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Why Do We Understand Emergency Messages—or Not? Identifying Their Explanatory Conditions Using csQCA

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ABSTRACT

Objective and significance of the study: In recent years, the frequency and intensity of natural disasters have significantly increased, prompting public managers to develop early warning systems. However, these systems have prioritized technological advancements over identifying the conditions that influence their adoption and use by individuals.

Methodology: This study examines the factors that explain citizens' understanding of emergency alert messages, applying crisp-set qualitative comparative analysis to a sample of 188 Internet users who have received such alerts.

Key findings: Based on the stimulus–organism–response theory, the findings indicate that understanding the content of these messages can be attributed to stimuli or the combination of stimuli and organisms.

Study limitations: The work focuses on a sample composed of people between 35 and 44 years old.

Practical value of the findings: The study explores the conditions underlying the lack of comprehension of these messages, emphasizing the importance of recipients' gender and highlighting how different combinations of stimulus and organism elements contribute to this outcome.

1. Introduction

The frequency and impact of catastrophic disasters, or extreme events, have dramatically increased in recent decades (Chatfield et al., 2013). These disasters are characterized by widespread disruption across governments, businesses, societies, and communities, resulting in restricted access to physical infrastructure, the destruction of homes, population displacement, business interruptions, and, in some cases, severe physical harm (Fischer-Preßler et al., 2024). To predict the likelihood of such disasters, research has advanced the development of sensors and decision-support systems aimed at forecasting the scale, timing, location, and potential impact of disasters, as well as the necessary evacuation measures. However, since citizens in at-risk areas require relevant and actionable information about imminent events, timely and effective communication of this information by public authorities is critical (Chatfield et al., 2013). During a crisis, it is vital to have transparent information that allows for identification (Sahid et al., 2025). Providing accurate and reliable information about the situation and protective measures can save lives and significantly reduce damage (Chen et al., 2024; Zhang et al., 2019).

Advances in information and communication technologies have considerably enhanced the ability of public emergency and disaster management agencies to reach large audiences quickly and efficiently (Chen et al., 2024; Fischer-Preßler et al., 2024). In this context, governments have developed early warning systems (EWS) that provide critical information to enable appropriate responses from affected communities (Chatfield et al., 2013). When well designed and effectively implemented, these systems can minimize the damage caused by extreme weather events (Trahan et al., 2023). It is crucial to analyze the implications of the digital transformation of the media as well as to reflect the fundamental role they have in contemporary society (Vailati et al., 2025)

According to reports from the United Nations (UN; 2006, 2008) on disaster reduction, EWS are structured around four fundamental pillars: risk knowledge, monitoring, dissemination of warnings, and community response capacities (Salgado et al., 2025). From an informational perspective, EWS must ensure speed, reach, and quality in their messages (Chatfield et al., 2013). Although, in most situations, specific alarms are issued, they do not guarantee that the receivers effectively understand the message and that they take the actions re-

quired to reduce local impacts (Meléndez-Landaverde & Sempere-Torres, 2025). However, the mass distribution of communications presents challenges in understanding how people receive, process, and react to information. This can lead to negative behaviors, such as not processing the information or delaying responses (Li et al., 2023). Thus, the effectiveness of EWS depends on both technical aspects and the response capacity and preparedness of the population (Al-Rawas et al., 2024; Lindenlaub et al., 2024; Tan et al., 2023). For an EWS to have a significant impact, messages must be received, understood, and acted upon (Trahan et al., 2023). Although improvements in public perception and comprehension of warning messages can enhance response capacity, these aspects have not been thoroughly explored within the context of EWS (Lindenlaub et al., 2024; Tan et al., 2023). Therefore, this study aims to analyze the factors influencing the comprehension of alert messages received by citizens.

The ubiquity of smartphone usage has led to the widespread use of Short Message Service (SMS) and notifications as tools for disseminating warnings to the public owing to their speed and efficiency in reaching large audiences in a short period (Luht-Kallas et al., 2023). Public authorities are increasingly promoting the use of warning apps, but achieving this requires an understanding of the factors driving their adoption (Fischer-Preßler et al., 2022). Since the effectiveness of warning notifications depends on factors such as visibility and comprehensibility (Bonaretti & Fischer-Preßler, 2021; Luht-Kallas et al., 2023), this study addresses the gap by analyzing how the design of warning notifications enables recipients to understand and act without hesitation (Bonaretti & Fischer-Preßler, 2021). In doing so, it responds to the need for improving the robustness of warning messages in EWS (Al-Rawas et al., 2024; Tan et al., 2023). Likewise, the call to assess the use of EWS by citizens and the evaluation of their dissemination channels is responded to (Meléndez-Landaverde & Sempere-Torres, 2025).

Given the complexity of human behavior during natural disasters, qualitative comparative analysis (QCA) was employed (Lyu et al., 2023). This is also because the adoption of EWS can be achieved through various combinations of influencing factors that, in some cases, compensate for one another (Kalpana, 2023). QCA identifies strategies to enhance consumer responses, as explained by the stimulus–organism–response theory, which models the different combinations of stimuli and organisms that explain varying responses (Kang et al., 2024; Li et al., 2024; Yan et al., 2023). Innovative conceptual contributions often emerge from the integration of diverse theoretical and methodological perspectives (Marzi et al., 2024).

To achieve the objectives of this study, a sample of 188 Internet users in Spain who were familiar with Es-Alert and had received a message (either test or real) was analyzed. In Spain, while 14% of respondents in 2023 considered the system improvable, this percentage increased to 21% in 2024. Despite this, perceptions of its usefulness (50.3–55.7%) and necessity (36.6–40.1%) also improved, although there remains room for further enhancement (AIMC, 2023; 2024).

The article begins with a literature review, which examines the stimulus–organism–response model, early warning systems, and information asymmetry. The proposed model and justification of the propositions are then presented. The methodology, including the method employed (QCA) and the sample, is then described. Following this, the results and their discussion are presented. Finally, the study concludes with a section on conclusions, contributions, limitations, and future research directions. The findings confirm that the comprehension of alert messages depends on both stimuli and their interaction with the organisms considered in this study. This reinforces the importance of message content in achieving the desired response when issuing an EWS. Additionally, to explain not understanding received messages, factors such as the individual's gender and the interaction between stimulus and organism factors must be considered. These interactions sometimes reflect compensatory effects between factors.

2. Literature Review

2.1. The Stimulus–Organism–Response

This research is grounded in the stimulus–organism–response (S-O-R) theory (Mehrabian & Russell, 1974), which explains how citizens respond to alerts issued by EWS. This theory emphasizes the importance of understanding the complex interplay between environmental characteristics, cognitive and emotional processes, and resulting actions when it comes to predicting and potentially influencing future behaviors (Li et al., 2024; Wang et al., 2024). The S-O-R theory (Mehrabian & Russell, 1974) posits that environmental factors [stimuli (S)] activate individuals' perceptions through cognitive and affective judgments [organisms (O)], which lead to behavioral decisions [responses (R)] (Al-Debei et al., 2022; Mehrabian & Russell, 1974; Payal et al., 2024; Shareef et al., 2021). In this framework, the organism mediates the impact of stimuli on behavioral responses (Goyal et al., 2022). The three components of the S-O-R model are connected, explaining their interaction (Roux & Maree, 2021; Wang & Musa, 2024). The S-O-R model is a flexible theoretical approach that integrates internal and external and tangible and intangible stimuli; experiential and non-experiential organisms (including attitude, emotion, perception, judgment, belief, and thought); and various responses, such as intentions, behaviors, or aversions (Rodríguez-Torrico et al., 2019; Sultan et al., 2021). The S-O-R model builds upon the law of effect or stimulus–response (S-R) theory, which suggests that behavioral responses leading to desired outcomes are likely to recur in response to similar stimuli. However, the S-R model assumes consumers make purely rational decisions, omitting mental states, motivations, processes, and individual differences—gaps that the S-O-R model addresses comprehensively (Sultan et al., 2021).

The stimulus (S) represents the initial point of action for an individual, encompassing environmental characteristics that can trigger psychological or behavioral responses (Goyal et al., 2022; Li et al., 2021; Obeidat et al., 2022). Traditionally, the

S-O-R framework views stimuli as external or environmental factors (physical or social) that influence individual perceptions (Kang et al., 2024; Wang et al., 2024). Recent research, however, includes internal stimuli alongside external ones (Goyal et al., 2022). The organism (O) comprises feelings, thoughts, and psychological and perceptual activities, serving as a transitional state between stimulus and response (Goyal et al., 2022; Li et al., 2021; Obeidat et al., 2022; Wang et al., 2024). Perception acts as a process of interpreting and deriving meaning from experiences when consumers are exposed to stimuli (Shareef et al., 2021). The organism encompasses both emotional/affective and cognitive/non-emotional reactions (Li et al., 2021; Obeidat et al., 2022; Wang et al., 2024). While initial literature emphasized affective reactions, both affective and cognitive internal states are essential for a comprehensive understanding of consumer behavior (Rodríguez-Torrico et al., 2019). Cognition pertains to the formation of perceptual images initiated upon receiving stimuli (Li et al., 2021; Sultan et al., 2021), involving perception, learning, and memory (Wang et al., 2024). The affective reaction involves emotions and moods induced by the stimulus (Wang et al., 2024). Emotional reactions include feelings triggered by stimuli, such as pleasure, arousal, or dominance (Li et al., 2021). The response (R) is the final outcome, reflecting consumers' approach or avoidance behaviors (Obeidat et al., 2022). It encompasses decisions, actions, or behaviors resulting from the interaction between stimulus and organism (Li et al., 2021; Wang et al., 2024). Positive responses include intentions to stay or engage favorably, whereas aversions may involve ignoring information (Sultan et al., 2021).

The S-O-R model effectively explains behavioral changes resulting from various marketing stimuli and cognitive factors (Sultan et al., 2021). Consequently, it has been widely employed in consumer behavior studies (Li et al., 2021; Obeidat et al., 2022; Sharma et al., 2024; Song et al., 2024), illustrating how external stimuli evoke consumer responses (Obeidat et al., 2022). S-O-R measures the influence of environmental stimuli on emotions and individual behaviors (Tong et al., 2022), offering valuable insights into the "black box" linking technology-related stimuli and consumer responses (Lim et al., 2021; Yan et al., 2023). In the context of mobile telephony, the stimulus includes factors affecting the effectiveness of value-added services (e.g., network quality, service content quality, and customer service quality). The organism reflects users' cognitive states (perceived value) and affective states (consumer satisfaction). Organisms serve as platforms for promoting specific behavioral outcomes, such as continued purchase intentions (R) (Al-Debei et al., 2022; Rodríguez-Torrico et al., 2019). Using the S-O-R model, it is possible to identify factors that stimulate internal cognitive and emotional mechanisms influencing responses to emergencies (Li et al., 2021).

2.2. Early Warning Systems

Access to accurate and timely information is crucial for understanding the dynamics of disasters (Sufri et al., 2020). Communication plays a fundamental role in enhancing community resilience during disasters by influencing citizens' attitudes and behaviors (Dargin et al., 2021). Emergency warning systems (EWS) are part of the critical infrastructure of countries and are designed to inform potentially affected groups about adverse weather conditions, fires, hazardous materials, and other disasters at the national, regional, or local levels (Woszczynski et al., 2020). Disaster communication through mass media includes the dissemination of alarm messages by governmental entities and media coverage of these events (Dargin et al., 2021; Sufri et al., 2020). Within this framework, EWS serve as essential platforms for the large-scale distribution of alarm messages across multiple channels (Bonaretti & Fischer-Preßler, 2021).

Communicating emergencies through multiple channels is essential (Sufri et al., 2020), as no single channel can universally or exclusively serve as the best medium for emergency alerts. The complementarity of channels suggests that introducing new communication methods does not replace existing ones but instead increases the likelihood of timely alerts reaching potential victims (Bonaretti & Fischer-Preßler, 2021). Designing an effective community-based EWS requires identifying the target population, their needs, response capacities, and the best protective actions to reduce risk during emergencies (Meléndez-Landaverde & Sempere-Torres, 2025). Furthermore, the effective design and operation of EWS require a comprehensive approach that actively involves communities in four essential pillars: risk knowledge, monitoring and alerting, information dissemination, and response capacity (Sufri et al., 2020). This approach ensures not only technological effectiveness but also active community participation, maximizing preparedness and minimizing losses.

The widespread use of smartphones and the ubiquity of the Internet have transformed emergency communications into a critical asset for reaching populations during emergencies, thanks to their ability to quickly engage users (Fischer-Preßler et al., 2022; Shareef et al., 2021). In this context, the credibility and authenticity of messages become key factors. Given the skepticism surrounding messages disseminated via social media, SMS has emerged as a reliable platform for direct communication with identified individuals (Shareef et al., 2021). Its unique features, such as personalization, immediacy, and convenience, along with its minimal reliance on advanced technologies, generate high expectations for its use in public sector communications (Shareef et al., 2019; Shareef et al., 2021). However, it is important to acknowledge the inherent limitations of SMS communications, such as their constrained capacity to transmit complex or detailed information, which could be particularly challenging for vulnerable populations.

Critics have also pointed to the "poverty" of content that characterizes SMS messages (David-West et al., 2020). Despite these limitations, SMS remains the most accessible channel for delivering push notifications directly to users' smartphones without requiring social media accounts, logins, or Internet connectivity (Bonaretti & Fischer-Preßler, 2021). For this reason, SMS has been actively integrated as an additional medium within public communication infrastructures (Shareef et al., 2017).

The distribution of SMS alerts as part of EWS is critical for emergency warnings, complementing the information provided through other channels (Bonaretti & Fischer-Preßler, 2021; Luht-Kallas et al., 2023). Additionally, warning apps have been developed for devices such as smartphones and smartwatches. These apps are designed to send one-way communications from authorities to relevant publics, aiming to minimize the adverse consequences of imminent emergencies (Fischer-Preßler et al., 2022). However, Sufri et al. (2020) emphasize that the effectiveness of many EWS is limited by the lack of integration between local and indigenous knowledge and scientific data.

Understanding appropriate response behaviors is essential to maximizing the effectiveness of EWS. Warning messages must not only convey information about impending risks but also include clear recommendations for appropriate actions (Lindenlaub et al., 2024). A warning SMS should, at a minimum, include the following elements: (1) clear and specific instructions that enhance response speed by explaining what to do and how to do it, (2) information on when and for how long protective measures should be taken, (3) a detailed guide on the areas affected by the hazard, (4) contextualization of the instructions within the message, and (5) assurance of the credibility of the source of the message (Luht-Kallas et al., 2023).

2.3. Information Asymmetry

Asymmetry is the situation in which some participants in an economic transaction have access to more, or better, relevant information than other participants (Eom et al., 2018). Thus, it is pointed out that markets do not achieve perfect efficiency due to the existence of information asymmetries (Velichety & Shrivastava, 2022). Information asymmetry exists when one or more parties have greater recognition of the relevant information to participate effectively in a given situation compared with the rest of the participants (Clarkson et al., 2007). Applied from a principal–agent relationship, information asymmetry exists when the agent has more knowledge or experience, which exacerbates the principal's uncertainty about whether the agent will choose to follow the principal's best interest (Eom et al., 2018). This principal–agent relationship and information asymmetry are present in the public sector (even between administrations at different levels) (Ma et al., 2024; Zhao et al., 2025). From another perspective, the information asymmetry between citizens (principal), political leaders (agent), and public managers (subagent) in civil administration services may be one of the main causes inhibiting their capacity to respond to unexpected situations (Eom et al., 2018).

Information asymmetry is often the product of practices linked to not sharing information, or even deliberately withholding it (Clarkson et al., 2007). Therefore, information provision is identified as the main formula for reducing information asymmetry (Zhang et al., 2024). In this sense, since the use of social media and other online means to provide information has become widespread, the interactions that occur there contribute to resolving the information asymmetry between government and citizens and strengthening the government's responsiveness (Eom et al., 2018; Velichety & Shrivastava, 2022).

Information asymmetry related to the environment can lead to biased judgments among public managers and the public (Zhang et al., 2024). The lack of information regarding the existence of natural disasters generates an information asymmetry that can impact the management of such risks (Lyle et al., 2024). Information asymmetry can imply a lack of a comprehensive view of the implementation of survival policies and uncertainty about the risks involved (Trüdinger & Streckermeier, 2017). Therefore, the use of EWS is proposed as a way to address information asymmetry in emergency situations (Ma et al., 2024; Zhao et al., 2025).

3. Proposed Model and Justification of Propositions

3.1. Proposed Model

This study builds upon Shareef et al. (2021) by extending the S-O-R framework to include factors related to SMS advertising content. The proposed model (***Fig. 1***) posits that individuals' perceptions of message characteristics (improvability, usefulness, and necessity), serving as stimuli (S), interact with individual traits (trust in e-commerce and use of fake news verification apps) as organisms (O), to explain the response (R) to messages issued via Es-Alert.

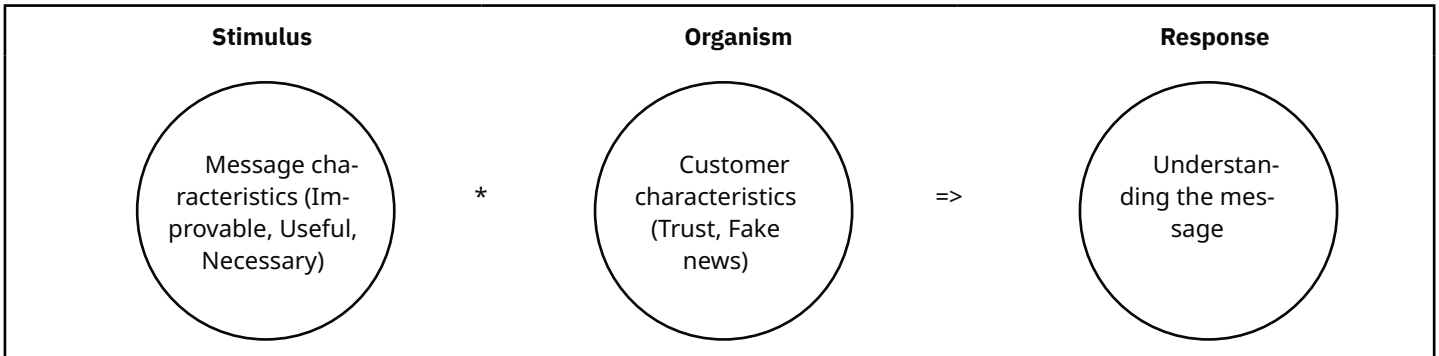

Figure 1. Proposed model.

3.2. Justification of Propositions

Among the stimuli included in the proposed model are aspects related to the perception of the message received by the individual. This perception is crucial for fostering a positive attitude and shaping behavioral intention (Shareef et al., 2021).

Communication can influence both hedonic and utilitarian attitudes (Sultan et al., 2021). In this regard, the perceived quality of information represents a key stimulus that reflects the recipient's evaluation of the performance of the message content (Abbasi et al., 2024; Wang & Musa, 2024) or its perceived value (Hussain et al., 2023; Molinillo et al., 2021). When recipients perceive the SMS content as interesting or useful, they tend to respond positively and develop a favorable attitude (Shareef et al., 2021). Furthermore, this attitude is reinforced when messages are personalized and have a clear purpose (Shareef et al., 2019). The effectiveness of a message thus depends on its ability to address the informational needs of the audience, thereby increasing its impact (Wang et al., 2024). The success of SMS as a communication tool is influenced by factors such as text, design, clarity of instructions, language, and presentation—that is, the overall content of the message (Shareef et al., 2017). Online information content can help reduce information asymmetry and moderate the relationship between stimulus and response (Rathim et al., 2024). This content must not only convey information about risks, areas of impact, and necessary actions but also establish the validity and source of the message (Chen et al., 2024). The effectiveness of SMS warning messages, measured by the likelihood of appropriate recipient action, depends on their visibility (the recipient's ability to receive and see them) and comprehensibility (the degree to which the recipient can interpret and understand them) (Luht-Kallas et al., 2023).

The recipient's evaluation of the utility and richness of an SMS directly influences their attitude toward it (Shareef et al., 2021). Message-linked involvement, understood as an organism, is the internal state of activation or attention evoked by the stimulus (Hussain et al., 2023). Key factors related to the "organism" in consumer behavior include attitude, satisfaction, and perceived value (Li et al., 2021). However, in the context of alerts and crises, satisfaction as a hedonic factor may not be the most appropriate focus (Tan et al., 2023). Therefore, the model incorporates factors such as trust (Abbasi et al., 2024; Goyal et al., 2022; Obeidat et al., 2022; Payal et al., 2024; Rodríguez-Torrico et al., 2019) and concern about fake news.

The validity, reputation, and reliability of messages received via mobile phones are critical for their effectiveness (Shareef et al., 2017). However, consumers may distrust the authenticity and reliability of SMS-delivered messages (Shareef et al., 2019). Perceived trust is a determining factor for high-risk technologies, where misuse could lead to severe consequences (Tan et al., 2023). Clear and reliable communication channels, along with trust in both the alert messages and their sources, are essential for the acceptance of EWS and effective disaster response (Tan et al., 2023). Thus, SMS serves only as a communication tool for reputable organizations (Shareef et al., 2017). Minimizing errors in alert system messages ensures public trust by emphasizing their validity, reliability, relevance, timeliness, and realism (Woszczynski et al., 2020). Furthermore, excessive message frequency can cause irritation, rejection, or ignorance, undermining the system's original purpose (Shareef et al., 2017; Shareef et al., 2019; Shareef et al., 2021). This challenge is exacerbated by the confusion generated by multiple EWS sources (Tan et al., 2023), as an overload of alerts can erode trust, even during emergencies (Woszczynski et al., 2020). Another critical aspect is the spread of misinformation through social networks, which have become a source of information for certain population segments (Neyazi et al., 2024; Ruiz & Nilsson, 2023; Sahid et al., 2025). Fake news exacerbates crises by increasing complexity and adding adverse consequences (Sievi & Pawelec, 2025), also impacting the information asymmetry (Velichety & Shrivastava, 2022). Owing to the ease with which users create and disseminate content, social media platforms are a perfect source for misinformation (Sahid et al., 2025). Public institutions recognize misinformation as a serious threat and implement strategies such as authoritative fact-checking, content bans, and user sanctions to mitigate its effects (Ruiz & Nilsson, 2023).

Key factors influencing positive attitudes toward SMS use by public administrations include timing and location, relevance, and reliability (Shareef et al., 2019). To maximize effectiveness, messages must be specific, precise, certain, and consistent, as these characteristics directly affect their perceived credibility (Chen et al., 2024). Additionally, perceived utility mitigates the effects of information overload on response delays (Li et al., 2023). The perception of an SMS

announcement also influences behavioral intention, mediated by the value and attitude toward the message (Shareef et al., 2021). In this context, message reliability serves as an organism factor that mediates the relationship between stimulus and response, determining the receiver's acceptance (Obeidat et al., 2022). Consumers who trust both the sender and the credibility of the message content are more likely to respond positively (Shareef et al., 2021). In some cases, the authenticity of messages received through public services is questioned. In virtual environments, the reliability of both content and context plays a crucial role in building consumer trust in SMS-delivered messages (Shareef et al., 2019). Misinformation can significantly affect individuals, organizations, and society, impacting readers' trust in the information ecosystem (Sahid et al., 2025). Consequently, perceived utility and trust significantly impact users' intentions to pay attention to EWS messages (Tan et al., 2023). Moreover, behavioral responses are directly related to satisfaction with the received services and perceived value (Al-Debei et al., 2022). While factors such as trust, social influence, and response efficacy positively influence the intention to use and effective use of a warning app, perceived vulnerability affects only the intention to use (Fischer-Preßler et al., 2022). Based on this analysis, the following propositions are established:

Proposition 1. Stimulus factors (related to message perception) and organism factors (related to the message recipient) interact in explaining the comprehension of the message received from the EWS.

Proposition 2. Stimulus factors (related to message perception) and organism factors (related to the message recipient) interact in explaining the negation of comprehension of the message received from the EWS.

4. Methodology

4.1. Method

Marketing studies are often dominated by variance-based approaches, which have significant limitations for understanding phenomena studied in macro-marketing. These phenomena frequently arise from different combinations of causal conditions, where the factors leading to the same outcome may differ from those preventing it (Brush et al., 2024; Ingrams, 2023). In traditional quantitative analyses, independent variables are treated as qualitatively separate cases, with autonomous or independent capacity to influence the level, intensity, or likelihood of the dependent variable. Consequently, the effects of independent variables are assumed to be linear and additive (Brush et al., 2024; Grofman & Schneider, 2009). Fiss (2011) highlights the use of set theory in configuration analysis, emphasizing that relationships between variables are often better understood in terms of set membership (Ott et al., 2019).

A set-theoretic approach, unlike variance-based correlational methods, does not analytically decompose cases into independent aspects. Instead, it treats configurations as distinct types of cases (Brush et al., 2024; Fiss, 2011). QCA is a set-theoretic method that enables the evaluation of factors collectively and identifies alternative explanatory pathways (Ingrams, 2023). QCA bridges the gap between case studies and large-sample research. However, it is not the sample size but its epistemological foundations that differentiate QCA from standard statistical techniques (Grofman & Schneider, 2009). Set-theoretic analysis differs from traditional quantitative methods by emphasizing calibration over measurement, configurations of conditions over independent variables, set-theoretic connections over correlations, and the analysis of causal complexity over net effects (Brush et al., 2024). While standard statistical techniques are effective for identifying net effects of individual variables, QCA focuses on causal complexity to detect different conjunctions of conditions (configurations) that lead to the same outcome through cross-case analysis (Grofman & Schneider, 2009; Zhao & Fan, 2021).

Unlike traditional quantitative techniques, which assume symmetry, QCA is asymmetric (Brush et al., 2024), distinguishing between explanations for a result and its negation. It also explains how different configurations of conditions can lead to the same outcome (equifinality), making it ideal for studying phenomena with complex relationships among conditional variables (Zhao & Fan, 2021). Additionally, QCA evaluates the combined effects of various conditions (conjunctural causation), which may be necessary and/or sufficient to achieve a configurational outcome (Ingrams, 2023; Nishant et al., 2024). Thus, in contexts where the phenomenon is presumed to result from causally complex structures involving hypotheses of necessity or sufficiency, QCA is an appropriate methodology (Grofman & Schneider, 2009). Furthermore, QCA aids in understanding the factors influencing risk identification (Kalpana, 2023).

The first variant developed within QCA, crip-set QCA (csQCA), simplifies complex configurations using Boolean logic and identifies configurational models of multiple causal pathways (Roig-Tierno et al., 2017). Boolean algebra, which underpins the creation of truth tables in set-theoretic techniques, employs variables that occur or do not occur in two binary states: true (present) or false (absent). This classification enables cases to be grouped on the basis of their membership or non-membership in a set, emphasizing qualitative differences (Mello, 2021; Oana et al., 2021; Zhao & Fan, 2021). Accordingly, csQCA operates exclusively within conventional sets where cases can either belong to or not belong to a set (Schneider & Wageman, 2013), using categorical conditions and dichotomous values that assign 1 (full membership) or 0 (full non-membership) to each condition (Nishant et al., 2024; Roig-Tierno et al., 2017; Tsutsunashvili et al., 2024). The choice of csQCA for this study stems from the empirical characteristics of the analyzed context (Medina-Molina et al., 2023; Nishant et al., 2024)

4.2. Data Collection

The Asociación para la Investigación de los Medios de Comunicación (AIMC) has been measuring Internet usage

in Spain since 1996. Between October 17 and December 11, 2023, AIMC conducted the fieldwork for its latest study targeting Internet users aged 14 years and above who visit Spanish websites. This edition produced a representative sample of 18,902 respondents, from which 188 surveys were selected for this study. The selected respondents were between 35 and 44 years of age and had heard of the new mobile emergency alert system (ES-Alert), having received at least one real or test alert.

Opinions about the alert system [useful (USEF), necessary (NECE), and needs improvement (IMPR)] were measured using a dichotomous scale with questions such as "What is your opinion about this new alert system?" and response options such as "Useful," "Necessary," or "Needs Improvement." Message comprehension (MESS) was assessed through the statement "When I received the alert message, I quickly understood its purpose," using a dichotomous scale. Perceptions of the impact of fake news (FAKE) were measured with a five-point Likert scale using questions such as "To what extent do you agree with each of these statements?" (1 = strongly disagree and 5 = strongly agree). Finally, trust in e-commerce (TRUS) was evaluated using another five-point scale through the question "How much trust do you have in e-commerce?" (1 = very high, 2 = high, 3 = medium, 4 = low, and 5 = very low).

5. Analysis

5.1. Preliminary Analysis

Initially, the conditions and the outcome included in the model were calibrated. Since both the outcome and several conditions were measured using dichotomous scales (e.g., MESS, USEF, NECE, and IMPR), all conditions were dichotomized (Table 1)

Table 1. *Calibration of conditions and outcome*

	MESS	USEF	NECE	IMPR	TRUS	FAKE
Full membership	1	1	1	1	≤ 2	4
Full non-membership	0	0	0	0	≥ 3	≤ 3

Next, the skewness of the data was analyzed, confirming that both the outcome and all conditions fell within recommended ranges (MESS = 68.62%, TRUS = 62.23%, NECE = 39.89%, IMPR = 20.21%, FAKE = 77.66%, and USEF = 51.06%) (Oana et al., 2021).

5.2. Identification of Necessary Conditions

The existence of atomic necessary conditions was analyzed (Table 2), confirming that none exceeded the thresholds required to be considered necessary. Similarly, no supersets reached the consistency [consistency for necessity (Cons.Nec) = 0.9] and relevance [relevance of necessity (RoN) = 0.6] thresholds.

Table 2. *Necessary conditions analysis for MESS/~MESS*

	Cons.Nec	Cov.Nec	RoN
USEF	0.605/0.305	0.812/0.188	0.836/0.541
NECE	0.473/0.237	0.813/0.187	0.890/0.649
IMPR	0.186/0.237	0.632/0.368	0.915/0.862
TRUS	0.636/0.593	0.701/0.299	0.670/0.464
FAKE	0.806/0.712	0.712/0.288	0.500/0.288
~USEF	0.395/0.695	0.554/0.446	0.701/0.653
~NECE	0.527/0.763	0.602/0.398	0.625/0.524
~IMPR	0.814/0.763	0.700/0.300	0.458/0.266
~TRUS	0.364/0.407	0.662/0.338	0.830/0.713
~FAKE	0.194/0.288	0.595/0.405	0.896/0.854

The tilde "~" denotes the logical operator "NOT." ***Cons.Nec*** consistency for necessity, ***Cov.Nec*** coverage for necessity, ***RoN*** relevance of necessity.

5.3. Identification of Sufficient Conditions

To identify sufficient conditions, a truth table was generated with a consistency threshold of 0.75 and a minimum of two cases per configuration. The parsimonious solution was selected, as it describes cases empirically connected to the outcome, although it may omit some factors that characterize such cases. At the same time, it is broad enough to encompass types of cases that have not been empirically observed (Glaesser, 2023). This choice facilitates the interpretation of causal models, as the parsimonious solution is the most suitable for reflecting causal structures (Baumgartner, 2015).

The parsimonious solution for MESS was ~TRUS*NECE + TRUS*USEF + NECE*IMPR + NECE*~FAKE, where the multiplication symbol "*" denotes the logical operator "AND," the addition symbol "+" the logical operator "OR," and the tilde "~" the logical operator "NOT." This solution exhibited high consistency [inclusion for sufficiency (inclS) = 0.851] and coverage [solution coverage (covS) = 0.667]. The parameters for each of the four terms are detailed in Table 3. The simplified solution is expressed as TRUS*USEF + NECE*(~TRUS + IMPR+ ~FAKE).

Table 3. *Parsimonious solution for MESS*

	inclS	covS	covU
~TRUS*NECE	0.885	0.178	0.132
TRUS*USEF	0.821	0.426	0.380
NECE*IMPR	0.818	0.070	0.016
NECE*~FAKE	0.917	0.085	0.047
Model	0.851	0.667	—

The multiplication symbol "*" denotes the logical operator "AND," and the tilde "~" the logical operator "NOT." ***inclS*** inclusion for sufficiency, ***covS*** solution coverage, ***covU*** unique coverage.

For ~MESS, the parsimonious solution was ~USEF*~NECE*~IMPR*~FAKE, with high consistency (inclS = 0.833) but limited coverage (covS = 0.169) (Table 4).

Table 4. *Parsimonious solution for ~MESS*

	inclS	covS	covU
~USEF*~NECE*~IMPR*~FAKE	0.833	0.169	—
Model	0.833	0.169	—

The multiplication symbol "*" denotes the logical operator "AND," and the tilde "~" the logical operator "NOT." ***inclS*** inclusion for sufficiency, ***covS*** solution coverage, ***covU*** unique coverage

In the case of a solution with low coverage, it is advisable to identify omitted conditions to recalculate the solution and improve the descriptive inference of the QCA study (Schneider, 2024). Descriptive inference involves using observations to gain insights into unobserved facts (Thomnan & Magetti, 2020). Since cluster analysis can help identify overlooked conditions that may hinder the generalization of results to the entire sample (Oana et al., 2021), a cluster analysis was performed using respondents' gender as the grouping variable. QCA is particularly useful for incorporating the effects of "quasi-moderator" variables into its analysis (Söderlund, 2023). As shown in Table 5, no relevant differences were identified in the solution obtained on the basis of the respondent's gender for explaining MESS.

Table 5. *Cluster analysis of MESS based on gender*

	~TRUS*NECE	TRUS*USEF	NECE*IMPR	NECE*~FAKE
Consistencies				
Pooled	0.885	0.821	0.818	0.917
Between 0 (92)	0.923	0.750	0.800	1.000
Between 1 (96)	0.846	0.872	0.833	0.833
Distances				
From "between" to "pooled"	0.031	0.053	0.014	0.064
Coverages				
Pooled	0.178	0.426	0.070	0.085
Between 0 (92)	0.194	0.339	0.065	0.097
Between 1 (96)	0.164	0.507	0.075	0.075

The multiplication symbol "*" denotes the logical operator "AND," and the tilde "~" the logical operator "NOT"

However, when performing a cluster analysis for the parsimonious solution of ~MESS (Table 6), the distance values suggest that the solution is not generalizable to the entire sample without considering gender as a condition (Oana et al., 2021).

Table 6. *Cluster analysis of ~MESS based on gender*

	~USEF*~NECE*~IMPR*~FAKE
Consistencies	
Pooled	0.833
Between 0 (92)	0.714
Between 1 (96)	1.000
Distances	
From Between to Pooled	0.118
Coverages	
Pooled	0.169
Between 0 (92)	0.167
Between 1 (96)	0.172

The multiplication symbol "*" denotes the logical operator "AND," and the tilde "~" the logical operator "NOT"

Based on the results, gender was included as an additional variable to explain the negation of message comprehension (~MESS), given its impact on technology adoption (Wang & Lu, 2025) and the use of digital devices across genders (Lluch et al., 2024). Previous studies highlight three major gender-based differences in decision-making: (1) men tend to be more pragmatic, (2) women exhibit greater anxiety when engaging in new activities, and (3) women are more influenced by their immediate social environment (Lim et al., 2021). Moreover, women respond more sensitively to complex contexts (Tong et al., 2022), prioritizing stimuli such as intimacy, immediacy, and interaction (Lim et al., 2021). Conversely, men tend to emphasize experiential stimuli in generating "organism" dimensions, such as engagement and co-creation behaviors. Additionally, the quality of information stimulus has a more significant effect on perceived value for men (Molinillo et al., 2021). Gender also moderates the S-O-R relationship (Hazari & Sethna, 2023; Sultan et al., 2021), influencing emotional and behavioral responses, with women displaying higher emotional levels (Tong et al., 2022). Furthermore, gender moderates individual behavior in emergencies (Mao et al., 2024), facilitating or hindering access to information provided by EWS (Trahan et al., 2023).

After including gender, the parsimonious solution for ~MESS is formulated as: ~USEF*~NECE*~IMPR*TRUS*~GENDER + ~USEF*~NECE*~IMPR*~FAKE*GENDER + ~USEF*NECE*TRUS*FAKE*GENDER + ~NECE*IMPR*~TRUS*FAKE*GENDER. This solution (Table 7) maintains high consistency (inclS = 0.818) and improves coverage (covU = 0.305). The simplified solution is expressed as: ~USEF*~NECE*~IMPR*TRUS*~GENDER + GENDER*[~USEF*~NECE*~IMPR*~FAKE + FAKE *(~USEF*NECE*TRUS + ~NECE*IMPR*~TRUS)]. This simplification demonstrates how gender interacts with stimuli and organism dimensions to explain the negation of message comprehension.

Table 7. *Parsimonious solution for ~MESS including gender*

	inclS	covS	covU
~USEF*~NECE*~IMPR*TRUS*~GENDER	0.800	0.136	0.136
~USEF*~NECE*~IMPR*~FAKE*GENDER	1.000	0.085	0.085
~USEF*NECE*TRUS*FAKE*GENDER	0.600	0.051	0.051
~NECE*IMPR*~TRUS*FAKE*GENDER	1.000	0.034	0.034
Model	0.818	0.305	

The multiplication symbol "*" denotes the logical operator "AND," and the tilde "~" the logical operator "NOT." ***inclS*** inclusion for sufficiency, ***covS*** solution coverage, ***covU*** unique coverage

5.4. Robustness of the Solutions

To evaluate the robustness of the solutions, the robustness test proposed by Oana and Schneider (2024) was applied. Three alternative models were generated, considering three cases per configuration and a consistency threshold of 0.8 for sufficiency. The solution for MESS exhibited high robustness parameters across both the robustness of fit [Robustness Fit Converage (RF_cov) = 0.907, Robustness Fit Consistency (RF_cons) = 0.993, Robustness Fit Set Coincidence minimum Test Set (RF_SC_minTS) = 0.901, Robustness Fit Set Coincidence maximum Test Set (RF_SC_maxTS) = 0.980] and the robustness case ratio [Robustness Case Ratio for typical cases (RCR_typ) = 0.907, Robustness Case Ratio for deviant cases (RCR_dev) = 0.867, Robustness Case Rank (RCC_Rank) = 3]. For the ~MESS solution incorporating gender, while the robustness of fit parameters were satisfactory (RF_cov = 0.610, RF_cons = 0.926, RF_SC_minTS = 0.448, and RF_SC_maxTS = 0.621), the robustness case ratio values were comparatively lower (RCR_typ = 0.550, RCR_dev = 0.222, and RCC_Rank = 4).

6. Discussion

First, this study demonstrates that no necessary conditions exist for understanding the content of the received alert message. This finding reflects the inherent complexity of the process of information reception and processing in emergency situations, as highlighted in the literature, where both technical and psychological factors interact to determine public comprehension and response (Lindenlaub et al., 2024; Tan et al., 2023). These results contrast with studies suggesting that stimuli are necessary factors for creating positive attitudes, an organism dimension (Lim et al., 2021).

The explanation for understanding the content of the received message is achieved through four terms. Three of these involve the combination of stimuli and organism dimensions (~TRUS*NECE, TRUS*USEF, and NECE*~FAKE), while one term considers only stimuli (NECE*IMPR). The latter term aligns with the S-R model, indicating that, if individuals perceive the message as having a clear purpose, they respond positively to it (Shareef et al., 2019). Indeed, the design, clarity, and defined purpose of the message are identified as critical factors for maximizing the effectiveness of alert messages (Luht-Kallas et al., 2023). When the stimulus "perceived as necessary" is combined with an organism, it compensates for the latter's low value (whether due to low trust or the perception of fake news as a threat). This finding aligns with prior research suggesting a potential trade-off between factors explaining the adoption of EWS (Kaplana, 2023). Moreover, in cases where stimuli and organism dimensions appear simultaneously, the response reflects decisions resulting from the interplay of both elements (Li et al., 2021; Wang et al., 2024).

Two of the terms show low coverage, indicating they explain a limited number of cases. This situation underscores the appropriateness of using QCA, as regression-based techniques might yield nonsignificant coefficients for such terms. However, these terms may still be theoretically, empirically, and substantively highly informative (Grofman & Schneider, 2009). Finally, since stimuli always appear with positive valence, the findings confirm that the better the alignment between the information provided and the individual's informational needs, the more effective the communication (Wang et al., 2024). This highlights the need to design messages that are clear, truthful, and specific, taking the audience's informational needs into account to maximize their impact (Chen et al., 20124). Accordingly, the style and content of the message help individuals respond positively upon receiving an EWS (Chan et al., 2024). Based on the above, proposition 1 is accepted.

The explanation for the outcome of "not understanding" the message content leverages QCA's asymmetry, recognizing that this outcome can both hinder and facilitate action (Sultan et al., 2021). Understanding why the message content is not comprehended requires considering the individual's gender, which may be linked to the specific age group in the sample, where gender differences in digital device usage are more pronounced (Lluch et al., 2024).

The first term is associated with women, who lack all three stimuli and have low trust in e-commerce. For men, there is also a term involving the absence of all three stimuli, but it further requires the negation of fake news. This highlights the importance of personalizing messages (Shareef et al., 2019), particularly by tailoring them to demographic characteristics such as gender, to enhance comprehension and effectiveness.

Finally, the remaining two terms correspond to men who perceive fake news as a significant problem and do not view the message as useful or necessary. This finding confirms that misinformation linked to fake news is a critical issue (Ruiz & Nilsson, 2023) and that the precision of the message directly impacts its credibility (Chen et al., 2024). Notably, in the third term, despite the presence of stimuli and organism dimensions, the negation of perceived usefulness leads to a lack of message comprehension. Perceived usefulness is therefore critical for generating positive responses, as noted by Shareef et al. (2021), and any deficiency in this aspect could hinder the desired response, as individuals might disregard messages issued by the EWS (Tan et al., 2023). In fact, throughout the explanation of message incomprehension, perceived usefulness is consistently absent, reinforcing the idea

that individuals must perceive the message as informative or useful to respond positively (Shareef et al., 2021). Based on the above, proposition 2 is accepted.

7. Conclusions, Contributions, Limitations, and Future Research Directions

7.1. Conclusions

The increase in natural disasters affecting communities has sparked interest in studying various tools that can aid in their prevention and minimize their impact by guiding public action. Many public administrations have turned to EWS, systems that have evolved primarily in technological terms, often overlooking the social and cognitive factors that influence their adoption and use by citizens. Accordingly, this study analyzes the factors that explain citizens' comprehension of alert messages they receive.

Using a model grounded in the S-O-R framework, the study identifies the conditions that explain whether or not individuals understand the content of an alert message. The findings reveal that understanding the content of such messages involves either an interaction between the stimulus and organism dimensions or the effects of the stimulus alone. However, stimuli compensate for certain deficits in organism dimensions. In contrast, explaining why messages are not understood requires incorporating variables such as gender, highlighting the complex interactions between stimuli and organisms and their potential to mutually compensate.

7.2. Contributions

This study confirms the suitability of the S-O-R framework for describing the use of digital technologies in emergency contexts. Furthermore, it reveals that in certain cases, the stimulus–response (S-R) interaction alone may suffice to explain the adoption of these systems, extending the applications of the S-O-R model beyond traditional marketing and consumption scenarios.

The findings offer valuable insights for organizations responsible for EWS. In particular, the study emphasizes that message design and content are critical elements for ensuring comprehension, especially in rural communities, populations with disabilities, or those with limited resources. This underscores the need to integrate community knowledge and scientific data to maximize the effectiveness of alert messages. The study highlights the importance of message content dimensions in ensuring adequate comprehension. Several practical recommendations are identified to be precise: First, in regard to public awareness campaigns, it is crucial to continue public outreach efforts to raise awareness about the importance of alert messages. This awareness can help overcome cognitive and attitudinal barriers that hinder the interpretation of warning messages. Second, regarding gender adaptation, the results reveal significant differences between men and women in the perception and comprehension of messages. Among women who do not understand the message, a high level of trust in e-commerce is observed, combined with a low perception of message content. This underscores the need to improve the clarity and relevance of the message content. For men, concerns about fake news emerge as a significant obstacle. Implementing information verification tools could be an effective strategy to mitigate these concerns and enhance the comprehension of warning messages.

In any case, public institutions must strive to overcome the information asymmetries identified in the literature so as to facilitate the public's access to their notifications containing timely information about the various environmental threats. In this regard, public administrations must remember that Sustainable Development Goal (SDG) 11, Sustainable Cities and Communities, is linked to target 11.5, which seeks, among other things, to significantly reduce the number of deaths caused by disasters, the number of people affected by them, and the economic losses associated with them. To achieve a reduction in the number of people affected, few tools can be as effective as having an EWS that is well-attended by the public.

From a methodological perspective, this study demonstrates the potential of QCA to address complex and nonlinear phenomena. The asymmetry of QCA reveals that the explanations for understanding a received message differ from those for not understanding it. Conjunctural causation is reflected in both the compensatory interactions between stimulus and organism dimensions and in the dependency of some conditions on the combinations they form with others. Finally, equifinality is evident in the fact that the explanations for both understanding and not understanding emergency messages each comprise four different terms. In other words, multiple configurations can explain the same phenomenon. Moreover, this study confirms the potential of QCA to incorporate conditions initially identified as having a "quasi-moderator" role into the model.

7.3. Limitations

This study has some limitations. First, trust in the sources issuing the messages was not directly measured; instead, a proxy variable—trust in e-commerce—was used. Second, the analysis is cross-sectional and focused on a specific geographic area, which may limit the generalizability of the findings.

7.4. Future Research Directions

Future research could include additional organism dimensions, such as perceived value or satisfaction with the message, to provide a more comprehensive understanding of the factors influencing message comprehension. Lastly, exploring how trust in the source can be directly integrated into the model would contribute to a more precise understanding of the mechanisms underlying adoption.

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