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From alert to action: Social latency of citizen response to Cell Broadcast warnings during the ES-Alert drill in Gran Canaria (Spain)

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A B S T R A C T

Public alert systems based on Cell Broadcast technology are essential tools in emergency management, but their effectiveness depends not only on the technical speed in transmitting the message to the devices (technical latency) but also the time it takes for citizens to execute the recommended self-protection actions after receiving the messages (social latency). Cell broadcast is closely related to the so-called windows of opportunity, which are key factors in risk management. This study presents a pioneering evaluation of social latency in Spain during the ES-Alert drill conducted in September 2024 on the island of Gran Canaria (Spain), with a participation that exceeded 50,000 people. Through the analysis of timestamps associated with access to a digital survey sent with the alert, the citizen reaction times were determined. The results show that more than 70 % of the participants reacted in less than 10 min, with a median response time of 1 min and 12 s. Significantly faster responses were observed in urban and tourist municipalities compared to rural areas with lower technological penetration. Additionally, the system was positively rated by 91.4 % of the participants. Limitations include a ~6 % response rate and the absence of device-level geocoordinates; location was self-reported at the municipality level only. The study highlights the importance of including social latency as a key metric in the evaluation of early warning systems, especially in insular and tourist contexts, and proposes the use of participatory strategies to improve risk communication and reinforce community resilience.

1. Introduction

Early warning systems (EWSs) play a critical role in disaster risk reduction [1,29]. Thanks to technological advances like Cell Broadcast, authorities can disseminate emergency messages immediately and massively to mobile devices, facilitating risk communication to populations exposed to imminent threats [2,3]. In Spain, this service is implemented through the ES-Alert system, integrated in the National Alert Network (RAN PWS), and has been mandatory since June 2022 in accordance with European Directive 2018/1972 Direccion General de Proteccion Civil y Emergencias. [32].

Cell Broadcast technology is now the global standard for broadcasting emergency alerts due to its ability to reach all users in an

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affected area without congesting networks and without requiring specific applications or prior registration (European Emergency Number Association [4]. In this way, the alert immediately reaches all devices connected to the antennas in the risk area [4]. However, the effectiveness of these systems depends not only on the speed and technical reliability of message delivery (known as technical latency [5]) but also on the time it takes for the population to implement the recommended actions after receiving an alert on their devices. This latter interval, which we call social latency, is a critical element in understanding the operating dynamics of EWSs and is the focus of our research.

Technical latency refers to the time from alert issuance to device reception. Recent WEA/Cell Broadcast evaluations report device-reception times in the order of seconds and robust performance under network load [5]. Work on crisis planning and communication further shows that optimizing delivery alone does not ensure protective action [6]. Technical latency provides context but is not our focus.

Our focus is social latency: the time from alert issuance, through reception on the device, to initiation of the recommended action. We treat it as a human behavior window which encompasses the initial reaction, message appraisal, and any confirmation-seeking. The following subsection reviews related constructs and evidence that inform this definition.

1.1. Conceptual foundations and determinants of human response to warnings

As proposed in this paper, social latency refers to the time interval that elapses between the sending and receipt of an emergency alert (e.g., on a mobile phone) and the actual execution of a self-protective action by the individual. This latency can be broken down for analytical purposes into three successive temporal phases, as follows:

$$LS = Tr + Tl + Tm$$

where *LS* is social latency, Tr is the reaction time before the effective reading of the message (interval between its technical reception and reading), *Tl* is the time spent reading and understanding the message, and *Tm* is the milling time (the time spent searching for additional information before performing the recommended action).

Tr reflects how quickly people notice and attend to the alert. It is shaped by attention capture and device access—salient audio/visual cues, phone proximity, competing tasks or situational constraints (e.g., work, driving)—and by pre-notification. Evidence shows that pre-notification and salient cues shorten orientation time (National Academies, 2018; [7,8]).

Tl reflects how quickly people parse and appraise the message. It depends on message length and structure (short, specific action statements), clarity about the hazard, location, and timing, language match/readability, and perceived credibility. Evidence shows that concise instructions with clear information shorten appraisal time and increase the likelihood of protective action [2,9–12,36].

While the term social latency has not been formally used in previous research, several studies have addressed this phenomenon employing similar terminology such as *protective action initiation time*, *protective action delay* or *behavioral response time* (National Academies of Sciences, [40]; Mileti, 2018; Nakayachi et al., 2023). These concepts coincide in one essential aspect: the human response to an alert is not immediate but is conditioned by cognitive, social, and contextual factors that influence decision making and generate an observable delay between the stimulus received and the action performed. It is this measurable time interval that is analyzed in the present study and which constitutes an original contribution to the study of EWSs.

Social latency is influenced by numerous factors which condition the speed or delay of response. Most notably, these include risk

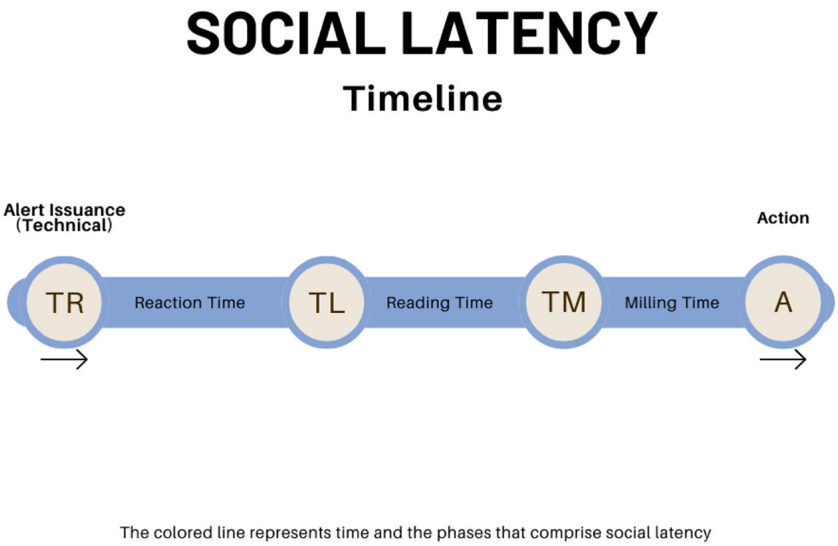

Fig. 1. Timeline of the concept of social latency: from message issuance to user action.
Source: Authors' own elaboration.

perception [11], trust in authorities, message clarity and comprehensibility [9,12], as well as previous experience or preparedness for emergency situations [31]. One of the most important psychological factors impacting social latency is the tendency to underestimate the likelihood and impact of disasters and to maintain an expectation of normality. This tendency, known as normalcy bias, has been extensively described in the literature. Omer and Alon [13] describe early denial and normalization processes after reception of a warning that can prolong the time to adopt self-protective behaviors. Kinateder et al. [14] show, in evacuation experiments/simulations, that people often continue routine activities and delay egress. Korteling et al. [15] synthesize how common cognitive biases degrade rapid decision-making under uncertainty, predicting slower transitions from appraisal to action [39]. Research on Hurricane Sandy (2012) has shown that interaction on social networks can improve situational awareness and partially counteract the inaction resulting from this bias [16,17].

Classic reviews of disaster behavior have described the impact of message appraisal and confirmation-seeking, also known as *milling*, prior to action [18]. Many people tend to verify the veracity of a message with other sources or contacts before acting, which introduces an additional delay in response time. This widely documented behavior [38, Wood et al., 2018), while natural, can reduce the effectiveness of an EWS if it is not accompanied by clear, direct messages capable of inducing immediate action.

Social latency consumes part of the limited so-called window of opportunity in which self-protective *actions remain effective between alert issuance and impact. Measuring* **social latency** *alongside delivery performance indicates whether populations can act in time, especially for fast-onset hazards. This framing motivates our focus on* **social latency** [7,9].

To graphically represent this conceptual sequence of temporal phases, we present a timeline (Fig. 1) that depicts social latency from alert issuance to user action. It is a schematic visualization that conveys the complexity of the pathway from warning to action. The line traces the successive phases analyzed in this study and is intended to clarify the model and highlight critical points that impact the effectiveness of EWSs.

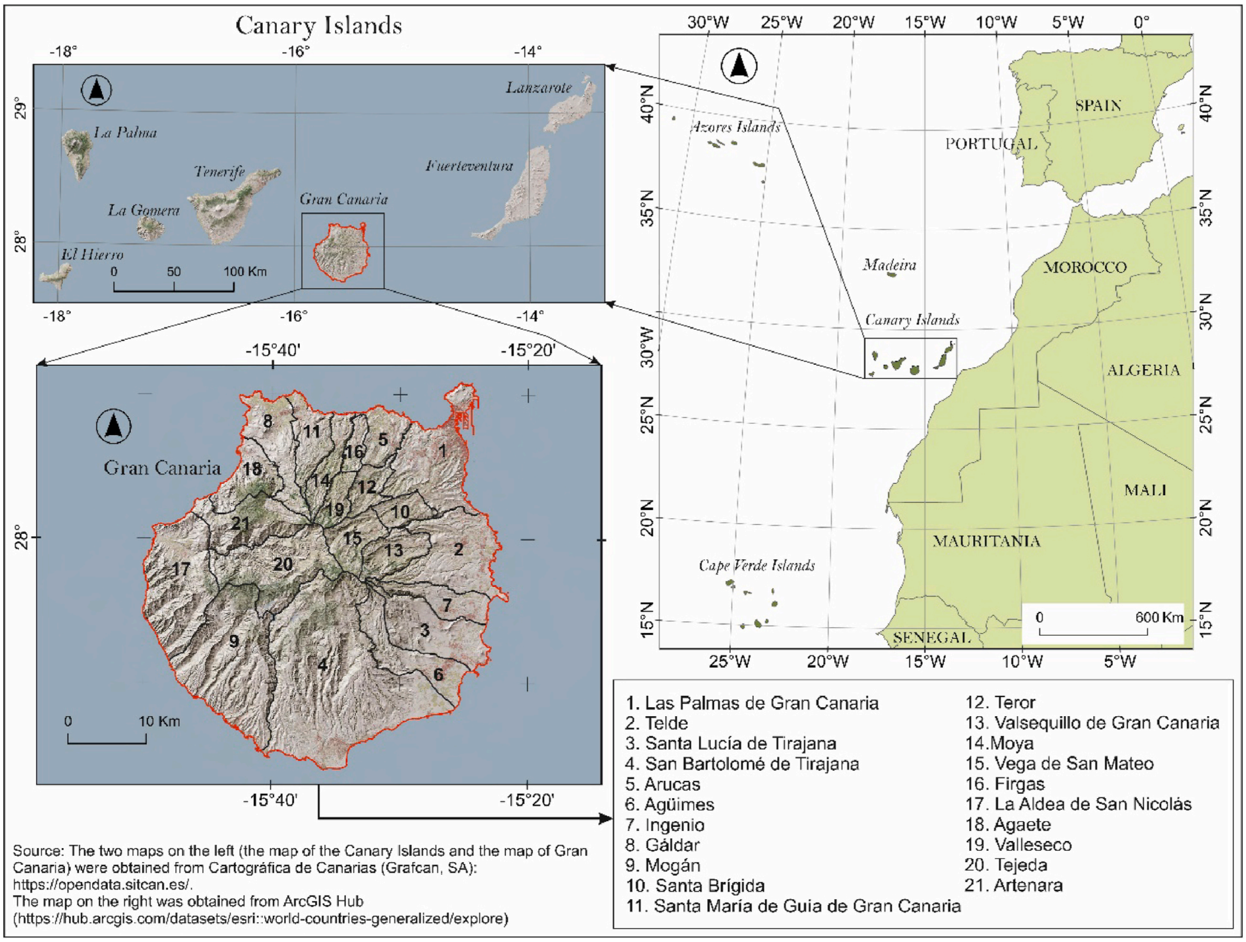

Fig. 2. Location of the Canary Islands in the Macaronesian region (Azores, Madeira, Canary Islands, and Cape Verde). The table in the lower right-hand corner lists the names of the municipalities of Gran Canaria, each identified by a corresponding number on the map to its left.
Source: Authors' own elaboration.

1.2. Scientific objectives

The island of Gran Canaria (Spain) was chosen as case study for two main reasons: (i) The availability of data from a survey included in an alert message sent in September 2024. This survey was part of a drill carried out to test the ES-Alert system in the Autonomous Community of the Canary Islands (survey data were requested from the Directorate General for Emergencies of the Government of the Canary Islands); and (ii) Gran Canaria has a high influx of tourists, is markedly geographically isolated, and has specific communication challenges related to island environments. In this context, the objectives of this work are: i) to analyze and introduce the concept of social latency; ii) to quantify social latency using the data obtained in the drill; and iii) to assess the compatibility of the reaction times observed with the windows of opportunity inherent to the main island risks. In addition, we also study the social perception of the system, with the aim of providing useful information to optimize future communication strategies and strengthen the concept of self-protection in island and tourist contexts.

In this context, we pose the following research question: "Can the measurement of the time elapsed between the receipt of an alert on a device and the execution of a specific action requested in the context of a drill—such as accessing a link to a digital survey—be used as a valid proxy to approach social latency in real emergency contexts, enabling the evaluation of its compatibility with the specific windows of opportunity associated with the main island risks?"

The drill in itself constitutes an initial test that allows for a first quantitative approximation of social latency in a controlled situation. We understand that the specific action considered (responding to a survey) does not reproduce the exact cognitive, emotional, and social conditions typical of a real emergency, such as an earthquake or forest fire, where additional factors like stress, uncertainty, or collective social behaviors come into play.

However, we believe that this study offers a useful and necessary first step in the quantitative understanding of the temporal dynamics of citizen reaction to a massive alert. The data obtained allow for an initial evaluation that can guide future, more sophisticated experimental designs, where additional variables and scenarios closer to real contexts can be incorporated. The exploratory and methodological value of the analysis that is conducted can serve as a starting point for the further exploration of social latency, its territorial implications, and its effective integration in emergency planning and management in insular territories.

2. Study context

2.1. Study area

The Canary Islands are a Spanish Atlantic archipelago located off the northwest coast of Africa, consisting of eight main islands and several islets (Fig. 2). According to data from the Canary Islands Institute of Statistics (ISTAC, 2025), Gran Canaria had 863,943 inhabitants in 2024 (almost 40 % of the inhabitants of the Canary Islands), with high population densities (554 inhabitants/km^2) and a strong urban concentration, as well as an intense annual tourist flow, with more than 15 million travelers in 2024 according to data from Spanish Airports and Air Navigation (AENA, 2025).

The island's economy is based on tourism, services and, to a lesser extent, agriculture and fishing. Most of the population live in the coastal and mid-altitude areas in the north, east and south of the island, though special mention should be made of the capital city, Las Palmas de Gran Canaria, with its more than 380,000 inhabitants. Importantly, the island also welcomes over 4.7 million tourists annually, which increases the complexity of risk management and emergency response. This high influx of tourists is an aggravating factor due to factors such as the visitors' limited familiarity with the local environment, language and cultural barriers, and the limited perception of risk associated with vacation spots [35].

Various studies have highlighted these specific challenges in tourism contexts. For example, Becken and Hughey [19] emphasize how tourists are often less aware of local threats and emergency procedures, thereby increasing their vulnerability. Furthermore, studies such as those by Drabek [20] have shown that the massive presence of tourists requires special communication and evacuation protocols, different from those used with the resident population.

Table 1
Examples of windows of opportunity with respect to island risks.

Type of island risk	Typical window of opportunity	Example of self-protective action
Rapid forest fires (wildland-urban interface)	15–60 min (highly variable, depending on the wind and terrain)	Orderly evacuation of vulnerable areas, protection of assets
Coastal phenomena (waves, groundswell, local tsunamis)	Local tsunami: 10–30 min Swell: hours to days	Move away from coastal areas, restrict access
Flash floods	5–60 min	Evacuate vertically (high floors), avoid driving in flood-prone areas
Severe storms (extreme wind, hail)	30 min – several hours (depending on the forecasting and alert capacity)	Protect loose objects, avoid movement
Volcanic eruptions	Hours - days (depending on the type of eruption)	Prepare for evacuation, confinement in case of gas emissions
Risks associated with tourism (crowds, sporting events, collective accidents)	Minutes to hours	Activation of local emergency plans, evacuation of venues

Source: Authors' own elaboration.

2.2. Risk profile and emergency management in the Canary Islands

Due to their volcanic origin, latitudinal position between the temperate and tropical worlds, and proximity to the African continent, the Canary Islands are exposed to various natural hazards such as heat waves, floods, extreme atmospheric phenomena, forest fires and volcanic activity. Numerous studies have addressed these issues in terms of hazard, vulnerability and risk factors (López Díez et al., 2018; [21,34]).

An analysis of fatalities associated with natural processes in the Canary Islands between 2001 and 2023, taking as a reference the Statistical Yearbooks of the Ministry of the Interior (2001–2023), shows that heat waves are now the leading cause of death, followed by victims of storms at sea, floods, landslides and strong winds. The increase in the number of fatalities due to heat waves is in line with trends observed in Europe and much of the world, as reflected in annual reports on natural disasters by insurance and reinsurance companies such as SwisRe (SIGMA, 2025) or AON (Climate and Catastrophe Insight, 2025). Such reports serve to highlight the importance of climate-related disasters in a scenario of global climate change.

Given the increasing number of victims and damage associated with extreme meteorological events, it is essential to promote, from the perspective of civil protection and risk prevention, emergency systems that can fully exploit the so-called *window of opportunity* (Table 1).

In insular contexts like the Canary Islands, the identification and proper management of these windows is critical. For example, in the case of rapid wildfires in urban-forest interface areas, the window of opportunity can range from 15 to 60 min, during which an orderly evacuation and the protection of property are essential. With respect to events such as local tsunamis or flash floods, which have significantly shorter windows of opportunity (5–30 min), it is essential to have effective and rapid alert systems that ensure the immediate implementation of specific actions such as vertical evacuation or the restriction of access to coastal areas.

2.3. Technical background: the ES-Alert system

ES-Alert is the official public Cell Broadcast alert system in Spain, developed in accordance with Directive (EU) 2018/1972 and international technical standards (Global System for Mobile Communications Association GSMA, European Telecommunications Standards Institute ETSI) [4]. It allows authorities to send emergency alerts simultaneously to all mobile phones connected to telephone antennas in a defined geographical area, without the need for prior registration or personal data. The system is activated from a centralized platform managed by the Directorate General of Civil Protection and Emergencies of the Spanish Ministry of the Interior. In the event of an emergency or drill, authorized personnel draft the alert message, define the geographical area and issue the alert through secure channels. The message is then disseminated to mobile phone operators, who relay it in real time to all devices in the selected area (Dirección General de Protección Civil y Emergencias. [33,4]. The main advantages of Cell Broadcast technology include its resilience (as it is not affected by network congestion), its compatibility with basic mobile phones and smartphones, and the possibility of broadcasting multilingual messages.

In the Canary Islands, ES-Alert is now a central tool in risk communication and civil protection, used in both drills and real emergencies [22]. In addition to numerous tests on all the islands, the system was deployed effectively during the forest fires that affected La Palma and Tenerife in the summer of 2023 (Appendix I). For example, on July 15, 2023, in response to a forest fire in the municipalities of Puntagorda and Tijarafe (La Palma), evacuation messages were issued to the residents of the affected neighborhoods, indicating evacuation routes and shelter locations (Dirección General de Seguridad y Emergencias, 2025). Similarly, during the Tenerife fire of August 2023, ES-Alert was used to order confinements (e.g., in the urban center of La Esperanza) and to order the evacuation of several interface zones, including municipalities such as La Orotava, La Matanza, La Victoria, El Sauzal, Santa Úrsula, Los Realejos and Tacoronte. In all cases, specific messages were sent about the measures to be taken and the resources available to the affected population (Dirección General de Seguridad y Emergencias, 2025).

These examples demonstrate the operational capability of ES-Alert in real-life situations, allowing the population to receive immediate and accurate instructions, which is a key advance for self-protection and efficient emergency management in island contexts.

Cell Broadcast technology is recognized as a standard for public alerts by bodies such as the International Telecommunication Union (ITU) and the European Telecommunications Standards Institute (ETSI), reinforcing its technical and operational validity at a global level. The Spanish experience with ES-Alert is part of a broader European trend of adopting public alert systems based on Cell Broadcast technology [4,23]. In the Netherlands, the NL-Alert system, in operation since 2012, has been positively evaluated for its effectiveness in disseminating emergency messages, although some studies point to the need to improve infrastructure and public awareness to optimize its operation [24]. In Germany, following severe floods in 2021, critical shortcomings in warning communication were identified, leading to development of the DE-Alert system, based on Cell Broadcast, with the aim of ensuring faster and more effective dissemination of warnings in crisis situations [25]. For its part, France has implemented FR-Alert, conducting a test in 2023 in the city of Cannes to assess the spatial accuracy of the system. Specific challenges were detected in dense urban contexts and technical adjustments were proposed to improve its performance [26].

These European experiences confirm the strategic value of Cell Broadcast as a fundamental tool in the civil protection architecture and reinforce its adoption as a standard mechanism for emergency management on a continental scale. As underlined by the European Emergency Number Association [4], the speed of delivery of the alert and its resilience to network congestion are key attributes of Cell Broadcast, making it the most suitable technology for immediate mass alerts in high-risk scenarios. This trend is not limited to Europe but is part of a global adoption of Cell Broadcast as a reference technology for national public warning systems. The international analysis undertaken in the EENA report (2021) shows the consolidation of its use in many countries, albeit with varying levels of development and integration with other warning systems. Table 2 summarizes the main characteristics of the use of Cell Broadcast in

Table 2
Comparative use of Cell Broadcast in national public[1] alert[2] systems.

Country	Cell Broadcast system	Date of implementation	Particular features
JP Japan	J-Alert + CB	February 2007	Sophisticated multi-channel system. Immediate tsunami warning.
CL Chile	Emergency Warning System (EWS)	March 2012	First Cell Broadcast in America. Integration with TV, radio and internet.
US United States	FEMA[1] IPAWS WEA	April 2012	Mandatory on new mobiles. High geographic accuracy.
NL Netherlands	NL-Alert	November 2012	Biannual public testing. Media integration.
SE Sweden	VMA + CB	July 2017	Regular use in combination with sirens and media testing.
CA Canada	Alert Ready	April 2018	Based on WEA. Mandatory biannual testing.
ES Spain	ES-Alert	June 2022	Compulsory nationwide implementation. Tests by Autonomous Regions.
FR France	FR-Alert	June 2022	Nearly 80 real alerts and over 300 tests.
DE Germany	DE-Alert	February 2023	Integrated in MoWaS[2] and combined with the NINA and KATWARN apps.
FI Finland	112Suomi + CB	Under development	Combined use with radio, TV and the 112Suomi app.
BE Belgium	BE-Alert (LB-SMS, no CB)	–	Currently uses LB-SMS (Localization by SMS), not CB.

Source: Adapted and updated based on the European Emergency Number Association (2021), GSMA [23] and Wikipedia (2024).

different national contexts, as described in the aforementioned report.

3. Methodology

3.1. Study design and drill communication

This study is based on the data obtained from the survey completed by the population after the ES-Alert drill carried out on the island of Gran Canaria on September 26, 2024. Thanks to this survey it was possible to obtain empirical and precise measurements of the time interval between the receipt of the warning and the initiation of the recommended action (Dirección General de Protección Civil y Emergencias [32]). This design makes it possible to analyze social behavior patterns and factors that influence the speed of citizen response, providing valuable data on the so-called windows of opportunity [9].

The drill consisted of sending a mass alert message via Cell Broadcast technology, activated from the national Civil Protection platform, to all mobile devices located on the island at 10:00 local time. The message asked citizens to access a web link to complete an anonymous evaluation survey (Fig. 3, left).

Prior to the drill, an information campaign was carried out by the Directorate General for Safety and Emergencies of the Canary Islands Government and the communication services of the Gran Canaria Island Council (Fig. 2). This campaign included the dissemination of press releases, publications on social networks (Fig. 3), advertisements in local media, collaborations with town councils and social entities, as well as the release of informative videos on digital platforms such as YouTube (Gobierno de Canarias, 2024).

3.2. Data collection instrument and analyzed variables

The online survey, accessible through the link received in the alert message (Fig. 3, left), collected data on key variables related to user experience, technical reception of the message, prior knowledge of the drill, subjective evaluation of the system, and the exact start time of the survey (proxy for citizen reaction) (see Table 3). In addition, the questionnaire was available via the public communication campaign (official websites and social media posts), allowing access for users who did not open the in-message link.

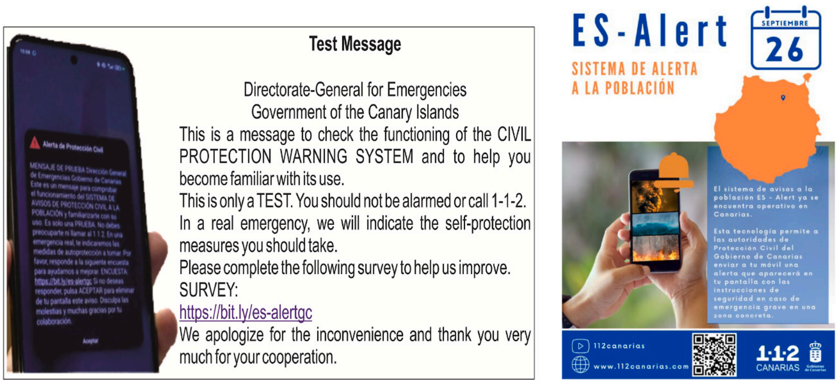

Fig. 3. ES-Alert Gran Canaria (2024) test message (left) and example of information campaign (right).
Source: (112 Canarias, 2024).

Table 3
Main survey variables.

Variable	Type	Description	Categories
Evaluation of the ES-Alert	Ordinal	Perception of the efficacy of the ES-Alert system using a 5-point scale	Very good, Good, Fair, Insufficient, Poor
Effective reception of the message	Dichotomous	Indicates whether the participant received the alert message in their mobile device	Yes/No
Geographical location	Categorical	Municipality or specific place where the participant was during the alert	Name of municipality
Device language	Categorical	Language used in the participant's mobile device	Spanish, English.
Prior awareness of the drill	Dichotomous	Indicates whether the participant knew beforehand that the drill would take place	Yes/No
Time of start of survey	Continuous	Time when the participant began the survey (proxy for citizen reaction)	Date and time (hour:min:sec)

Source: Authors' own elaboration based on data from 112 Canarias (2024).

3.3. Measurement of social latency

Social latency is defined in this study as the interval, in minutes and seconds, between the time the message was sent (10:00:00 local time) and the time each participant started the survey. The action of accessing the survey was considered an excellent proxy for immediate citizen reaction, as it was the only behavior explicitly requested in the received message.

We fully acknowledge that this proxy has limitations, given that accessing a survey after a test message does not necessarily imply a reaction comparable to what would occur in a real alert situation. In real situations, the requested behavior (for example, evacuation, seeking shelter, or taking specific self-protection measures) would probably require a more extensive initial evaluation by the individual (the phenomenon known as milling), which could significantly lengthen the observed social latency. However, we consider that measuring the initial response time to an explicit and simple request, such as the one we propose here, constitutes a methodological first step to evaluate the initial speed with which a population responds to a notification issued via Cell Broadcast.

3.4. Data processing and statistical analysis

The data processing and statistical analysis were carried out in various stages. First, duplicate responses were removed, and the consistency of the timestamps was validated. The names of municipalities and places were standardized to ensure geographical consistency.

At the descriptive level, absolute and relative frequencies were calculated, as well as measures of central tendency (mean, median) and dispersion (standard deviation, percentiles) of the social latency, both globally and segmented in a time interval ($\leq$300 s). The temporal dynamics of the social latency were visualized using histograms and bar charts. For the territorial analysis, the median social latency was calculated by municipality and represented through a thematic map of the island of Gran Canaria. This cartographic visualization enabled identification of spatial differences in the reaction times of the population to the emergency alert. The map facilitates a clear comparison between municipalities, highlighting territories with higher levels of social latency, as well as areas with faster response times, providing a territorial reading of the analyzed phenomenon. When the information was available, the relationship between social latency and variables such as municipality, prior knowledge of the drill, or device language was descriptively explored. All data processing and graphical representations were carried out using Python, employing the Pandas and Matplotlib libraries.

4. Results and discussion

4.1. Participation

According to official data (112 Canarias, 2024), a total of 51,879 people filled in the survey in the hours following the drill. Of these, 49,319 corresponded to users who were physically present in municipalities on the island of Gran Canaria. This high level of participation, equivalent to 6 % of the island's population, reflects a significant civic engagement in the drill. The survey was answered by people in 21 municipalities of Gran Canaria. Although individual demographic data such as age or place of residence were not collected, it is reasonable to assume that some of the respondents might not be residents. According to data from the Gran Canaria Island Council (2024), 314,423 tourists visited the island in September (with a record total of 4.71 million over the entire year) [30]. Like those who came for work or other reasons, these people also received the message and had access to the survey.

Responses were received from all the municipalities on the island, with a special concentration in the main urban areas (Las Palmas

[1] WEA (Wireless Emergency Alerts) is the wireless emergency warning system in the United States. It allows authorities to send alert messages to mobile phones through Cell Broadcast technology without the need for internet connection. It is integrated in the national alert system IPAWS and managed by the federal agency FEMA.

[2] MoWAS (modular warning system)) is Germany's national emergency warning system, managed by the Federal Office of Civil Protection (BBK). It enables multi-channel alert dissemination, including mobile apps, media, and Cell Broadcast.

de Gran Canaria, Telde, Santa Lucía de Tirajana) and the tourist areas in the south (San Bartolomé de Tirajana, Mogán). The high volume and territorial dispersion of the responses demonstrate a high degree of message penetration and broad population coverage, despite the voluntary nature of the requested action. Moreover, 78 % of the respondents stated that they had prior knowledge of the ES-Alert system before receiving the alert message, a result that can be attributed to the extensive media coverage that preceded the event and favored the informational reach among the population.

4.2. Evaluation of the system

The results reflect a broadly positive perception of the ES-Alert system. A total of 73.2 %, which corresponds to 36,101 individuals, rated the system as "Good" and 18.2 % as "Very good". This means that 91.4 % gave a positive evaluation of the systems, while 6.7 % rated it as "Fair". The percentages of negative responses were very low: only 1.2 % considered the system to be "Insufficient" and 0.6 % rated it as "Poor". Notably, the 0.6 % who rated it as "Poor" were respondents who reported that they had not received the alert and had accessed the survey via the public information campaign (official website/social media), rather than through the in-message link. These results reflect a high level of confidence and satisfaction with the mass notification tool, supporting the system's usefulness both in terms of technical coverage and citizen perception. The high percentage of favorable evaluations may be related to the effectiveness of the prior information campaign and the context of the drill, which allowed the population to familiarize themselves with the system without causing alarm.

4.3. Territorial distribution of the participation

The results in Table 4 show that the municipalities with the highest resident population had, as expected, the highest absolute number of responses to the survey Las Palmas de Gran Canaria, with 378,797 inhabitants, contributed 26,615 responses (51.7 % of the total, while Telde (102,472 inhabitants) and San Bartolomé de Tirajana (52,936 inhabitants) had 5396 and 4013 responses, respectively, accounting for 10.5 % and 7.8 % of the total (Fig. 4). Together, these three municipalities account for more than 75 % of all responses, with Las Palmas de Gran Canaria representing approximately half of the participants.

However, when analyzing the relative participation rate (percentage of responses relative to the resident population), notable differences are observed. Tourist municipalities like Mogán (8.5 %) and San Bartolomé de Tirajana (7.6 %) had higher rates than Las Palmas de Gran Canaria (7.0 %) (Fig. 5), despite having significantly lower populations (20,331 and 52,936 inhabitants respectively). This could be attributable to the high presence of floating or non-resident population in these tourist areas, which increases the volume of participants beyond the local census.

Most of the municipalities maintained a general participation rate of between 4 % and 6 %, reflecting a significant involvement of the island's citizens in the exercise. Only the inland municipalities, characterized by a lower population density and a greater primary sector weight (Fig. 5), presented rates below 4 %. These differences may be related to lower technological penetration or less exposure to the informational campaigns prior to the drill, factors that condition citizen participation in exercises of this type (source: 112 Canarias, 2024).

Table 4
Participation by municipality (ordered by total population).

Municipality	Map No.*	Total population	Number of respondents	% of total respondents	Participation rate (%)
Las Palmas de Gran Canaria	1	378,797	26,615	51.7 %	7.0 %
Telde	2	102,472	5396	10.5 %	5.3 %
Santa Lucía de Tirajana	3	74,560	2907	5.6 %	3.9 %
San Bartolomé de Tirajana	4	52,936	4013	7.8 %	7.6 %
Arucas	5	38,369	1886	3.7 %	4.9 %
Agüimes	6	32,067	1896	3.7 %	5.9 %
Ingenio	7	31,932	1395	2.7 %	4.4 %
Gáldar	8	24,567	1157	2.2 %	4.7 %
Mogán	9	20,331	1725	3.4 %	8.5 %
Santa Brígida	10	18,341	888	1.7 %	4.8 %
Santa María de Guía	11	13,838	835	1.6 %	6.0 %
Teror	12	12,667	501	1.0 %	4.0 %
Valsequillo	13	9490	429	0.8 %	4.5 %
Moya	14	7870	365	0.7 %	4.6 %
Vega de San Mateo	15	7682	390	0.8 %	5.1 %
Firgas	16	7581	274	0.5 %	3.6 %
La Aldea de San Nicolás	17	7536	233	0.5 %	3.1 %
Agaete	18	5633	345	0.7 %	6.1 %
Valleseco	19	3750	102	0.2 %	2.7 %
Tejeda	20	1813	84	0.2 %	4.6 %
Artenara	21	1030	37	0.1 %	3.6 %

(*) The column "Map No." refers to the number used to identify each municipality as shown in Fig. 1.
Source: ISTAC (2024).

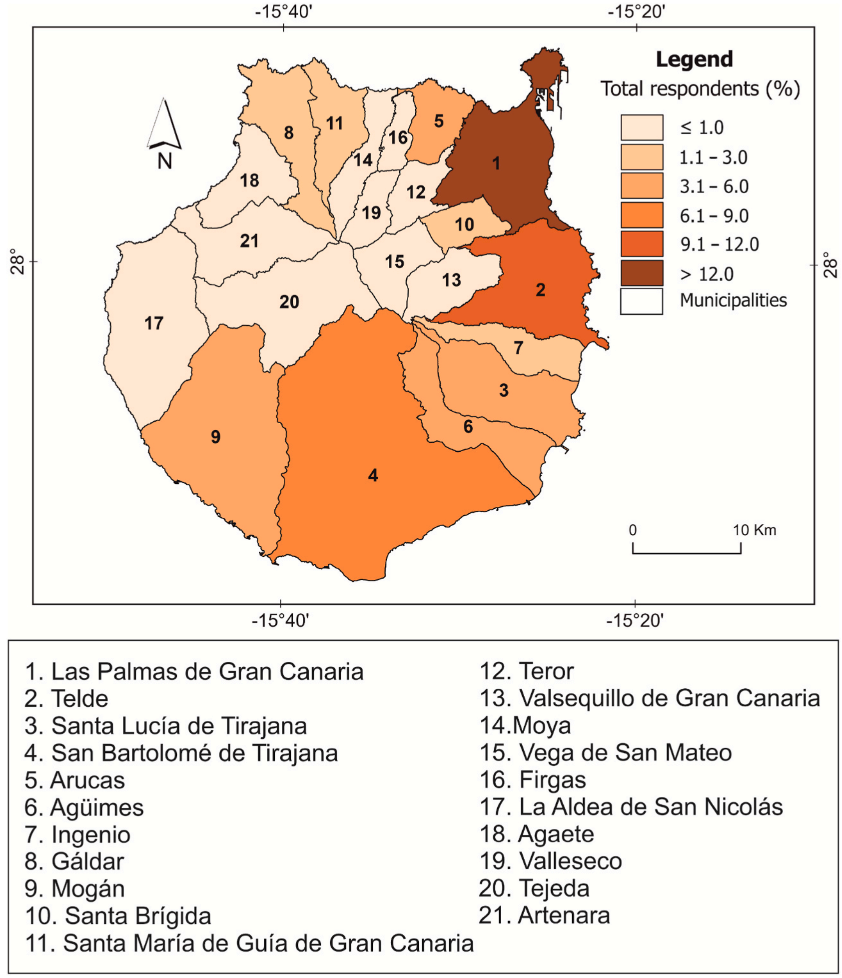

Fig. 4. Total respondents (%) by municipality.
Source: Authors' own elaboration based on 112 Canarias data (2024).

4.4. Social latency of the citizen response

A histogram of the temporal distribution of social latency was generated (Fig. 6) to allow a progressive and specific observation of the dynamics of the response over the course of the first 5 min. A significant peak of responses can be seen in the first moments after the alert, indicating a high reaction capacity. Most responses are concentrated in the first 2 min, revealing a rapid reaction trend by a substantial part of the population (Fig. 6). Finally, the long tail of the distribution shows that a non-negligible fraction of users completed the recommended action (accessing the survey) in a more delayed manner. The inclusion of a reference line, which corresponds to the median observed latency, facilitates interpretation of the results, highlighting the importance of social and contextual factors in the speed of citizen response.

The analysis of social response latency shows a quick and sustained reaction of the population following issuance of the alert at 10:00:00 h (Fig. 7).

- The recorded average latency was 21.3 min (1277.5 s), with a median of 1 min and 12 s (72 s).
- 38.5 % of the respondents (22,000 people) accessed the survey within the first 2 min after the message was sent.
- 52.2 % (29,882 respondents) did so in less than 5 min.
- 71.1 % (33,276 respondents) completed the action in less than 10 min.

Fig. 7 groups the responses by broader time intervals (in minutes), allowing visualization of the persistence of the action over time and the general response pattern, including cases of delayed response. A spike in responses can be seen in the first few minutes, followed by a progressive decline and a long tail of users who responded after 30 min (16.5 % of the total). This pattern indicates a high capacity for immediate reaction, fundamental in real emergency contexts, but also the existence of a significant portion of the population that interacted with the alert over longer periods. This extended latency may be linked to various factors, such as personal

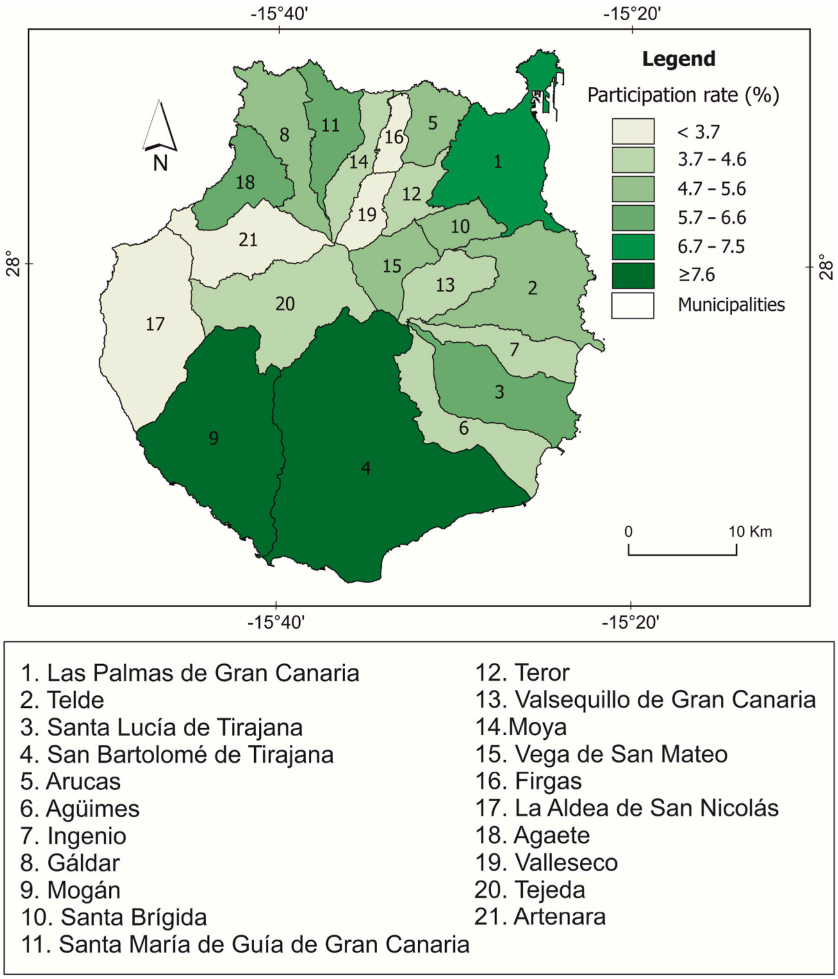

Fig. 5. Participation rate (%) by municipality.
Source: Authors' own elaboration based on 112 Canarias data (2024).

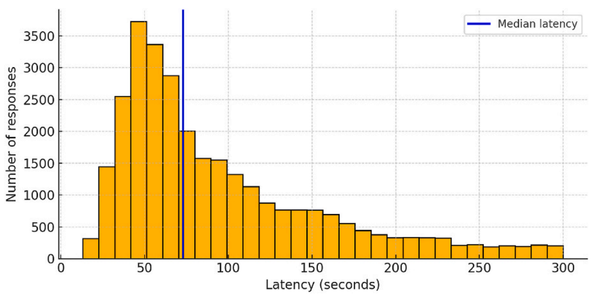

Fig. 6. Histogram of the evolution of social latency.
Source: Gran Canaria ES-Alert drill (2024). Authors' own elaboration. The vertical blue line indicates the median social latency.

availability at the time of the alert, the level of attention given to the mobile device (for example, if it is out of sight, or if the user is engaged in other activities that prevent an immediate response), as well as the physical and social environment in which the alert is received (work, commuting, meetings, etc.). All these elements influence response time and should be considered when designing emergency communication strategies to take into account the diversity of everyday contexts.

The territorial dimension of social latency is also important, given that factors such as urban structure, technological connectivity, or sociocultural habits can influence the speed of response of the population. The median social latency was therefore calculated for each municipality with the aim of identifying possible territorial differences in response speed after receiving the alert message. The

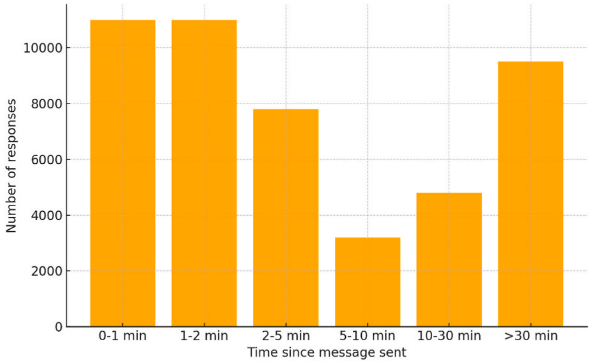

Fig. 7. Distribution of social latency.
Source: Gran Canaria ES-Alert drill (2024). Authors' own elaboration.

median was used as a measure of central tendency to represent the typical behavior of participants in each area, avoiding the distortion that extreme values (very quick or very late responses) could cause. The results allow for a direct comparison of the relative speed of citizen response in each municipality.

Significant differences between municipalities can be observed (Fig. 8). Firgas has the highest median latency (11 min), followed by Artenara (8 min), while municipalities like Vega de San Mateo (1.93 min) and Valsequillo de Gran Canaria (2.07 min) have the lowest latencies. It was found that smaller or rural municipalities tend to exhibit higher latency values, which could be related to both

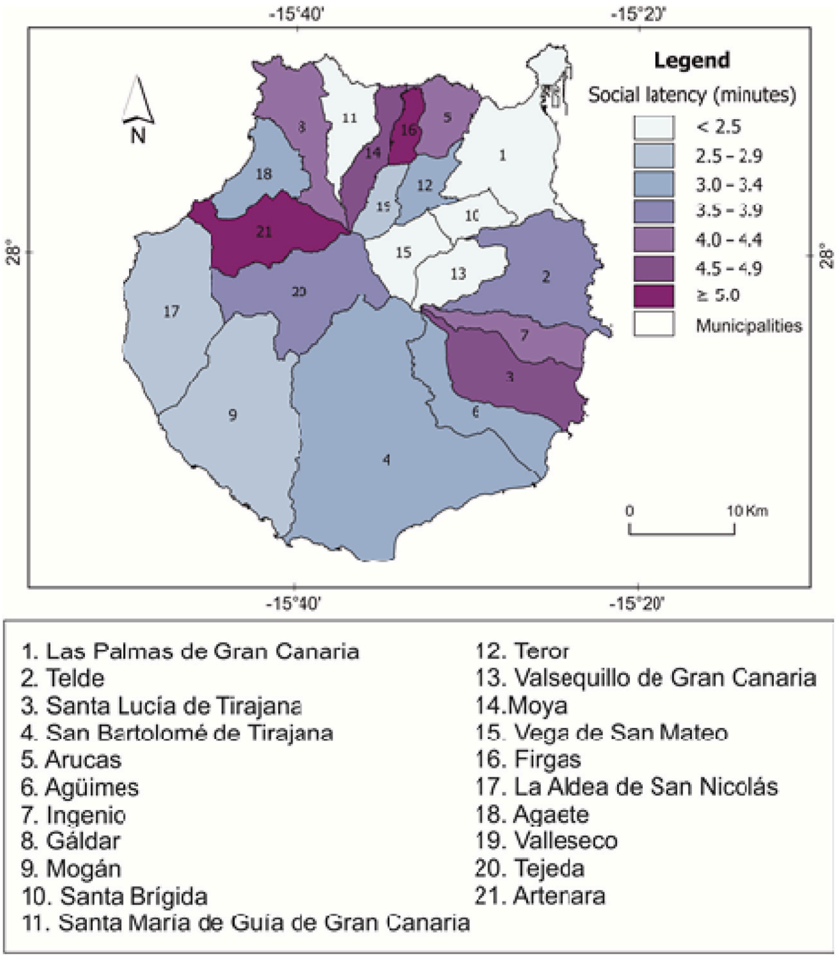

Fig. 8. Median social latency by municipality.
Source: Gran Canaria ES-Alert drill (2024). Authors' own elaboration.

demographic factors (higher proportion of elderly population or lower use of mobile technology) and territorial factors (network coverage or local culture of response to alerts). However, it should be noted that this interpretation is only an approximation, as specific demographic data obtained in the survey for each municipality is not available. This hypothesis can be addressed and verified in future studies, when more detailed information about the composition and characteristics of the respondents in each locality becomes available.

In contrast, lower social latency values were obtained for municipalities with a higher population density, urban or tourist areas such as Las Palmas de Gran Canaria, San Bartolomé de Tirajana, and Mogán (Fig. 8). These lower values indicate a greater responsiveness to alerts, possibly due to more familiarity with the use of mobile devices and digital services, a higher penetration of informational campaigns, and the existence of more active social networks.

This variability in social latency could serve to provide relevant information for the design of future awareness and training campaigns, directing efforts towards municipalities where the response was slower. It also highlights the importance of adapting messages and communication channels to the characteristics of each territory, taking into account sociodemographic particularities and the available technological infrastructure.

4.5. International comparison and initial learnings

The results obtained in the present study are similar to or higher than those reported for other international public alert trials using Cell Broadcast [4]. In recent studies on the ShakeAlert system in California [5], the median message reception time was 6–12 s (technical latency), but the participation rate in proposed actions rarely exceeded 5 % of the target population. The analysis undertaken in this study also provides an original metric for the European context: social latency, understood as the reaction time to the action suggested by the alert. The rapid reaction observed in the Gran Canaria drill demonstrates the potential of mass alert systems and the willingness of citizens to cooperate with the instructions given in the alert messages, especially when the requested action is clear and accompanied by prior informational campaigns. However, the study also highlights the importance of analyzing factors that limit participation and of developing strategies to improve the understanding, trust, and accessibility of the ES-Alert system, particularly for vulnerable groups, tourists, or people who are not very familiar with this technology.

4.6. Study limitations

The analyses undertaken in this study only consider respondents who voluntarily accessed the survey (~6 % of the island population and visitors present during the drill), so non-response—due to factors such as disinterest, distrust, access barriers, or the drill context—limits generalizability. We also lack individual-level demographics (e.g., sex, age, socioeconomic status) and other social covariates. Accordingly, we report territorial/collective patterns in observed social latency—measured as the elapsed time from alert issuance to survey start—rather than attributing differences to individual profiles.

The approach taken in this study allows the identification of how long it takes to react, how many people do so, and from which geographical areas of the island, providing a valuable territorial approximation of response times. However, the available data do not explain why a particular reaction is faster or slower, a question that would require cross-referencing with demographic and social information that was not collected on this occasion. In this sense, the results obtained provide value as an initial diagnosis and reinforce the need for future research that integrates demographic and sociocultural variables to enrich the analysis of social latency patterns and advance towards a more precise and segmented understanding of citizen response to EWSs. Likewise, it should be stressed that the act of completing the survey constitutes a conservative approximation of actual self-protection behaviors, as in real emergency situations the urgency and nature of the threat can significantly alter response patterns. Therefore, future research should thoroughly analyze the reasons for inaction and complement this type of study with qualitative approaches.

Another relevant limitation of the study is related to the geolocation of the participants. Exact coordinates of the location of those who received the message were not obtained, only the municipal information voluntarily provided by those who completed the survey. This level of detail prevents accurate identification of the specific zone or area in the island where the alert was received and responded to. The possibility of having more precise location data in the future—such as through the automatic georeferencing of receiving devices—would allow for a deeper analysis of response spatial patterns and optimize the delineation of alert areas. In this regard, effective integration of the data provided by mobile operators is essential. The operators should be required to provide information about the location of the devices that receive public alert messages, something that is currently not mandatory in Spain.

In the case study of Gran Canaria, its insular condition clearly delineates the activation zone, as the message is sent exclusively to the mobile phone antennas located on the island. This facilitates control of the target area but also limits the spatial resolution of the analysis as only municipal-level information is available.

5. Conclusion

The present study constitutes the first empirical approach in the European context to measuring the social latency of the citizen response to public alerts issued through Cell Broadcast technology. Based on a case study of an ES-Alert drill in Gran Canaria, an analysis is made of the patterns of citizen reaction to an official warning. The action of filling out a survey after receiving a message on a mobile device provides data that can be considered an approximation to data corresponding to actions taken in the event of a real alert. The drill results indicate that 91.4 % of participants rated the system positively, and the median social latency was 1 min and 12 s, with 52.2 % of responses recorded in the first 5 min.

However, significant differences were observed between municipalities in terms of median social latency, ranging from 11 min to 1.93 min. This spatial variability suggests that factors such as the size of the municipality, its rural or urban character, the average age of the population, access to mobile networks, and familiarity with digital technologies can influence the speed with which a requested action is carried out. Urban or tourist municipalities, such as Las Palmas de Gran Canaria or San Bartolomé de Tirajana, tended to show greater response immediacy, possibly due to greater prior exposure to the communication campaign, a more robust digital infrastructure, and a citizenry more accustomed to intensive mobile use.

The results reported here confirm previous international findings, where the effectiveness of early warning systems does not depend solely on the technical speed of the message, but also on the speed with which the population adopts the recommended action [5,9]. Social latency is an essential factor for a comprehensive evaluation of the effectiveness of a public alert system. The rapid reaction rates found in the present study can be attributed to actions such as the extensive media coverage of the drill, which prepared the population and reduced levels of surprise or skepticism, and the simplicity of the required action (accessing a link and filling out a survey).

However, the fact that a majority of people did not react to the alert (at least in terms of completing the survey) suggests the presence of a significant "action gap" [37]. Nonetheless, it should be stressed that the absence of a response to the survey does not allow us to scientifically conclude that these people will not react to future instructions from the administration in a real emergency situation. Currently, there are no studies or data that allow for an in-depth understanding of the reasons behind this lack of participation, nor to directly infer the degree of willingness of these individuals to follow future official instructions. For this reason, it is important to move towards a participatory system of data collection in emergencies in the Canary Islands. The massive and systematic collection of citizen data after an adverse event has become one of the most innovative tools for the management and study of emergencies. The paradigmatic example is the American "Did You Feel It?" (DYFI) system developed by the U.S. Geological Survey (USGS), which for over two decades has allowed millions of people to report in real time their perceptions of and responses to an earthquake in their area. The enormous value of DYFI has been demonstrated not only through the acquisition of high-resolution seismic intensity maps but also the analyses of social response, risk perception, and the usefulness of alert systems [27]. Moreover, DYFI has facilitated a more direct relationship between the population and scientific agencies, promoting a culture of self-protection and trust in official information [28].

International experience shows that these participatory systems are not only applicable to earthquakes but can also be adapted to other risks such as wildfires, floods, volcanic eruptions, or extreme weather events. The key lies in enabling flexible and accessible mechanisms (based on the internet or mobile technologies) that allow citizens to report their experience, perception, degree of impact, and reaction to the emergency. In this way, a valuable flow of data can be obtained that allows for improved crisis management, adjustments to risk communications, and proper evaluation of the actual functioning of alert systems in different contexts [2].

In the case of the Canary Islands, the recent implementation of the ES-Alert system and the pilot experience of the drill conducted in Gran Canaria in 2024 represent an exceptional opportunity to advance towards this participatory model. One of the conclusions of this study is to confirm the feasibility and usefulness of systematically collecting the social perception of and reaction to emergencies through digital instruments, extrapolating the DYFI model to our insular and tourist context. Consolidation of this approach would allow the future availability of an open and continuous database on the experiences of citizens in emergencies in the Canary Islands, covering not only earthquakes but also wildfires, storms, or volcanic eruptions. In addition to improving the technical evaluation of alert systems, this strategy would facilitate the design of informational campaigns and decision-making based on the reality experienced by the affected population, thereby strengthening social resilience and the effectiveness of civil protection measures.

Although the data obtained in this study enabled the characterization and analysis of the reaction of the population that did participate, a future line of research would be to explore in greater depth the causes of the observed action gap and, especially, the relationship between the lack of response to mock drill surveys and the actual response to an emergency. Understanding and reducing this gap represents one of the main challenges for the effectiveness of mass alert systems in the Canary Islands, particularly in contexts of high demographic diversity, tourist mobility, and vulnerable groups.

From the perspective of emergency management, the results of this study constitute a useful exploratory tool for approaching citizen reaction time in various risk scenarios. Although it is a simulated exercise, the observed patterns can serve as an initial reference for the design and improvement of communication and response strategies in real situations.

Finally, the methodological approach used—based on the automated recording of citizen reactions—can be replicated and adapted for future drills or real situations, both in Spain and in other European countries. The integration of social latency as a standard indicator in the evaluation of early warning systems is, in the authors' opinion, an essential line of advancement in the science applied to risk and civil protection.

The generalization of this type of analysis will improve preparedness, management, and communication in emergency situations, bringing civil protection closer to international standards and fostering social resilience in the face of disasters.

CRediT authorship contribution statement

Fernando Medina Morales: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Pablo Máyer Suárez:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Formal analysis.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Pablo Mayer Suarez reports financial support, administrative support, article publishing charges, and writing assistance were provided by Interreg Europe. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2025.105794.

Data availability

Data will be made available on request.

References

[1] J.E. Quansah, B. Engel, G.L. Rochon, Early warning systems: a review, J. Terrest. Observat. 2 (2) (2010) 5.
[2] H. Bean, J. Sutton, B.F. Liu, S. Madden, M.M. Wood, D.S. Mileti, The study of mobile public warning messages: a research review and agenda, Rev. Commun. 15 (1) (2015) 60–80, https://doi.org/10.1080/15358593.2015.1014402.
[3] M. Al-Dalahmeh, O. Al-Shamaileh, A. Aloudat, B. Obeidat, The viability of mobile services (SMS and cell broadcast) in emergency management solutions: an exploratory study, Int. J. Interact. Mobile Technol. 12 (1) (2018), https://doi.org/10.3991/ijim.v12i1.7732.
[4] European Emergency Number Association, Public warning systems: update version 3.0. EENA. https://eena.org/wp-content/uploads/2021_02_18_PWS_Document_FINAL_Compressed.pdf, 2021.
[5] S.K. McBride, D.F. Sumy, A.L. Llenos, G.A. Parker, J. McGuire, J.K. Saunders, R. de Groot, Latency and geofence testing of wireless emergency alerts intended for the ShakeAlert® earthquake early warning system for the West Coast of the United States of America, Saf. Sci. 157 (2023) 105898, https://doi.org/10.1016/j.ssci.2022.105898.
[6] R.L. Heath, J. Lee, L. Ni, Crisis and risk approaches to emergency management planning and communication: the role of similarity and sensitivity, J. Publ. Relat. Res. 21 (2) (2009) 123–141, https://doi.org/10.1080/10627260802557415.
[7] H. Bean, B.F. Liu, S. Madden, J. Sutton, M.M. Wood, D.S. Mileti, D.P. Eisenman, Disaster warnings in your pocket: how audiences interpret wireless emergency alerts, J. Contingencies Crisis Manag. 24 (3) (2016) 136–147, https://doi.org/10.1111/1468-5973.12116.
[8] D.S. Mileti, J.H. Sorensen, Communication of Emergency Public Warnings: a Social Science Perspective and state-of-the-art Assessment (No. ORNL-6609), Oak Ridge National Lab.(ORNL), Oak Ridge, TN (United States), 1990.
[9] M.K. Lindell, R.W. Perry, The protective action decision model: theoretical modifications and additional evidence, Risk Anal. 32 (4) (2012) 616–632, https://doi.org/10.1111/j.1539-6924.2011.01647.x.
[10] J. Sutton, S.C. Vos, M.M. Wood, M. Turner, Designing effective tsunami messages: examining the role of short messages and fear in warning response, Weather Climate Soc. 10 (1) (2018) 75–87, https://doi.org/10.1175/WCAS-D-17-0032.1.
[11] G. Wachinger, O. Renn, C. Begg, C. Kuhlicke, The risk perception paradox—Implications for governance and communication of natural hazards, Risk Anal. 33 (6) (2013) 1049–1065, https://doi.org/10.1111/j.1539-6924.2012.01942.x.
[12] D. Paton, Disaster preparedness: a social-cognitive perspective, Disaster Prev. Manag. 12 (3) (2003) 210–216, https://doi.org/10.1108/09653560310480686.
[13] H. Omer, N. Alon, The continuity principle: a unified approach to disaster and trauma, Am. J. Community Psychol. 22 (2) (1994) 273–287, https://doi.org/10.1007/BF02506866.
[14] M.T. Kinateder, E.D. Kuligowski, P.A. Reneke, R.D. Peacock, Risk perception in fire evacuation behavior revisited: definitions, related concepts, and empirical evidence, Fire Sci. Rev. 4 (2015) 1, https://doi.org/10.1186/s40038-014-0005-z.
[15] J.E. Korteling, G.L. Paradies, J.P. Sassen-van Meer, Cognitive bias and how to improve sustainable decision making, Front. Psychol. 14 (2023) 1129835, https://doi.org/10.3389/fpsyg.2023.1129835.
[16] K.A. Lachlan, P.R. Spence, X. Lin, K. Najarian, M.D. Greco, Screaming into the wind: examining the volume and content of Twitter messages during Hurricane Sandy, Commun. Stud. 65 (5) (2014) 500–518, https://doi.org/10.1080/10510974.2014.956941.
[17] J. Sutton, E.S. Spiro, B. Johnson, S. Fitzhugh, B. Gibson, C.T. Butts, Warning tweets: serial transmission of messages during the warning phase of a disaster event, Inf. Commun. Soc. 17 (6) (2014) 765–787, https://doi.org/10.1080/1369118X.2013.862561.
[18] T.E. Drabek, Human System Responses to Disaster: an Inventory of Sociological Findings, Springer, 1986, https://doi.org/10.1007/978-1-4612-4960-3.
[19] S. Becken, K.F. Hughey, Linking tourism into emergency management structures to enhance disaster risk reduction, Tour. Manag. 36 (2013) 77–85, https://doi.org/10.1016/j.tourman.2012.11.006.
[20] T.E. Drabek, Disaster responses within the tourist industry, Int. J. Mass Emergencies Disasters 13 (1) (1995) 7–23, https://doi.org/10.1177/028072709501300102.
[21] P. Dorta Antequera, A. López Díez, J. Díaz Pacheco, P. Mayer Suárez, C. Romero Ruiz, Tourism and natural hazards in Macaronesia. A comparative analysis (Turismo y amenazas de origen natural en la Macaronesia. Análisis comparado), Cuad. Tur. 45 (2020) 61–92, https://doi.org/10.6018/turismo.45.426041.
[22] F. Medina Morales, P. Máyer Suárez, Percepción del sistema ES-Alert: un análisis exploratorio en la Universidad de Las Palmas de Gran Canaria, Invest. Geográficas (84) (2025) 31–41, https://doi.org/10.14198/INGEO.29092.
[23] GSMA, Cell broadcast for emergency alerts: technology overview and implementation, Mobile for Development, https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2023/11/Cell-Broadcast_R.pdf, 2023.

[24] H.M. Jagtman, Cell broadcast trials in the Netherlands: using Mobile phone technology for citizens' alarming, Reliab. Eng. Syst. Saf. 95 (1) (2010) 18–28, https://doi.org/10.1016/j.ress.2009.07.005.
[25] A.H. Thieken, P. Bubeck, A. Heidenreich, J. von Keyserlingk, L. Dillenardt, A. Otto, Performance of the flood warning system in Germany in July 2021 – insights from affected residents, Nat. Hazards Earth Syst. Sci. 23 (4) (2023) 973–990, https://doi.org/10.5194/nhess-23-973-2023.
[26] E. Bopp, J. Douvinet, N. Carles, P. Foulquier, M. Péroche, Spatial (in)accuracy of cell broadcast alerts in urban context: feedback from the April 2023 cannes tsunami trial, Comput. Environ. Urban Syst. 107 (2024) 102055, https://doi.org/10.1016/j.compenvurbsys.2023.102055.
[27] J.D. Goltz, D.J. Wald, S.K. McBride, E. Reddy, V. Quitoriano, J.K. Saunders, The Ojai California earthquake of 20 August 2023: earthquake early warning performance and alert recipient response in the Mw 5.1 event, Seismol Res. Lett. 95 (5) (2024) 2745–2760, https://doi.org/10.1785/0220240023.
[28] V. Quitoriano, D.J. Wald, USGS "did you feel it?"—science and lessons from 20 years of citizen science-based macroseismology, Front. Earth Sci. 8 (2020) 120, https://doi.org/10.3389/feart.2020.00120.
[29] P. Aldunce, R. Beilin, J. Handmer, M. Howden, Framing disaster resilience: the implications of the diverse conceptualisations of 'bouncing back, Disaster Prev. Manag. 24 (3) (2015) 294–309, https://doi.org/10.1016/j.gloenvcha.2014.10.010.
[30] Cabildo de Gran Canaria, Tourism sector situation. Year 2023 (Situación del sector turístico. Año 2023) [Informe], https://www.grancanaria.com/turismo/fileadmin/PDF/informes/ICT_cierre_2023.pdf, 2024.
[31] G.A. Cid Ortiz, C.P. Castro Correa, V. Rugiero de Souza, "Risk Perception Related to Self-Protection and Self-Management Capacities as Relevant Elements for Reducing Vulnerability in the City of La Serena" (Percepción del riesgo en relación con capacidades de autoprotección y autogestión, como elementos relevantes en la reducción de la vulnerabilidad en la ciudad de La Serena), Rev. INVI 27 (75) (2012) 105–142, https://doi.org/10.4067/S0718-83582012000200004. In Spanish. English summary.
[32] Direccion General de Proteccion Civil y Emergencias. (n.d.-a). ES-Alert. https://es-alert.proteccioncivil.es/.
[33] Direccion General de Proteccion Civil y Emergencias. (n.d.-b). Public warning system. Protección Civil – Coordinación Redes RAN. https://www.proteccioncivil.es/coordinacion/redes/ran/public-warning-system.
[34] P. Dorta Antequera, Catalogue of climate risks in the Canary Islands: hazards and vulnerability (Catálogo de riesgos climáticos en Canarias: amenazas y vulnerabilidad), Geographicalia 51 (2007) 133–160.
[35] Hannah Eboh, Courtney Gallaher, Thomas Pingel, Ashley Walker, Risk perception in small Island developing states: a case study in the Commonwealth of Dominica, Nat. Hazards 105 (1) (2021) 889–914, https://doi.org/10.1007/s11069-020-04342-9.
[36] E. Kuligowski, P. Dootson, Emergency Notification: Warnings and Alerts. Encyclopedia of Wildfires and wildland-urban Interface (WUI) Fires, 2018.
[37] S.K. McBride, J.S. Becker, D.M. Johnston, Exploring the barriers for people taking protective actions during the 2012 and 2015 New Zealand ShakeOut drills, Int. J. Disaster Risk Reduct. 37 (2019) 101150.
[38] D.S. Mileti, L. Peek, The social psychology of public response to warnings of a nuclear power plant accident, J. Hazard Mater. 75 (2–3) (2000) 181–194.
[39] A. Murata, T. Nakamura, W. Karwowski, Influence of cognitive biases in distorting decision making and leading to critical unfavorable incidents, Saf. Now 1 (1) (2015) 44–58, https://doi.org/10.3390/safety1010044.
[40] National Academies of Sciences, Engineering, and Medicine, Emergency Alert and Warning Systems: Current Knowledge and Future Research Directions, The National Academies Press, 2018, https://doi.org/10.17226/24935.