

# Potential impact of earthquakes during the COVID-19 pandemic

---

Nicole Paul, Vitor Silva

19/11/2020

# Motivation

---

Since early 2020, countries around the world have been affected by the COVID-19 pandemic, which is likely to continue to disrupt our lives for many more months to come

In this timeframe, there has been and is potential for additional coincident natural hazards, including earthquakes

Our study aimed to investigate past incidents of disease outbreaks and natural hazards, perform a scenario study to assess potential impact of earthquakes on COVID-19 cases and deaths, and identify regions of potential concern



# Past natural hazards and disease outbreaks

"All the News  
That's Fit to Print"

# The New York Times

VOLCXLIV., NO. 49,829

Copyright © 1994 The New York Times

NEW YORK, SATURDAY, SEPTEMBER 24, 1994

78 miles beyond the greater New York metropolitan area

Late Edition

New York. Today, we cloud, fog, rain, snow, sleet and fog. High 76, tonight, cloudy, 60. Low 50. Tonight, 60. High 78, low 57. 58°. Details, page 25.

60 CENTS

Women seeking to flee an outbreak of pneumonic plague waited on a rail

## Thousands Flee Indian City In Deadly Plague Outbreak

By JOHN F. BURNS

Special to The New York Times

**N**EWS DELHI, Sept. 23.—As many as 200,000 people have fled the city of Surat, India, in the last two days in a break of pneumonic plague that medical experts consider one of the most serious reported in the world in recent decades. officials said.

Less than 40 hours after the first confirmed cases of the disease, officials in the industrial city said that 170 people had died since Aug. 22, when 100 others were being treated in hospitals. But the toll was probably higher, accounts from doctors working in Surat, a city of 1.6 million, suggested, and the toll was expected to rise as house-to-house searches turned up more victims.

Residents of Surat, a city of 1.6 million, have been under a state of confusion and panic reminiscent of the days of the 1984 chemical devastated Indore before the advent of 故障

insects in the 1980's.

The disease, in forms of both bubonic and the less severe lymph nodes, is spread by fleas. Pneumonic plague, from the spread of plague from the lungs to the blood, is spread by breathing in droplets from an infected person.

"We're appealing to people not to panic," said Dr. Rakesh Patel, a doctor at the city's main hospital, said that he had been overwhelmed by the number of patients. "The first words were in 'semiconscious condition. Another doctor, Parvez Patel, said, "The first words come walking in with the patient."

After the first deaths became known in Thursday, officials in Surat imposed a curfew and closed all public gathering places, including movie theaters, restaurants and bars. Most factories and businesses that remained in the city were told to stay at home.

Police cordons were reported to have been set up around areas in which the disease had been found, in an effort to prevent people from leaving. Some 100,000 residents were said to be touring other cities in India, while others fled to rest- ports to cut the exodus.

P. Trivedi, the district collector,

of top civil servants in Surat, said in a telephone interview that the city was facing a "war footing." Officials were using every means, from television to loudspeakers, to speak to the city to public appeals for calm, and to banish rumors of a cholera-like infection wherever they go," Mr. Tri-

vedi said.

After the first deaths became known in Thursday, officials in Surat imposed a curfew and closed all public gathering places, including movie theaters, restaurants and bars. Most factories and businesses that remained in the city were told to stay at home.

The police cordon, now moving on the streets, were said to be covering entire neighborhoods with searchlights or medical masks to limit the

Continued on Page 5, Column 1

rick of infection.

Prakash Kotra, an executive of one of the country's exporting companies, said that Surat, the city's largest industry, described the city as "a ghost town."

Reached by telephone, he said he had been in Surat for three days, having driven his family to the neighboring city of Mumbai. He said that he had discovered that most of Surat's population appeared to be dead or dying, and that he had no idea whatever they could do, he said, except whatever they could, to save themselves.

Mr. Mehta said that city officials appeared to be giving deliberately misleading information about the number of dead and that there were rumors that the city's chief minister had died. He said he had stood outside a hospital where he had seen several dead bodies in the hospital grounds, seven bodies in the hospital grounds, and he had asked the hospital to relatives for further confirmation.

A report by Reuters, with a reporter who was not identified as saying he had been in Surat, said that "more than 100 people had died."

Surat, a textile, petrochemical and chemical center, has been one of the fastest-growing in-

ports in India. It has a large chemical industry, which has expanded to cover almost the entire northern part of the state. It is also a major port on the fringes of the Latur earth-

## The Plague Strikes City In West India

Continued From Page 1

quake zone.

"The situation in Surat is so bad that it is no cause for alarm," he said. M.S. S. Narasimha Rao, a top official of the Health Ministry.

Health officials said that statements might be intended mainly to prevent a wholesale exodus of the city's population, which had reached 1.6 million.

After an emergency meeting in Mumbai, the capital, on Friday, Dr. P. V. Narasimha Rao, Health Minister of Maharashtra, said that the state had millions of doses of the antibiotic streptomycin available, and that DDT and other insecticides to Surat would be sent to the city as soon as possible.

Medical experts said prompt treatment would be effective, but that the disease had been carried to Surat by workers from the Latur area of Maharashtra, which has a population of more than 10 million.

In August, officials reported an outbreak of bubonic plague in Latur, on the fringes of the Latur earth-

## Congressional Memo With Eyes on Elections, Senate Finds an Impasse

By DAVID E. ROSENBAUM

Special to The New York Times

WASHINGTON, Sept. 23.—Even as the Senate began to move on a campaign finance bill, the political maneuvering in Congress continued in different forms by the House and Senate. The main issue was whether to include in the bill a clause partially financing the Senate campaign, and voluntary limits on campaign spending.

Under Senate rules, three procedures must be followed before a bill can be sent to conference to reconcile the differences between House and Senate bills. They are passed routinely, but the Senate has delayed the campaign finance measure because of the dispute over voluntary limits on campaign spending.

Under Senate rules, three pro-

cedures must be followed before a bill can be sent to conference to reconcile the differences between House and Senate bills. They are passed routinely, but the Senate has delayed the campaign finance measure because of the dispute over voluntary limits on campaign spending.

Under Senate rules, three procedures must be followed before a bill can be sent to conference to reconcile the differences between House and Senate bills. They are passed routinely, but the Senate has delayed the campaign finance measure because of the dispute over voluntary limits on campaign spending.

Under Senate rules, three procedures must be followed before a bill can be sent to conference to reconcile the differences between House and Senate bills. They are passed routinely, but the Senate has delayed the campaign finance measure because of the dispute over voluntary limits on campaign spending.

Phone Companies Call Plan  
Too Partial to Cable TV —  
Key Senator Says

By EDMUND L. ANDREWS

Special to The New York Times

WASHINGTON, Sept. 23.—The authorizing of telephone companies to offer local telephone service to the nation's telecommunications laws, intended to encourage competition between telephone and cable television companies, has been delayed in the Senate amid feuding between

the Senate and the House.

Rep. John J. LaFalce, Democrat of Brooklyn, who is chairman of the House Energy and Commerce Committee, said yesterday that the Senate had agreed to his proposal to add a provision to the Senate campaign finance measure that would allow telephone companies to offer local telephone service. The provision would be included in a conference committee report.

Rep. John J. LaFalce, Democrat of Brooklyn, who is chairman of the House Energy and Commerce Committee, said yesterday that the Senate had agreed to his proposal to add a provision to the Senate campaign finance measure that would allow telephone companies to offer local telephone service. The provision would be included in a conference committee report.

Rep. John J. LaFalce, Democrat of Brooklyn, who is chairman of the House Energy and Commerce Committee, said yesterday that the Senate had agreed to his proposal to add a provision to the Senate campaign finance measure that would allow telephone companies to offer local telephone service. The provision would be included in a conference committee report.

Rep. John J. LaFalce, Democrat of Brooklyn, who is chairman of the House Energy and Commerce Committee, said yesterday that the Senate had agreed to his proposal to add a provision to the Senate campaign finance measure that would allow telephone companies to offer local telephone service. The provision would be included in a conference committee report.

Rep. John J. LaFalce, Democrat of Brooklyn, who is chairman of the House Energy and Commerce Committee, said yesterday that the Senate had agreed to his proposal to add a provision to the Senate campaign finance measure that would allow telephone companies to offer local telephone service. The provision would be included in a conference committee report.

Rep. John J. LaFalce, Democrat of Brooklyn, who is chairman of the House Energy and Commerce Committee, said yesterday that the Senate had agreed to his proposal to add a provision to the Senate campaign finance measure that would allow telephone companies to offer local telephone service. The provision would be included in a conference committee report.

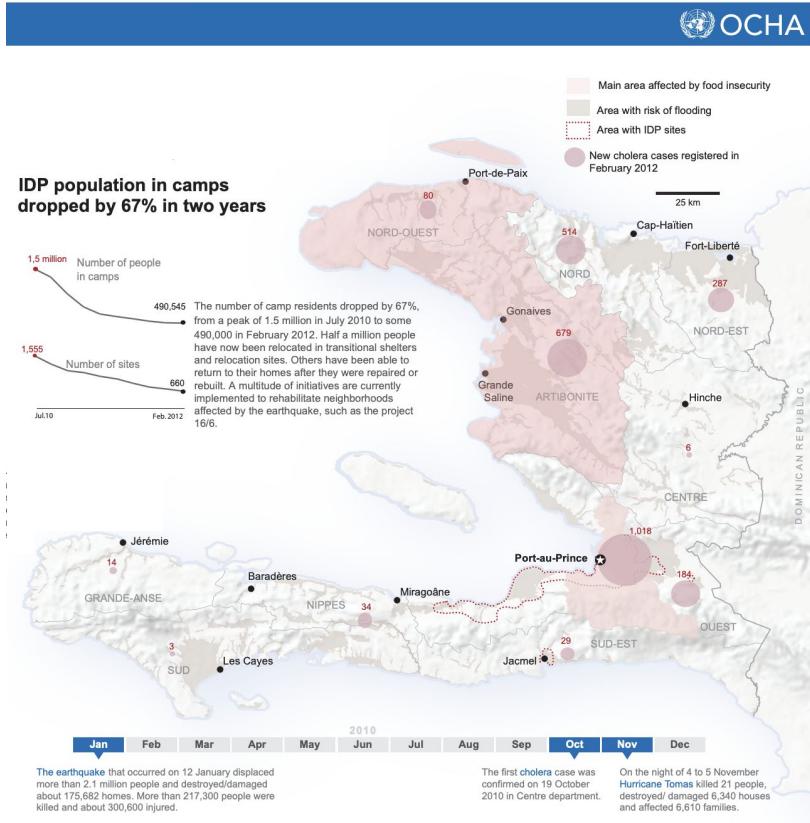
Rep. John J. LaFalce, Democrat of Brooklyn, who is chairman of the House Energy and Commerce Committee, said yesterday that the Senate had agreed to his proposal to add a provision to the Senate campaign finance measure that would allow telephone companies to offer local telephone service. The provision would be included in a conference committee report.

# Disruption to natural ecosystem

Earthquakes can cause disruption to the natural ecosystem, bringing animals in contact with human populations

The origin of a 1994 plague outbreak in Western India was attributed to the 1993 Latur earthquake, which destabilized rat populations

# Past natural hazards and disease outbreaks



Worsened response due to overwhelmed sanitation and healthcare infrastructure

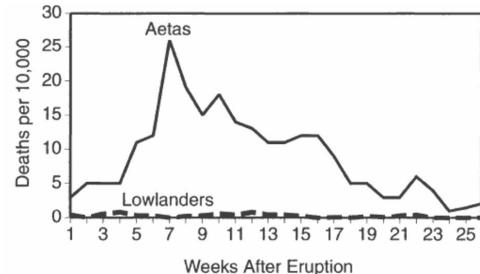
Earthquakes can cause damage and injuries, which can overwhelm existing systems and hamper response

Following the devastating 2010 earthquake in Haiti, international workers arrived to assist, some from countries where cholera was endemic

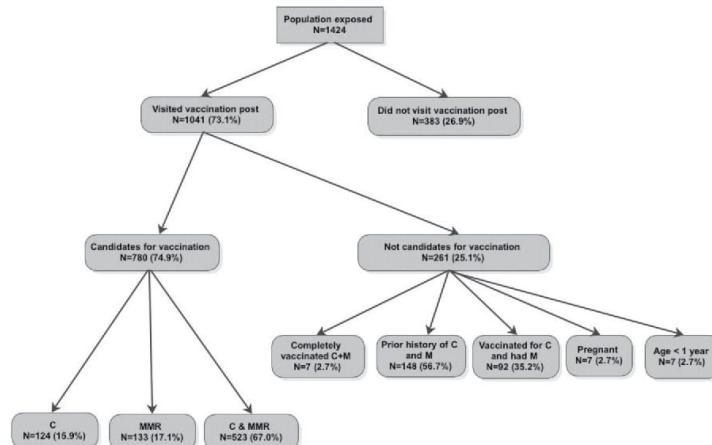
The severity of the outbreak was contributed to by the further decimation of Haiti's sanitation facilities in the earthquake, and unsanitary conditions in some displacement camps



# Past natural hazards and disease outbreaks



Surmieda, Maria Ruth S., et al. "Surveillance in Evacuation Camps After the Eruption of Mt. Pinatubo, Philippines." Morbidity and Mortality Weekly Report: Surveillance Summaries, vol. 41, no. SS-4, 1992, pp. 9–12. JSTOR, www.jstor.org/stable/24675587.



## Displacement and subsequent crowding

Natural hazards can lead to displacement and subsequent crowding, creating ideal conditions for spread of communicable diseases

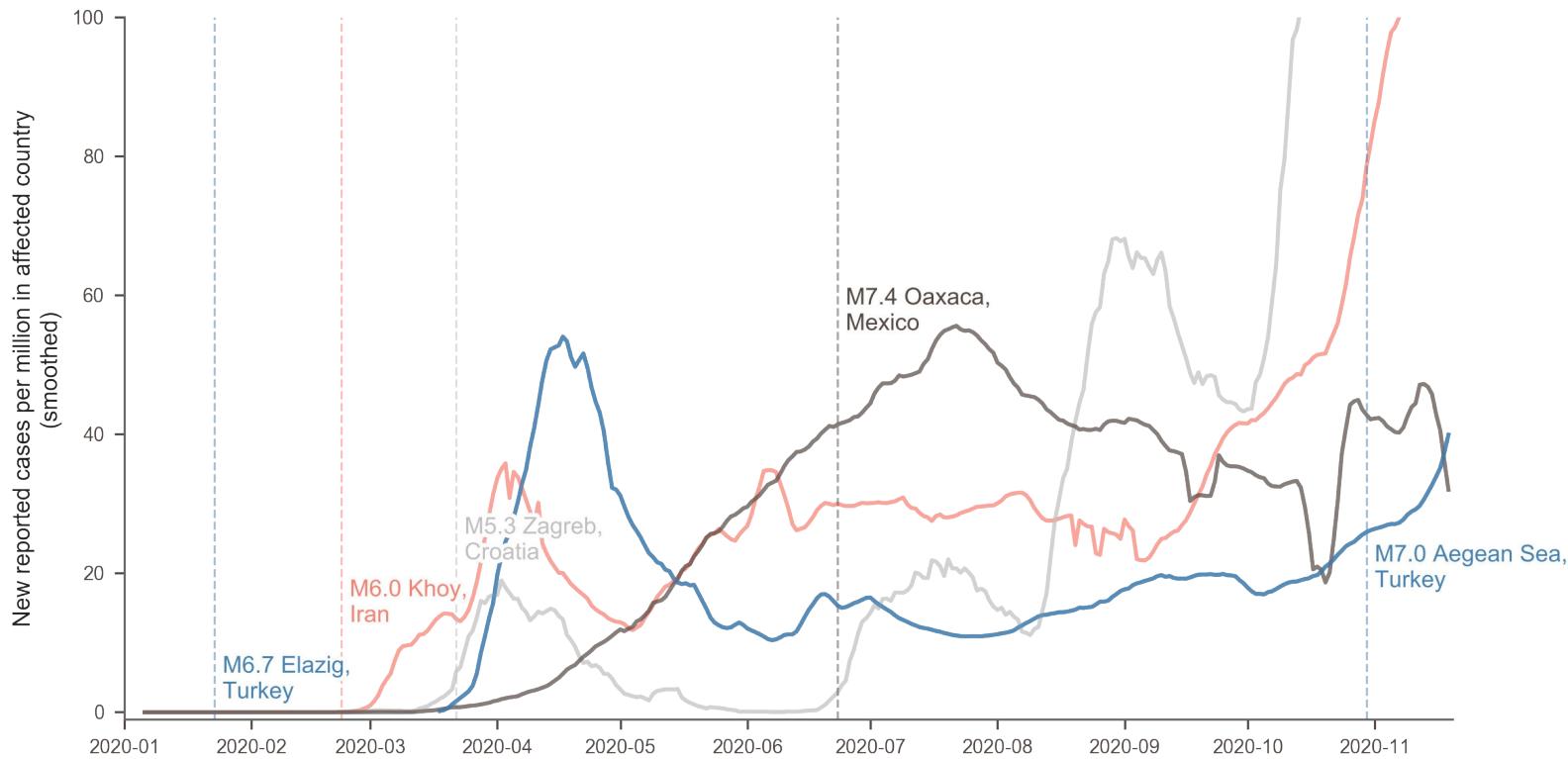
The effect is particularly notable if there are low baseline vaccination rates or poor sanitary conditions in emergency shelters

Examples include the 1991 Mount Pinatubo eruption (measles) and the 2011 Lorca earthquake in Spain (chickenpox)

Jáime Jesús Pérez-Martín et. al. (2017) Vaccination campaign at a temporary camp for victims of the earthquake in Lorca (Spain), Human Vaccines & Immunotherapeutics, 13:7, 1714-1721, DOI: 10.1080/21645515.2017.1296611



# Recent earthquakes during the COVID-19 pandemic



# Recent earthquakes during the COVID-19 pandemic

## Aegean Sea Earthquake in Turkey & Greece

Local NGO Support To Life (STL) reported that at least thousands of people have lost their homes and are staying in temporary tents in the Izmir region

Municipalities have conducted COVID-19 tests amongst emergency responders, with some already testing positive

Hygiene kits are being distributed to vulnerable populations, but more masks are needed per the Dunya Doktorlari Rapid Assessment report



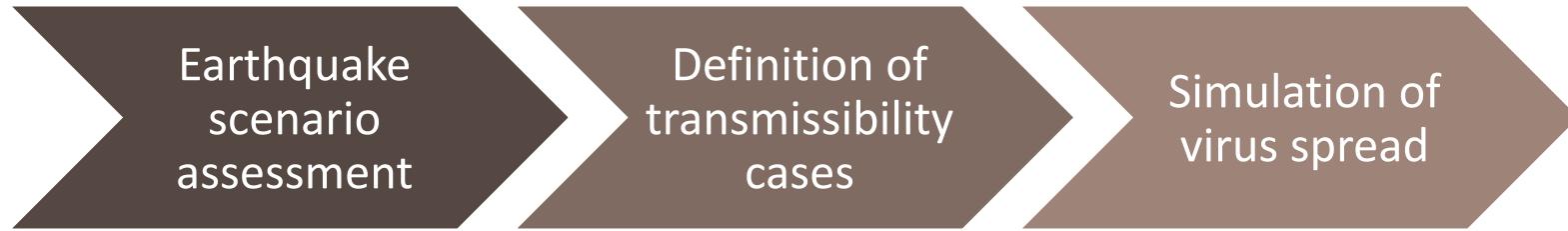
"Breaking news ... AFAD team of 25 people assigned in the Izmir earthquake was quarantined". November 11, 2020. Haber Turk. (Translated from Turkish).

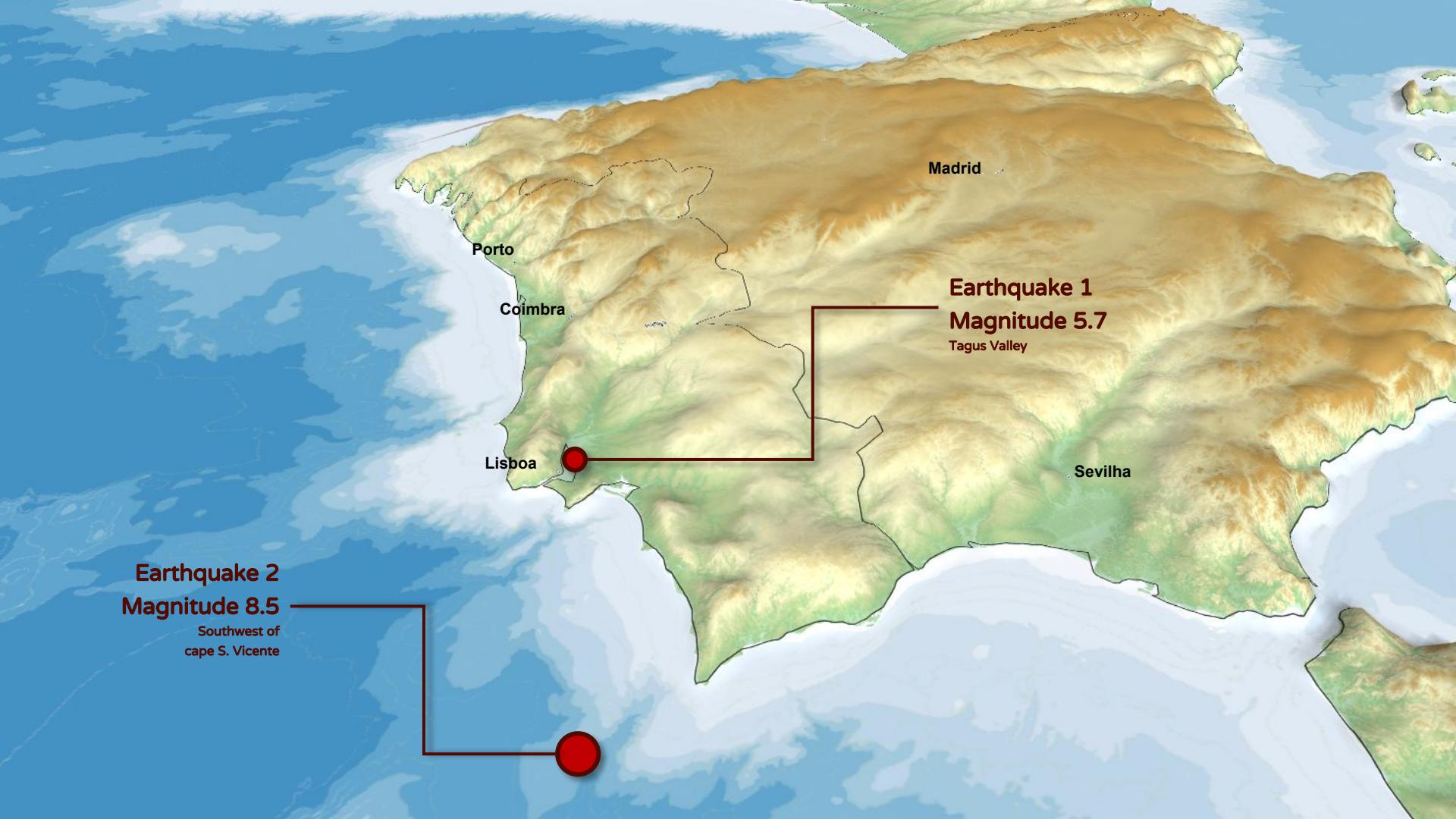


International Blue Crescent (IBC). Izmir Earthquake Assessment Report of IBC. November 11, 2020.

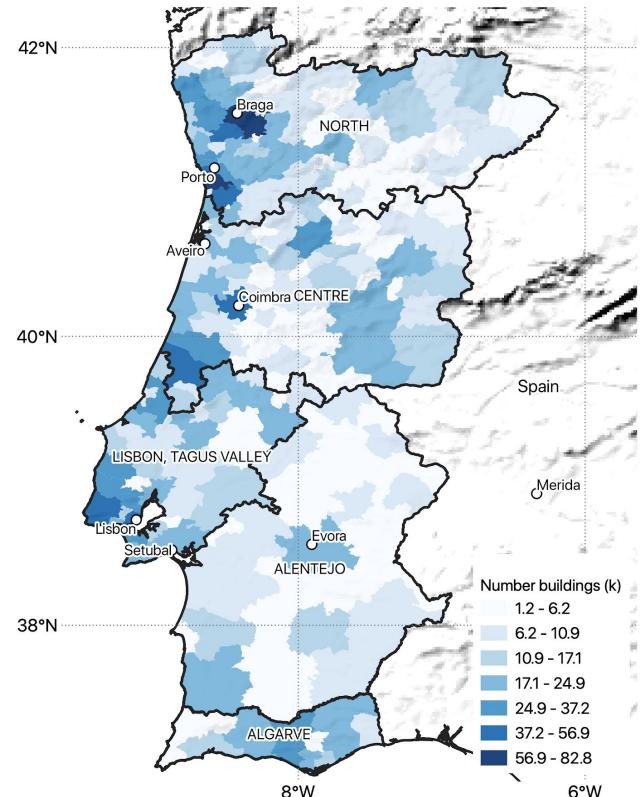


# Simulating spread of COVID-19 due to earthquakes

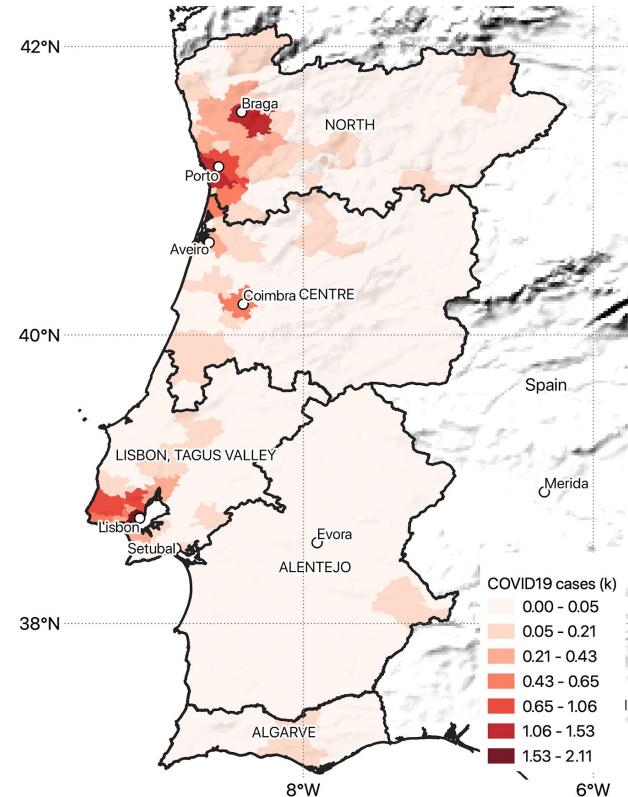




# Simulating spread of COVID-19 due to earthquakes

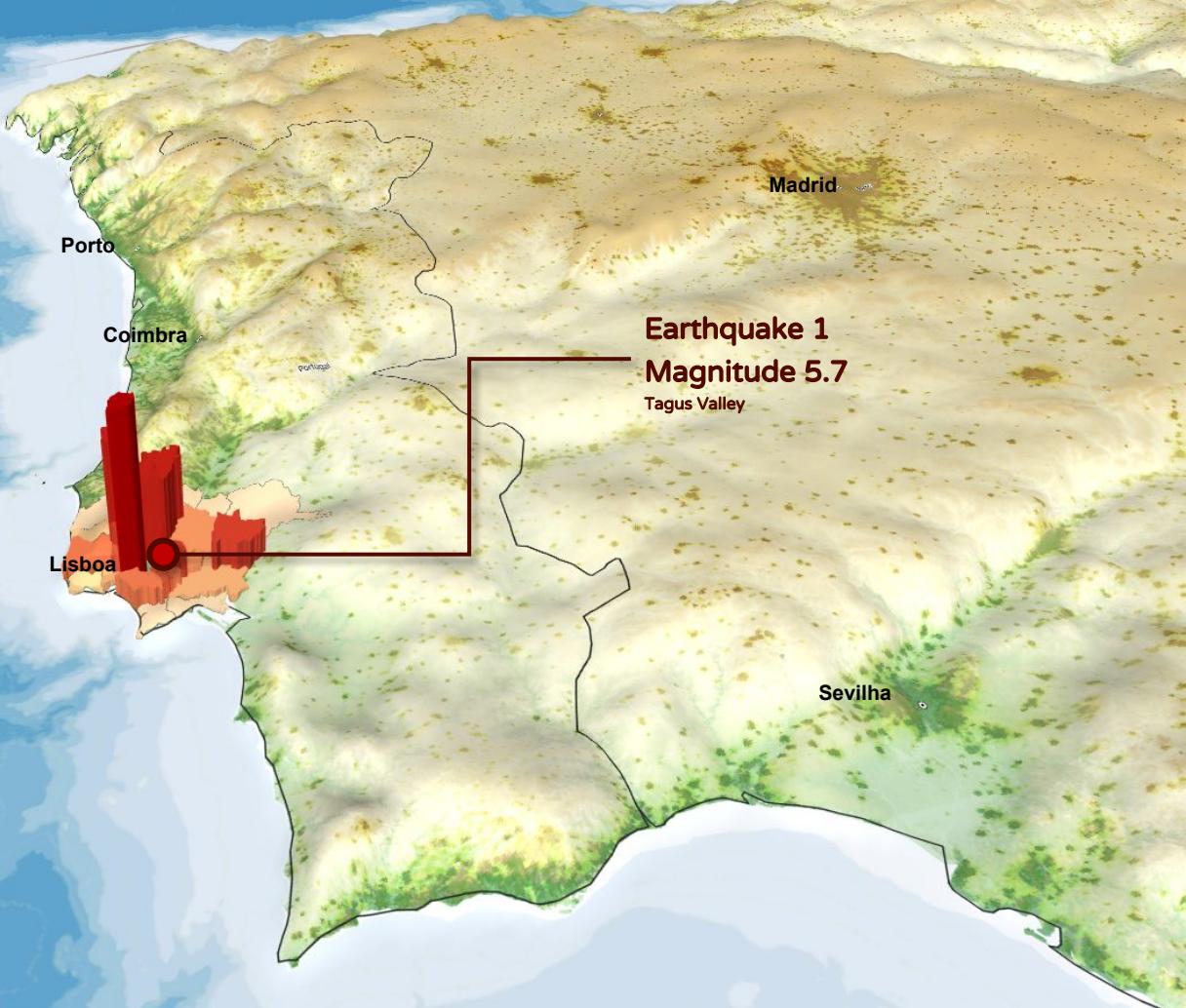


Silva V, Crowley H, Pinho R, Varum H. (2014). Seismic Risk Assessment for mainland Portugal. *Bulletin of Earthquake Engineering*, 13(2):429-457.

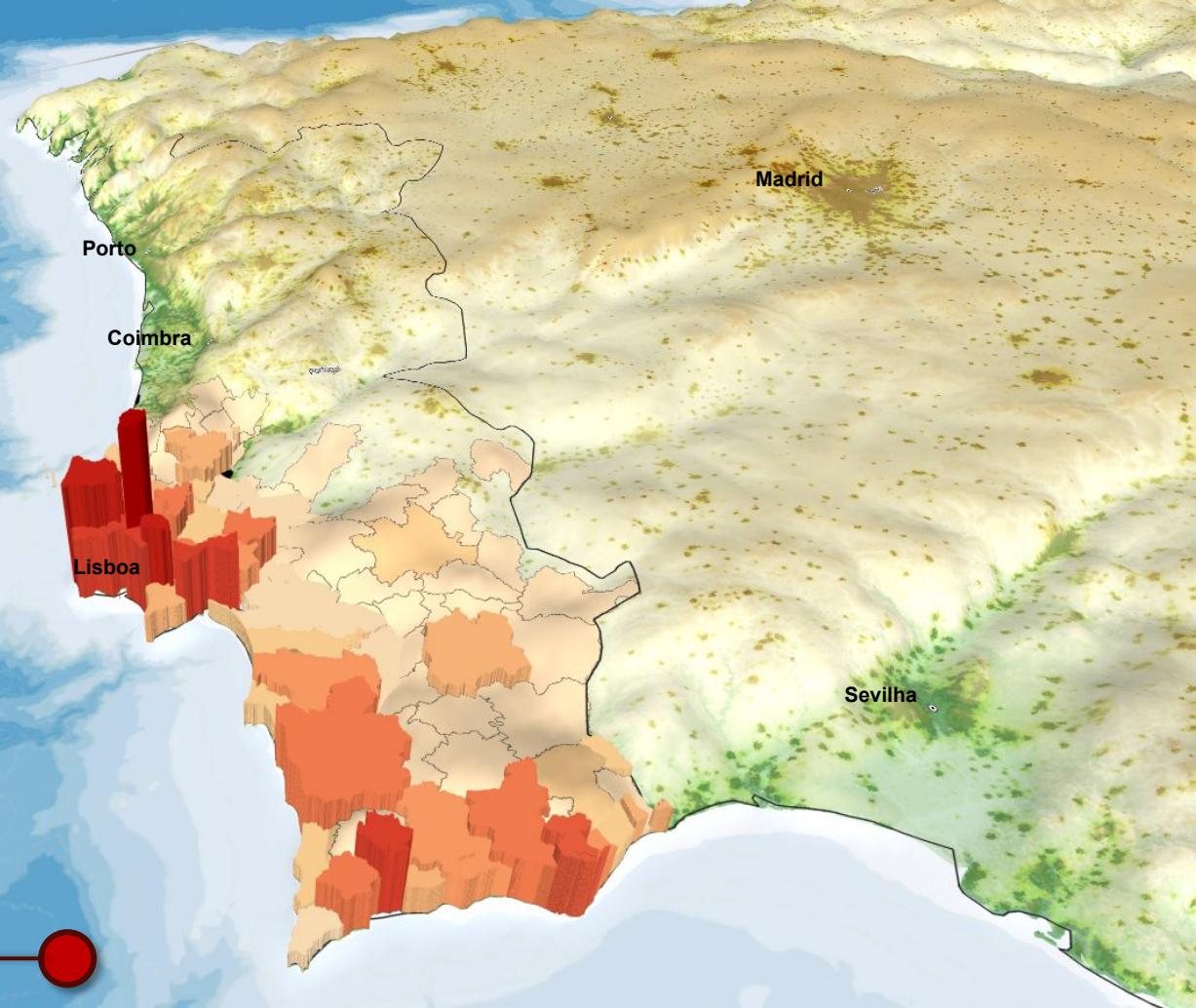
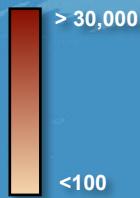


Silva V, Paul N (2020). Potential Impact of Earthquakes during the 2020 COVID-19 Pandemic. *Earthquake Spectra*.

Population left  
homeless or injured



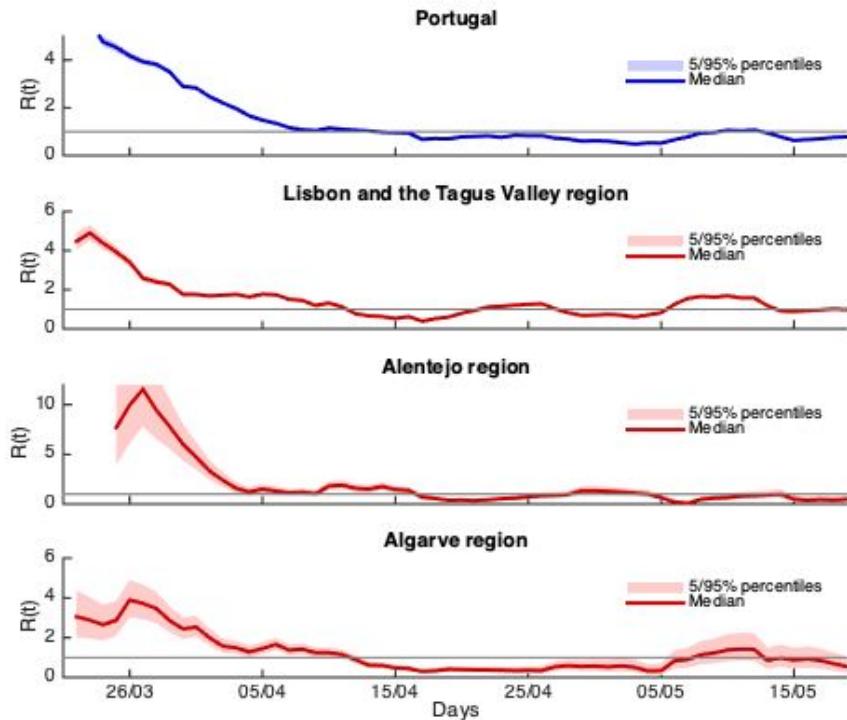
Population left  
homeless or injured



Earthquake 2  
Magnitude 8.5

Southwest of  
cape S. Vicente

# Simulating spread of COVID-19 due to earthquakes



$R_t$  represents the average number of new infections caused by a single infected individual at a time  $t$  in the partially susceptible population

Post-earthquake scenarios modeled:

## A. Optimistic

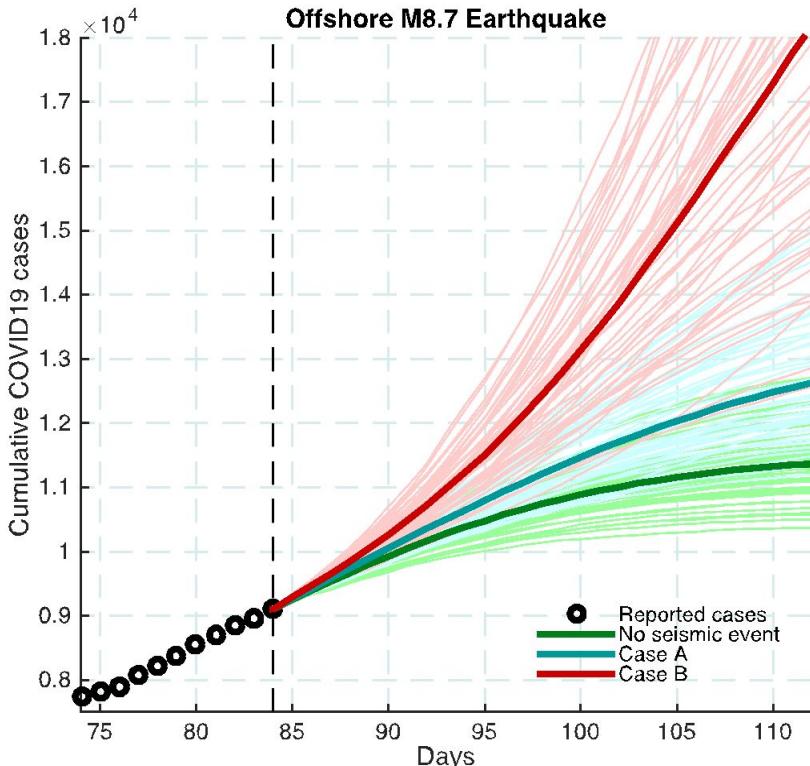
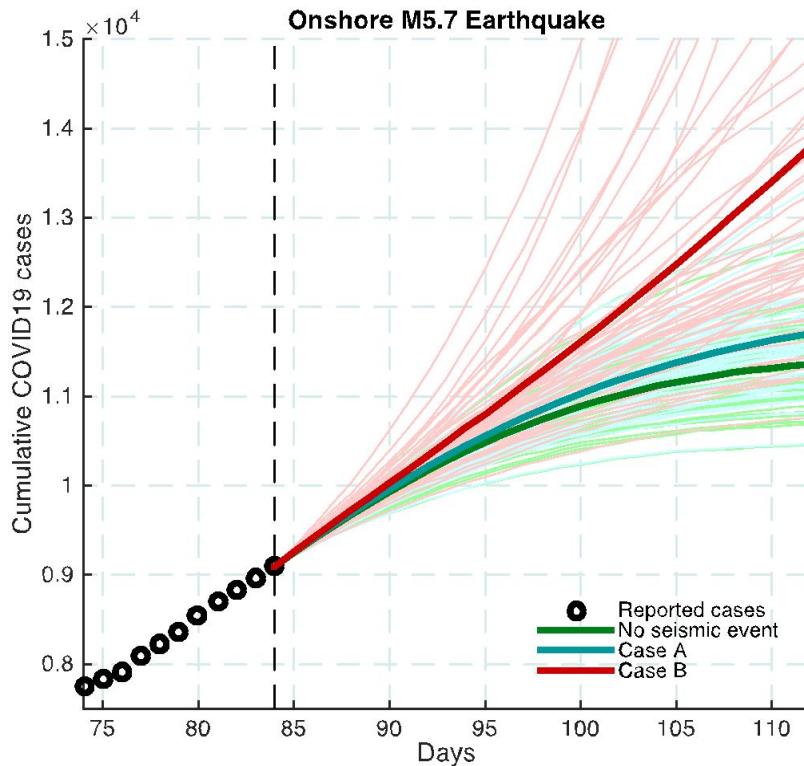
$R_t$  slightly increases after the seismic event (~2.5), comparable to the first 2 weeks after emergency declaration within Portugal

## B. Pessimistic

$R_t$  sharply increases after the seismic event (~4.1), the value registered by Portugal during the peak of infection

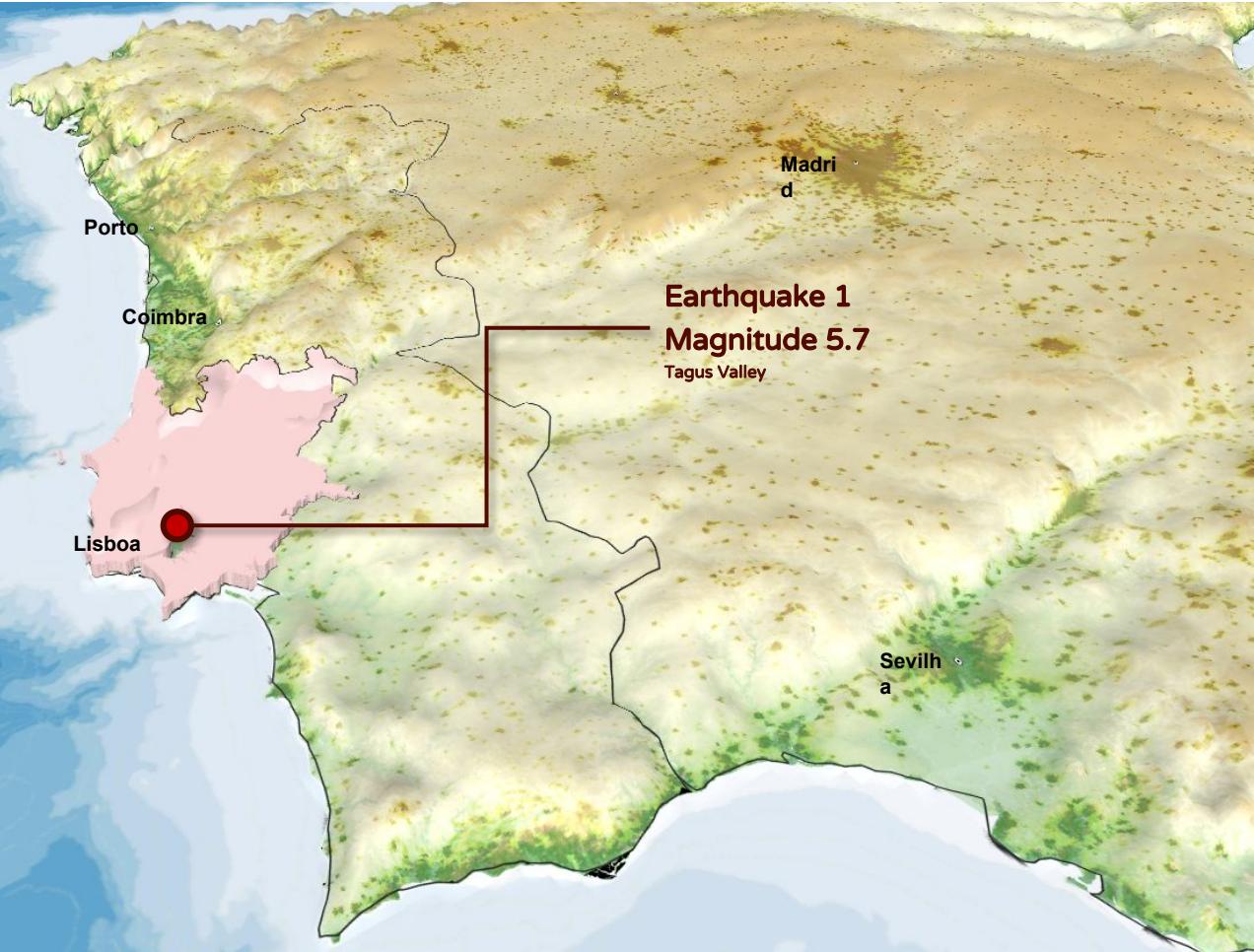
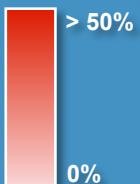


# Simulating spread of COVID-19 due to earthquakes



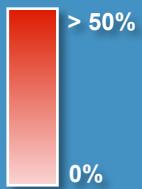
# Case A - Optimistic

Increase in the number of  
COVID-19 cases



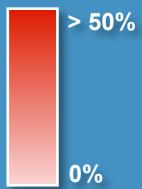
# Case B - Pessimistic

Increase in the number of  
COVID-19 cases



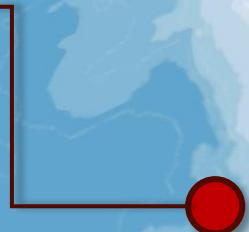
# Case A - Optimistic

Increase in the number of  
COVID-19 cases



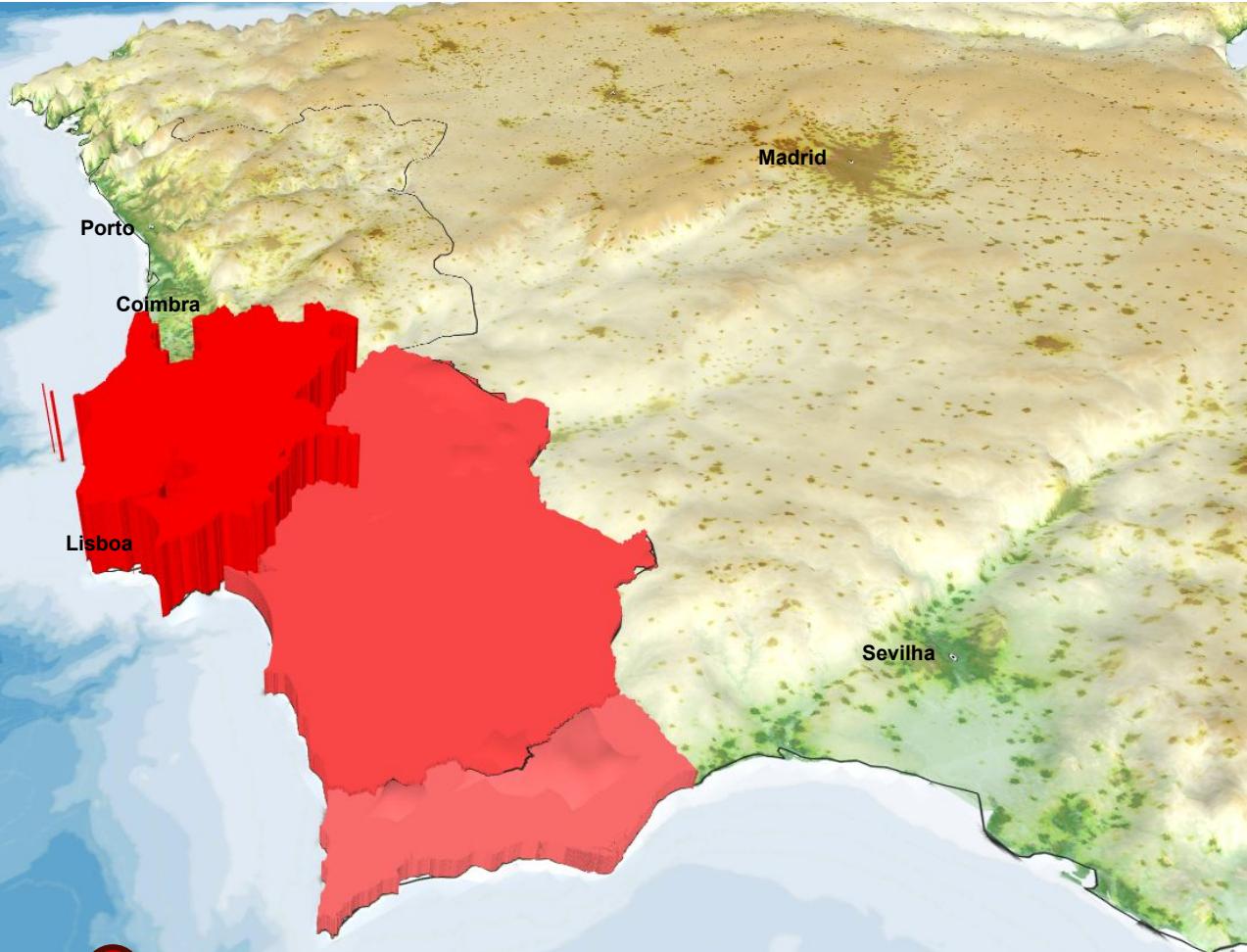
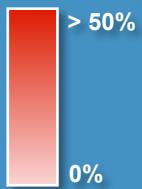
Earthquake 2  
Magnitude 8.5

Southwest of  
cape S. Vicente



# Case B - Pessimistic

Increase in the number of  
COVID-19 cases



Earthquake 2  
Magnitude 8.5

Southwest of  
cape S. Vicente

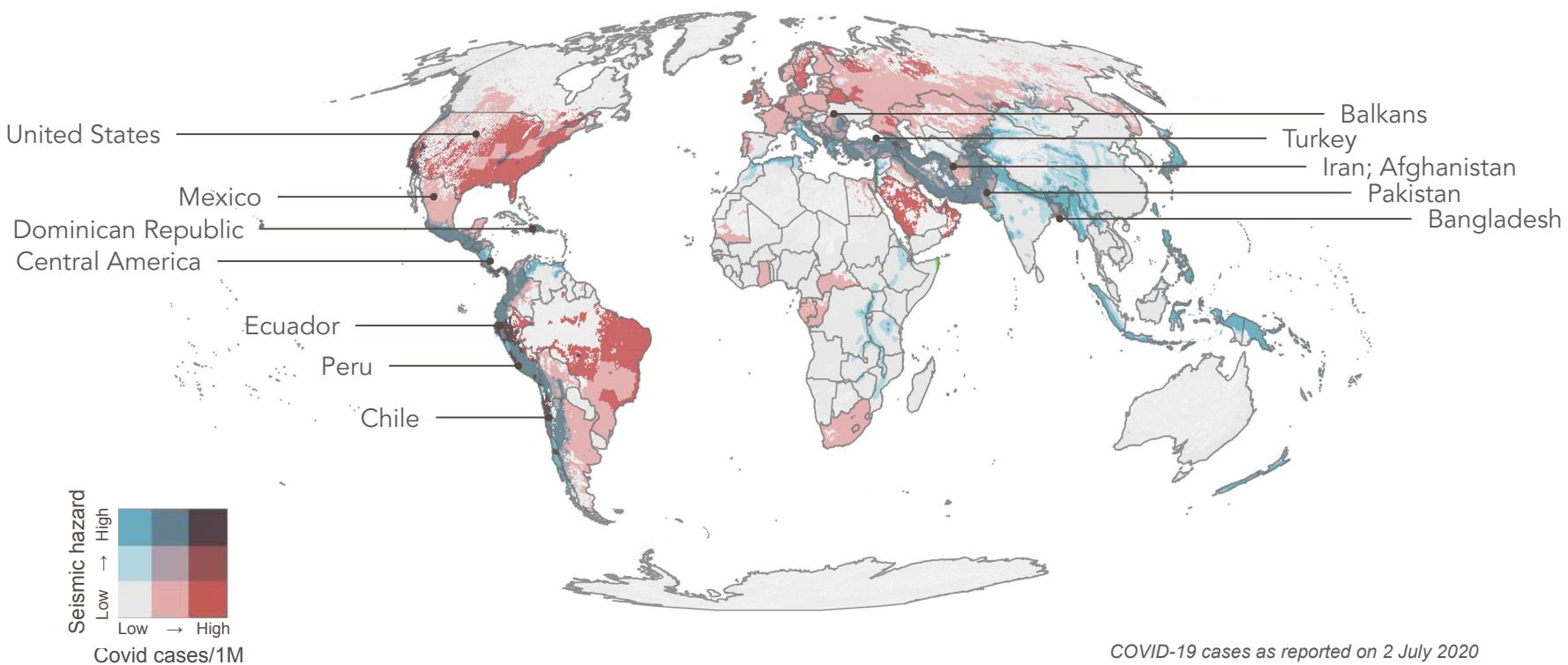
# Estimating additional fatalities due to earthquake

| Effective reproduction number case | M8.7 Offshore earthquake         |                |                             | M5.7 Onshore earthquake          |                |                             |
|------------------------------------|----------------------------------|----------------|-----------------------------|----------------------------------|----------------|-----------------------------|
|                                    | Due to additional COVID-19 cases |                | Due to structural collapses | Due to additional COVID-19 cases |                | Due to structural collapses |
|                                    | $M_r = 4.3\%$                    | $M_r = 11.5\%$ |                             | $M_r = 4.3\%$                    | $M_r = 11.5\%$ |                             |
| A: $R_t \sim 2.5$                  | 52                               | 138            | 1,729                       | 0.6                              | 1.6            | 292                         |
| B: $R_t \sim 4.1$                  | 257                              | 687            |                             | 2.4                              | 6.4            |                             |

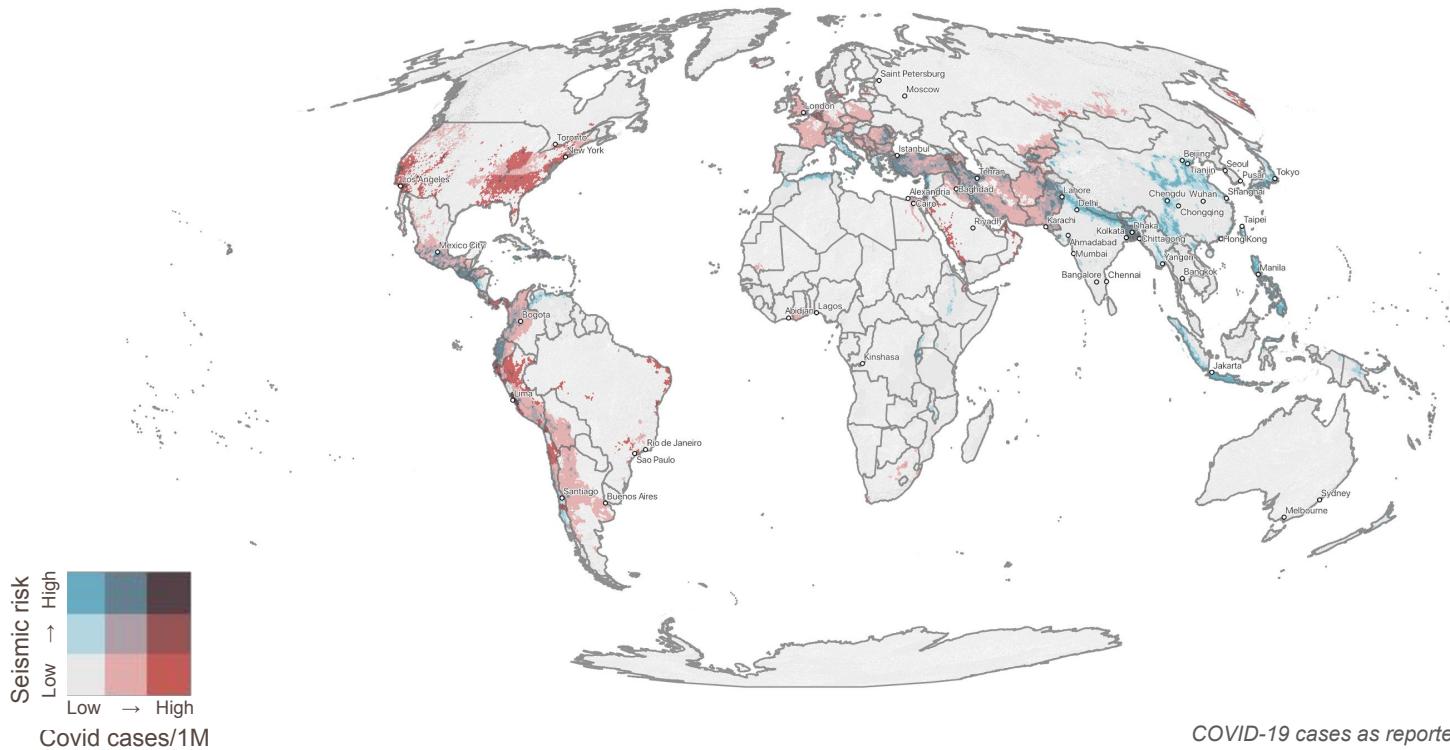
$M_r$  is the assumed mortality rate, where 4.3% represents a scenario where the healthcare system is not overwhelmed and 11.5% represents a case where the healthcare system is overwhelmed



# Combined seismic hazard and COVID-19 cases globally



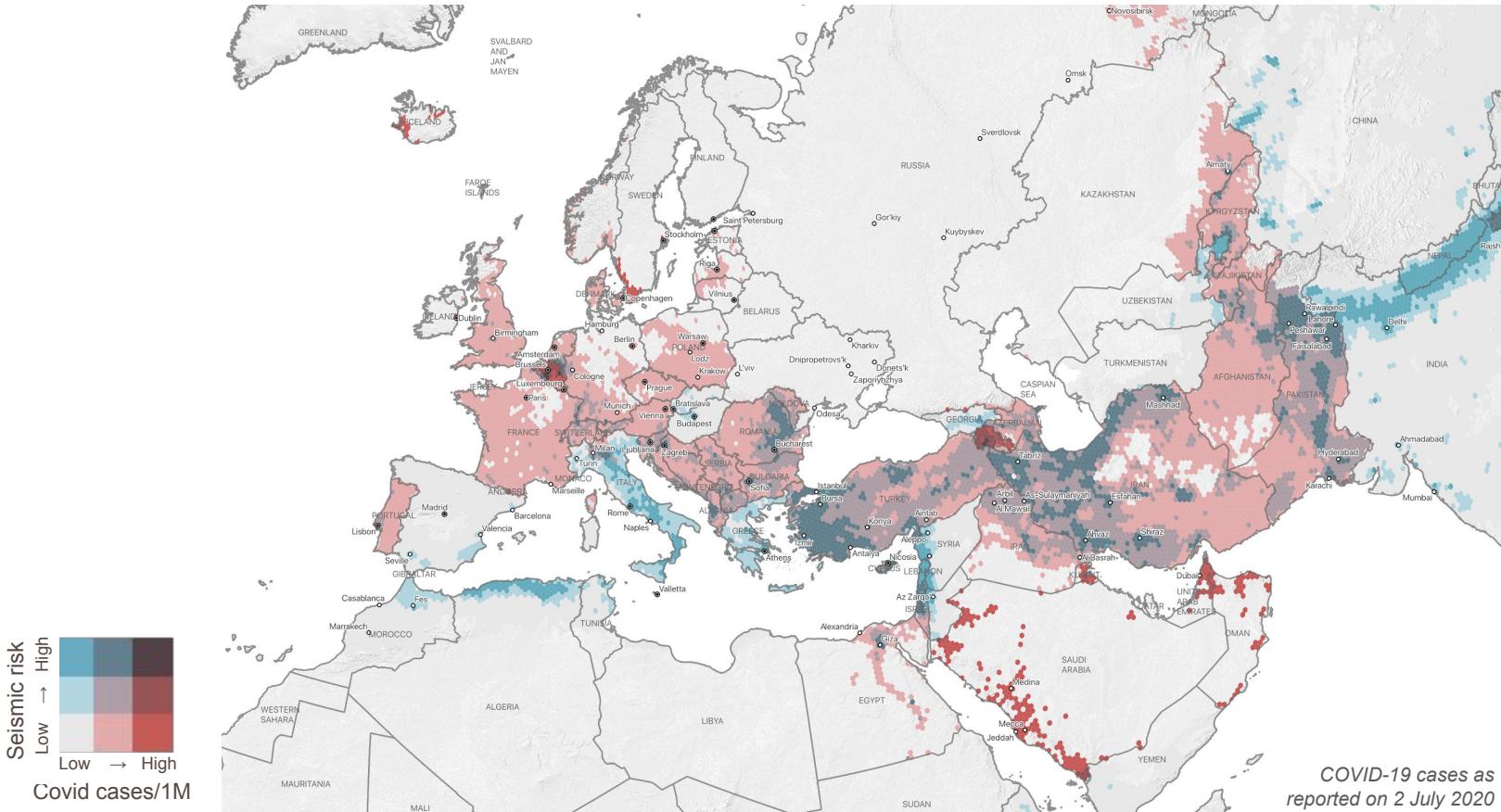
# Combined seismic risk and COVID-19 cases globally



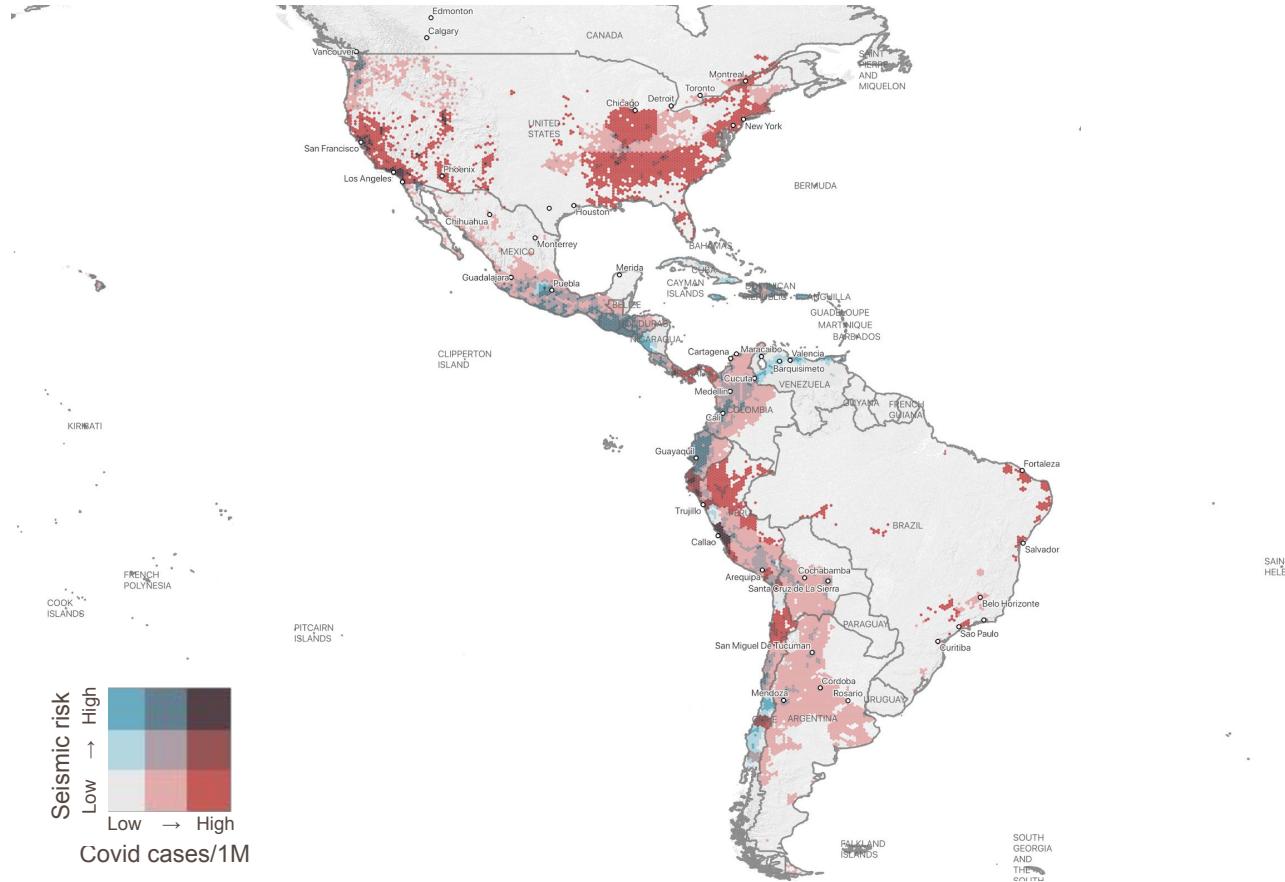
COVID-19 cases as reported on 2 July 2020



# Combined seismic and COVID-19 risk in Europe & Asia

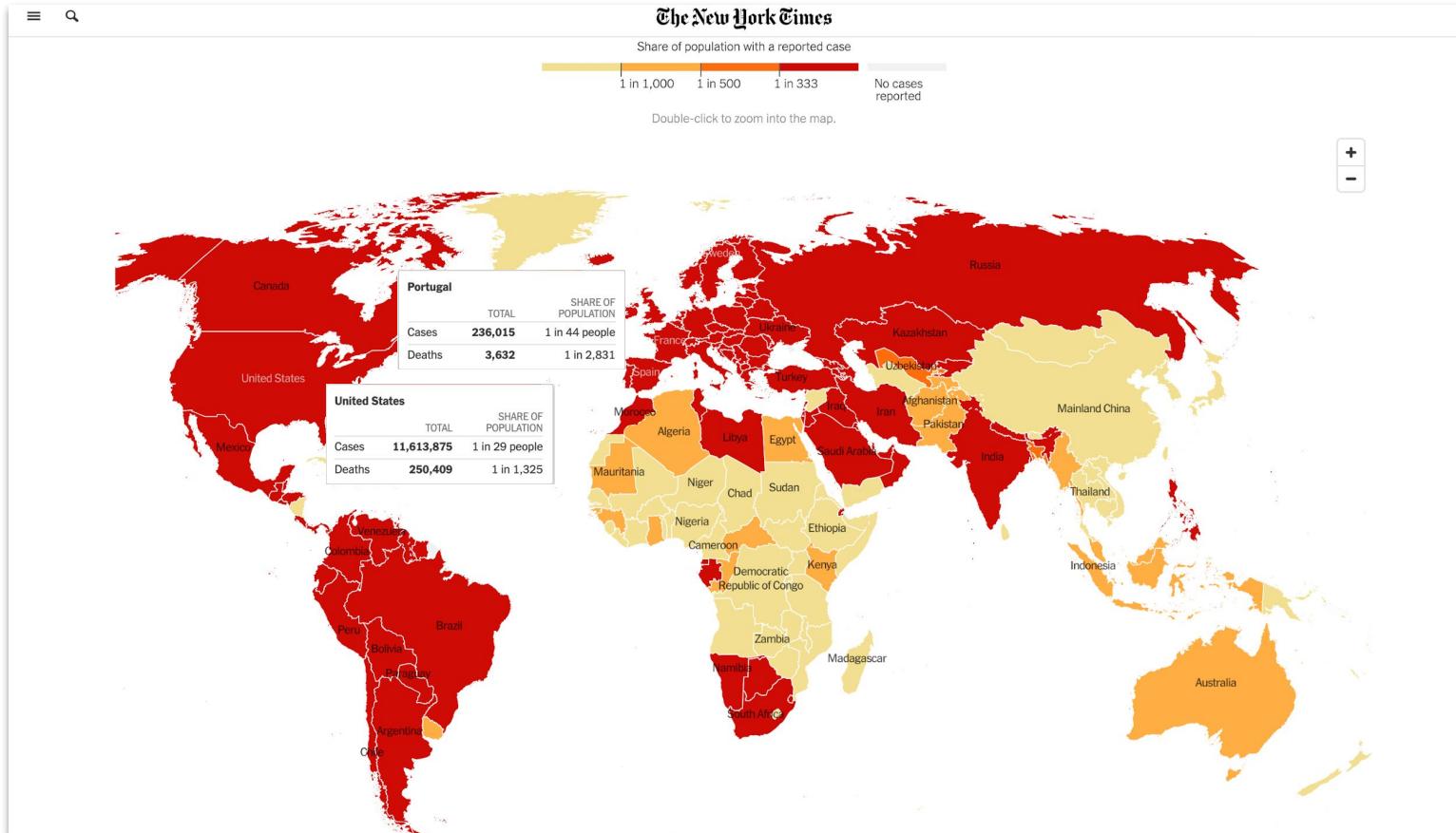


# Combined seismic and COVID-19 risk in the Americas

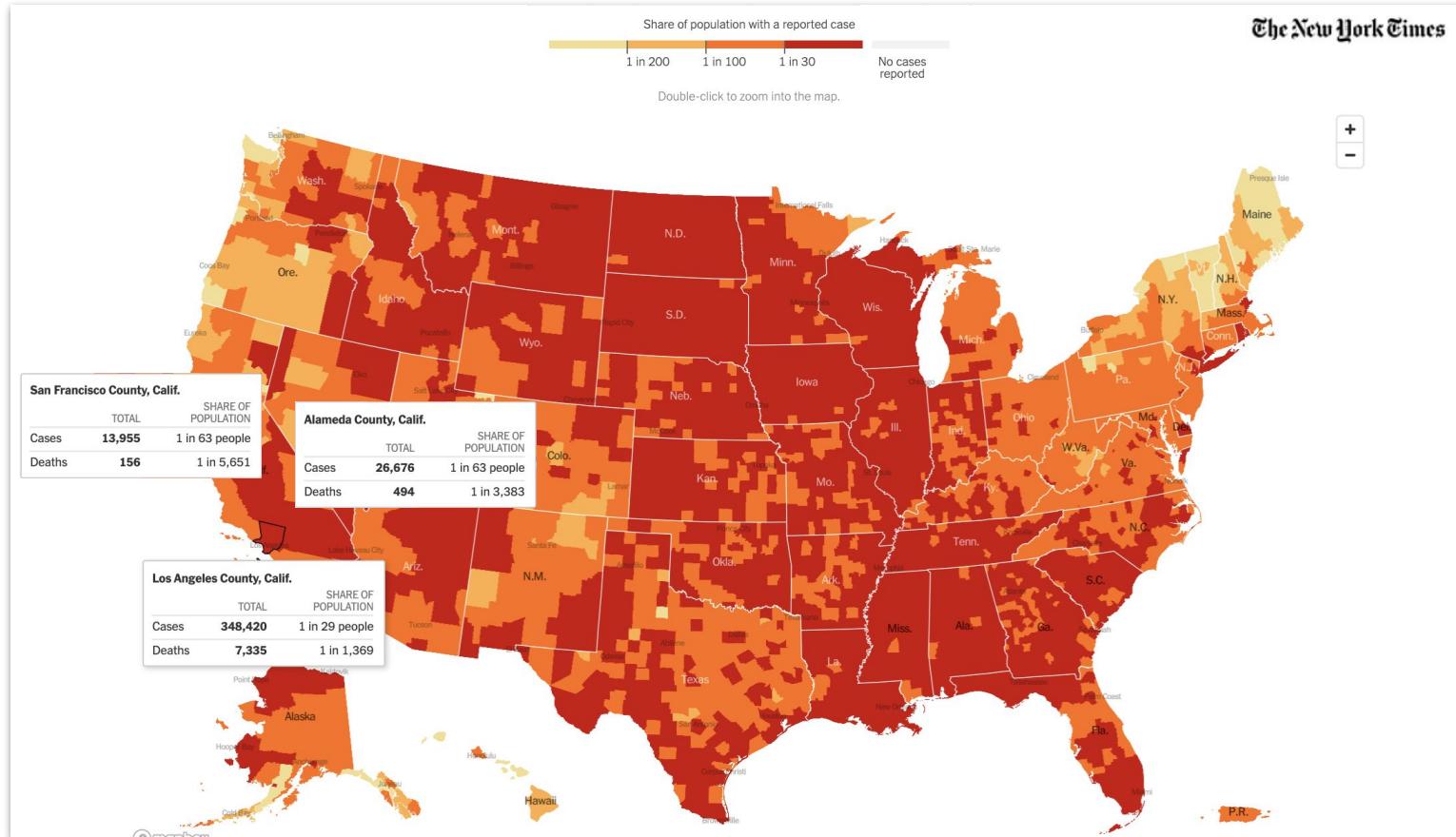


COVID-19 cases as reported on 2 July 2020

# Current state of COVID-19 pandemic



# Current state of COVID-19 pandemic



# Thank you!

---



Vitor Silva

vitor.silva@globalquakemodel.org  
ResearchGate: @Vitor\_Silva7  
Twitter: @VitorS1lva



Nicole Paul

nicole.paul@globalquakemodel.org  
ResearchGate: @Nicole\_Paul6  
Twitter: @nicopurr  
LinkedIn: @nicoleapaul