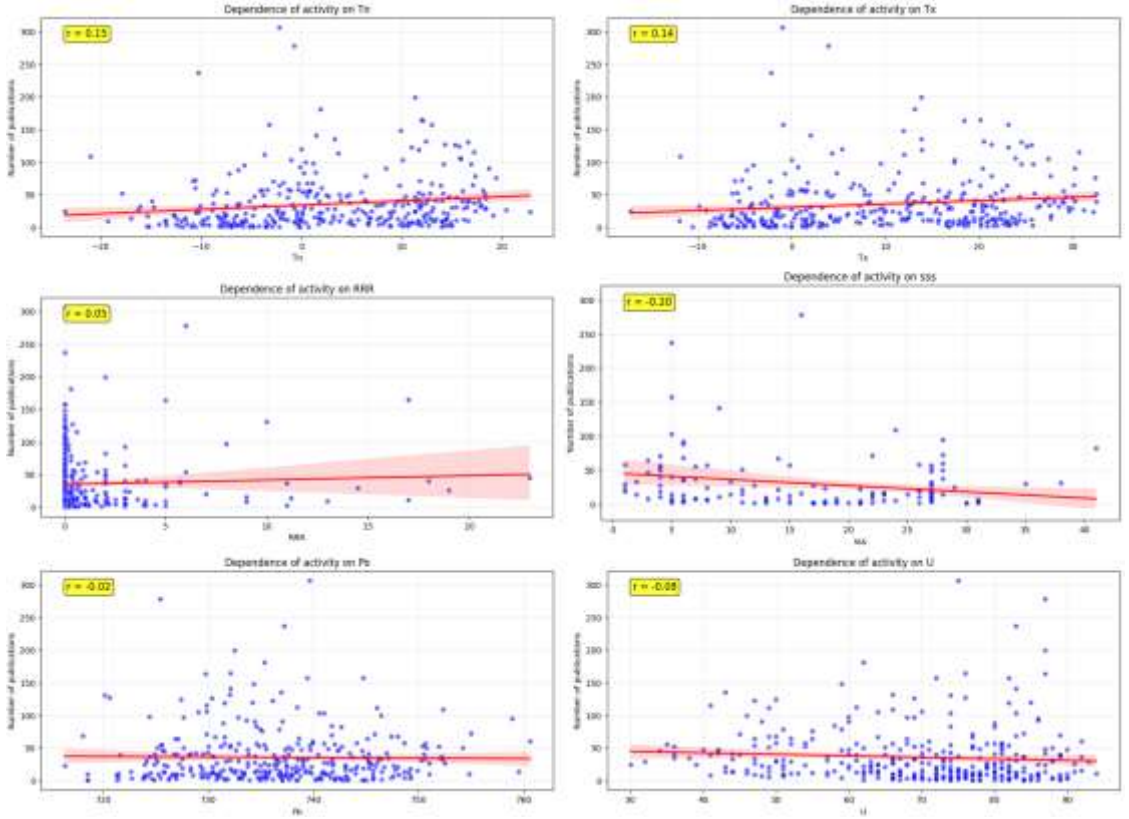


**Figure 4:** *Dependence of Public Activity in the "Fire" Category on Weather Data*

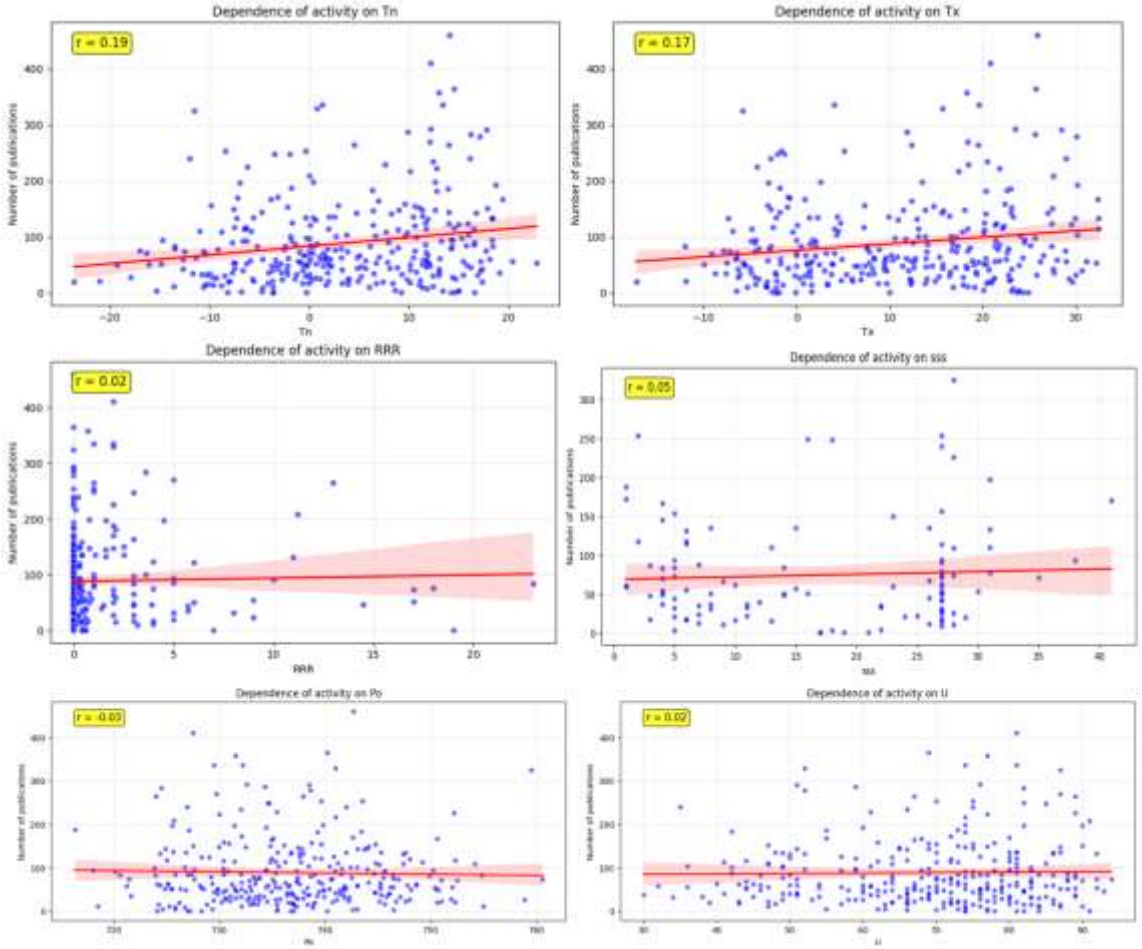


**Figure 5:** *Dependence of Public Activity in the "Road Accident" Category on Weather Data*

**Table 2:** *Summary Conclusions from Comparative Analysis*

| Parameter | «Fire» Category | «Road accident» Category |
|---|---|---|
| Tn/Tx | Activity spikes around zero temperature | Maximum activity at T > 10°C |
| RRR | Inverse relationship: more precipitation leads to fewer publications (fewer days with heavy precipitation) | Same inverse relationship (publication/comment) |
| Sss | Activity decreases when sss > 5 cm | Activity increases with snowfall onset |
| Po | No clear dependency | No clear dependency |
| U | Moderate increase when U < 85% | Increase when U < 80%, decrease when U > 80% |

Analyzing correlation dependencies between social activity and meteorological factors revealed key user behavior patterns on social media in the context of ES. For the "Fire" category, dominant factors are temperature, air humidity, and absence of precipitation, confirming the seasonality of fire risks. For "Road Accidents," temperature, soil condition, and air humidity have the greatest impact, especially during transition seasons. Thus, comprehensive analysis of social media data combined with meteorological information opens new opportunities for enhancing urban resilience to emergencies through timely public information and coordination of actions by the public and emergency services.

*Seasonal and Calendar Patterns*

Bar charts (Figure 8) compare average publication counts for two ES categories ("Fire" and "Road Accident") by day types (weekdays, weekends, holidays) and seasons. Analysis reveals seasonal and calendar patterns of social activity, potentially linked to both increased incident numbers and changes in user behavior on social media.

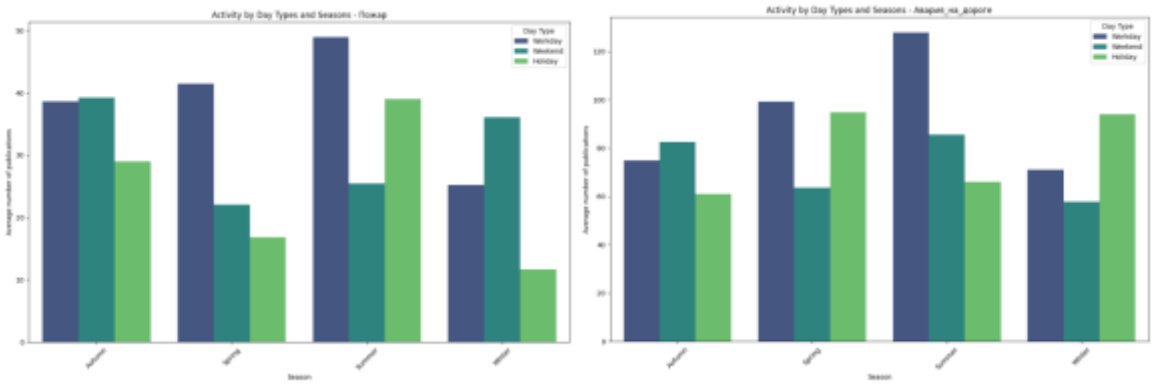

**Figure 6:** *Comparison of Activity Across Different Days for the "Fire" and "Road Accident" Categories*

Graphs show pronounced seasonal and calendar dependencies of user activity on social media across various ES categories, confirming the hypothesis that social activity reflects both informational anxiety and real risks. Holidays are key risk points for both ES types. In summer, the highest activity in the "Fire" category relates to open flame use, increasing fire risks. In the "Road Accident" category, peaks occur during spring and winter holidays due to mass departures and traffic congestion, where weather conditions and altered driving modes raise danger and reduce driver attentiveness. Thus, analyzing seasonal and calendar patterns allows predicting potential threats, making social media data an important tool for ES management.

## V. Conclusion

This study demonstrates the promise of using social media data to analyze and predict population behavior in the context of ES. The developed methodology includes three key stages: data collection, mathematical processing, and dependency analysis. Each stage has practical value and can be applied to solving practical tasks.

Different ES categories are characterized by unique activity patterns. For instance, discussion spikes in the "Fire" category are more common in summer, especially on holidays when open flame use increases. Meanwhile, activity peaks in the "Road Accident" category occur during spring and winter holidays associated with mass departures and changes in road surface conditions. This highlights the need for an individualized approach to analyzing each category.

Further development of the methodology opens new possibilities for improving public opinion monitoring systems, planning preventive measures, and developing informational campaigns. This research laid the foundation for creating a powerful tool that enhances effective ES management and strengthens public safety.

**CONFLICT OF INTEREST**

Authors declare that they do not have any conflict of interest.

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