Considerations for creating equitable and inclusive communication campaigns associated with ShakeAlert, the earthquake early warning system for the West Coast of the USA

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Abstract

Purpose – The 2019 Global Assessment Report on Disaster Risk Reduction (GAR) cites earthquakes as the most damaging natural hazard globally, causing billions of dollars of damage and killing thousands of people. Earthquakes have the potential to drastically impact physical, social and economic landscapes; to reduce this risk, earthquake early warning (EEW) systems have been developed. However, these technical EEW systems do not operate in a vacuum; the inequities in social systems, along with the needs of diverse populations, must be considered when developing these systems and their associated communication campaigns.

Design/methodology/approach – This article reviews aspects of social vulnerability as they relate to ShakeAlert, the EEW system for the USA. The authors identified two theories (relationship management theory and mute group theory) to inform self-reflective questions for agencies managing campaigns for EEW systems, which can assist in the development of more inclusive communication practices. Finally, the authors suggest this work contributes to important conversations about diversity, equity and inclusion (DEI) issues within early warning systems and earthquake preparedness campaigns in general.

Findings – To increase inclusivity, Macnamara (2012) argues that self-reflective questioning while analyzing perspective, philosophy and approaches for a campaign can help. Specific to EEW campaigns, developers may find self-reflective questions a useful approach to increase inclusion. These questions are guided by two theories and are explored in the paper.

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Research limitations/implications – Several research limitations exist. First, this work explores two theories to develop a combined theoretical model for self-reflective questions. Further research is required to determine if this approach and the combination of these two theories have adequately informed the development of the reflective questions.

Originality/value – The authors could find little peer-reviewed work examining DEI for EEW systems, and ShakeAlert in particular. While articles on early warning systems exist that explore aspects of this, EEW and ShakeAlert, with its very limited time frames for warnings, creates unique challenges.

Keywords Diversity, equity and inclusion (DEI), Earthquakes, Earthquake early warning systems, Communication

Paper type Conceptual paper

Introduction

Natural hazard events reveal, create and augment social vulnerabilities (Miles and Chang, 2006; Tapsell *et al.*, 2010), and the 2019 Global Assessment Report on Disaster Risk Reduction (GAR) cites earthquakes as the most damaging natural hazard globally. Early warning systems, as defined by the United Nations International Strategy for Disaster Reduction (UNISDR, 2009), are a set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss. Kelman and Gantz (2014) further explain that warning systems are inherently connected to social processes, which should be intertwined with the society that manages those systems.

The US Geological Survey (USGS) manages the ShakeAlert earthquake early warning (EEW) system for the West Coast of the USA, publishing ShakeAlert Messages [1] that contain data about the location, depth, estimated magnitude of an earthquake and expected shaking distribution, which in turn is published by delivery partners (Given *et al.*, 2018). EEW systems aim to mitigate damage by notifying individuals and automated infrastructure systems about shaking from an earthquake in progress, so they can take protective action (Wald, 2020; Minson *et al.*, 2019; Given *et al.*, 2014; Cochran *et al.*, 2018). Essentially, the USGS acts as the official "voice" of the warning system, as explored in Landis (2003); however, it is also supported by numerous private and public partnerships, as well as diverse alerting distributors, to manage this system.

Population characteristics, such as income, education, race and ethnicity, have been linked to a person's ability to recover from potential losses from disasters and simultaneously influence risk perceptions and preparedness behaviors (Schmidlin, 2006; Wolkin *et al.*, 2015). Garcia and Fearnley (2012) suggest that these be considerations for early warning systems to be more effective in diverse contexts. In this article, we explore how preparedness and earthquake communication campaigns might consider diversity, equity and inclusion (DEI) to better serve socially vulnerable populations, with a specific focus on ShakeAlert. We then offer theoretically informed self-reflective questions as a contribution to the conversations about DEI in EEW campaigns.

For this article, we define diversity as the range of perspectives, as shaped by social identities and experiences (Weissmann *et al.*, 2019), represented on a given topic. We define equity as nondiscriminatory access (Puritty *et al.*, 2017), which in this case requires an understanding of disparities in preparedness resources. Additionally, we distinguish this from inclusion, which relates to a deeper sense of communal involvement and welcome (Puritty *et al.*, 2017). We further use the definition of social vulnerability from Cutter *et al.* (2003) as "partially the product of social inequalities—those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond. It also includes place inequalities—those characteristics of communities and the built environment, such as the level of urbanization, growth rates, and economic vitality, that

contribute to the social vulnerability of places" (p. 242). Based on these definitions, issues of DEI are fundamentally connected to an individual or group's level of social vulnerability (for a complete review of social vulnerability definitions, see Tapsell *et al.*, 2010). For earthquakes in particular, a person's age, gender, socioeconomic status and/or ability may influence their capacity to receive, comprehend and respond to ShakeAlert messages (McBride *et al.*, 2021). Thus, campaigns associated with ShakeAlert are not detached from ideological systems of oppression, such as racism, classism and ableism. For the purposes of this article, we define campaigns broadly to include public education and communication programs promoting protective actions (Drop, Cover and Hold On), scientific and technical information about the ShakeAlert system, post-alert messaging and earthquake preparedness.

ShakeAlert, the EEW system in the USA

ShakeAlert can potentially provide seconds of notice before an earthquake is felt and has been publicly available in California since October 2019 and Washington and Oregon since spring 2021. A Cascadia subduction zone earthquake, modelled with the ShakeAlert EEW system, has the potential to provide 50-80s of warning before the seismic waves hit population centers (McGuire *et al.*, 2021). An estimated 51 million people live on the West Coast of the USA (U.S. Census, 2019), and the region is home to one of the fastest growing populations in the country (U.S. Census Bureau, 2010). This growth may require ShakeAlert's communication, and education programs to expand in an effort to continually reach as many people as possible through associated campaigns (McBride *et al.*, 2020; Cochran *et al.*, 2018). Given that the ShakeAlert system is growing, it is an important time to explore these issues to better inform future communication campaigns.

Socially vulnerable populations and risk communication

Emergency preparedness campaigns often use a one size fits all approach; however, risk messaging is multidimensional and needs to account for audience characteristics to be effective (Mileti and Fitzpatrick, 1992; Herovic *et al.*, 2014). Few studies have analyzed strategic communication efforts and campaigns targeted at diverse publics prior to earthquake events or during the recovery and aid process (Liu, 2007; Moore *et al.*, 2004; Marti *et al.*, 2020; McBride *et al.*, 2021). Baker and Cormier (2015), Bolin and Kurtz (2018) and Julca (2012) argue that the unique needs of economically vulnerable and marginalized communities are routinely neglected. Further, vulnerability and its supporting concepts should be approached with caution, as Marino and Fass (2020) suggest that defining a community as vulnerable is rife with colonialism and othering. Blake *et al.* (2017) argue this neglect and othering leads to the creation of exclusive preparedness campaigns that further propagate economic privilege.

Defining socially vulnerable populations is complex (Parker *et al.*, 2009; Tapsell *et al.*, 2010), yet social vulnerability becomes apparent after a hazard event. As Tapsell *et al.* (2010) note, "While all people living in hazard areas are vulnerable, the social impacts of hazard exposure often fall disproportionately on the most vulnerable people in society – the poor, minorities, children, the elderly and disabled" (p. 2). While social vulnerability is often examined in academic literature as it relates to an individual or group's ability to recover from hazard events, we focus our attention on the need to incorporate social vulnerability into communication efforts before an earthquake occurs. For this article, we focus on four variables of vulnerable populations from Cutter *et al.* (2003) that are particularly relevant for EEW campaigns:

(1) race, ethnicity and language,

(2) physical and mental access and functional needs,

(3) economic inequality and

(4) infrastructure and housing.

We acknowledge that other factors exist in the USA—e.g. immigration status (Méndez *et al.*, 2020), incarceration status (Purdum and Meyer, 2020), family structure (Peek, 2008), among many others—that are beyond the scope of this paper. In an effort to contribute to the conversation about how social vulnerability affects communication research and practice, we very briefly explore these variables while recognizing the intersectionality and complexity of each. Each variable constitutes entire fields of literature that should be more fully discussed and integrated into EEW campaigns.

Race, ethnicity and language

In the USA context, understanding the history of diverse racial and ethnic groups is paramount. Systems within the USA have historically upheld oppressive and exclusionary policies which have consequences for vulnerable populations during and after disasters (Bolin and Kurtz, 2018). Race is a socially constructed identity that classifies people based on interpretations of perceived physical characteristics, as explored in Weber (1998). Ethnicity refers to cultural practices, shared ancestry and language and also has implications for communities during disasters (Fothergill *et al.*, 1999). As Cutter *et al.* (2003) outline, non-white and non-Anglo populations may face increased language and cultural barriers in relation to accessing natural hazard preparation and recovery resources. In the USA, there are over 350 languages spoken, with a large diversity of languages spoken on the West Coast where ShakeAlert is operating (U.S. Census, 2015). Terms developed by researchers and scientists may not be easily translatable into other languages (Chmutina *et al.*, 2020), and social norms around protective actions may differ significantly for diverse ethnic groups (McBride *et al.*, 2019). Overall, considerations of race, ethnicity and language are critical to creating equitable and inclusive campaigns and warnings (Phillips and Morrow, 2007). Currently, ShakeAlert Messages are available in English and Spanish, while other campaign resources are translated into six languages (English, Spanish, Tagalog, Chinese, Russian and Vietnamese).

Abilities

Individuals with access and functional needs, defined as hearing, mobility, cognitive intellect, speech or mental health impairments, account for 20% of the US population (Okoro *et al.*, 2018) yet have been rendered socially invisible in many disaster planning efforts (Campbell, 2018). Physical mobility influences an individual's ability to take protective actions, like "Drop, Cover and Hold On", which is part of earthquake drills and ShakeAlert Messages (McBride *et al.*, 2019). People older than 65, pregnant people, babies and children may also have differing abilities that need to be considered (Baker and Cormier, 2015). Standards such as the American with Disability Act of 1990 (ADA) and Section 504 of the Rehabilitation Act are required by law and should be considered baseline for inclusive communication involving populations with a range of access and functional needs (Okoro *et al.*, 2018). Campaigns designed to include messages for those with access and functional needs, given their vulnerability to earthquakes, are an important outcome.

Economic inequality

Socioeconomic status influences both natural hazard preparedness and disaster recovery. Feedback loops amplify vulnerability, so communities who are less able to prepare for

disasters are less able to recover, creating entrenched cycles of disadvantage (Tapsell *et al.*, 2010). Fothergill and Peek (2004) synthesize the literature on disaster and poverty, which found that income greatly shapes vulnerability, as low-income people suffer the greatest losses during disasters, while having much more limited access to preparedness and recovery resources. Although low-income communities perceive disasters as great threats, they are less likely to partake in costly preparedness behaviors. Economic inequalities and perceptions of "economic burden" have been found to influence preparedness behaviors (Anbarci *et al.*, 2005; Palm, 1998). After a disaster, socioeconomic status influences how well people can respond and recover (Weichselgartner and Kelman, 2015). Anbarci *et al.* (2005) found communities with greater income inequality are more likely to have higher fatality rates, likely due to poorly built infrastructure and lack of education on protective actions.

Infrastructure and housing

Homeownership is a driver of wealth, tied to local funding of schools and infrastructure, which have lasting implications in terms of racial disparity (Squires and Kubrin, 2005). Segregation and exclusionary housing policies, such as redlining, which is when less services are offered to communities due to their race or ethnicity, have created cities with uneven environmental burden and cycles of disinvestment (Squires and Kubrin, 2005). Poorly constructed buildings in lower income areas can accelerate negative impacts for people who live in these buildings when earthquakes occur (McMahon, 2007), and individuals who live in mobile homes or rent are more at risk for displacement after a hazard event (Heinz Center for Science, Economics, and the Environment, 2000; Cutter *et al.*, 2003). Earthquake preparedness can be a discourse largely for financially stable people who own property, living in suburban environments as explored in McBride *et al.* (2019), and natural hazard public communication campaigns often exclude marginalized groups, like renters and the homeless (Blake *et al.*, 2017). People experiencing homelessness are important to consider in campaign efforts (Vickery, 2019) as an estimated 188,731 people in California, Oregon and Washington were unhoused in 2019 (U.S. Department of Housing and Urban Development, 2019).

Theoretical frameworks for EEW communication strategies

We identified two theories relevant to developing a series of self-reflective questions for EEW campaign developers seeking more inclusive practices. These two theories address vulnerability while providing an overview of relationships with information sources and publics. These theories emphasize the need for two-way communication, mutual benefit and more dialogic and participatory approaches to EEW campaigns rather than reproducing the problematic deficit model (Trench, 2008) that has long been embodied in communication approaches (Gustafson and Rice, 2016).

Relationship management theory (RMT) underscores the importance of relationship cultivation and maintenance between an organization and its publics (Ledingham and Bruning, 1998), and it specifies how an organization can work toward a two-way model of communication (Hon and Grunig, 1999; Ledingham, 2003). There are five dimensions of an organization's relationship management: (1) trust, which is created when organizational behaviors align with mission, goals and objectives; (2) openness, which is cultivated when an organization shares future plans and goals with the community; (3) involvement, which is when an organization is involved with community welfare; (4) investment, which is when an organization is "investing in the welfare of the community"; and (5) commitment, when an organization is "committed to the welfare of the community" (Ledingham and Bruning, 1998, p. 62).

The application of RMT is more effective when combined with muted group theory (MGT). MGT emphasizes the importance of including voices that are oftentimes marginalized, stating that social hierarchies, where some groups are privileged over others, control the production of discourse for both dominant and nondominant groups (Ardener, 1975, 1978). The theory states that "this process [of social reproduction] renders marginalized groups as largely muted because their lived experiences are not represented in these dominant structures" (Orbe, 1998, p. 4). MGT is particularly relevant to EEW communication campaigns because of its emphasis on language. Scholars using MGT focus on the power of dominant groups to use language to name experiences, thus determining what experiences are socially accepted, legitimate, and respected (Barkman, 2018). While MGT has been widely applied to study gender differences in language and communication systems, it has been utilized to study the power of language and naming in a variety of other contexts that provide valuable lessons for communication campaigns (Wall and Gannon-Leary, 1999). MGT also carves out space for creating change. As Barkman (2018) notes, "MGT has the capacity to explain how muting occurs so that corrective action by both dominant and non-dominant groups can be taken to the ultimate benefit of both" (p. 4). If public satisfaction of all dimensions is met, then an organization may achieve theoretical outcomes (see Figure 1). These five dimensions have been studied as predictors of an organization's public perceptions, attitudes and behavior (Ledingham and Bruning, 1998; Ledingham, 2003).

While critics of RMT argue that the focus is too much on relationship building and not enough on strategic management of relationships that are mutually beneficial, we argue these dimensions are foundational for building stronger relationships between emergency management agencies and diverse populations. RMT can be utilized in communication

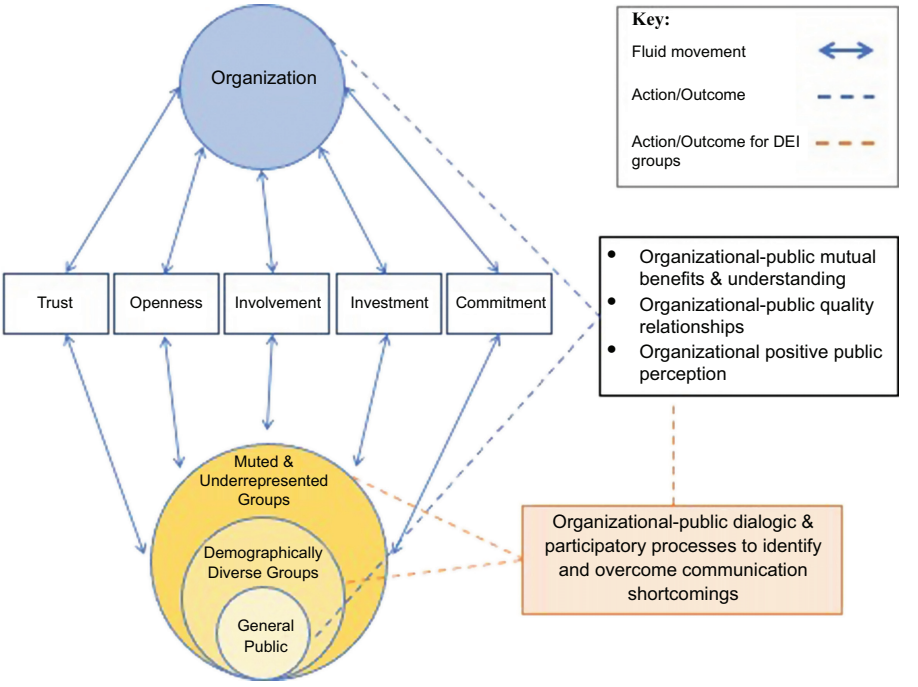

Figure 1.
Including attributes of MGT with RMT to specify how organizations may create mutually beneficial, quality relationships with all publics through the action of two-way flows of communication, obtainment of five theoretical dimensions and participatory processes with muted, underrepresented or demographically diverse groups

campaign research and practice to identify mutual interests and values of the organization and communities. It also can inform the development of EEW communication campaigns that not only promote greater understanding of EEW systems and earthquake preparedness, but trust and openness. What is particularly relevant about RMT and its implicit application of the two-way model of communication is that it emphasizes behavioral relationships, which means that communication is not nearly a pro forma image building exercise but is based on actual actions (Grunig, 1993) that require listening and information exchange. Adopting this relational approach is particularly important for inclusive communication campaigns, as many marginalized groups may feel disempowered to act on early warning or preparedness information (Lejano *et al.*, 2020).

These two theories together offer one perspective on developing reflexivity in EEW communication campaigns (See Figure 1). They offer tools for identifying and understanding power dynamics in communication systems (MGT) and provide an approach that emphasizes two-way flows of information in effort to build mutually beneficial relationships (RMT).

Developing a reflexive framework

In an effort to provide clear steps forward, we highlight the opportunity for researchers and practitioners to be reflexive in their work. Reflexive approaches have been explored in other fields of participatory research and science communication (Clark *et al.*, 2010; Canfield and Menezes, 2020). Canfield and Menezes (2020) define reflexivity as the "continuous, critical, and systematic reflection on the communicators' and audiences' personal identities, practices, and outcomes, followed by adaptation as needed to redress inequitable interactions" (p. 2). This is particularly important for the groups who develop campaigns. Weaver *et al.* (2014) found that emergency management in the USA is largely monoethnic (white), male and older (45+), with 80% of survey respondents in their study identifying as such. It is important to note that the emergency managers engaged in communication campaigns specifically have not had a demographic study, so this group may better reflect its community.

Geosciences as a discipline is one of the least diverse science, technology, enigineering, and math (STEM) fields (NSF, 2018) and has seen little change in the last 40 years: 86% of all PhDs are awarded to Caucasian/white students, which is not aligned to the US population race and ethnicity composition (Bernard and Cooperdock, 2018). In particular, academic spaces in geoscience can be hostile and harmful to individuals from underrepresented backgrounds (Marín-Spiotta *et al.*, 2020; Ali *et al.*, 2021; Dutt, 2020). Given the lack of diversity to reflect the communities these groups seek to serve, McBride *et al.* (2019) argue that campaigns can be jargon-filled and create an echo chamber that is not reflective of what may be valuable to various publics.

To increase inclusivity, Macnamara (2012) argues that self-reflective questioning while analyzing perspective, philosophy and approaches for a campaign can help. Specific to EEW campaigns, developers may find self-reflective questions a useful approach to increase inclusion (McBride, 2017). These questions are guided by MGT and RMT; we note which theory was used to develop each question.

Self-reflective questions:

(1) Who might be left out in terms of access to information about EEW? Where are the silences? (MGT)

(2) Who are the people we are communicating with about EEW? Do we have developers, scientists, emergency managers and creators who are representative of these communities? (RMT)

(3) How can we amplify the voices of people with different experiences and needs via our work? (MGT)

(4) Have we spoken directly with the communities we hope to serve and cultivated a two-way flow of information? (RMT/MGT)

(5) Is our language inclusive? (RMT/MGT)

(6) Can people access our campaigns or are we relying on technological privilege? (RMT/MGT)

Conclusion

This work aims to contribute to an engaged space for relationship building and increased community preparedness for EEW systems. To achieve this, inclusion and equity are essential components (Weissmann *et al.*, 2019; Puritty *et al.*, 2017). Without diverse voices included in the production of risk information, individuals and communities continue to be marginalized and excluded. This article only touches on how research and practice can more fully consider social vulnerabilities in EEW communication campaigns and ShakeAlert in particular. Future work should explore how DEI are considered in the ShakeAlert system, specifically regarding usability and protective actions. We hope this brief article offers value to the discussion on these essential issues.

Note

1. Messages are capitalized due to trademark issues.

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Further reading

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Appendix

Comments

I welcome the intent of the paper to encourage reflection on equity and inclusion in disaster communication campaigns. This is not a simple task based on my exposure to different professional fields, I am aware of how jargon and perspectives can easily become insulated if left too long without exposure to more diverse influences. I, therefore, congratulate the authors as they endeavor to bridge gaps, which they have analyzed as likely to be present in the process of delivering science to the people.

The paper indicates pathways for more inclusive disaster studies by striving to provide a more substantial characterization of different stakeholders in disaster communication. The authors outline literature on the diversity and inequality within target populations and point out the weaknesses of a "one size fits all" orientation in communication. They also model reflexivity by noting gendered demographics in the field of geoscience, from where information is sourced.

What stands out for me in this paper is its focus on the role of organizational culture in both sources and channels of communication. The two theories that they apply attempt to provide a framework to address how organizations might improve their understanding and ability to engage with diversity and marginalization. While I am more used to looking at broader ideological and structural aspects of addressing vulnerability, the approach that is presented here has led me to consider how specific action at the personal and organizational levels might be brought about.

One positive implication of this for my own work is the reminder that scientists can also be quite invested in finding ways to better connect with the general population in order to make knowledge more relevant. The article also allows me to see how population diversity might be regarded by science-based institutions and provides another discussion for imagining even more positive outcomes from interdisciplinary collaborations, for instance, with sociologists, evaluation researchers or community development practitioners.

All in all, I appreciate how the paper advances disaster practice and theory by putting forward organizational reflection as a complement to evidence-based planning in disaster communication, not only in the specific context of an early warning system for earthquakes but also in terms of the broader agenda of making science more relevant to the safety and welfare of everyone.

Response by authors

We thank Torres for their thoughtful and clear reflection on the paper. As Torres noted, we explored the importance of organizational reflection in the development of communication campaigns for ShakeAlert, the earthquake early warning systems for the West Coast of the United States, and how this approach may be fundamental in reaching those who live in or visit the states in which ShakeAlert is currently operational (CA, OR and WA). Jargon filled campaigns and the echo chambers they create are indeed a challenge for working in environments that lack diverse perspectives. Writing this paper, we wanted to highlight previously unexplored spaces and make note of some places where silences exist in our work. Science communities develop, at times, mono-culturally and can be demographically homogeneous in terms of gender, culture, ethnicity and race.

We acknowledge our own gaps in diversity and inclusion in order to make a more equitable and accessible space for those who previously have been underrepresented in the communication of science. Torres rightly points out our concern for the people who are not represented by the organizations who seek to help them.

We agree with Torres that it is critical to note that science agencies and groups mean well; the harms are rarely intentional. However, as Torres noted, we cannot ignore exclusionary tactics that are baked into the social structures that develop and support science. Therefore, we developed a strategy, based on two complementary communication theories, to make ShakeAlert a more approachable and open space for groups that were previously excluded. We utilized these two communication theories because we found that other theories were extremely useful to develop an overall approach to these issues but did not provide specific, actionable tactics. We also wanted to include thoughtful and robust communication theories to provide a framework for this kind of work. Just as economists, sociologists and engineers use their lenses to enrich disaster research, we included communication theories developed by communication researchers to do the same.

We recognize that creating equitable and inclusive communication campaigns is an ongoing process, without an end. As our earthquake early warning systems expand and technology continues to advance, we must continue to challenge our biases and learn about the unique barriers people are faced with when it comes to disaster preparedness. We are excited to continue this work and are thankful for the space given to provide such in-depth reflection.

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