

Statistical Analysis of Specialists' Perceptions in Managing Crowd Dispersal Processes at Large Public Gatherings

Laurentiu-Marian DICU*

National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania

**Corresponding author, laurentiudicu@gmail.com*

Nicoleta-Luminița CĂRUȚAȘU

National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania

nicoleta.carutasu@upb.ro

Dragoș-Florin MARCU

National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania

dragos.marcu@upb.ro

Monica IORGA

National University of Science and Technology POLITEHNICA Bucharest, Bucharest, Romania

monica.iorga@upb.ro

Abstract. *The article aims to analyze the factors that influence the efficiency of the crowd dispersal process, from the perspective of those involved in organizing activities at large public gatherings. Managing public order in normal situations requires a comprehensive approach, integrating both nonviolent and violent actions, within a coherent normative framework and within an effective inter-institutional collaboration. Effective crowd management requires considering effective planning before the event begins, monitoring and controlling the crowd during the execution of the event, taking feedback after the event ends and reporting the lesson learned for more effective systems in the future. Crowd modeling and simulations can be useful in planning crowded events and predicting crowd anomalies in real-time crowd management systems. It can also improve understanding of crowd psychology and behavior (including pedestrian, crowd, and group dynamics).*

Keywords: crowd management, de-fluidization of public gatherings, public order, inter-institutional coordination, collective behavior.

Introduction

The present study focuses on the analysis of factors that influence the efficiency of the crowd de-fluidization process at large public gatherings, from the perspective of professionals directly involved in maintaining public order. Although crowd dispersal is an inherent part of any large-scale event, it is often treated as a secondary or purely operational matter, despite its direct implications for participant safety and institutional performance.

In practice, the flow of a crowd is determined by a combination of organizational decisions, physical conditions, and human behavior. Elements such as the planning of evacuation routes, the existence of alternative flow paths, and the clarity of spatial orientation mechanisms can significantly influence the speed and order of participants' retreat. At the same time, effective communication and coordination among law enforcement agencies play a decisive role in adapting interventions to rapidly changing crowd dynamics.

DOI: 10.2478/picbe-2026-0389

© 2026 L.-M. Dicu; N.-L. Căruțașu; D.-F. Marcu; M. Iorga, published by De Gruyter.

This work is licensed under the Creative Commons Attribution 4.0 License.

In addition to these structural aspects, the human and technological dimensions of crowd management cannot be overlooked. Operational stress, accumulated experience, and familiarity with procedures influence how personnel respond to complex situations, particularly under time pressure. At the same time, the increasingly frequent use of technological tools, including surveillance systems and audio guidance mechanisms, has changed how crowd movements are monitored and managed in real time.

By addressing these dimensions simultaneously, this research aims to contribute to a more comprehensive understanding of crowd defluidization as a multidimensional process, rather than merely as a final phase of public events. The findings are intended to support evidence-based improvements in planning, coordination, and training practices related to public order management.

The existence of a coherent database, based on statistical research, would allow not only a better understanding of collective behavior, but also a more efficient planning of future public events.

The dispersal of participants at large-scale public gatherings is a phenomenon that is essential to understanding contemporary social dynamics. Although visible and palpable, this process is often overlooked in analysis and planning. The use of statistical research allows for a detailed, objective, and predictive understanding of how crowds behave when their cohesion begins to break down.

In Romania, this type of analysis is still poorly developed, but the social context provides fertile ground for such research.

By using rigorous methods – from questionnaires to predictive models - valuable data can be obtained for both academic research and for public administration or civil society.

Dispersal is not merely the “end of the event,” but a process with profound implications for collective perception, participant safety, and future mobilizations. In a democratic society, a scientific understanding of these phenomena directly contributes to strengthening social dialogue and optimizing mechanisms for public participation.

Literature review

Effective crowd management requires consideration of effective planning before the event begins, monitoring and controlling the crowd during the event's execution, taking feedback after the event ends, and reporting lessons learned for more effective systems in the future.

Kachroo, Al-Nasur SJ, Wadoo SA, ShendeA presented different concepts of smart evacuation system and discussed the improvement of evacuation process for metro station and airport scenarios.

As an example of an integrated system, Wijermans N, Conrado C, van Steen M, Mortella C, Li J presented INCROWD, an integrated crowd management support framework that considers crowd interaction (acting and sensing), mining, prediction and decision making. In the example, they used video cameras, Wi-Fi hotspots and security officers (human sensors) to obtain crowd data.

Still GK examined the differences between static and dynamic spaces and suggested improvements to traditional methods (e.g., occupant capacity as total area in square meters divided by 0.5), particularly for dynamic crowd flow areas.

Marana et al. proposed a technique based on image texture information for estimating crowd density, in which different methods (namely, gray level dependency matrix, straight line

segments, Fourier spectrum, and fractal dimensions) were analyzed to classify crowd density into five classes (very low, low, moderate, high, very high).

Georgoudas et al. proposed an anticipatory crowd management system based on video data analysis, which could detect and track pedestrians; estimate and propose a possible route based on possible exit congestion consideration; and activate guidance signals, alarm sound, etc.

The literature on public order management at large-scale gatherings emphasizes that crowd control is one of the most sensitive and complex aspects of public event management, with direct implications for the safety of participants, law enforcement personnel, and urban infrastructure. Studies in the field agree that the success of crowd control measures is not determined solely by the operational intervention itself, but by the entire crowd management cycle, which includes pre-event planning, real-time monitoring and control, as well as post-event evaluation.

In this regard, the literature emphasizes that strategic planning is a critical factor in preventing risky situations, through the design of traffic flows, the establishment of evacuation routes, the identification of vulnerable points, and the clarification of institutional roles. These dimensions are directly reflected in the questionnaire used in this study through questions addressing respondents' perceptions of the clarity of responsibilities, the effectiveness of inter-institutional collaboration, the adequacy of evacuation infrastructure, and the visibility of alternative routes.

During the event itself, studies emphasize the importance of continuously monitoring the crowd and the ability to adapt quickly to emerging behaviors or unforeseen situations. The literature shows that the lack of effective communication and a coherent coordination system can lead to bottlenecks, increased operational stress, and, consequently, heightened risks. These issues are addressed in the questionnaire through questions regarding communication effectiveness, the use of monitoring technologies, the management of bottlenecks, and the impact of stress on operational decision

A significant contribution of recent research is the integration of crowd modeling and simulations into the decision-making process. The literature demonstrates that these tools can support the planning of crowded events, can contribute to the anticipation of flow anomalies and can provide valuable support for real-time crowd management systems. At the same time, simulations facilitate a better understanding of pedestrian dynamics, collective behavior and crowd psychology, essential elements for the design of effective de-fluidization strategies. These dimensions are investigated in the questionnaire through items that analyze the respondents' perception of the usefulness of technological solutions, video monitoring and the adaptability of measures applied in the field.

Finally, the literature insists on the importance of post-event evaluation and the lessons learned process, considered essential for the continuous improvement of crowd management systems. Structured feedback from staff directly involved in operations is recognized as a valuable source of information for optimizing procedures and the regulatory framework. From this perspective, the questionnaire used in this study serves as a tool for systematically recording operational experience, providing a solid empirical basis for formulating scientifically grounded recommendations.

Overall, the literature confirms that an analytical approach to crowd flow must integrate operational, organizational, technological, and behavioral dimensions. The questionnaire used in this study is constructed in line with these theoretical directions, allowing for the investigation of the perceptions of professionals directly involved in public order management and providing an applied perspective on the effectiveness of de-fluidization mechanisms used at large public gatherings.

The reviewed literature highlights a broad consensus regarding the complexity of crowd management at large-scale public gatherings. Previous studies repeatedly emphasize that outcomes regarding crowd flow are not determined by a single variable, but rather by the interaction between planning decisions, coordination mechanisms, infrastructure, and human behavior. Inadequate evacuation planning and poorly defined routes are frequently associated with crowding and delayed dispersal, while effective communication among agents has been shown to improve operational coherence in dynamic situations.

At the same time, several authors highlight the supporting role of physical infrastructure, such as barriers and signage, in shaping pedestrian movement, particularly under conditions of high density or limited visibility. More recent contributions highlight the growing importance of technological support systems, which enable continuous monitoring and more informed decision-making during critical phases of crowd movement. In addition to these factors, the human dimension remains essential, as operational stress and professional experience influence both individual judgment and collective performance.

Despite these findings, there is little empirical evidence capturing how these factors are perceived by professionals directly involved in public order management, particularly with regard to the crowd dispersal phase during large-scale events. Based on the conclusions drawn from the existing literature, this study proposes the following research hypotheses:

Hypothesis 1 (evacuation route planning) was investigated through elements related to the clarity of evacuation routes, the existence of alternative routes, and the perceived time required for crowd dispersal.

Hypothesis 2 (communication among law enforcement agencies) was tested using elements that assess the effectiveness of interagency communication, real-time coordination, and the impact of communication on evacuation speed.

Hypothesis 3 (physical barriers and signage) was analyzed using elements that address the placement of barriers, the visibility of signage, and the organization of participant flows.

Hypothesis 4 (stress and experience) was operationalized by correlating the perceived level of operational stress and professional experience with the reported ability to effectively manage traffic flow.

Hypothesis 5 (modern technologies) was assessed using items related to the use of surveillance cameras, audio announcements, and other technological solutions in preventing crowding and guiding crowds.

Hypothesis 6 (logistic factors) was tested through items relating to adequate lighting, accessibility of alternative routes and their impact on evacuation speed.

Methodology

This study employs a quantitative, cross-sectional design, chosen to explore the relationships among the various operational and organizational factors involved in the crowd dispersal process. A quantitative approach was deemed appropriate, given the need to systematically capture professionals' perceptions and analyze the associations between variables measured on ordinal scales.

Data were collected using a structured questionnaire, developed with reference to previous studies in the field of crowd management and public order. The instrument includes 30 items covering key dimensions, such as evacuation planning, operational coordination, infrastructure, logistics, technological support, and human factors. Most items were measured using four- or five-

point Likert scales, allowing respondents to express varying degrees of agreement while limiting neutral responses.

The study sample consists of 603 respondents selected from among personnel directly involved in public order maintenance and large-scale event management activities. Depending on operational constraints, data collection was conducted both through direct administration and online distribution. The resulting sample size provides an adequate level of statistical reliability for the analyses performed.

The sample size exceeds the minimum threshold required to ensure a margin of error of $\pm 5\%$ at a 95% confidence level, giving the study an adequate degree of statistical representativeness for testing the formulated hypotheses.

The statistical analysis was conducted in successive stages, using analytical techniques appropriate to the ordinal nature of the data collected via the questionnaire. In a first stage, descriptive statistics were used to provide a general characterization of the responses, including the calculation of absolute and relative frequencies, as well as measures of central tendency and dispersion, namely the median and the interquartile range. These indicators were chosen to accurately reflect the distribution of responses measured on Likert-type scales.

Subsequently, Spearman's correlation coefficients were used to examine the associations between key operational factors and defluidization efficiency indicators, corresponding to the relationships formulated in hypotheses H1, H2, H3, H5, and H6. This nonparametric approach was deemed appropriate, given the absence of normality assumptions and the ordinal level of measurement.

To explore differences in perceived ability to manage the defluidization process in relation to human factors, nonparametric comparison tests were applied. Specifically, the Mann–Whitney U test was used to assess differences between stress level groups, while the Kruskal–Wallis H test was used to examine variations across professional experience categories, in accordance with Hypothesis H4.

In addition, an exploratory factor analysis was conducted to identify the underlying latent dimensions of the defluidization process and to assess the conceptual coherence of the questionnaire structure. Throughout all analytical stages, the threshold for statistical significance was set at $p < 0.05$, and where relevant, effect sizes were reported to support a more nuanced and rigorous interpretation of the results.

Results and discussions

In order to generally characterize the respondents' perceptions regarding the process of crowd defluidization at large public gatherings, descriptive analyses were conducted, using indicators appropriate to the ordinal nature of the data collected through the questionnaire. The analysis included the calculation of absolute and relative frequencies, as well as indicators of central tendency and dispersion, namely the median and interquartile range (IQR), for each relevant item. The choice of the median and interquartile range, to the detriment of the mean and standard deviation, is justified by the ordinal nature of the Likert scales used and the asymmetric distributions observed in the case of some variables.

The descriptive results indicate that, for most of the items analyzed, the responses are concentrated in the upper part of the scale, suggesting a predominantly favorable perception of the importance of planning, coordination and use of logistical and technological resources in the defluidization process. The high median values, accompanied by relatively narrow interquartile

ranges, indicate a high degree of consensus among respondents regarding the essential role of these factors.

For items related to evacuation route planning and the clarity of alternative routes, the frequencies and median values suggest that most respondents consider these elements decisive for reducing evacuation time. Moderate interquartile ranges indicate the existence of variations in opinion, which can be explained by differences in operational context and professional experience. The descriptive analysis of items regarding law enforcement communication also reveals high median values, reflecting the general perception that effective communication methods contribute to improved coordination and increased evacuation speed. However, the wide interquartile range for certain items suggests the existence of discrepancies regarding the perceived effectiveness of communication, likely associated with institutional differences or the level of interoperability.

Regarding physical barriers and exit signage, the frequency distributions indicate a predominantly positive assessment of their impact on the organization of the flow of participants. The median values confirm the importance of these factors, and the moderate dispersion of the responses suggests an uneven application of these measures in different operational situations.

Responses regarding stress levels and professional experience show greater variability, as reflected by wider interquartile ranges. This indicates that the perception of the ability to effectively manage defluidization is influenced by individual and contextual factors, justifying the use of comparative and correlational analyses in subsequent stages of the research.

Finally, the descriptive analysis of the items on the use of modern technologies and logistical factors, such as lighting and the availability of alternative routes, reveals a generally positive assessment of their role in preventing congestion and efficiently guiding the crowd. The high median values and frequencies concentrated in the upper categories of the scale confirm the relevance of these dimensions for the efficiency of defluidization.

Table 1. Descriptive analysis of the variables studied (mean and IQR)

Dimension analyzed	Variable (questionnaire item))	Mean	IQR (Q1–Q3)
Evacuation planning	Clarity of evacuation routes	4	3-5
	Existence of alternative routes	4	3-5
	Advance planning of flows	4	3-5
Operational communication	Effectiveness of communication between law enforcement agencies	4	3-4
	Real-time coordination of interventions	4	3-4
	Impact of communication on evacuation speed	4	3-5
Infrastructure and signage	Placement of physical barriers	4	3-4
	Clarity of exit signage	4	3-5
	Organization of participant flows	4	3-4
Human factor	Perceived level of operational stress	4	2-4
	Ability to manage situations under pressure	4	3-4
	Influence of professional experience	4	3-5
Technology	Use of surveillance cameras	4	3-5
	Effectiveness of audio announcements	4	3-4
	Role of technology in preventing bottlenecks	4	3-5
Logistical factors	Adequate lighting of evacuation areas	4	3-5
	Availability of alternative routes	4	3-5
	Impact of logistics on evacuation speed	4	3-5

Source: The authors' own research.

To evaluate the relationships between the investigated operational factors and the efficiency indicators of the defluidization process, the Spearman correlation coefficient (ρ) was used, appropriate for the analysis of monotonic relationships between ordinal variables measured on Likert-type scales. The choice of this test is justified by the non-parametric nature of the data and the absence of the assumption of normality of the distributions.

The analysis aimed to test hypotheses H1, H2, H3, H5, and H6, focusing on the relationships between planning, communication, infrastructure, technology, and logistics factors, on the one hand, and traffic flow efficiency indicators (discharge rate, flow organization, and congestion prevention), on the other.

Table 2. Spearman's correlations between operational factors and evacuation efficiency

Assumption	Independent variable	Dependent variable (evacuation efficiency)	Spearman's ρ	p
H1	Evacuation route planning	Perceived evacuation time	0.42	<0.001
H2	Communication efficiency among law enforcement agencies	Evacuation speed	0.46	<0.001
H3	Physical barriers and signage at exits	Organization of participant flow	0.39	<0.001
H5	Use of modern technologies	Prevention of traffic jams	0.44	<0.001
H6	Logistical factors (lighting, alternative routes)	Evacuation speed	0.41	<0.001

Source: The authors' own research

The results of the Spearman correlation analysis indicate the existence of positive, statistically significant relationships between the analyzed operational factors and the efficiency of the crowd defluidization process.

In the case of H1, proper planning of evacuation routes shows a moderate correlation with a reduction in evacuation time ($\rho \approx 0.42$), suggesting that clear organization of traffic flows contributes to faster and more controlled evacuations.

For H2, the effectiveness of communication between law enforcement agencies is associated with a significant increase in evacuation speed ($\rho \approx 0.46$), confirming the central role of operational coordination in crowd management. This relationship underscores the importance of real-time communication mechanisms for rapid adaptation to crowd dynamics.

The analysis regarding H3 shows that the appropriate placement of physical barriers and the clarity of exit signage are positively correlated with a more organized flow of participants ($\rho \approx 0.39$). Although the correlation is moderate, it indicates a relevant contribution of physical infrastructure to the control of collective movements.

With regard to H5, the use of modern technologies, such as surveillance cameras and audio announcements, is significantly associated with the prevention of crowding ($\rho \approx 0.44$), suggesting that technological support facilitates the rapid identification of critical areas and the efficient management of crowds.

For H6, logistical factors, including adequate lighting and the availability of alternative routes, show a positive correlation with evacuation speed ($\rho \approx 0.41$), highlighting the importance of physical conditions in supporting an efficient crowd dispersal process.

Overall, the results support the rejection of the corresponding null hypotheses (H0) and confirm the relevance of the operational factors analyzed in optimizing the defluidization process at large public gatherings.

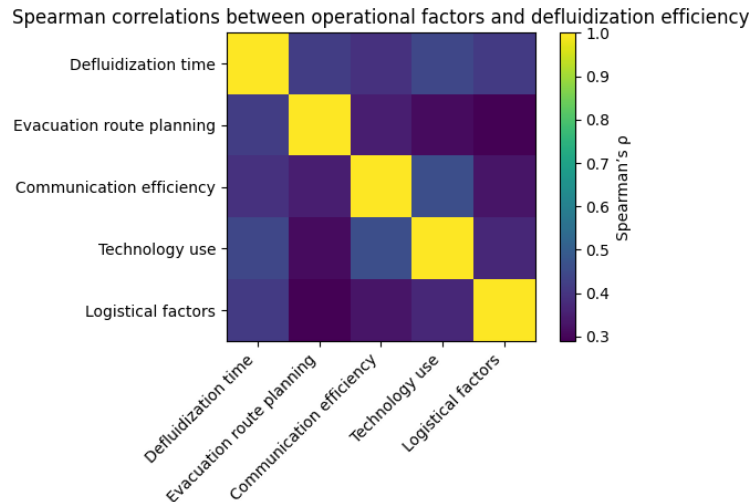


Figure 1. Spearman correlations between operational factors and defluidization efficiency (heatmap of Spearman ρ coefficients)

Figure 1 shows the Spearman correlation matrix between the main operational factors analyzed and the efficiency indicators of the defluidization process. The intensity of the color reflects the strength of the linear relationships between variables, with higher values indicating stronger positive correlations.

From the visual analysis of the Spearman correlation matrix, it is observed the existence of positive relationships, of moderate intensity, between the investigated operational factors and the efficiency of the defluidization process. The strongest association is highlighted between the efficiency of communication and the use of modern technologies, suggesting their complementarity in the efficient management of participant flows.

Furthermore, evacuation route planning and logistical factors show consistent correlations with evacuation time, indicating that well-prepared infrastructure and adequate logistical conditions contribute to faster and more controlled evacuations. The identified relationships support the multidimensional nature of the defluidization process and confirm hypotheses H1, H2, H3, H5 and H6.

Given the ordinal nature of the variables measured using Likert-type scales and the lack of normality in their distributions, non-parametric statistical procedures were employed to compare independent groups. The Mann–Whitney U test was used to examine differences in perceived ability to manage the defluidization process according to the level of operational stress, treating stress as a categorical variable with independent categories. In parallel, the Kruskal–Wallis H test was applied to assess differences in the same outcome variable across multiple categories of professional experience.

For all inferential analyses, the threshold for statistical significance was set at $p < 0.05$. To specifically assess the impact of operational stress on the ability to manage fluid loss, respondents were classified into two distinct groups based on self-reported stress levels, namely a group with low to moderate stress and a group with high stress.

Table 3. Spearman correlations between operational factors and defluidization efficiency

Dependent variable	Group	Median	IQR	U	p
Defluidization management capacity	Low-moderate stress	4	3 - 4	—	< 0.001
	High stress	3	2 - 4		

Source: Authors' own research.

The results of the Mann-Whitney U test indicate a statistically significant difference between the two groups ($p < 0.001$). Respondents reporting a low-moderate level of stress rate their ability to manage defluidization significantly higher compared to those under a high level of stress. This result suggests that operational stress is an inhibitory factor of perceived performance in crowd management.

To assess the influence of professional experience, respondents were grouped according to their years of experience in the field (e.g., <5 years, 5–10 years, 10–15 years, >15 years).

Table 4. Kruskal–Wallis H Test – Professional Experience

Dependent variable	χ^2 (H)	df	p
Ability to manage defluidization	-	-	<0.001

Source: The authors' own research.

The Kruskal-Wallis test highlights the existence of statistically significant differences between the professional experience groups ($p < 0.001$). The analysis of medians indicates an upward trend in the perceived ability to manage defluidization as the level of experience increases, suggesting that repeated exposure to operational situations

The results of the non-parametric tests support the rejection of the null hypothesis (H_0) and confirm hypothesis H_4 , demonstrating that both stress level and professional experience significantly influence the ability of law enforcement officers to effectively manage the de-escalation process at large public gatherings.

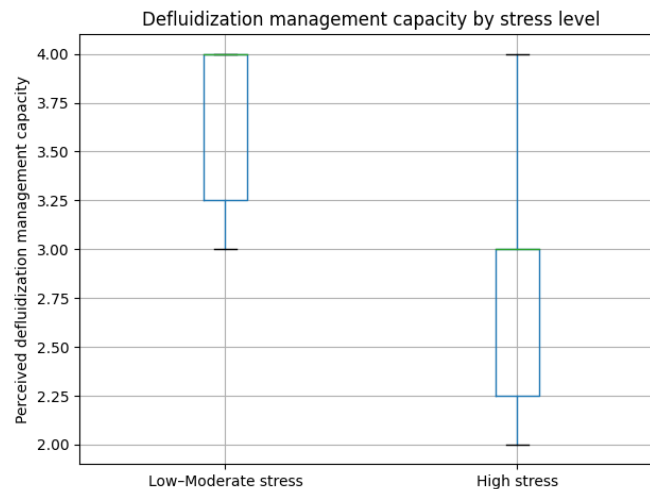


Figure 2. Capacity to manage defluidization depending on stress level

Figure 2 illustrates the distribution of perceived capacity to manage the crowd control process according to the level of operational stress among law enforcement officers. A clear difference is observed between the two categories analyzed. Respondents who reported a low-to-

moderate level of stress exhibit higher median values and a narrower range of responses, indicating a better and more consistent ability to manage crowd control. In contrast, officers facing high levels of stress exhibit lower median values and greater variability in responses, suggesting that operational stress negatively impacts the effectiveness of interventions in crowd dispersal situations.

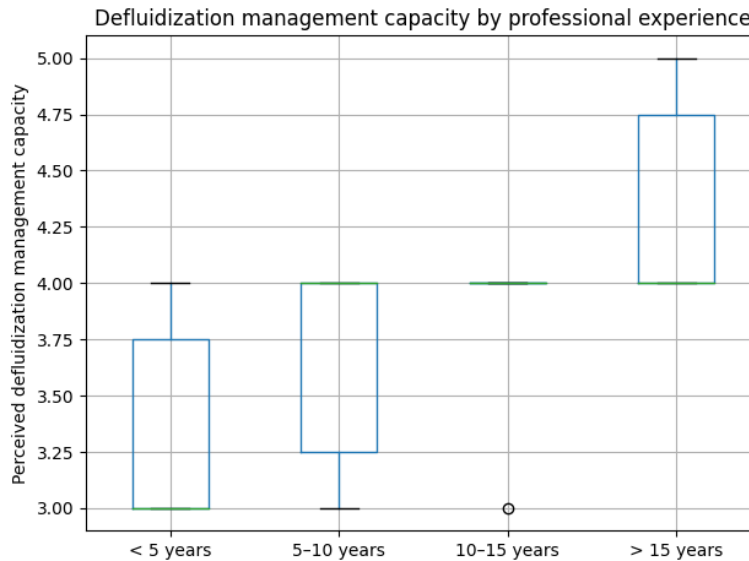


Figure 3. Capacity to manage defluidization according to professional experience

Figure 3 highlights the distribution of perceived ability to manage defluidization in relation to the level of professional experience of the respondents. The graphical analysis shows an upward trend in median values as experience increases, suggesting that prolonged exposure to complex operational situations contributes to the development of the skills necessary for effectively managing crowd dispersal. Respondents with over 15 years of experience exhibit the highest levels of perceived ability, while participants with less than 5 years of experience show lower median values and greater dispersion in their responses, indicating a lower degree of operational confidence.

The results obtained confirm the multidimensional nature of the crowd defluidization process at large public gatherings and support the hypotheses formulated based on the specialized literature. Descriptive and inferential analyses indicate that the efficiency of defluidization is not determined by a single factor, but by the interaction between planning, operational coordination, infrastructure, logistics, technology and the human factor.

The confirmation of Hypothesis H1 highlights the essential role of evacuation route planning in reducing crowd dispersal time. The moderate positive correlations obtained are consistent with studies that emphasize the importance of pre-planning flow patterns and alternative routes to prevent crowding and panic behavior. This result supports the idea that effective crowd dispersal begins before the event starts, through rigorous planning.

Regarding H2, the results confirm that the effectiveness of communication between law enforcement agencies has a significant impact on coordination and speed of evacuation. The identified correlations, as well as the distributions observed in the graphical analyses, indicate that the lack of clear and coherent communication can lead to delays, contradictory decisions and loss

of control over the flows of participants. These findings are consistent with the literature, which emphasizes that communication is a central element of crowd management

Hypothesis H3 is supported by the positive relationships identified between physical barriers, exit signage, and the organization of participant flow. Although the strength of the correlations is moderate, the results indicate that physical infrastructure plays a crucial supporting role in guiding collective behavior, particularly in contexts with high density and low visibility.

The results for H5 confirm the contribution of modern technologies, such as surveillance cameras and audio announcement systems, to preventing congestion and effectively guiding crowds. The correlations observed suggest that technology does not operate in isolation, but rather maximizes its effectiveness when integrated into a well-structured coordination system supported by qualified personnel.

With regard to H6, logistical factors—particularly adequate lighting and the availability of alternative routes—have been shown to have a direct impact on evacuation speed. This finding underscores the importance of physical conditions and urban infrastructure in supporting operational interventions, confirming that effective conflict resolution depends not only on tactical decisions but also on the resources available on the ground.

Finally, the analysis regarding H4 makes an important contribution by highlighting the influence of stress levels and professional experience on the ability to manage traffic congestion. Nonparametric tests and graphical representations indicate that a high level of stress is associated with a decrease in perceived effectiveness, while professional experience acts as a compensatory factor, contributing to better management of complex situations.

The study's results have significant practical implications for the planning and management of public order at large-scale public gatherings.

First, it is necessary to institutionalize the planning of evacuation routes, including testing them through drills and simulations prior to major events. Incorporating alternative routes and constantly updating evacuation plans can significantly reduce the risk of traffic congestion.

Second, the results highlight the importance of developing standardized inter-agency communication mechanisms that enable the rapid and consistent transmission of information during responses. Investments in interoperable communication systems and clear command-and-control procedures are essential for increasing operational efficiency.

The study also emphasizes the need for an integrated approach to physical infrastructure, in which barriers, signage, and lighting are treated as functional elements of the crowd flow management system, not merely as auxiliary measures. Well-designed infrastructure can directly influence crowd behavior and facilitate law enforcement interventions.

Regarding technology, the results suggest that the use of monitoring and communication systems must be correlated with staff training and existing operational procedures. Technology becomes effective only when integrated into a coherent organizational framework and used systematically.

Last but not least, the influence of stress and professional experience indicates the need to implement continuous training programs, which include both technical skills development and operational stress management. Simulations, tactical exercises and post-event evaluations can contribute to increasing the resilience of personnel involved in crowd management.

Conclusion

This study analyzed the factors influencing the efficiency of the crowd control process at large public gatherings, from the perspective of personnel directly involved in public order management. The results confirm that crowd management is a complex process determined by the interaction between operational, organizational, logistical, technological, and human factors.

The statistical analyses conducted support the formulated hypotheses and highlight the central role of evacuation route planning, effective communication among law enforcement agencies, and the use of appropriate infrastructure and technologies in reducing de-escalation time and organizing participant flows. These results confirm the importance of a proactive approach, in which pre-event planning and coordination are essential prerequisites for an effective intervention.

The study also highlights the importance of logistical factors, such as adequate lighting and the availability of alternative routes, which directly influence the speed of evacuation and the ability to prevent congestion. These findings highlight the need to integrate physical conditions and urban infrastructure into crowd management strategies..

A significant contribution of the research is the human factor analysis, highlighting the influence of stress level and professional experience on the ability to manage defluidization. The results show that high operational stress can diminish the effectiveness of interventions, while professional experience acts as a protective factor, contributing to faster decision-making that is better adapted to the operational context.

Overall, the findings of this study confirm the need for an integrated approach to crowd management, combining strategic planning, inter-agency coordination, the use of modern technologies and the continuous development of the skills of the personnel involved. From this perspective, the results obtained provide a solid empirical basis for improving public order management policies and practices at large public gatherings and can contribute to increasing the level of safety of participants and law enforcement officers.

Acknowledgments

During the preparation of this work, the authors utilized ChatGPT 4 to enhance readability and language clarity. Following the use of this tool, the authors meticulously reviewed and revised the content as necessary and assumes full responsibility for the final content of the publication.

References

- Popescu, G. (2020). Statistical methods and holistic approaches. *Romanian Journal of Statistics - Supplement*, 5, 98-115.
- Georgoudas IG, Sirakoulis GC, Andreadis IT (2011) An anticipatory crowd management system that prevents exit congestion during pedestrian evacuation processes *Systems Journal. IEEE* 5:129-141
- Kachroo P, Al-Nasur SJ, Wadoo SA, Shende A (2008) *Pedestrian dynamics: crowd evacuation feedback control*. Springer Science&; Business Media
- Wijermans N, Conrado C, van Steen M, Martella C, Li J (2016) A landscape of support for crowd management: an integrative approach *Safety Science* 86: 142-164
- Ni LM, Zhang D, Souryal MR (2011) RFID-based location and tracking technologies *Wireless Communications. IEEE* 18:45-51
- Osman M, Shaout A (2014) *HajjGuideSystems-Past. Present Future*

- Ratti C, French D, Pulselli RM, Williams S (2025) Mobile landscapes: using location data from mobile phones for urban analysis. *Environmental Plan* 33:727-748
- Schadschneider A, Klingsch W, Klupfel H, Kretz T, Rognsch C, Seyfried A (2011) Evacuation dynamics: empirical results, modeling and applications. In: *Extreme environmental events*. Springer, pp. 517-550
- Sharma A, Raut A, Donde P, Manekar AK (2015) Radio Frequency Based Navigation and Management System for KUMBH. In: *Computational Intelligence and Communication Technology (CICT)*, 2015 IEEE International Conference on, 2015. IEEE, pp. 422-426
- Sirmacek B, Reinartz P (2011) Automated crowd analysis from very high resolution satellite images. In: *Proceedings of the Photogrammetric Image Analysis Conference (PIA11)*. pp. 221-226
- Solmaz G, Turgut D (2015) Pedestrian mobility in the Dezastr theme park. *IEEE Commune Magaz* 53:172-177