

EARLY WARNING SYSTEMS AND HUMANITARIAN LOGISTICS: PERCEPTIONS OF YOUNG PEOPLE IN THE REPUBLIC OF CROATIA

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ABSTRACT¹

In the conditions when crisis situations are becoming increasingly frequent and intense, early warning systems play a crucial role in reducing risk and protecting the people. Therefore, the quality of the messages that are sent via those systems are of grave importance. Special focus needs to be placed on the young population, them being dominant users of digital communication channels who, at the same time, demonstrate specific patterns of perception, trust and response to warnings. The results of the conducted empirical research show that respondents recognize the importance of the early warning system, especially in the context of providing timely information and more effective organization of delivering aid during catastrophic events. However, the perception of their actual effectiveness is moderate, and the most common factors contributing to this are the failure to deliver the messages on time, low level of trust in the system and poor understanding of its functioning by the young people. The results also confirm that timeliness, clarity and sufficient information represent key elements for the effectiveness of the system, but, at the same time, point to the existence of a gap between theoretical assumptions and their practical implementation. It is necessary to further improve the communication aspect of early

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warning systems, with special attention given to the design of the messages to better suit the trends of the young people and to strengthening their informedness, with the aim of increasing the entire society's effectiveness of response and resilience to crises.

Key words: early warning systems, SRUUK, humanitarian logistics.

1. INTRODUCTION

Since catastrophes can happen any time any place, and over the course of the last years we have been witnessing climate changes that lead to a rising number of natural disasters (floods, storms, earthquakes), together with those caused by the human intervention, there is a growing need for developing proper systems for planning, monitoring and early warning. Preventive actions can reduce potential damage, but also contribute to, if a catastrophic event occurs, preventing its effects from developing into a crisis. Humanitarian logistics plays an important role in crisis management as it enables timely and efficient delivery of help to the affected areas.² Early warning systems are crucial for efficient humanitarian activities because they provide timely and targeted reactions that save lives and livelihoods.³ However, their effectiveness is highly dependent on the user perception and behaviour. Early warning systems that have been adequately implemented enable more successful interventions and strengthen cooperation among the risk management institutions.⁴ Furthermore, they enable anticipatory action and better preparedness for crisis situations and catastrophic events.⁵

At the moment when a catastrophe occurs or when it is about to occur, it is a priority to properly and on time inform the citizens about the event. In line with that, young people, as a digitally oriented population, represent a specific group, since their attitudes and reactions can significantly affect the success of the implementation of an early warning system.

The analysis of the young people's attitudes on the functioning of the early warning system during the extreme weather that hit Zagreb County and parts

² Köstepen, Z. N., Selim, H.: Literature Review on Humanitarian Logistics in Disaster Management: A Risk-Oriented Approach. *Sustainability*, 17(21) 2025, pp. 9773.

³ Herteux, J., et al.: Forecasting trends in food security with real time data. *Communications Earth & Environment*, 5(1) 2024, pp. 611. DOI: <https://doi.org/10.1038/s43247-024-01698-9>

⁴ Bompotas, A., et al.: 2022 IEEE 27th International Conference on Emerging Technologies and Factory Automation (ETFA), IEEE Press, 2022, pp. 1-8.

⁵ United Nations Office for Disaster Risk Reduction | World Meteorological Organization Centre of Excellence for Climate and Disaster Resilience: Early Warning Systems and Early Action in Fragile, Conflict-affected and Violent Contexts: Addressing Growing Climate and Disaster Risks, Geneva: United Nations Office for Disaster Risk Reduction, 2024.

of Karlovac County, Primorje-Gorski kotar County and Lika-Senj County on 26 and 27 March 2026 provides an insight into the level of effectiveness of the communication channels, understanding the warning messages and the preparedness to react adequately, which is crucial for the optimization of the future humanitarian logistics activities.

This paper is structured into six chapters. Following the introduction, a literature review on the early warning systems in the Republic of Croatia and broader, across the European Union, is presented. The third chapter explains the methodology and the fourth chapter displays the results of the research. The discussion in the fifth chapter is followed by the conclusion and limitations of the conducted research in the final chapter.

2. LITERATURE REVIEW

Early warning systems are developed to save and protect lives, livelihoods and the environment. In the European Union, there are different authorities that are responsible for the early warning systems, and there are different systems developed across the EU. Specialized early warning systems across at the level of the European Union function as supporting systems for the national early warning systems.⁶

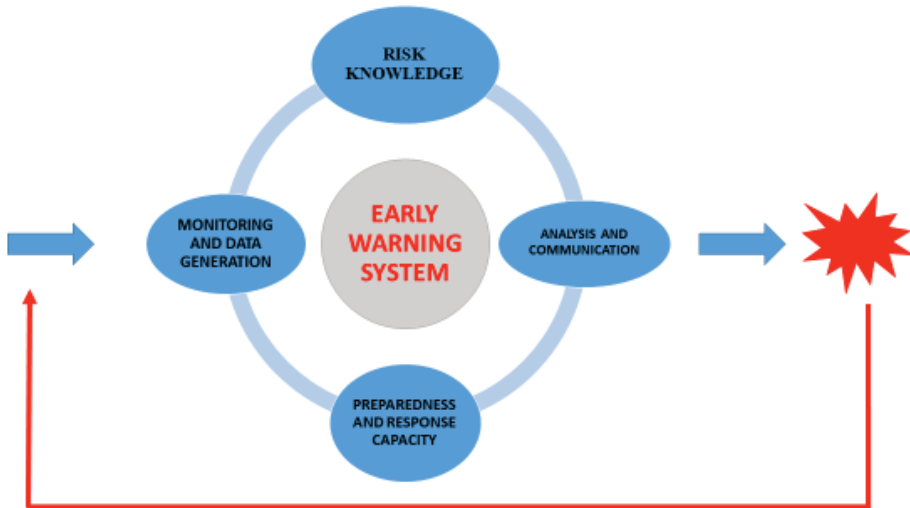
2.1. EARLY WARNING SYSTEMS IN THE REPUBLIC OF CROATIA

The concept of early warning system encompasses a huge number of people involved in the processes of discovering the threat to the actions that are to be undertaken to mitigate its consequences. Picture 1 shows how, before a catastrophic event even occurs, early warning implies planning and preparations for the phases of prevention and preparedness. Then, after the event has occurred, the early warning system provides a scope of activities aimed at direct protection of life, goods and the environment to save lives and mitigate damage. Different threats can develop at different speed. Therefore, it is crucial that early warning systems adequately recognize the imminent danger and ensures that the endangered people and the authorities receive the warning and act accordingly.⁷

⁶ European Commission: European Early Warning and Information Systems, <https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/european-early-warning-and-information-systems_en>, last accessed on 20/02/2026.

⁷ Republika Hrvatska Ministarstvo unutarnjih poslova. Ravnateljstvo civilne zaštite: Kakve sustave ranog upozoravanja koristimo.

Picture 1. Early warning system



Source: authors adjusted according to data from Republika Hrvatska Ministarstvo unutarnjih poslova. Ravnateljstvo civilne zaštite: Kakve sustave ranog upozoravanja koristimo.

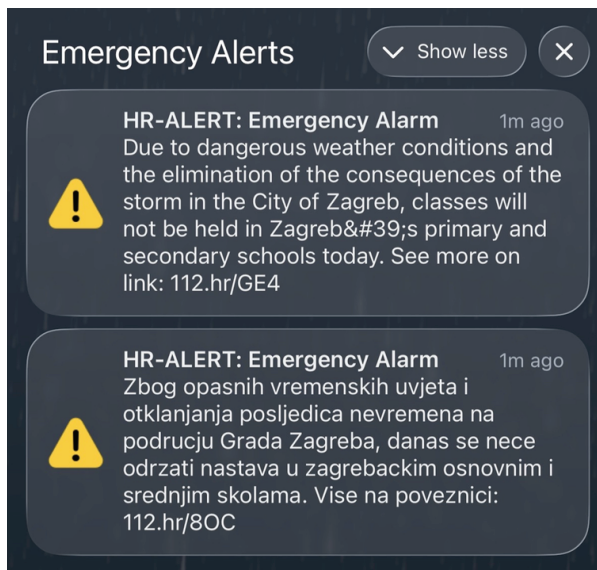
In the Republic of Croatia, authorities have several warning tools at their disposal. If an imminent danger is detected, sirens, public address systems, electronic media and mobile messages are used for public alerts. Sirens are used to broadcast warning signals that are prescribed and taught in schools and through other forms of education (different signals for different threats). Public communication is key when it comes to effective protection and avoiding general panic. Timely information should be given to the public via public address systems, electronic media and mobile messages immediately after the siren signals. The siren signals warn about immediate and impending danger, and there are also signals indicating the end of danger. On the first Saturday of every month at noon, the functioning of sirens used as a crucial part of the warning system in the Republic of Croatia is checked by sounding the “end of danger” signal. This practice aims at ensuring proper operation of the system and coordination with electronic media.⁸

It is important to point out that, together with the above-mentioned protocols, since August 2023, the authorities in the Republic of Croatia have been using The Early Warning and Crisis Management System – SRUUK. This system

⁸ e-Citizens Information and Services. Warning signals, <<https://gov.hr/en/warning-signals/1640>>, last accessed on 21/02/2026.

is a unique tool that contributes to the overall response capability and increases the capacity of the crisis management in the Republic of Croatia through elevating the level of preparedness of the Ministry of the Interior, being the central authority in the national crisis management system, for the prevention and timely and adequate responses to crises or disasters brought about either by natural causes or technical, technological or human error. SRUUK is a system that sends the citizens of the Republic of Croatia and its visitors a warning message on their mobile phones in case of an emergency event in that area that represent potential danger to the lives and health of people, material resources or the environment. These events may include natural disasters and catastrophes, big accidents, epidemics or other types of crises. The message contains the information about the occurring or expected event and, depending on the type of the threat, the measures that should be urgently taken to minimize possible negative consequences.⁹ The implementation of this system has contributed to the improvement of two strategic areas: reduction of risk from catastrophic events and better preparedness of the crisis management.

Picture 2. Emergency alert message on 27 March 2026 sent on mobile phones in Zagreb County



Source: index.hr: Zagrepčanima stigao ALERT na mobitele, 27.03.2026.

⁹ Ministarstvo unutarnjih poslova. Ravnateljstvo civilne zaštite: SRUUK – Sustav za rano upozoravanje i upravljanje krizama, <<https://civilna-zastita.gov.hr/sruuk-sustav-za-rano-upozoravanje-i-upravljanje-krizama/7097>>, last accessed on 21/02/2026.

It is via the SRUUK system that the people with a compatible mobile devices in Karlovac County, Primorje-Gorski kotar County (with the exception of the islands) and Lika-Senj County received a message on their mobile phones in the early morning of 26 March 2026 warning them to be prepared for dangerous weather conditions.¹⁰ The message was issued by the State Civil Protection Directorate based on the warning from the Croatian Meteorological and Hydrological Service. The people of Zagreb County received a message on their phones via the SRUUK system on 27 March 2026 informing them that due to dangerous weather conditions and mitigation of the consequences of such weather, primary and secondary schools were closed, as can be read in Picture 2.¹¹

2.2. EARLY WARNING SYSTEMS IN THE EUROPEAN UNION

The previous section focused on the early warning systems in the Republic of Croatia, which represents the analysis of the systems at the national level. This section focuses on the early warning systems at the European Union level. In time of crises, effective measures need to be taken to prevent such events to develop into large-scale catastrophes. One of the key elements of proper response is warning the public about the danger and providing information about the actions that can help avoid or reduce the effects of such an event. Traditional means of communication, like sirens and broadcasting on television or radio are often not informative enough and not available on time and they often fail to properly inform even about smaller incidents. For that reason, various projects (“Chorist” and “EU-Alert”) have been developed with the aim of finding a more effective informing system. One of the solutions lies in the Cell Broadcast (CB) mobile technology with the following characteristics¹²:

- it uses the existing mobile communication infrastructure;
- messages are received on the mobile devices that users always keep at hand;
- it enables the entire population to receive a warning within minutes;
- it does not slow down the network and it functions even when the network is congested, as in times of crises.

¹⁰ Index Vijesti: Upozorenje za tri županije: Ne idite na put, stiže mećava i olujni vjetar, 26.03.2027.

¹¹ Salvia, V.: Poruka da danas nema škole kasnila je više od sat vremena. MUP: Zagreb nam nije javio, 27.03.2026.

¹² RTP NT Service: Mass Alert – Public Alerting Dissemination Solution, n.d.

Croatian SRUUK system supports sending messages via the CB, but also via conventional SMS that everybody can receive. However, telecommunication service providers have systems that are not designed to support the sending of a large number of SMSs at once. For that reason, sending SMSs in this case takes longer.¹³ In times of crises, the availability of detailed information contributes to safety and protection of the citizens of the European Union. Early warning and informing systems in the European Union help the Emergency Response Coordination Centre (ERCC) to monitor the global situations that include tropical cyclones, forest fires, tsunamis and earthquakes.¹⁴

Table 1. Components of the Copernicus Emergency Management Service

COMPONENT	DESCRIPTION
EARLY WARNING AND MONITORING	This component provides global geospatial information through continuous monitoring and forecasting of droughts, floods, and forest fires. Systems such as EDO/GDO (drought), EFAS/Glo-FAS (floods) and EFFIS (forest fires) operate as near real-time monitoring, and they support and complement national systems.
ON-DEMAND MAPPING	This component provides mapping products for natural and man-made disasters and humanitarian crises worldwide, supporting all phases of disaster management—from preparedness to response and recovery. The service is activated by authorised users, typically civil protection authorities, for risk assessment, rapid impact analysis and recovery planning.
EXPOSURE MAPPING	This component helps in assessing risk to settlements and population using the Global Human Settlements Layer (GHSL), based on satellite and census data. It supports mapping, early warning and monitoring to determine risk areas, and urbanisation training endorsed by the European Commission and the United Nations.

Source: authors compiled according to data from the Copernicus: About us.

At the European Union level, many early warning systems have been developed that are mostly part of the Copernicus Emergency Management Service (CEMS). The Copernicus Emergency Management Service provides timely

¹³ Ministarstvo unutarnjih poslova: Sustav za rano upozoravanje i upravljanje krizama (SRUK) <<https://mup.gov.hr/UserDocsImages/2023/8/SRUUK%20dodatno.pdf>>, last accessed on 23/02/2026.

¹⁴ European Commission: European Early Warning and Information Systems, <https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/european-early-warning-and-information-systems_en>, last accessed on 20/02/2026.

and accurate geospatial information to support decision-making in emergency response and disaster risk management for natural and man-made disasters. Its components are presented in Table 1. Based on their description, it can be concluded that through its components, the Copernicus offers a complete, data-based approach to crisis management, encompassing the phases of prevention, readiness, response and recovery.

The three best known early warning systems in the EU are: the European Flood Awareness System, the European Forest Fire Information System and the European Drought Observatory.¹⁵ The European Flood Awareness System and Global Flood Awareness System are systems that can detect possible future flooding up to 10 days ahead. They provide preventive and protective measures for flood events, especially in large transnational river basins. The European Forest Fire Information System and Global Wildfire Information System have the same time span of 10 days for forecasting dangerous weather conditions and they provide near real-time information on active fires and burnt areas. These systems aim at analysing risk of forest fires and their threat to the local population and the environment which enables authorities to make informed decisions on the deployment of the rescEU resources. The European and Global Drought Observatories give information on potential and ongoing droughts, including meteorological indicators, soil moisture anomalies, vegetation stress and river low flows.¹⁶

It is important to include here the Galileo Emergency Warning Satellite Service (EWSS): a system of 30 Galileo satellites and ground stations that provide geographic positioning information. Through Galileo EWSS, as of 2026, Member States will be able to broadcast alert messages to population when local Civil Protection authorities deem necessary.¹⁷ This service has a valuable role in terms of humanitarian logistics as well, since timely and geographically precise warnings enable faster mobilization of resources and a more effective coordination of the supply chains in the early phases of crises. This can facilitate the planning of the distribution of the humanitarian aid and reduce delays in delivery of necessary goods to the affected population.

¹⁵ European Commission: European Early Warning and Information Systems, <https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/european-early-warning-and-information-systems_en>, last accessed on 20/02/2026.

¹⁶ European Commission: European Early Warning and Information Systems, <https://civil-protection-humanitarian-aid.ec.europa.eu/what/civil-protection/european-early-warning-and-information-systems_en>, last accessed on 20/02/2026.

¹⁷ European GNSS Service Centre. (2023). *Galileo Open Service – Service Definition Document (OS SDD)*, Luxembourg: Publications Office of the European Union, 2023.

The above-mentioned strategies of the European Union lead to the conclusion that the EU aims at developing smart, coordinated and proactive systems of early warning that need to provide timely response, minimize the consequences and improve the security of the people.

3. RESEARCH METHODOLOGY

The empirical research was conducted with the aim of achieving the goal of this paper. It was carried out immediately after the severe weather that hit Croatia, especially Zagreb County, on 26 and 27 March 2026. The primary goal was to establish the attitudes young people have towards the quality of the early warning and crisis management system (SRUUK) that was used during the severe weather on 26 and 27 March 2026. The system was implemented by the Ministry of the Interior. The Ministry had created the technical preconditions for the systems back in September 2022 and it was tested in June 2023. It is important to note that the warning message is sent only via mobile devices, no matter whether the user is a resident or a visitor. The system registers and notifies all those present in the area of the imminent danger.¹⁸

The questionnaire had been created in Google Forms, with a list of statements used in previous research on similar topics¹⁹ and distributed via email (and social networks: WhatsApp and Facebook; student communication channels), targeting primarily the population of students in the Republic of Croatia. The purpose of the research was explained in the introductory part of the questionnaire. The second part focused on the demographic characteristics of the respondents and contained four questions (gender, age, education and employment status).

The perception of timeliness and clarity was investigated in the third part of the questionnaire through three statements where respondents expressed the

¹⁸ Ministarstvo unutarnjih poslova: Sustav za rano upozoravanje i upravljanje krizama (SRUUK) <<https://mup.gov.hr/UserDocsImages/2023/8/SRUUK%20dodatno.pdf>>, last accessed on 23/02/2026.

¹⁹ Raphela, T. D., Ekeke, N.: Resilience and the dissemination of flood disaster early warning messages in a township in South Africa. *Frontiers in Communication*, 10 2025, pp. 1503016; Aboque, C. B.: Enhancing Disaster Preparedness: Evaluating the Efficiency of Weather Advisories in Legazpi City. *International Journal of Research and Scientific Innovation*, XIII(1) 2026, pp. 2441-2450; Mokhele, M. O., Mvanyashe, A.: The role of language as a catalyst in communicating early warning messages: a case study in Walmer Airport Valley informal settlement, Gqeberha, South Africa. *International Journal of Disaster Risk Reduction*, 126(August) 2025, pp. 105573; Pariyar, B., Kimanthi, L. N.: Short text emergency warnings in high-risk settings: Behavioural and representational insights from the British high commission (BHC) in Nairobi, Kenya. *Progress in Disaster Science*, 29(January) 2026, pp. 100539.

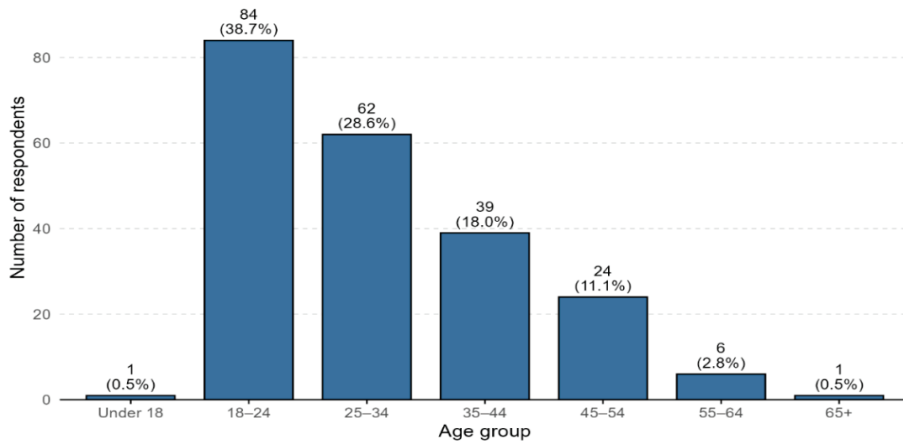
level of agreement on a Likert scale (1 = completely disagree, 5 = completely agree). The fourth section of the questionnaire was directed at the trust and channels of communication, response and behaviour, investigated through six statements with a Likert scale like in the previous section. The Likert scale was used in the fifth section of the questionnaire as well, to assess the link between early warning and humanitarian logistics through five statements. The final part of the questionnaire offered respondents an opportunity to comment, make suggestions or write about their experiences relating to the early warning system.

4. RESEARCH RESULTS

4.1. SAMPLE CHARACTERISTICS

The questionnaire was circulated online, and it collected 217 valid responses. Respondents were predominantly women (61.3%), mostly younger adults: 38.7% of respondents were aged 18–24, 28.6% were aged 25–34, and 18.0% were aged 35–44, while 14.4% of the sample belonged to the older age groups (Graph 1).

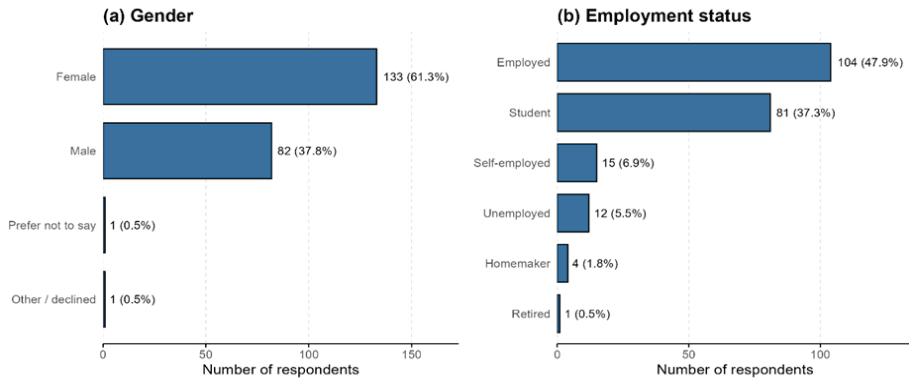
Graph 1. Age structure of respondents



Source: authors' calculation

Regarding the employment status of respondents, 47.9% were employed, 37.3% were students, 6.9% were self-employed, 5.5% were unemployed, 1.8% declared being homemakers and 0.5% retired (Graph 2).

Graph 2. Gender distribution and employment status of respondents



Source: authors' calculation

38.2% of respondents have a high school degree, while 61.8% had completed some level of higher education.

4.2. RELIABILITY OF MEASURES

The Likert scale that measured the level of agreement or disagreement with the 14 statements in the questionnaire showed high overall internal consistency (Cronbach's $\alpha = 0.89$). The reliability for the timeliness-and-clarity scale ($\alpha = 0.81$, $k = 3$) and for the trust-and-behaviour scale ($\alpha = 0.84$, $k = 6$) was good, while the early-warning-and-humanitarian-logistics scale showed acceptable reliability ($\alpha = 0.66$, $k = 5$). The heterogeneity of the statements composing the questionnaire, ranging from agreement with abstract principles of the EWS effectiveness to media-channel preferences and overall satisfaction, is reflected in the lower value.

4.3. ITEM- AND SUBSCALE-LEVEL FINDINGS

Table 2 presents the means, standard deviations and the proportion of agreement (scores of 4 or 5 on the 5-point Likert scale) and disagreement (scores of 1 or 2) for each of the 14 statements. 84.3% of respondents agreed that a timely alert can reduce the need for emergency interventions (Q10; $M = 4.41$, $SD = 0.93$) and 84.8% agreed that the EWS contributes to a more efficient organisation of aid in crisis situations (Q11; $M = 4.40$, $SD = 0.96$). The majority of respondents (80.6%) agreed to using digital channels for alerts more than traditional media (Q13; $M = 4.30$, $SD = 0.99$). This shows that respondents demonstrated the highest levels of agreement with the principle-level statements.

However, the evaluation of the actual functioning of the SRUUK system during the March 2026 storm offered a different picture. Only 45.6% of respondents agreed that they had received the alert in time (Q1; M = 3.21, SD = 1.44) and only 45.6% expressed trust in the system as a source of information (Q4; M = 3.29, SD = 1.20). 47.9% agreed, 31.8% were neutral and 20.3% expressed their disagreement (Q14; M = 3.38, SD = 1.18) when they were asked to express their level of agreement with the functioning of the EWS during the storm.

The statement that received the most negative evaluation was related to the level of informedness. Only 40.6% of respondents agreed that young people in Croatia are sufficiently informed about the functioning of the EWS (Q12; M = 3.24, SD = 1.26).

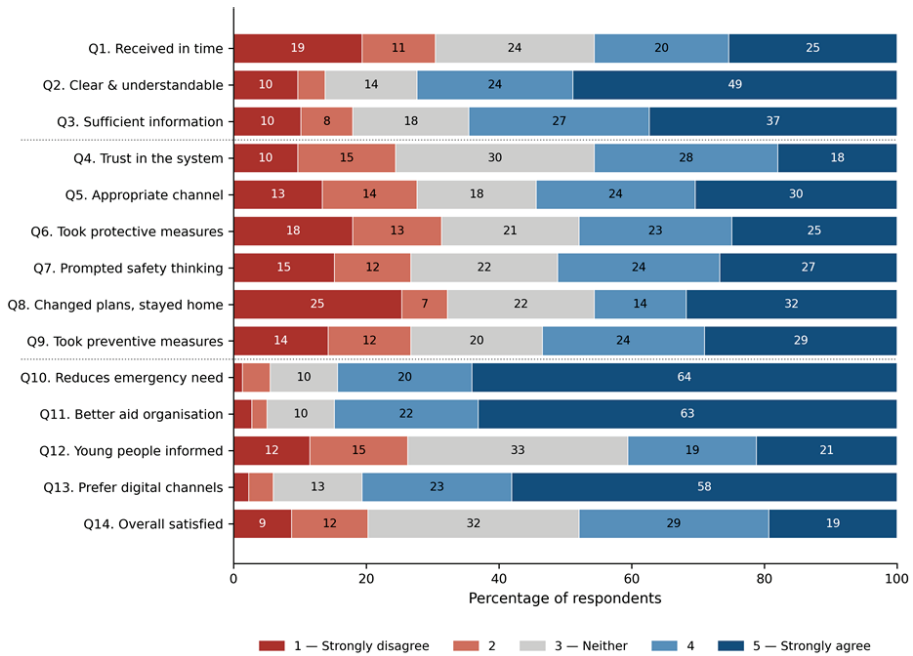
Table 2. Item-level descriptive statistics (n = 217)

Item	Statement	M	SD	% agree (4 + 5)	% disagree (1 + 2)
Q1	I received the SRUUK alert in time	3.21	1.44	45.6	30.4
Q2	The content of the alert was clear and understandable	3.98	1.29	72.4	13.8
Q3	The alert contained sufficient information for action	3.74	1.31	64.5	18.0
Q4	I trust the EWS used in Croatia as an information source	3.29	1.20	45.6	24.4
Q5	The way I received the alert (SMS, media) was appropriate	3.44	1.40	54.4	27.6
Q6	After receiving the alert I took certain protective measures	3.24	1.43	47.9	31.3
Q7	The alert prompted me to think about my own safety	3.36	1.38	51.2	26.7
Q8	I changed my plans and stayed home after the alert	3.20	1.57	45.6	32.3
Q9	I took preventive measures to better protect myself / my property	3.41	1.39	53.5	26.7
Q10	A timely alert can reduce the need for emergency interventions	4.41	0.93	84.3	5.5
Q11	EWS contributes to more efficient organisation of aid in crises	4.40	0.96	84.8	5.1
Q12	Young people in Croatia are sufficiently informed about EWS	3.24	1.26	40.6	26.3
Q13	I use digital channels more than traditional media for alerts	4.30	0.99	80.6	6.0
Q14	Overall I am satisfied with EWS during the recent storm	3.38	1.18	47.9	20.3

Source: authors' calculation. Likert scale: 1 = strongly disagree, 5 = strongly agree.

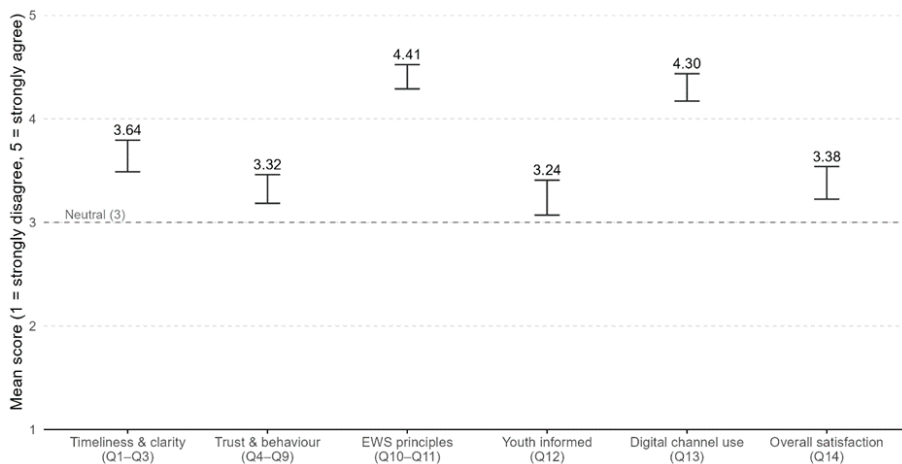
The timeliness-and-clarity index reached a mean of 3.64 (SD = 1.15), the trust-and-behaviour index a mean of 3.32 (SD = 1.04), and the early-warning principles index (Q10–Q11) a mean of 4.41 (SD = 0.88). Graph 3 shows the distribution of responses across the 14 statements measured with a Likert scale. The comparison of the principles is presented in Graph 4: respondents supported the principles of the EWS strongly; however, they expected more from the operational aspect of the SRUUK system during this specific event.

Graph 3. Response distribution across the 14 Likert items (n = 217)



Source: authors' calculation

Graph 4. Subscale means with 95% confidence intervals



Source: authors' calculation

4.4. INFERENCE ANALYSIS: LINEAR REGRESSION AND MODERATION

A simple linear regression with the timeliness-and-clarity composite (mean of Q1-Q3) as the predictor and Q14 as the outcome was used to test whether the perceived timeliness and clarity of the SRUUK system is in connection with overall satisfaction with the EWS during the recent storm. The relationship was strong and highly significant: $\beta_1 = 0.709$ (SE = 0.051), $t(215) = 13.99$, $p < .001$, with the predictor explaining 47.7% of the variance in satisfaction ($R^2 = 0.477$).

A multiple linear regression with mean-centred predictors was used to determine whether trust in the system moderates the effect of timeliness and clarity on the overall satisfaction of respondents: satisfaction (Q14) was regressed on the timeliness-and-clarity composite, on trust (Q4), and on the interaction term timeliness \times trust. The full model accounted for 60.6% of the variance in satisfaction ($R^2 = 0.606$, adjusted $R^2 = 0.600$; $F(3, 213) = 109.17$, $p < .001$). Both main effects were statistically significant: timeliness-and-clarity $\beta = 0.435$ (SE = 0.061, $t = 7.15$, $p < .001$) and trust $\beta = 0.453$ (SE = 0.055, $t = 8.27$, $p < .001$), which indicated that each effect contributed independently to satisfaction. On the other hand, the interaction term was not statistically significant ($\beta = 0.052$, $t = 1.46$, $p = .147$), indicating that trust and perceived timeliness/clarity do not show interactive effects on overall satisfaction with the EWS, but rather simply add to it.

These results point to the conclusion that operational improvements that increase the perceived timeliness and clarity of warning messages, and the efforts exerted by the authorities to make institutional improvements that build public trust, are independently effective tools for raising user satisfaction with the SRUUK system. This means that each tool is independent and they do not function as a means of compensating for weakness of the other.

4.5. QUALITATIVE REMARKS FROM OPEN-ENDED RESPONSES

Out of 217 respondents that completed the questionnaire, forty-three respondents provided open-ended comments where they expressed their opinions and attitudes towards the elements of the SRUUK system. The comments support the quantitative findings.

Respondents gave the greatest number of negative comments to delayed delivery. They claimed that the SRUUK message arrived after the storm had already begun and they already left their homes. Some stated that they had already received the information about the severe weather conditions through digital news media before the official alert reached their phones. Additionally, a relevant number of respondents reported they had not received the message on their mobile devices at all, even though they were in the area. Furthermore, the content of the message was criticized because it focused on the cancellation of school classes rather than providing information about the dangerous weather or giving instructions what protective measures to take. The geographical coverage of the system was also commented: respondents in regions adjacent to the City of Zagreb (e.g. Hrvatsko Zagorje) report their areas experiencing similar weather conditions but not receiving the warning message. These findings are in line with the comparatively low ratings given to the timeliness statement (Q1) and the trust statement (Q4). They also support the international evidence reviewed in Section 2 that show how delays, ambiguous and insufficient content and channel mismatch undermine the effectiveness of the EWS. Authorities have the obligation to develop policies and procedures of disaster preparedness planning in different languages so they can be understood by everyone, including linguistic minorities.²⁰

The findings of the research presented above clearly indicate that the timeliness, clarity and comprehensibility of alert messages are crucial for an effective early warning system. One other determinant that can be added to the

²⁰ Mokhele, M. O., Mvanyashe, A.: The role of language as a catalyst in communicating early warning messages: a case study in Walmer Airport Valley informal settlement, Gqeberha, South Africa. *International Journal of Disaster Risk Reduction*, 126(August) 2025, pp. 105573.

equation is the sufficiency of information, because too little or too much information can cause confusion and misunderstandings. This research supports other similar studies that show how clear and informative messages increase user trust and encourage a timely response, whereas a lack of clarity or information leads to confusion, reduced preparedness and failure to properly follow the established instructions.

5. DISCUSSION

The results of the previously conducted empirical researches (Aboque, 2026²¹; Wang et al., 2026²²; Ghose et al., 2023²³, Raphela and Ekeke, 2025²⁴) consistently show that sending a warning message on time represents one of the key determinants of user satisfaction with the early warning system. Messages received at the right moment develop the trust in the system, contribute to a timely response and they are perceived as the indicators of precision and quality²⁵. On the other hand, delayed messages reduce their effectiveness, together with user satisfaction. Delayed responses caused by inconsistent or held-back information, unpreparedness and slow reactions reduce public trust, create confusion and disable proper following of instructions.²⁶ Raphela and Ekeke point out that even warnings that are issued on time are not necessarily effective, depending on the content of the message being clear enough and the trust the receiving party has in the sender. The case is that some rely more on the information given by the neighbour and spoken messages and give more trust to their local radio and shared social networks.²⁷

²¹ Aboque, C. B.: Enhancing Disaster Preparedness: Evaluating the Efficiency of Weather Advisories in Legazpi City. *International Journal of Research and Scientific Innovation*, XIII(1) 2026, pp. 2441-2450.

²² Wang, H., et al.: Leveraging LLMs and Social Media to Understand User Perception of Smartphone-Based Earthquake Early Warnings. *arXiv*, preprint 2026.

²³ Ghose, A., et al.: Leveraging the digital tracing alert in virus fight: The impact of COVID-19 cell broadcast on population movement. *Information Systems Research*, 35(2) 2024, pp. 570-589.

²⁴ Raphela, T. D., Ekeke, N.: Resilience and the dissemination of flood disaster early warning messages in a township in South Africa, *Frontiers in Communication*, 10 2025, pp. 1503016.

²⁵ Aboque, C. B.: Enhancing Disaster Preparedness: Evaluating the Efficiency of Weather Advisories in Legazpi City. *International Journal of Research and Scientific Innovation*, XIII(1) 2026, pp. 2441-2450.

²⁶ Sacyaten, C. S.: Crisis Communication in Times of Disasters: Public Perceptions on the Timeliness and Clarity of Safety Announcements: A Systematic Literature Review. *International Journal of Disaster Risk Management*, 7(2) 2025, pp. 193-208.

²⁷ Raphela, T. D., Ekeke, N.: Resilience and the dissemination of flood disaster early warning messages in a township in South Africa. *Frontiers in Communication*, 10 2025, pp. 1503016.

It is important that the messages sent by the early warning system are sufficiently clear because that improves safety.²⁸ Since users often read messages quickly, they need to be simple and clear to ensure proper understanding. The effectiveness of short messages sent via the early warning system depends on their clarity, comprehension and sufficiency of the information. The differences in the interpretation among the users can significantly affect their response. The results of a research study in South Africa show that limited availability and ambiguity of the early warning system messages can have negative effects on the preparedness of the people, which in turn complicates the planning and implementation of humanitarian logistics and reduces the effectiveness of the aid distribution in times of crises.²⁹ Ghose et al. established that warnings sent via early warning systems encourage people to leave the affected areas or the area under threat.³⁰ The effectiveness of the early warning system messages depends on clearly defined key elements (location, response instructions and urgency) that enable faster and more precise decision-making. This leads to direct improvement of the planning and coordination of humanitarian logistics in crisis situations.³¹

Messages sent in the early phase of a threat are extremely effective, while sending too many messages can have an opposite effect (it may happen that the users ignore them).³² Warning messages have had stronger impact on the younger people and the male respondents.³³ Effective strategies for the development of early warning systems rely on the use of dominant languages, interpersonal communication, clarity and timely messages. People in general

²⁸ Sacyaten, C. S.: Crisis Communication in Times of Disasters: Public Perceptions on the Timeliness and Clarity of Safety Announcements: A Systematic Literature Review. *International Journal of Disaster Risk Management*, 7(2) 2025, pp. 193-208.

²⁹ Mokhele, M. O., Mvanyashe, A.: The role of language as a catalyst in communicating early warning messages: a case study in Walmer Airport Valley informal settlement, Gqeberha, South Africa. *International Journal of Disaster Risk Reduction*, 126(August) 2025, pp. 105573.

³⁰ Ghose, A., et al.: Leveraging the digital tracing alert in virus fight: The impact of COVID-19 cell broadcast on population movement. *Information Systems Research*, 35(2) 2024, pp. 570-589.

³¹ Pariyar, B., Kimanthi, L. N.: Short text emergency warnings in high-risk settings: Behavioural and representational insights from the British high commission (BHC) in Nairobi, Kenya. *Progress in Disaster Science*, 29(January) 2026, pp. 100539.

³² Ghose, A., et al.: Leveraging the digital tracing alert in virus fight: The impact of COVID-19 cell broadcast on population movement. *Information Systems Research*, 35(2) 2024, pp. 570-589.

³³ Ghose, A., et al.: Leveraging the digital tracing alert in virus fight: The impact of COVID-19 cell broadcast on population movement. *Information Systems Research*, 35(2) 2024, pp. 570-589.

show a high level of trust in local radio stations and social media, like Twitter, as the type of information source that help the population in high-risk areas to initiate adequate and necessary measures.³⁴

The effectiveness of early warning systems depends on timely, comprehensive and reliable communication that includes local and informal networks, where the quality of the dissemination directly affects the community's resilience.³⁵ The implementation of multidimensional strategies of crisis communication, with the focus on timeliness and clarity of information, boosting the public trust and adjusting means and manners of communication to the needs of the community represent some of the ways to achieve successful crisis management.³⁶ Governments and humanitarian organizations have to shape policies that ensure multilingual communication and include linguistic minorities in the planning of crisis protocols.³⁷

While earlier research efforts in this field accentuate a positive effect of timely and clear messages on user trust and response, the results of this study show that evident shortcomings of timeliness, trust and informedness may significantly limit the actual efficiency of the system. This gap bears direct implications relating to humanitarian logistics, since reduced trust and perception of untimeliness can lead to poor levels of readiness and make delivering aid to the affected areas difficult to organize. Based on the results of the conducted research, but also bearing in mind the results of previous research studies, it can be concluded that timeliness, clarity and comprehension of the messages and sufficient information represent key determinants of the effectiveness of early warning systems. However, as previously pointed out, the results of this research reveal a certain discrepancy between the theoretically recognized importance of those factors and their actual practical application. Clear and informative messages build up user trust and encourage timely response, while poor clarity and lack of information lead to confusion, low preparedness and impede following instructions.

³⁴ Sacyaten, C. S.: Crisis Communication in Times of Disasters: Public Perceptions on the Timeliness and Clarity of Safety Announcements: A Systematic Literature Review. *International Journal of Disaster Risk Management*, 7(2) 2025, pp. 193-208.

³⁵ Raphela, T. D., Ekeke, N.: Resilience and the dissemination of flood disaster early warning messages in a township in South Africa. *Frontiers in Communication*, 10 2025, pp. 1503016.

³⁶ Sacyaten, C. S.: Crisis Communication in Times of Disasters: Public Perceptions on the Timeliness and Clarity of Safety Announcements: A Systematic Literature Review. *International Journal of Disaster Risk Management*, 7(2) 2025, pp. 193-208.

³⁷ Mokhele, M. O., Mvanyashe, A.: The role of language as a catalyst in communicating early warning messages: a case study in Walmer Airport Valley informal settlement, Gqeberha, South Africa. *International Journal of Disaster Risk Reduction*, 126(August) 2025, pp. 105573.

6. CONCLUSION

Messages sent via the early warning system in crisis situations represent a key link between technology and public behaviour. However, the effectiveness of the early warning system messages does not simply depend on their timeliness, but also on the clarity, comprehension and sufficient information that together enable quick and wise decision-making. Therefore, the quality of communication directly affects the process and success of humanitarian logistics, since timely response and adequately informed population reduce chaos, enable better organization of evacuation activities and, ultimately, facilitate the planning and distribution of humanitarian aid.

Considering that younger population are regarded as being primary users of digital communication channels, but at the same time, display different levels of trust and engagement, the focus of the primary research was placed on the population of students in the Republic of Croatia. The adjustment of the messages to their communication habits, along with keeping the clarity and relevant content, can significantly contribute to a more effective response to crisis situations. An integrated approach that connects the technological possibilities of the early warning system, composition of clear messages and understanding the needs of different social groups, including the young, represents the grounds for boosting social resilience and improving the effectiveness of humanitarian logistics.

The perceived discrepancies between the theoretical and empirical findings point to the fact that further studies should be conducted aiming at analysing the actual implementation of early warning systems, with special attention to user perception, efficiency of communication channels and customization of the messages to different target groups, especially the young.

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