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Resilience Through Community Engagement and Technology

2025 EERI LFE Travel Study - Mexico: Lessons Learned from Earthquake Early Warning Systems, Earthquake Preparedness, and Disaster Response and Coordination

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ABSTRACT

Mexico provides a valuable case study in integrated seismic risk management, combining earthquake early warning (EEW) systems, preparedness practices, and emergency response coordination. This study draws on field observations of key institutions, including Mexico City's Centro de Comando, Control, Computación, Comunicaciones y atención al Ciudadano (C5) and participation in the 2nd National Drill 2025. Mexico's Sistema de Alerta Sísmica Mexicano (SASMEX) EEW system, operated by Centro de Instrumentación y Registro Sísmico (CIRES), provides critical lead times through multi-channel alerts, though challenges remain in achieving full coverage and sustaining public trust following false alarms. Preparedness initiatives, such as the symbolic September 19 drills, reflect strong institutional commitment but also reveal gaps in realism, inclusivity, and tailored approaches for vulnerable populations. The C5 command center demonstrates high-capacity coordination, with lessons on managing extreme call volumes, maintaining redundant communication systems, and integrating psychosocial support. Insights from past international aid responses underscore the need to better connect available assistance with community-level access. Overall, the Mexican experience highlights how aligning technical systems with governance, public engagement, and scenario-based training can strengthen resilience and serve as a model for earthquake-prone regions seeking to integrate warning, preparedness, and response into a cohesive risk management strategy.

Introduction

Mexico is one of the most seismically active countries in the world [1], a reality underscored by repeated devastating earthquakes. Among the most catastrophic was the 1985 Michoacán earthquake (M_w 8.1), which claimed over 10,000 lives and destroyed more than 200 multistory buildings [2]. In response, Mexico pioneered the world's first public Earthquake Early Warning (EEW) system, Seismic Alert System of Mexico (SASMEX), which began operating in 1991 [3,4]. Designed to provide seconds of advance notice before seismic waves arrive, SASMEX has since become a cornerstone of Mexico's disaster preparedness.

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Yet the system's effectiveness was truly tested during the September 2017 earthquake sequence. The magnitude 8.2 and 7.1 events exposed both the strengths and limitations of early warning technologies in a complex urban environment like Mexico City. In the wake of these earthquakes, the Earthquake Engineering Research Institute (EERI) dispatched a multidisciplinary team to investigate not only the technical performance of the alert system but also how it was received by the public and used by institutions responsible for emergency response [5].

As part of EERI's 2025 Learning From Earthquakes (LFE) Travel Study Program, our team returned to Mexico to explore the evolution of seismic preparedness since 2017. This field study focused on the intersection of early warning systems, emergency coordination, and public resilience. We visited key institutions, including the Centro de Instrumentación y Registro Sísmico (CIRES), the nonprofit organization that developed and maintains SASMEX, and Mexico City's Centro de Comando, Control, Cómputo, Comunicaciones y Contacto Ciudadano (C5), which coordinates alerts through over 12,000 outdoor sirens. We also held technical discussions with seismic engineers and researchers at the Centro Nacional de Prevención de Desastres (CENAPRED), which monitors natural hazards such as volcanoes, earthquakes, and meteorological events to generate risk scenarios and early warnings for the public and authorities and maintain the Mexican National Risk Atlas [6].

This paper offers a synthesis of the lessons learned from these experiences, grounded in the decades of seismic expertise developed in Mexico. Our aim is to provide an outside yet informed perspective that can inform similar efforts worldwide, particularly in regions implementing or refining their own earthquake early warning and disaster response systems.

Earthquake Early Warning and Public Alerts

Mexico's EEW system, SASMEX, uses 97 seismic sensors along the Pacific coast (Fig. 1) to detect faster P-waves and estimate the arrival of slower, damaging S-waves. In the best cases, such as large offshore events, Mexico City can receive 60–120 seconds of notice, enough time to shut down equipment, take cover, or evacuate. Not all earthquakes allow that cushion. The 19 September 2017 Puebla earthquake had an epicenter only 34 miles south of Puebla City, Mexico, and approximately 75 miles from Mexico City, such that the alert and the onset of strong shaking occurred almost simultaneously, underscoring what CIRES stresses: *warning time depends on distance and ground conditions*.

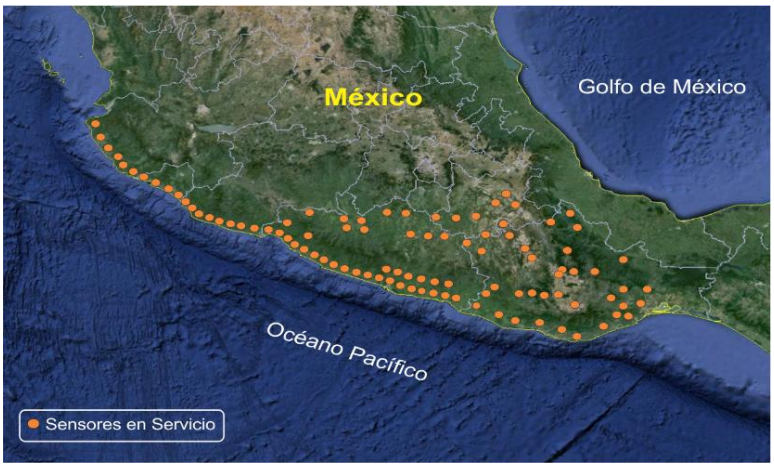


Figure 1. Distribution of the 97 SASMEX seismic sensors currently in service along Mexico's Pacific coast. Source: CIRES.

Detection is only half the story. Mexico distributes alerts through more than 83,000 alert dissemination points overall, the latter including loudspeakers, outdoor sirens, radio and television interruptions, and

receivers in schools and hospitals. We heard the sirens during our visit, and they are impossible to miss. More recently, apps and pilot cell broadcasts have been added. This redundancy matters: a commuter downtown may only hear a loudspeaker, while someone at home gets a phone alert. Still, coverage is uneven. Some states, like Chiapas, opted out of SASMEX [4]; loudspeakers sometimes fail; and private apps create confusion. Telecom providers have also been slow to roll out nationwide cell broadcast.

Because SASMEX issues alerts before the full impact is known, some alarms are not followed by strong shaking. While technically explainable, people often just remember the false alarm, risking a "cry wolf" effect. At C5, staff emphasized the importance of simplicity. Official alerts stick to one word, "Sismo" or "Earthquake", avoiding complex instructions so that institutions can decide the right response.

Preparedness and Drills

September 19 holds profound significance in Mexicans' memory. On this date in 1985, the 8.1 Michoacán earthquake struck Mexico City, leaving behind catastrophic devastation. Thirty-two years later, on September 19, 2017, the tragedy repeated itself when the Puebla earthquake caused the collapse of over 40 buildings and severely affected Mexico City as well as the states of Puebla and Morelos.

In response to these events, the date became symbolic. What began in 2014 as a local drill in Mexico City has since grown into a nationwide drill (the *Simulacro Nacional*, in Spanish) held every September 19 (Fig. 2). While earthquake drills now occur multiple times throughout the year, where some buildings conduct their own internal drills independent of the Simulacro Nacional, the September 19 drill remains the most emblematic, as it coincides with the anniversaries of Mexico's two most impactful modern earthquakes.

These drills are designed to reproduce realistic emergency scenarios, allowing institutions and communities to practice coordinated responses. Beyond immediate preparedness, they serve as opportunities to detect flaws and weaknesses in emergency procedures. Each exercise provides feedback that informs the continuous improvement of emergency planning, helping ensure that Mexico is better equipped to respond effectively when disaster strikes.

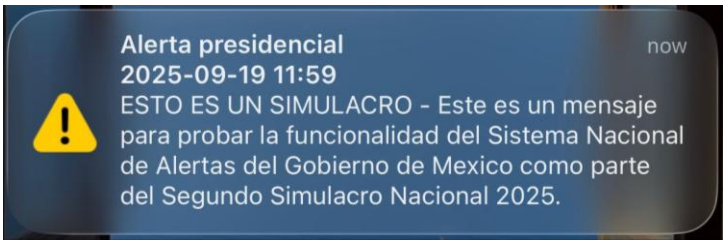


Figure 2. Phone alert for the 2025 National Drill (*Simulacro Nacional*) (Translation: THIS IS A DRILL – This is a message to test functionality of the National Alert System of the Government of Mexico as part of the Second National Drill 2025).

A key strength of the *Simulacro Nacional* is its nationwide participation, which reinforces a culture of prevention by encouraging people to practice evacuation routes, meeting points, and safety procedures. The drills also demonstrate strong institutional coordination, with agencies and various levels of government collaborating to enhance preparedness. Notably, in the most recent exercise, more than 80 million cell phone users received alerts for the first time, a milestone that highlights both the broad reach of participation and the ongoing improvements to Mexico's early warning systems.

Despite the clear strengths of the *Simulacro Nacional*, several limitations remain. One challenge is the ritualized format: because the drill occurs on the same date and time (12 P.M. local time) every year, it may lose effectiveness in preparing people for surprise events or nighttime emergencies. During our stay, for

instance, we received a message in our hotel noting that a drill would take place and that "participation is optional," which further reduced the sense of urgency. Another limitation concerns realism and inclusivity. Special contexts such as hospitals, stadiums, and high-rise buildings, as well as the needs of people with limited mobility, are not always fully addressed. To increase their impact, future drills could incorporate unannounced exercises, night-time scenarios, and tailored protocols for vulnerable groups and critical facilities.

Emergency Response and Coordination

Emergency response in Mexico reflects decades of learning from major earthquakes. The CENAPRED plays a central role by monitoring hazards, producing risk assessments, and training communities. In Mexico City, the C5 command center manages emergency communication, handling up to 20,000 daily 911 calls, most of them false alarms, and maintaining redundant communication systems and support services during crises. Investments in surveillance and infrastructure, such as those tied to the upcoming FIFA 2026 World Cup, illustrate the city's emphasis on preparedness and rapid response.

International coordination has also evolved. Fragmented responses during the 1985 and 2017 earthquakes prompted reforms to building codes, enhanced multi-agency protocols, and improved search and damage-assessment operations. While mortality has declined, vulnerabilities in older and informal housing remain. The United Nations Office for Disaster Risk Reduction highlights Mexico's progress but stresses the continued enforcement of standards, retrofitting of high-risk buildings, and regular drills, such as the annual September 19 National Drill, to ensure that seismic warnings lead to effective action.

Concluding Remarks

Earthquake early warning alerts alone are not sufficient to ensure effective response. They must be complemented by clear guidance and tailored protocols, alongside expanded seismic monitoring coverage to reach a broader population. Drills should also evolve beyond symbolic exercises, incorporating surprise scenarios, inclusivity measures, and specific action plans. Social media and video-based communication can further broaden outreach and engagement. As illustrated in Fig. 3, where a word cloud summarizes the main terms emerging from existing literature, concepts such as *protocols*, *inclusivity*, *coordination*, and *resilience* consistently appear as priorities for improving preparedness.

Persistent challenges in coordination remain. Stronger bridges are needed between local, national (e.g., C5, 911), and international (e.g., UN) actors to reduce the gap between the availability of aid and its effective distribution. Ultimately, a more integrated approach that combines technology, protocols, and multi-level coordination will strengthen resilience in the face of seismic hazards. Even with these challenges, Mexico continues to stand as a global reference in the development and application of earthquake early warning systems.



Figure 3. Word cloud summarizing recurring concepts in the literature on EEW, seismic preparedness and response.

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