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The Concealed Weaknesses of Strong Early Warning Systems. The Case of Mexico

Abstract

In September 2017, in only 17 days, two enormous earthquakes triggered Mexico's earthquake early warning system (EEWS) in a unique sequence of events that tested its capabilities. Through a series of unforeseen circumstances, including a test and an accident, during those two and a half weeks the EEWS was also activated three additional times. The EEWS presents several remarkable strengths. Mexico's entire emergency management system is relatively well resourced and has helped produce a more resilient culture that appreciates the alert system. Public agencies in all levels of government work in close coordination. However, the system has not been able to overcome continual political expediency and general public distrust of some of its components. The consequence is an alert system that is relatively strong in Mexico City but leaves much of the rest of the country unprotected. But even in Mexico City, the system suffers from extensive concealed vulnerabilities that put the population and the city's infrastructure at risk. In this paper, two specific weaknesses are analysed. The first is a result of weak regulations and inappropriate business models, which impacts the country as a whole. The second is essentially a local complication resulting from the increased risk generated by the excessive trust of the population in the sirens that are so characteristic of the system. The data were collected during a reconnaissance trip organized by the Earthquake Engineering Research Institute (EERI) in October 2017.

Keywords: early warning system, earthquake, Mexico Seismic System

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Ukryte słabe strony silnych systemów wczesnego ostrzegania. Przypadek Meksyku

Abstrakt

We wrześniu 2017 r., w ciągu jedynie 17 dni, dwa potężne trzęsienia ziemi uruchomiły system wczesnego ostrzegania przed trzęsieniami ziemi w Meksyku (EEWS) w unikalnej sekwencji wypadków, które poddały próbie jego możliwości. W wyniku szeregu nieprzewidzianych okoliczności, w tym przeprowadzonego testu oraz wypadku, w tym 2-tygodniowym okresie EEWS został dodatkowo aktywowany trzykrotnie. System EEWS oferuje szereg niezwykłych zalet. Cały system zarządzania kryzysowego Meksyku jest stosunkowo dobrze wyposażony, dzięki czemu sprzyjał stworzeniu bardziej odpornej kultury, która docenia system ostrzegania. Agencje publiczne na wszystkich poziomach funkcjonowania rządu ściśle współpracują. Niestety system nie był w stanie pokonać ciągłej zależności politycznej oraz ogólnego braku zaufania publicznego w stosunku do niektórych elementów składowych. Konsekwencją jest system ostrzegania, który jest stosunkowo niezawodny w Meksyku, lecz jednocześnie nie zapewnia odpowiedniej ochrony reszcie kraju. Jednak nawet w samym mieście Meksyk system cierpi z powodu pewnych szeroko rozumianych ukrytych słabości, które narażają na ryzyko ludność miasta i jego infrastrukturę. W niniejszym artykule autor analizuje dwie słabe strony. Pierwsza z nich wynika ze słabych regulacji i niewłaściwych modeli biznesowych, co wywiera wpływ na kraj. Druga natomiast stanowi lokalny problem wynikający ze zwiększonego ryzyka generowanego przez nadmierne zaufanie ludności do syren, które są charakterystyczną cechą systemu. Dane zostały pozyskane w czasie wyprawy badawczej zorganizowanej przez instytut Earthquake Engineering Research Institute (EERI) w październiku 2017 r.

Słowa kluczowe: system wczesnego ostrzegania, trzęsienie ziemi, system sejsmiczny Meksyku

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Приховані недоліки систем раннього попередження. Приклад Мексики

Анотація

У вересні 2017 року, лише за 17 днів, два величезні землетруси перевірили можливості мексиканської системи попередження про землетруси (EEWS). Через низку непередбачених обставин, включаючи перевірку та нещасний випадок, протягом цих двох з половиною тижнів EEWS був активований ще три рази. EEWS має кілька сильних переваг. Вся система управління в надзвичайних ситуаціях в Мексиці має достатні засоби і допомогла створити стійку культуру, яка цінує систему попередження. Державні установи всіх рівнів влади працюють у тісній координації. Однак система не змогла подолати постійне політичне втручання та недовіру широкої громадськості до деяких її складових. Наслідком цього є система попередження, яка є досить сильною в Мехіко, але залишає більшу частину країни незахищеною.

Але навіть у Мехіко, система не є досконала і наражає населення та інфраструктуру міста на небезпеку. У цій роботі проаналізованоую два конкретні недоліки. Перший – результат слабких норм та невідповідних бізнес-моделей, що впливає на країну в цілому. Другий, по суті, є локальним ускладненням, що виникає внаслідок підвищеного ризику, викликаного надмірною довірою населення до сирен, які так характерні для системи. Дані були зібрані під час розвідувальної поїздки, організованої Інститутом землетрусних інженерій (EERI) у жовтні 2017 року.

Ключові слова: систем раннього попередження, землетрус, Сейсмічна система Мексики

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1. Introduction

Following the devastating magnitude 8.0 1985 earthquake, Mexico engaged in mitigating the harmful effects of future events. Thirty-two years later, in only 17 days, the Mexico Seismic System (SASMEX) experienced an unprecedented test as a result of a unique sequence of five events that left many lessons to be learned. On September 6, a technician accidentally triggered the alarm system for the first time. On the following night, an 8.1 magnitude earthquake hit the Chiapas region triggering the alarms for the second time. Because of the distance between Mexico City and Chiapas, the alarm sounded in the capital two minutes before any shaking was felt. Although there was little impact in the capital city, the effects in Chiapas, however, were considerable. Twelve days later, on September 19, the anniversary of the disastrous 1985 earthquake, Mexico City carried out its annual emergency system drill. The entire response system was activated at 11.00 am after the test's warning sirens sounded. A few hours later, SASMEX detected a 7.1 magnitude earthquake centered near Puebla, only a few hundred kilometers south of Mexico City. The proximity of the epicenter gave no warning time to the residents as the primary (p) wave was felt strongly approximately 5 seconds before the alert system operated; the secondary (s) wave hit just 20 seconds later (Allen et al. 2018). Finally, on September 23, a magnitude 6.0 aftershock impacted Chiapas, triggering the system for the fifth time, but the earthquake had little impact. In the aftermath of those events, the Earthquake Engineering Research Institute (EERI) deployed a multidisciplinary group of scientists on a reconnaissance trip to collect perishable data about how the Mexican Early Warning System (EWS) had performed.

This article uses the data collected during the trip to reflect on the evaluation of the performance and effectiveness of earthquake early warning systems (EEWS). EEWS is defined here as a protective mechanism that focuses attention on the security of the individual. In this sense, in this paper a somewhat different approach to traditional earthquake and disaster research methodologies has been adopted which conceive EEWS either as a communications mechanism (Tierney 2000, Espinosa-Aranda et al. 2009) or as a social subsystem (Kelman and Glantz 2014). In the first case, research focuses mostly on EEWS's technical aspects (Malone 2008), where message precision and accuracy are considered the essential element. In the second case, social scientists conceive of EEWS as a "subsystem within larger social and cultural (including economic and political) contexts" (Kelman and Glantz 2014, p.98). In both cases, attention is mostly put into its constitutive parts, instead of the wellbeing of the people.

The primary contribution of this paper lies in a discussion of issues that are typically considered tangential in the evaluation of EEWS, such as how the business model of organizations involved can limit the coverage of the system, political conflicts that impede inter-jurisdictional compatibility or societal forces that generate animosity among the different sectors involved in managing the system. It seeks to contribute to the study of EEWS by adding to a growing body of literature that puts the wellbeing of the individual at the center of attention.

In this paper, I break with the traditional conceptualization of EEWS and present instead an alternative notion that interprets an EEWS as a protective mechanism. This new approach falls under the new approach on Human Security proposed by the Commission for Human Security. The "Human Security Now" report of 2003 declares that "security becomes an all-encompassing condition in which individual citizens live in freedom, peace and safety and participate fully in the process of governance".

The United Nations International Strategy for Disaster Reduction (UNISDR) in 2006 stated that "among both developed and developing nations, the weakest elements concern warning dissemination and preparedness to act. Warnings may fail to reach those who must take action and may not be understood or address their concerns." (p.vi). With this statement in mind, and the definition presented above as a guide, I will scrutinize the performance of two elements of the Mexican EEWS. In the following section, I discuss elements that prevent warnings from reaching the population in an entire country by looking at a business model of one of the agencies in charge of running the technical portion of the system. The following section relates to what I consider to be an illusion of security provided by the numerous sirens that sound public alerts. These two elements are analyzed through a lens that has the individual citizen at the center of attention, and it explores to what extent, even if the system might have performed as expected, it still fails to provide human security.

2. Methods

One month after the five EEWS activations, the Earthquake Engineering Research Institute (EERI) deployed a multidisciplinary group of scientists (including myself) on a reconnaissance trip. The objective of this type of trip is to collect perishable data (Stallings 2006) such as documents and perceptions of the people, which can change over time as they are subject to phenomena such as memory decay (Bourque, Shoaf & Nguyen 1997). The original field observations help highlight important issues that might benefit from further research but do not provide conclusions that are methodologically strong.

Each member of the group was given liberty to learn from the events according to their understanding and areas of expertise. In my case, the focus was to evaluate how well the Earthquake Early Warning System performed when analyzed from the point of view of the overall wellbeing of the population.

The data collected included documents, photographs, direct observations, interviews, and informal conversations with a multitude of respondents from different socio-economic backgrounds, sectors and educational levels, policymakers, scholars, and regular citizens. Approximately 10 formal interviews with decision-makers from multiple agencies were held. Data were collected from all sites visited. Interviews were organized using snowball sampling, a data collection method that allows scientists to connect with people that meet research criteria but that are unknown to the researcher. Team members organized a few meetings before arrival in Mexico, and interviewees were asked to provide references and introduce us to other friends and colleagues (Gliner, Morgan and Leech 2009). The research team held informal conversations with nearly 20 individuals we had met during the trip, including drivers, hotel employees, and other residents of impacted locations. The data were analyzed after the trip using an inductive approach, which allows "gaining direct information from study participants without imposing preconceived categories" (Hsieh and Shannon 2005 p. 1280).

3. EEWS as a protective mechanism?

At first glance, a superficial comparison of the impact of the 1985 event and that of 2017 appeared to corroborate the success of the Mexican efforts. Until 1985 Mexico had no EWS, and the Mexican population did not have training for comprehensive emergency response (Esteva 1988). In contrast, in 2017, Mexico had a more robust response system that includes public education programs. The earthquake of 1985 took the lives of at least 10,000 people and injured further 30,000 in Mexico City (Espinosa-Aranda et al. 2009). In 2017 these numbers were much lower to 370 and 6,000 approximately. The difference in strength and duration of the tremors between the two earthquakes was significant, and it would consequently be imprudent to adjudicate this apparent lower impact on the effectiveness of the early warning system.

Nonetheless, during the 2017 events, the individual elements of the system seem to have functioned appropriately. The motion sensors worked well, and the signals were sent and retransmitted to the different recipients. References from many people corroborated the first impressions of gratitude and satisfaction with the performance of the system. A slightly more in-depth analysis, however, uncovered deficiencies in several of its elements that are rarely addressed in the EEWS literature. I noticed animosity between several of the executives who had been interviewed, and even strong discrepancies in their evaluations as to how well the system had performed. These two entirely dissimilar assessments informed the formulation of the question that drives this research: "Using a human security perspective, how well did the Early Warning System of Mexico perform?".

A significant portion of the literature agrees that Earthquake Early Warning Systems are composed of two main elements, and namely the seismological triggering system and its dissemination to end-users (Banerjee 2016, Given et al. 2018, Tierney 2000). The purpose of an EEWS is "to reduce the impact of earthquakes and save lives and property by providing alerts that are transmitted to the public via mass notification technologies" (Given et al. 2018 p.1). In other words, they "provide notification that an earthquake is occurring and that potentially damaging ground motion is approaching" (Goltz 2002 p.2). Consequential to this traditional approach, "most social-scientific studies on warning response and self-protective actions employ some variant of the well-known Source-Channel-Message-Receiver-Effect-Feedback model" (Tierney 2000, p.20)[1]. Social scientists have expanded this approach, and even though they acknowledge the importance of the technical aspects, they proclaim that such technology must always be understood in its social context (Kelman and Glantz 2014).

Using these approaches, the Mexican Earthquake Early Warning System appears to have performed as expected, but a closer look using a human security perspective suggested otherwise. People referred to issues that are not usually undertaken in traditional EEWS literature, but that is an essential source of vulnerability. For example, one woman said: "I heard the sirens, but many of my employees did not, and then I heard them talking and suggesting that it had been my fault for having soundproof walls and windows in the factory so we don't bother the neighbors." She later shared with me: "If someone does not hear the siren whose fault is that? Knowing this government, I bet that many of the sirens are not even working". Her reflections pointed out two critical observations.

On the one hand, they emphasized the probable incompatibility of the goal of the EWS of warning its citizens of imminent tremors, with current governmental regulations that prevent outside noise from entering specific locations (such as hospitals). This point becomes even more critical, considering that the Mexican Earthquake Early Warning System depends in no small extent to the warnings issued by a network of sirens located in public open spaces. On the other hand, her comments were indicative of the distrust of the population in public agencies, which affects, among other things, the relationship between the people and the different elements of the system.

In the hotel in which I stayed, signs were pointing to a single location on each floor. This location was marked with a sign that showed an image describing "the triangle of life." The triangle of life is a controversial theory that advocates that in the worst scenario of the building collapsing, individuals would be safer next to solid objects such as a door and contradicts another widely used protective measure called "drop cover and hold" which proposes that the best place to find protection is underneath a table (Johnson and Ronan 2014). That negative feeling of distrust was shared by another informant that said to me: "these signs mean nothing. The system is so corrupted that it does not matter where you put the signs. If an inspector arrives, you will just

1 See also Mileti and Sorensen 1990.

give him some money to make him go away. You cannot trust those signs. They can be pointing to any direction". The generalized cynicism of the government translates into distrust in the warning system, which could help explain the motionless action found by Nakayachi et al. (2019). It could also serve as an explanation to the growing participation of private companies. In the case of Mexico, SkyAlert, for instance, compete in the market by providing alerts through phone applications.

Many of my informants made strong additional references to how corruption and deviant practices from public officials affected the effectiveness of the EWS. As it is normal in countries with high levels of corruption, some of these circumstances were rapidly covered by the media. In some cases, the coverage involved agencies that are central to the overall performance of the system. One digital newspaper, for instance, published an article about the Center for Seismic Instrumentation and Registry (CIRES). CIRES is a non-profit organization that owns and manages a significant portion of the seismic network (including the sensors) and, according to the article, has faced legal problems due to what has been characterized as unethical and illegal maneuvers in the provision of their service (Martinez 2017). A few of my informants mentioned that right after the earthquake, individuals wearing official municipal uniforms were knocking on people's doors with the excuse that they had to enter the property to establish the structural strength of the building. Once the resident accepted to leave, they would enter the house and steal the belongings. The first of the informants that referred to this was confident that these individuals were just criminals that were taking advantage of the situation. Another one, on the contrary, who seemed to be familiar with the levels of public corruption and the relationship between the public sector and organized crime, emphatically claimed that those individuals were "not real governmental officers, but delinquents who were part of the machinery of the government." Even before the earthquake happened, there existed evidence that many buildings "would have an inadequate performance during an intense earthquake" (Reinoso, Jaimes and Torres 2016), a conclusion that was portrayed by the media to be related to control mechanisms that create incentives for developers to declare buildings safe, when they are not (Linthicum 2018).

These examples are not presented here to assert illegal practices. But delinquency, corruption, and deviant political actions are already an existing element of the disaster literature (Green 2005), and their media coverage (regardless of their validity and authenticity) strongly affects the tone of the conversation among regular citizens. In the case of Mexico, they were proven to be elements of substantial importance as they helped produce negative social imagery of the government that evolved into the generation of contradictory feelings, distrust, and reduced confidence in the EEWS.

The traditional definition has proven to be somewhat narrow and simplistic. Its application prevents us from identifying that underneath visible strengths, there might be concealed systemic weaknesses. Early warning systems must put the people at the center (UNISDR 2006) and not technology. Performance assessment under this traditional definition concentrates on the effectiveness and precision of its composing elemental parts. Still, its limited scope hinders the full protection of the people, their infrastructure, and society at large as it fails to acknowledge two critical things. On the one hand, that its elemental parts play a simultaneous dual role with other systems such as security and health. On the other, all systems (including EEWS) are the outcome of economic, political, and even social and environmental issues that are complexly intertwined across many jurisdictional boundaries. Understanding EWSs as protective mechanisms framed under a human security approach is an alternative doctrine that incorporates these two critical dimensions into the analysis. It does so by not conceiving EEWS as technological by nature. Much differently, they are mechanisms aimed at ensuring a higher level of security and survival rate to populations at risk, which in turn could contribute to the well-being of the system (Glasius 2006)

The revision through this lens not only redefines its purpose. It also forces the redefinition of its scope and composition. All new actors, elements and their relationship considered, in the case of Mexico the EEWS looks more like a fragmented and unarticulated network than a cohesive system capable of protecting people's lives. The different regional concerns, business strategies, and jurisdictional boundaries of the multiple stakeholders provide fertile soil for the germination of conflicts.

4. The business model and the absence of the state

An accelerometer is a device used to sense the beginning tremors of an earthquake. It measures the amplitude and high-frequency seismic waves. When it captures movement, it generates signals that are converted into alerts informing the population of an imminent quake event. This type of system is used in Mexico and is called 'front detection' (Allen et al. 2009). Earthquake waves travel more slowly across the land in all directions away from the epicenter (Given et. al 2018), similarly to water waves when a stone hits the surface of a lake. The time difference between the reception of the alerts and the arrival of the shaking 'is a function of the distance of the user from the earthquake epicenter' (Allen et al. 2009 p.682). The areas very close to the potential epicenter of an earthquake get little to no warning. These are called 'blind zones' (Given et al. 2018). In the case of Mexico City, for instance, its distance from the Guerrero Fault, which is probably the area with the most intense seismic activity, would be approximately 60 seconds (Espinosa-Aranda et al. 1995). As alert messages reach all receivers almost automatically and simultaneously, EEWS provides relatively more benefit to those that are the farthest from the epicenter. It is important to emphasize that even with high-speed electronic communications, users may get an alert more slowly depending on the mechanism used to deliver the warning to users.

Considering the unpredictability of time and space in the origin of earthquakes, the most advantageous distribution of accelerometers is one in which they cover the largest territory possible. The best configuration for the distribution of the signals would also be one in which alerts are "distributed as widely as possible" (Allen et al. 2018). Unfortunately, Mexico's SASMEX is not yet close to this ideal due its unique historical circumstances.

CIRES is an independent non-profit organization that was founded after the 1985 earthquake with the backing of the Mexico City government (Espinosa-Aranda et al., 2009). Its exclusive purpose was to manage a project that was started by a regional state government. In other words, the startup of the system was not a federal initiative, but an accord between a single state government and a public, non-profit organization. The original configuration, which became operational in 1991, was conceived to warn Mexico City residents and was named Mexico City Seismic Alert System (SAS). (Espinosa-Aranda et al., 1995; Goltz and Flores, 1997). In 1999 as a consequence of the M6.7 earthquake that hit Oaxaca, CIRES and the state government of Oaxaca agreed to create a similar network that became operational in 2003 and was called SASO. The 37 seismic stations of the Oaxaca alert system (SASO) were added to the 12 of the Mexico City (SAS), and together they conformed the Mexican alert system SASMEX (Espinosa-Aranda et al., 2009).

The Mexico City system was developed with the assumption that the next catastrophic event would, like the 1985 earthquake, also originate in the Guerrero fault, off the coast of Michoacán in the Pacific Ocean (Allen et al. 2018, Espinosa-Aranda 2009). This assumption led officials to place motion sensors primarily in the region of the fault. After the 1999 earthquake that hit Oaxaca, CIRES also negotiated with the state government an expansion of the system to cover this area. New negotiations have taken place in the past few years, and SASMEX has been expanded to cover a part of the center and south of the country. Currently, SASMEX issues alert to 7 cities

(CIRES, 2018). The services provided by CIRES can also be contracted privately. In this way, the system alerts more than 250 institutions, including schools, public buildings, and emergency organizations (Espinosa-Aranda 2009).

Mexico Seismic System (SASMEX)

Extracted from http://www.cires.org.mx/sasmex_es.php on the 17th of June 2020

In all cases, both public and private entities who choose to be connected to SASMEX, must enter into private negotiations with CIRES and pay for their services. One interviewee recognized that the cost of this service forces many state and local governments to speculate on where the next earthquake will occur. Considering that the warning time is a function of the distance to the epicenter, those who believe the next earthquake will originate far from their location will be more inclined to agree with CIRES. Those who think they are more likely to be within a 'blind zone' or close to it would be less inclined to pay for the service.

From a 'demand' point of view, the likelihood of a particular population benefiting from the warnings issued by SASMEX seems to be a function of the apparent 'gambling' or 'predictive' strategy of state and local governments. But this is not the case. The prioritization of public concerns and the decisions as to which issues would be addressed in the public agenda is one of the prerogatives of governments. In the case of Mexico, the seemingly passive role of the state in matters of early warning systems seems to be more legal than historical. Two of the experts with whom I spoke with during my trip agreed that the only way forward is to declare SASMEX as a matter of National Security, expropriate the system from CIRES and transfer their responsibilities to the national government. In a recent interview, Carlos Valdés González, General Director of the Center for the Prevention of Disasters (CENAPRED), stated: "… but I would say that the Seismic Alert System should belong not just to the Mexico City Government but to the federal government… I am very clear, it should belong to all the citizens of this country, and if this association (CIRES) is the one that will manage it, there should be someone above to control them… a powerful scientific committee that decides what is done and what is not done and those decisions are not exclusive of a civil association" (Martinez 2017).

The critical role of the state in emergency management has been widely covered in the literature (Aguirre 2005, Kelman and Glantz 2014). In the specific case of Mexico, the role of government is determined by their possibility to access the necessary technology. So, from a 'supply' point of view, the provision of the warning service depends on two things. First is the CIRES' business model. Although CIRES is a non-profit organization, currently the only way they can provide the warning service is by charging a fee, which may limit who can benefit from their services. Also, CIRES is constrained by its structure. Expanding its system to other regions of the country requires them to assign economic and human resources to the difficult task of 'selling' their service to public and private businesses. This strategy leads us to the second important variable. CIRES and the Mexican warning system are not exempt from political considerations. The expansion of the network requires engaging in complex and lengthy negotiations with many state and local governments from different political ideologies, in addition to identifying and developing the necessary technical requirements. This could be a tricky and cumbersome process that depends on a well-designed business and political strategy.

5. The fallacy of the sirens

Alert messages can be distributed over a wide variety of end-user applications, including mobile phone apps and other mass distribution applications (Given et al. 2018). In the event of imminent tremors, the people of Mexico City receive a warning through various mechanisms, including media channels and thousands of loud sirens that are distributed across the city (Suarez et al., 2009). The sirens are a salient aspect of the system. They are forceful and curious artifacts that usually go unnoticed by citizens going about their daily lives.

During my stay in Mexico, besides formal interviews held with public officials, I engaged in informal conversations with nearly 50 regular citizens. They all knew of the existence of the sirens. However, roughly 90 percent of them were unaware of anything more than their existence. They did not know who owned them, how they functioned, or how they were distributed. They were unfamiliar with their technical aspects and were utterly uninformed about how, why, and when they were installed. Even more surprising, many Mexico City residents did not know that the sirens did not exist elsewhere in the country. Likewise, some of those who had recently moved to Mexico City were not aware of the siren's existence until they heard them for the first time during the events of 2017.

Not long after starting a casual conversation with an individual, I would explain to them the purpose of my trip. I identified myself as a researcher from the University of Delaware collecting information about the Earthquake Early Warning System. At some point during the conversation, I would ask, "What do you know about SASMEX?". The vast majority of those individuals made almost exclusive reference to the existence of the sirens, and it became clear that for many of the regular citizens, the sirens are not the most essential piece of the system, but the system itself.

This was not surprising. There are many parts of the systems that make up a society in which people often know nothing more about than that they exist and their general purpose. This idea became important during the rest of my trip because I sensed that Mexico City residents seem to have a blind trust in the sirens, believing that no matter where they are and or what they are doing, they would be warned should anything occur. In a certain sense, their relationship with the sirens is similar to the relationship many have with the police force. They might not be very familiar with everything there is to know about the police department, might not even know where police officers are, but live their lives with the confidence that they are somewhere around the corner. But blind trust can be a dangerous thing when there are only have a few seconds to react to a potentialy deadly situation, as is the case when an earthquake alert happens.

Even though the sirens issue earthquake warnings, this is not their primary goal. The sirens were initially placed to issue other messages to the population to supplement the surveillance cameras with which they share a pole. The sirens' location is contingent on the placement of the cameras, which were positioned with security concerns in mind, such as crime, traffic problems, and health emergencies. A distribution based on security concerns may not superimpose well with a distribution that meets the need to warn the population of an imminent ground shaking.

There are several arguments against this particular aspect of the system. Firstly, the agency in control of the security cameras is also in control of the sirens, which grants it a significant influence in siren placement. Therefore, expansion of the siren system depends on the needs and objectives of this particular agency, hindering the possibility of increasing the coverage to the entire population. Secondly, and to some extent as a consequence of the first argument, the siren system serves the citizens exclusively in the area of Mexico City. Other cities could very well produce a similar system, as long as they hire the services of CIRES. However, the weaknesses of CIRE's business model have attracted the attention of private companies who have decided to compete for a market share.

Skyalert is a private company that offers a similar service to that of CIRES but with a completely different business model. They have developed and installed motion sensors across the territory, and their cloud application allows them to send warning messages to anyone connected to their network. Their presence in the market has added several layers of complexity to the discussions. In the first place, the spectrum of types of notifications and distribution channels has increased and become more complex, hence, more difficult for the population to understand (Naylor, Chantler and Griffiths 2004). In Mexico City, people can receive multiple, sometimes competing, or even contradictory messages through their phones, the media, and the siren system.

Surprisingly, the existent Mexican EEWS does not reach every corner of the country, nor does it even reach every corner in Mexico City. Besides the number of people that did not hear the sound of the sirens, the system is ill-prepared to meet the particular circumstances of special populations, such as those with hearing problems and those that live and work in noise-proof buildings such as basements, something that has been already discussed.

The content of warnings and alerts became a topic of contention with the entrance of new players into the market. Until then, SASMEX was the only provider, and its alerts were binary. The sound of the sirens would only communicate the proximity of a shaking event without further information. But modern technology allows messages to contain more robust information, including earthquake magnitudes, locations, expected seismic intensities, and the probability that the alarm is correct (Given et al. 2018).

6. Conclusion

In this paper, I expanded the more traditional (technical and social) interpretations of warning systems to focus instead on the wellbeing and security of people. I broadened the understanding to analyze critical issues that affected the performance of the

EEWS of Mexico during the past events of September 2017. Under this new approach, elements that impede individuals from enjoying the highest probability of continuing their lives in a safe environment are considered sources of vulnerabilities.

Overall, the people I interviewed showed great appreciation and gratitude for the EEWS system. This article supports previous research that has concluded that the attitude of the people across the country towards the Mexican EEWS was generally positive (Allen et al. 2018). However, such feelings should not be interpreted as indicators of an early warning system that is challenge free.

The analysis also uncovered weaknesses that are generally concealed when analyzed with the use of more traditional interpretations. These issues deserve attention and further research. Under this new alternative approach, the boundaries of EEWS expand significantly. In this article, I covered two of these developments. On the one hand, I covered issues such as the business model used by the many actors involved, including private companies that compete for a market share (Kelman and Glantz 2014). The research found that in the case of Mexico, the absence of state regulation has promoted the evolution of business models, both in public and private entities, that focus their attention in the generation of profit and sustainability rather than in quantity and quality of the coverage.

This new approach also examines how the general population relates to the system. In the case of Mexico, for instance, it would appear that the presence of a physical component such as the sirens, gives the people a misleading sense of security.

Overall, there is a need to analyze EEWSs using new perspectives that can help understand how different elements that are generally not considered by other approaches affect the security of the population understood in its largest and more comprehensive sense. This newly expanded environment requires the generation of a framework that calls for broad dialogue, and that makes the public an active participant (Loster 2012). But this requires a new vision that places EEWS in the center of human life.

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