Seismic noise to public health signal: investigating the effects of pandemic guidance in Mexico

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ABSTRACT
Understanding public activities and developing thoughtful public health strategies are key goals in efforts to manage the COVID-19 pandemic. This paper explores how seismic noise data can be used as part of such efforts. We show that the fluctuation of seismic noise levels has the capacity to demonstrate aggregate human movement. When considered in relation to major public health efforts, these data can help us evaluate the effectiveness of public health communication strategies that seek to limit social activity. We show evidence that, broadly speaking, Mexican national efforts to encourage “lockdown” worked for a few months in areas around seismic stations, and broke down as time went on. Further, we suggest that changes in the levels of human activity detected in seismic noise can be read alongside social data that provide some clues as to why people respond or not to health recommendations. Our findings have implications for both efforts to understand the nature and effects of public trust in the Mexican state and also the practicalities of using seismic noise data in this manner. An interdisciplinary analysis allows us to address these data and their possible use in a way that takes seriously the opportunities and challenges that emerge in the context of contemporary biopolitics and emerging configurations of surveillance technologies. Analyzing anthropogenic seismic activity opens up new opportunities for ethical data collection and use.

Do ruído sísmico ao sinal de saúde pública: investigando os efeitos das recomendações durante a pandemia no México

RESUMO
Compreender as atividades públicas e desenvolver estratégias de saúde pública são objetivos principais nos esforços para controlar a pandemia de COVID-19. Este artigo explora o uso de dados de ruído sísmico como parte desses esforços. Mostramos como a...
flutuação de níveis de ruído sísmico permitem refletir movimentos humanos em áreas perto da instrumentação sísmica. Quando os dados de ruído sísmico são considerados, em relação com esforços de saúde pública, podemos avaliar a eficácia das comunicações sobre saúde pública que procuram limitar a atividade social. Demonstamos como esses dados podem ser úteis para a produção de conhecimento sobre os efeitos do discurso de saúde pública e a percepção pública do risco no México. Apresentamos aqui uma análise interdisciplinar desses dados e suas promessas. Tratamos desses dados e o uso deles de uma maneira que tira por sério as oportunidades e desafios que surgem no contexto da biopolítica contemporânea e as configurações emergentes de tecnologia de vigilância. A análise da atividade sísmica antropogênica abre novas oportunidades para a compilação e o uso de dados, embora fazer isso também requeira cuidado com os aspectos éticos que pudessem envolver.

**De ruido sísmico a señal de salud pública: investigando los efectos de las recomendaciones durante la pandemia en México**

**RESUMEN**

Comprender actividades públicas y desarrollar estrategias de salud pública son objetivos clave en los esfuerzos para controlar la pandemia de COVID-19. Este artículo explora el uso de datos de ruido sísmico como parte de dichos esfuerzos. Mostramos cómo la fluctuación de niveles de ruido sísmico tiene la capacidad de reflejar movimientos humanos agregados en áreas cercanas a la instrumentación. Cuando se consideran los datos de ruido sísmico en relación con esfuerzos de salud pública, podemos evaluar la efectividad de las comunicaciones sobre salud pública que buscan limitar la actividad social. Mostramos evidencia de que la campaña “Quédate en Casa” funcionó durante algunos meses en las áreas adyacentes a las estaciones sismológicas: sin embargo, esto cambió con el tiempo. Sugerimos cómo estos datos pueden servir para la producción de conocimiento sobre los efectos del discurso de salud pública y la percepción pública del riesgo en México. Presentamos aquí un análisis interdisciplinario de estos datos y sus promesas. Abordamos estos datos y su uso de una manera que toma en serio las oportunidades y desafíos que surgen en el contexto de la biopolítica contemporánea y las configuraciones emergentes de tecnologías de vigilancia. El análisis de la actividad sísmica antropogénica abre nuevas oportunidades para la recopilación y el uso de datos, aunque hacerlo también requiere un cuidado de los aspectos éticos que podría involucrar.

**1. Introduction**

Seismologists have begun to explore what the data they produce can reveal about human activity. It was over a decade ago that Gross and Ritter showed that human activity could be distinguished in seismic records above 1 Hz (2009), and other researchers have since developed ways to understand pedestrians (Alyamkin and Eremenko 2011) and low-speed urban road traffic (Green et al. 2017) in the frequency band between 1 and 5 Hz.
Building on this work, seismologists have been turning what is otherwise defined as “noise” into a meaningful “signal” about public behavior.

When seismic data collected during the COVID-19 pandemic are analyzed, patterns in human behavior can be revealed. In several cities around the world – including Querétaro and Mexico City – seismologists have found a reduction in seismic noise during times when people were encouraged to stay home (Lecocq et al. 2020). Major papers in seismology respond to such findings by heralding the utility of seismic noise for producing socially meaningful data (e.g. Lecocq et al. 2020; Cannata et al. 2020; Nimiya, Ikeda, and Tsuji 2020; Poli et al. 2020; De Plaen et al. 2021). Some authors go so far as to suggest that seismic noise data might present a tool for surveillance (for example, Lecocq et al. 2020). Seismic noise provides, these authors argue, a unique opportunity to monitor anthropogenic activity patterns without the ethical challenges presented by social media or mobile phone location tracking.

Changes in seismic noise data indeed showed key moments when Mexicans near the detection stations followed recommendations to shelter, and also when public health guidance became less effective. In this article, we argue that seismic noise data alongside social data can be used to illuminate the social dynamics of the Mexican population’s response to public health policy. In the following pages, we consider patterns in seismic noise picked up by broadband seismic stations operated by the Servicio Sismológico Nacional (SSN, National Seismological Service of Mexico) in the country, and Mexico City in particular (Figure 1). We then examine these patterns alongside COVID-19

Figure 1. Station locations with symbols color-coded according to the base noise level, the darker the higher.
quarantine guidance from the office of the Mexican Undersecretary of Health. We draw on media analysis and consider regional and national surveys on social trust in the government, science, and health staff to suggest that trust might be key to explaining the social response to public health measures. We also reflect on the extent of public concerns over the virus, the economy, and crime, suggesting that a fluctuation of concern over the virus vis-à-vis economy and crime might contribute to public compliance with lockdown measures. The correlations we show between human movement and Mexican political sentiment are quite general, but nonetheless offer insight into the Mexican experience of COVID-19. In light of these findings, we interrogate themes related to trust in and enforcement of public health guidance in Mexico. Considering these issues together allows us to evaluate the biopolitical implications of seismic noise data analysis for future pandemic governance and to frame key questions for future research into whether and how Mexicans made the choice to shelter in place during the COVID-19 pandemic.

Seismic noise data analysis may be useful for understanding human movement during a pandemic. However, this potential utility is complicated by the material and social conditions in which lives are lived, tracked, and guided by public health interventions; thus, they must be approached critically. We are motivated by the concerns sketched out by Italian philosopher Roberto Esposito, who makes the case that in the “explosion of coronavirus, with the geopolitical consequences that we have endured, we are coming to the very climax of the direct relation between biological life and political interventions” (Esposito 2020). With this statement, he draws our attention to how public health leaders and political authorities (who may or may not work in tandem) have scrutinized population behavior during the ongoing COVID-19 pandemic. Like Esposito, we also believe that the ways biological life is made subject to political intervention are changing and that these changes could be dangerous. Esposito reflects on how certain segments of the population are considered to be at risk or bearers of risk, and might easily become the subjects of emergency state action. We are cognizant of the urgency to implement innovative data analysis for public health as well as the need to carefully assess how innovation might facilitate harm, especially to segments of the population that are already marginalized. These twin concerns animate our analysis of seismic noise readings and Mexican social responses to public health recommendations.

Undertaking this analysis, we contribute to conversations in Science and Technology Studies (STS) about biopolitics. Interrogating technologically facilitated knowledge about and power over life is an important theme in STS. Doing so, scholars can come to new understandings about how contemporary states manage the inclusion, health, and sometimes even lives and deaths, of their populations (see, for example, Agamben 2007; Mbembe 2008; Rose 2008; Collier and Lakoff 2014; Povinelli 2016; Puig de la Bellacasa 2010; 2017). Conducting proper conduct – in this case, convincing people to choose to act in ways that public health officials suggest will limit virus spread – has been crucial to managing the COVID-19 pandemic.

As we explore Mexican pandemic governance and the implications of seismic noise analysis, we are also involved in “doing” STS (Cf. Downey and Zuiderent-Jerak, 2021) through multidisciplinary collaboration. In the pages which follow, we draw on our

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1“Hasta la explosión del coronavirus, con las consecuencias geopolíticas que ya vamos viendo, estamos llegando al climax de la relación directa entre la vida biológica y las intervenciones políticas.”
respective expertise in seismology, medical sociology, and STS to consider how seismic noise can reveal human activity in a high-stakes pandemic moment and make meaningful theoretical and practical comments on it. Here, in the context of Mexican state efforts to direct public behavior, the trends we identify have implications for understanding public trust in and compliance with the state’s strategy to contain the virus. This article is a critical discussion of seismic data use in public health research and frames practical questions about contemporary biopolitics and surveillance technologies.

2. Materials and methods

2.1. Seismic noise, data collection, and analysis

Seismographs record ground motion. Seismologists are mainly interested in those vibrations generated by earthquakes; however, the seismic record contains vibrations from other origins, which are referred to as seismic “noise” – a term used to describe data that do not pertain to the “signals” related to ground motion that seismologists are often interested in studying. Possible sources for this “noise” include movement near instruments. This might include pedestrians, moving vehicles, or machinery in operation. To avoid collecting noise data along with the data about ground motion that they can put to use, seismologists often site instruments in places that can be somewhat isolated from human activity. However, this is not always possible. Data about the ground motion in cities (particularly in uniquely sensitive cities like Mexico City) might be unavailable to seismologists if they simply refuse to put instruments in highly populated areas. For this reason, many seismic networks include a few instruments in urban sites along with others thoroughly remote from human activity. Furthermore, The world changes around seismic stations, some once-remote instruments are now in populated places.

The Mexican National Seismological Service (SSN) was officially inaugurated in 1910 with a station in Tacubaya. Tacubaya, just to the southwest of Mexico City’s historic center, at the time was located outside the city, but is now a highly populated part of the metropolitan area. Eight more stations were installed in the country in the following dozen years despite the start of the Mexican Revolution (Suárez and Pérez-Campos 2020). These stations were located near important cities. 110 years later, the SSN still operates a national network (Pérez-Campos et al. 2018) and a regional network focused on the Valley of Mexico, for a total of 92 stations. 26 of them are now within counties with more than 100,000 inhabitants (Figure 2). Of the 29 stations in the Valley of Mexico (Quintanar et al. 2018), 18 are located within Mexico City. This makes them likely to record anthropogenic noise and opens up new opportunities for data analysis and interpretation. Data from all these stations, along with those from other regional and local networks, are transmitted continuously in real-time to the monitoring center of the SSN. There, in the main campus of the Universidad Nacional Autónoma de México, automatic systems detect and locate earthquakes within the country (Pérez-Campos et al. 2019). In this study, we analyze the data from January 2019 to December 2020 produced by 84 SSN-operated stations (Figure 1): 24 stations within Mexico City and 60 stations distributed in the country.
SSN seismic records include frequencies between 0.008 and 50 Hz. This encompasses vibrations with frequencies above 1 Hz (e.g. Groos and Ritter 2009; Boese et al. 2015) generated by human activities. Analyzing data at these anthropogenic frequencies usually involves obtaining the average displacement within daily records. The largest variations usually take place in the band from 1 to 5 Hz, which has been related to pedestrians (Alyamkin and Eremenko 2011) and urban road traffic (Green et al. 2017). Faster-moving vehicles on a freeway can be detected at distances between 5 and 8 km from instruments, but their frequency range is higher (10–20 Hz, according to Long 1971). Most SSN stations are located far from freeways, and although the speed limit is 80 km/h in the fastest arteries in Mexico City, this is rarely reached due to the city’s constant traffic jams. We can both anticipate and demonstrate through frequency analysis, then, that the main contribution of noise in seismic stations comes from pedestrians and slow traffic.

For each day, at each station, we obtained the power spectral density of 60 s windows as well as the median of their distribution. We then obtained the rms displacement at a 1–5 Hz frequency band. The base noise level was set to be the displacement median for all the weekdays during 2019, including holidays. We set this as 100% and compared the rms displacement of each 2020 day to obtain the daily percentage of the noise drop at each station. For further details, see Pérez-Campos et al. (2020). Figure 2 shows the maximum noise drop percentage for each station.

Comparing shifting seismic noise levels to meaningful local calendars can help us understand where seismic noise comes from. For example, Figure 3 shows seismic

![Figure 2. Noise level of the seismic stations operated by the SSN. Stations located within Mexico City are outlined. County population is from CEDRUS (2019).](image-url)
noise as demonstrated through daily variation of the average displacement for the station located at the main Universidad Nacional Autónoma de México (UNAM) campus from 1 January 2019 to 31 December 2020. This station is about 1 km away from one of the main subway stations in the city as well as a densely populated neighborhood. Additional sources of activity include campus avenues, which are not only driven by university faculty, staff, and students, but are also frequently used as shortcuts to some of the main arteries on the south side of the city, causing significant traffic jams on weekdays. The weekly cycle demonstrated in average displacement calculations is noticeable: the lowest values happen on Sundays and the highest occur on weekdays. The average displacement amplitude is reduced during summer vacations and holidays. On Saturdays, the UNAM campus is open only half of the day, which we can see in the moderate seismic noise level. This analysis also shows low levels of noise on days with no classes in January, June, and the period between late July and early August. However, while the campus may be closed during vacations (e.g. first three weeks of July), research institutes remain open. This results in vehicles and people moving through campus, reflected by the noise levels comparable to that on Saturdays when school is in session. Broadly, comparing seismic noise values to the UNAM campus calendar can help us understand the anthropogenic seismic noise detected by this station as a byproduct of a range of activities taken in aggregate.

To develop an analysis of human activities in multiple sites, we developed the following procedure. First, we set the base level of the seismic noise for each station as the

Figure 3. Average daily displacement at station PZIG, located on the main UNAM campus. Pink and blue shadows indicate week and weekend days. Yellow areas indicate university vacations. Magenta and yellow dashed lines indicate the median noise level during weekdays and Sundays of 2019, respectively. The weekday level represents the noise base level. The days of the main announcements by the federal government and the color of the traffic light in Mexico City are also marked.
Seismic noise data can tell a story about 2020. Analysis allowing them to do so relies on a similar procedure to that described above. Average daily displacement, in the 1–5 Hz frequency band, can be taken and compared to the base seismic noise level calculated in a similar manner for 2019. This can be expressed as a percentage, as shown in Figure 4, where a negative value indicates a drop in the seismic noise and a positive value, an increase with respect to the base level from 2019 (Figure 4).

2.2. In/forming public policy: media analysis and other methods to look at public opinion

STS scholarship can illuminate the relations, networks, and assemblages that constitute sciences, technologies, and medicine (Da Costa Marques et al. 2012). What elsewhere might be approached simply as scientific facts can become, in this context, assemblages or networks in and of themselves, the intelligibility of which is a product of complex, ongoing institutional and social practice (for example, Latour 2005). With this perspective in mind, our approach to technologies with the potential to provide “facts” about human activity during a pandemic centers not just on seismic noise analysis, but also on various discourses, institutions, events, and accounts of public opinion that lend these “facts” meaning.

Public opinion is a particularly challenging but necessary element of this account. Since the early twentieth century, the significance of public opinion has been debated in relation to its power to shape democracy, its role as a “network of sensors” that shapes the public sphere, and its potential to shape public policy. Opinion polls, often in the form of surveys, are the most common method to gather the view of the public on any specific subject. Surveys are frequently linked to the merits of evidence-based policy. However, caution must be taken when looking at surveys as the “aggregate of all that is thought and said on a subject” (Fulton 1920). As Adashi et. al (2020, 437) note:

One important criticism of opinion polls is that respondents often offer “non-attitudes” to pollsters because their underlying views are unstable. Furthermore, when it comes to complex topics or those that have escaped sustained public attention, individual responses are unlikely to have benefitted from information, reflection, and judgment. The aforementioned imperfections notwithstanding, the bent of public opinion polls must not be dismissed or ignored as a potential driver of public action.

Despite their limitations, public opinion surveys provide a key indicator of public perception, preferences, and sentiments that could drive public policy, and evaluate its effectiveness and acceptance. Resources like public opinion surveys and popular media and
shaped by, and in turn shape, the atmosphere within the nation. The ways that national
public health discourse has engaged popular attention during the COVID-19 pandemic
guides us to focus particularly on mainstream news media and public opinion surveys
for the purposes of our analysis.

Traditional mass media and social media are also key players in the formation of public
opinion. Media analysis has been of particular interest to STS scholarship because of the
way it can shape and be shaped by public perceptions and attitudes (Shapin and
Schaffer 1985; Gieryn 1999; Gouyon 2016). The media has power in the cultural context
in which scientific and medical discourses and debates take place, and can reveal

Figure 4. Percentage of seismic noise reduction for 2020 in Mexico City. The gray lines correspond to
the daily variation for each station, while the black line is the median of all stations within Mexico City.
Important events in the discourse are marked by red, orange, and green arrows. The maximum drop
was 11.8%; the minimum level is indicated by the yellow dashed line; the noise level by December
2020 was still 5% lower than the base level (purple dashed line).
“traces” of broader communication processes, too. It can transform scientific or technological breakthroughs – and the scientists and doctors involved – into national achievements, the product of heroes, or shameful scandals (Henderson and Kitzinger 2007; Bharadwaj 2016; González Santos, Stephens, and Dimond 2018). As González-Silva (2010, 150) notes, media analysis is a highly subjective approach which cannot offer statistical evidence. However, it does offer much-needed contextual perspectives into the study of any scientific or health-related event. In other words, “the study of science in the press allows us to trace the public discussions and controversies that surrounded science at a given historical moment, the actors participating in them, and their respective arguments.”

In this article, we look at the media as both an echo of public opinion and a major influence over public response to the “Stay at Home” campaign during the COVID-19 pandemic. Our analysis is not interested in looking at the veracity of the claims made in and through the media, but instead, we look at the power of such claims to influence people’s behavior and response to public measures during the pandemic. What the media communicates can only ever be part of a story about Mexican public health, but we nonetheless understand media as an important element of the conditions of possibility for the project of seismic noise analysis and the human mobility that it reveals.

Through iterative discussion and writing, we developed a collaborative effort to draw these data sources and analytic methodologies together. In the following sections, messages

**Figure 5.** Evolution of the percentage of the daily seismic noise level reduction with respect to the base level during 2019, observed at seven seismic stations located in Mexican cities.
and official recommendations from the Mexican Undersecretary of Health and popular media depictions of public health are paired with seismic noise, and regional and national surveys. Considering seismic data analysis and media analysis together, we can produce insights far more robust than would be possible without interdisciplinary collaboration.

3. Seismic noise and public health discourse in Mexico

By 27 March 2020, as rates of COVID-19 infection were rapidly escalating elsewhere in the world, the Mexican government had reported 717 confirmed cases and 12 deaths. For some, this suggested that the country would easily navigate the pandemic (Gilet 2020; García Soto 2020). Others, however, thought these figures were unlikely to represent the true scale of the problem due to under-testing and under-reporting (Gobierno de México 2020; Anzarut et al. 2020). Since the beginning of the pandemic, Mexico has been host to one of the lowest testing rates in the Americas, with only 2350 per 1 million people examined. For some, the government’s strategy of testing only serious cases made it difficult to understand the scope of the pandemic in Mexico or develop appropriate interventions (Agren 2020; Ornelas-Aguirre and Vidal-Gómez-Acalá 2020). The government criticized the commercial opportunism of private laboratories and opted to invest in educating the public on the nature of the virus and the behaviors associated with the spread of COVID-19 (Cullell 2022). One of the most successful communication strategies was a series of conferencias vespertinas (evening lectures).

Starting in late February 2020, the Mexican government offered daily televised briefings on the pandemic hosted by the national Undersecretary of Health, Hugo López-Gatell Ramírez. Gatell, as the public calls him, is a charismatic epidemiologist with a robust experience in health crises. His daily COVID-19 briefings covered issues such as domestic violence and mental health problems linked to the stress of isolation or “lockdown.” Gatell presented himself as an approachable, dedicated, and caring representative of the state. Special briefings were designed to let him answer concerns from mothers and children on national holidays devoted to them. Thoughtful political alliances (i.e. with feminist organizations calling for abortion rights) were key to developing a public perception of Gatell as trustworthy. He was not only trustworthy but popular: soon after the briefings started, Gatell became a trending topic on Twitter. He was reported to be the third most popular epidemiologist in the world (Ojeda and Ruiz 2020).

Seismic noise can help us understand what happened next, and make sense of Mexican responses to both COVID-19 and Gatell’s guidance. Gatell’s approval rate could very well have influenced people’s mobility and compliance with confinement. Indeed, the reduction of seismic noise in Mexico coincides with some of Gatell’s key daily COVID-19 briefings (Figure 4). While Mexico City experienced ordinary anthropogenic seismic noise at the beginning of 2020, a steady reduction of seismic noise started by the second week of March. This coincides with Gatell’s first announcement of a “Stay at Home” campaign. At this point, Mexican educational institutions and companies began a transition to enable workers and students to stay home. This is reflected in a drop of 1.5% of the seismic noise as compared with that of the same time in 2019. By 23 March, the official beginning of the “Stay at Home” program that Gatell had announced the week before, the decrease in the seismic noise level was near 3%.
Because little reduction of mobility was observed in data from Google, Apple, and social networks, and in light of an increased number of documented COVID-19 contagions, the Undersecretary of Health gave a strong statement during the Sunday 29 March evening press conference. He told Mexicans that they were at a precarious moment; that they had reached their last opportunity to self-isolate and control the spread of the virus. The popular response is evident in seismic data, where we see an extra 2.2% drop of anthropogenic noise. The following week was Christian Holy Week. Usually, there is very little activity in Mexico City during this time. In 2019, for example, anthropogenic seismic noise levels were as low during Holy Week as they were in the week between Christmas and the New Year.

The comparatively lowest level noise during 2020, though, was recorded between 20 April and 8 May. This coincides with Gatell’s announcement of the beginning of “Phase 3,” during which the highest number of cases yet were supposed to be reached. This low point for seismic noise coincided with both Gatell’s highest public approval and reports of strong popular fears regarding the virus and the economy. At that time, an ongoing national survey of Mexicans 18 years and older reported that 57.5% of respondents believed that Gatell’s office was performing well. Only 16.2% said that they disapproved of Gatell’s efforts to address the pandemic (Consultas Mitofsky 2020). The same survey asked about concerns during the pandemic. Between 19 April and 10 May, that is, the start of “Phase 3” and the expected uptick in COVID-19 cases, people reported significant fear about contracting the virus. This survey reported both the highest levels of fear regarding the coronavirus (between 39.3 and 40.6%) and the highest fear of the effect of the pandemic on their personal finances (between 38.8 and 39.5%). The paired worry is no surprise, as in Mexico the fear of COVID-19 infection and the fear of its impact on personal finances have been closely related throughout the pandemic. In comparison, fear of being a victim of crime – an issue that might also keep Mexicans from leaving their homes – has fluctuated throughout the pandemic. The lowest rate of reported fear was found precisely during the period when the beginning of Phase 3 was announced (Consultas Mitofsky 2020), just as seismic noise analysis indicates that many Mexicans were limiting their movement.

4. The signal in the noise

The reduction of seismic noise at certain times, as described above, can become more “signal” than “noise” when it is understood to suggest how people living or moving near SSN instruments can be treated as a likely proxy indicator of issues like fear of contracting the virus, trust in the government and public health officials, and willingness to comply with official prescriptions. We cannot, of course, understand the specific bases of individual choices to limit movement during this period. Our method only allows us to observe trends at the population level. These trends may nonetheless offer insight on the effects of the “Stay at Home” campaign and suggest some potential explanations for the choices Mexicans made. For example, in a country with more than half of its working population in the informal economy and with 41.9% of its population living in

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2The Mexican government designed a system of phases (1, 2, and 3) to classify its response to the pandemic. Phase 3 entailed a rapid increase in contagion and hospitalization and therefore more extensive community outbreaks.
poverty (INEGI 2020), it is significant that the fear of COVID-19 might be reported in surveys at roughly the same rate as the fear of losing income. Staying at home, an action appropriate to address the first fear is, for many, the very opposite of the remedy for the second fear. For the Mexican population who rely on low-wage labor and the informal economy and who want to avoid the coronavirus, telecommuting is rarely an option. It is likely that the tensions of their position are evident in fluctuating seismic noise levels, which may show how popular endurance during lockdowns is limited by the economic pressures they experience.

Further, seismic noise analysis suggests that mobility – that is, failure to comply with public health guidance – seems to coincide with the level of public approval of Gatell’s performance. Seismic noise started to increase as Gatell’s approval rates descended. After a high approval rating of 56.3% on the 26th of April, Gatell’s popularity dipped. As the number of COVID-19 confirmed cases and fatalities rocketed, measures of public trust in public health officials suggest that trust decreased. Simultaneously, people seemingly began to neglect recommendations and move more freely.

Mexican public trust in the government has proven crucial to cooperation during the COVID-19 pandemic. Trust can motivate the choice to take recommended actions (i.e. lockdown) without coercive state action. During the pandemic, trust in government actors seems to have been in short supply. For example, Cairney and Wellstead (2020) recently compared trust in experts, politicians, and the public in the United Kingdom and in the United States. They found that in the UK, people reported losing trust after a general lack of preparedness, the institution of new policies that could harm schools and businesses, and well-known people disregarding public health guidelines with impunity. In the case of the US, the authors highlight a national history of anti-rationalism that has informed popular distrust of government leaders and institutions. Refusal to comply with government guidance related to public health is differently, but strongly, linked to issues of distrust in state agencies in each country. Much as it has in the UK, trust in the government and other public health figures such as Gatell has been gradually eroding in Mexico. The Mexican President’s refusal to wear a face mask and practice social distancing has not escaped public notice and has increasingly been the subject of outrage. Meanwhile, Gatell himself was observed disregarding his own public health guidelines during the December holidays. This has also been the source of much consternation, especially when he continues to tell Mexicans that isolating themselves at home is their national duty.

Mexican mistrust in the government has been detrimental to public health efforts before: Rodríguez Medina, Pandal de la Peza, and Shrum (2019) explore the way that the issue of trust in the government shaped Mexicans’ response to the Zika outbreak in 2016. The authors found low compliance with official advice to be a result of a general mistrust in the government’s interest and capacity to control the spread of the virus. Respondents believed that the information provided by the government was not reliable, and some went as far as suggesting that the virus was developed and spread by officials in order to distract public opinion from other social and political matters. A similar display of distrust has also been seen in the COVID-19 crisis. For instance, at the beginning of May 2020, family members of a COVID-19 patient forced entrance into a public hospital in the municipality of Ecatepec. “They are killing them!”, the group yelled as they attempted to find their deceased relative, filming bodies lying on the
hospital’s corridors and sanitized bags containing corpses as they moved through the hospital corridors. The group accused the hospital of misinformation and the incident provoked national outrage. It showed both the extent of the vulnerability of health staff and the impact of people’s disinformation and distrust (Animal Político 2020).

In 2018, a *Latinobarometro Inform* survey of people in all 18 nations in Latin America found that only 16% of Mexicans reported trusting the government, and 35% reported trusting the media. However, in the context of the pandemic, other social institutions matter when it comes to public trust. The Gallup-Wellcome survey found that in Central America and Mexico, doctors and nurses were trusted by 81% of respondents (Gallup 2019, 64) and 76% trusted doctors and nurses when in need of health advice (Gallup 2019, 71). According to a recent national survey on public perception of science and technology, Mexicans trust scientists (83.6% of respondents trusted scientists who worked in a public university and 84.4% trusted in scientists working for a private university). The majority considered scientific research important for technological (89.6%) and economic (74%) national development. Most respondents (81.3%) expected government support for scientific research and approved further investment in research and development of science and technology (92%) (ENPCYT 2017). These findings indicate that Mexico does not exhibit the anti-rationalism often associated with popular distrust of government leaders and institutions in the US (Cairney and Wellstead 2020).

Compliance with health advice from public officials could, of course, be linked to issues beyond trust in medicine and science. As Cairney and Wellstead (2020) suggest, in the case of COVID-19, high initial compliance with the lockdown could be explained by the perceived threat of the virus, local community norms, sympathy with those infected, and a feeling of national solidarity. As mentioned above, concerns over the economy, violence, and organized crime could also be linked to Mexicans’ levels of compliance to pandemic public health guidance. These factors could explain the variance of seismic noise we found in different cities (Figure 5). These variances could also be related to differences between the 31 states of the Mexican Republic.

Whatever its cause, variance in seismic noise in cities that host SSN stations increased over time. On 1 June, local governments acted according to the national guidance, opening up economic activities to get to a “new normality.” In Mexico City, the corresponding increase in seismic noise was slow, as Figure 4 shows. Other cities around Mexico experienced the same behavior (Figure 5), with a shared drop in the level of seismic noise in the second week of March, which reached its lowest level in the first week of May, when peak contagion was expected. After that, seismic noise in each city can be understood in relation to state and local discourses rather than national direction. For example, Sonora was one of the few states in Mexico that implemented strict measures to ensure lockdown. During the first week of April 2020, the governor announced that the state was going into forced lockdown for the last half of the month, to be imposed through heavy fines and, when necessary, force (Gobierno del Estado de Sonora 2020). Perhaps due to these measures, the city of Hermosillo experienced the largest drop in seismic noise levels of all those that we collected data from, showing a 29% decrease of activity after the governor’s statement. Although this might suggest that coercive strategies work to encourage populations to follow public health guidance, it is worth noting that Hermosillo also saw the greatest increase in seismic noise of all cities measured, returning to its normal levels by July even with penalties in
place. This translated into a fast rate of contagion. As a direct result, the governor of Sonora called for another lockdown, which can be seen in the abrupt seismic noise drop of 20% of the seismic noise in early August through October. A sudden 10% increase of seismic noise levels followed, and after that the seismic noise measured held steady at that level through the end of the year. In contrast, states that did not use coercive methods show higher but more stable levels of seismic noise. This suggests that the use of state force could be a contradictory measure for pandemic responses in some countries. Further analysis and correlations could be used to demonstrate the impact of coercive state action, not only in relation to the potential collateral damage to people’s wellbeing (i.e. mental health, increases in domestic violence), but also in terms of the effects that forced lockdowns can have on social behavior once the mandate is over.

5. The biopolitics of noise

If analyzing seismic noise can contribute to our understanding of how populations are responding to public health guidance, then STS-informed analysis of the contours and implications of that knowledge is essential. To do so, we turn our attention to the biopolitics of seismic noise. “Biopolitics” has been used to evaluate a variety of ways that governments may concern themselves with human welfare. Foucault’s work on biopolitics showcased how modern governments had developed policies and practices concerned especially with the biological health of whole populations collectively (2003). Other scholars have taken biopolitics in different directions, addressing how people and other beings might be included in or marginalized from full membership in their communities, and the high-stakes of the difference (Agamben 2007; Rose 2008; Mbembe 2008; Collier and Lakoff 2014; Povinelli 2016). As STS scholar Puig de la Bellacasa (2010; 2017) has argued, the most important work of these concepts is to sensitize us to how power can be enacted through attention to health and wellbeing, and interrogate the ways that this might be a matter of ethical concern.

All efforts to manage the COVID-19 pandemic have been the topic of intense state and international efforts. A variety of technologies have been enrolled in the project of pandemic governance. In a short article for Republica, Esposito (the philosopher with whom we began this paper) outlined serious concerns in relation to pandemic management. Some of his concerns are especially important to consider when reflecting on the biopolitics of noise: specifically, how individuals and certain segments of the population are understood to be either at risk or bearers of risk for others and who might easily become the subjects of emergency state action.

From the beginning of the pandemic, Mexican officials decided not to impose coercive measures to force a national lockdown. In contrast to many countries imposing strict restrictions, the national policy in Mexico was to refuse curfews, arrests, and fines. During an interview, Gatell explained that this strategy was decided responding to a long and shameful history of authoritarian rule in Mexico. The country could not afford the risk of abuse by security forces or social unrest that could spread the virus further (Sheridan 2021). Further, imposing a strict quarantine could prove to be impractical or outright impossible in a country in which poverty and informal employment is so widespread. Mexico’s reluctance to impose restrictions could also be explained by a particular
approach to the ethics of health interventions. As Bulcock (2010) suggests, Ibero-American bioethics has historically identified itself not so much as a specialized area of academic thought best explored in philosophy departments (as bioethics is treated in the United States), but as a social and political movement. This distinctive mode of engaging bioethics makes it a matter of popular discourse, informing non-specialist discussions related to human rights, public health, and social inequality. Broad engagement with such concerns in Mexico makes coercive regulatory action impractical and unlikely to gain popular support, even during a global health crisis.

Some Mexican states have, over time, diverged from national policy. Jalisco and Sonora, for example, imposed strict measures such as fines and jail terms for those that disobeyed the rules. Enforcing public health guidance in this way came at a cost. Not only was it associated with rapid decreases and increases of activity as reflected in the seismic noise data from Hermosillo discussed earlier in this paper, but it also provided a rationale for violence. For example, weeks after the governor of Jalisco state announced such measures, Giovanni López, a 30-year-old bricklayer, was beaten to death by police officers for not wearing a face mask in public. López’s treatment in Jalisco suggests how coercive regulation can hold the potential for violence. The biopolitics enacted in this event is tragic. In Mexico, as in many parts of the Americas, police brutality must be seen as a preexisting condition that complicates the imposition of heavy-handed efforts to enforce compliance during a health emergency. When police can understand a person’s compliance with directives to protect the physical health of the population to be more important than that person’s value to the social community, and, indeed, their individual life, this is dangerous biopolitics. Although seismic noise data may only be used to understand compliance in communities around instrumentation, at least the data it produces is aggregated and cannot be subject-identifiable in the same ways that visual information or GPS tracking might be.

Early reports suggest that the findings presented in this paper are far from unique, and that reduction of seismic noise is consistent with a reduction in public mobility observed by other means (Ojeda and Ruiz, preprint). With appropriate interpretive work, seismic noise data may offer a pathway to bypass the challenges of other means of monitoring and assessing public activities. Seismic noise monitoring and analysis performed in real-time could provide a means of surveillance without the danger entailed in producing and analyzing subject-identifiable data that could be compromised to reveal personal patterns in movement or simply put to harmful uses in the future by state agencies or businesses. However, this technique is unlikely to supplant other data sources and moves of surveillance on a grand scale, and it is important to take into consideration the way seismic noise data could collide with other modes of data collection.

For instance, under the COVID-19 Host Genetics initiative, phenotypes around the world are being investigated to determine major genetic risk factors for the virus across populations (see COVID-19 Host Genetics 2021). Brazil, Paraguay, Argentina, and Chile are part of this initiative. Some have suggested that a shared Latin American indigenous ancestry could be one variable in COVID-19 clinical outcomes in this region (Valenzuela 2020). While this may be borne out in data, there are pivotal ethical, legal, and social issues that must be assessed in the analysis and use of such findings. Geller et al. (2020) identify crucial questions for clinical practice, noting that projects like the COVID-19 Host Genetics initiative could inform (already highly controversial) bioethical
guides for the distribution of limited medical resources and therefore patient possibilities of survival. Certainly, the risk of differential distribution of vaccines or therapies is important to consider. There are other risks, though, that might concern us. Personal genetic profiles might be used as a factor to decide issues like who could act as first responders to the pandemic and to determine sites where the imposition of coercive measures, such as enforced quarantines for populations identified as potential super-spreader. In Latin America, race is highly related to both social class and to physical patterns of residence (Monteiro 2008; Valle 2018; Solís and Güémez 2021). Because of this, the use of genetic data linked to ancestry to distribute first responder status or to identify “at risk” communities presents opportunities for compounded danger.

Seismic noise data could well be deployed along with this kind of genetic analysis to put marginalized populations at risk of mistreatment. For instance, if a particular population group is identified as genetically susceptible to the virus and enforced quarantines are imposed, seismic data could be used to target the places they live. In cities where racialized “ghetto communities” already have reduced access to resources and power in comparison to others, this is worth considering seriously. These places might also be subject to further limitations of services or even the kinds of over-policing by first responders without ties to or respect for these communities that we already see elsewhere (for example, Ramírez 2020). Although this is, at the moment, a hypothetical scenario, research on science and technology sensitizes us to how the production and use of data is always a value-laden enterprise that must be constantly and cautiously monitored (Harding 2011).

6. Discussion and conclusion

In this paper, we have shown that fluctuation of seismic noise levels during key moments of the pandemic has the capacity to demonstrate aggregate human movements in areas near instrumentation. Further, we have shown how this seismic noise data hints at the dynamics of popular responses to public health policy and guidance. There is evidence here that Mexicans trusted public health officials and followed recommendations to shelter in place and limit time outside of their homes. The data also shows us when public health guidance became less effective for different communities. They are especially useful when considered alongside survey data and a timeline of communications and events related to the office of Mexico’s Undersecretary of Health.

STS scholarship frames our approach to this “signal” within seismic noise, guiding our use of data from SSN stations, public health guidance, pandemic-related events, and assessments of public trust. In this way, our findings may help us understand some aspects of its influence on Mexican public behavior. There is, as this case and others have shown, actual utility for using seismic data in social research and in public health activities. Considering patterns in the aggregate anthropogenic noise around seismometers can allow us to better understand how a population might be responding to public health guidance. While the density of instrumentation does not allow us to make nuanced, comparative claims related to different Mexican communities, this analysis helps us consider Mexican life with the COVID-19 pandemic and the consequences of public health communication and the behavior of officials.
While these findings have policy implications, we caution that they should be examined judiciously. One might also argue from these data that relaxed strategies in relation to regulating behavior during the COVID-19 pandemic have limited efficacy and that Mexico may need to be firmer in using its power to regulate movement. We are concerned, however, that this could have disastrous implications for populations without sufficient financial support to weather lockdown without normal income. Further, while this form of seismic noise analysis has much to recommend it as an aggregate mode of surveillance, it too should be treated with care. Like any surveillance tool, it could very easily be deployed with other data in ways that might do harm.

The utility, promises, and cautions presented here all emerge in the context of multidisciplinary collaboration. The process we follow here for making signal of noise means producing new meaning by considering the relationship between trends in low-Hertz seismometer data and events likely to have consequences for public behavior. Our work also relies upon a new collaborative relationship between researchers with expertise in fields that enable us to analyze these data cautiously and critically. We hope that such collaborations will continue to influence the development of seismic noise analysis and its applications.

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