

**GEM**

GLOBAL  
EARTHQUAKE  
MODEL

working  
together to  
assess  
risk

# Potential impact of earthquakes during the COVID-19 pandemic

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19/11/2020

# Motivation

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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

Large Edition  
New York, Today, no clouds, fog, then some sun. High 76. Tonight, clouds and fog. Low 63. Tomorrow, cloudy, late showers. High 77. Yesterday, high 77, low 58. Details, page 28.

VOL.CXLIV . . No. 49,829 Copyright © 1994 The New York Times NEW YORK, SATURDAY, SEPTEMBER 24, 1994 18 cents beyond the greater New York metropolitan area. 60 CENTS



Women seeking to flee an outbreak of pneumonic plague waited on a rail platform in Surat, India, last week. **Thousands Flee Indian City In Deadly Plague Outbreak**

**By JOHN F. BURNS**  
*Special to The New York Times*

NEW DELHI, Sept. 23 — As many as 200,000 people have fled the city of Surat in western India after an outbreak of pneumonic plague that medical experts described as one of the most serious reported in the world in recent decades, officials here said today.

Less than 48 hours after the first confirmed death from the disease, officials in the industrial city said that 29 people had died and 33 others were being treated in hospitals. But unofficial reports, including accounts from doctors working in Surat, said that at least 100 people had died, and that the toll was expected to rise as house-to-house searches turned up scores of new patients.

Residents of Surat, a city of 1.6 million in Gujarat state, reported scenes of confusion and the advent of effective antibiotic treatment and inoculations in the 1980s.

The bubonic form of plague, which leads to the swelling of lymph nodes, is spread by fleas. Pneumonic plague, a fatal pneumonia, can result from the spread of plague from the lymph nodes to the lungs or can be transmitted by droplets in the air.

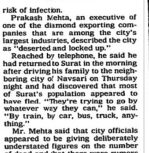
Witnesses in Surat described huge crowds at the city's main railroad and bus stations and on roads leading out of the city. Judging from ticket sales, officials said as many as 200,000 people may have left over the last few days.

Police cordons were reported to have been thrown up around areas where many of the cases originated, in an effort to prevent people from leaving. "We will keep people out," one city official said. "But health workers were said to be luring other people out of the cordons and telling them not to join the exodus."

F. V. Trivedi, the district collector,

### The Plague Strikes City In West India

Continued From Page 1



of the city arrived in Surat, said in a telephone interview that the city had been put "on a war footing." Officials were using every means, from calling meetings and inoculations to the city to public appeals for calm, to stop the disease from spreading. "We're appealing to people not to panic because they could spread the infection wherever they go," Mr. Trivedi said.

After the first deaths became known on Thursday, officials in Surat used emergency powers to close all public gathering places, including schools, hospitals, restaurants and bars. Most factories and businesses were also closed, and most residents who remained in the city were said to be staying indoors.

The few people moving on the streets were said to be carrying their face with cloths, handkerchiefs or medical masks to limit the risk of infection.

Prokash Kotia, an executive of one of the diamond exporting companies that are among the city's largest industries, described the city as "deserted and locked up."

Reached by telephone, he said he had returned to Surat in the morning after driving his family to the neighboring town of Navsari on Thursday night and had discovered that many of Surat's population appeared to have fled. "They're trying to go by whatever way they can," he said. "By train, by car, by truck, by anything."

Mr. Mehta said that city officials appeared to be giving deliberately understated figures on the number of dead and that there were rumors in the city that as many as 500 people had died. He said he had stood outside the grounds of the main hospital and watched workers cremating seven bodies in the hospital grounds. "They're not releasing the bodies to relatives for fear of further contamination," he said.

Robert A. Reiners, a correspondent in Surat, quoted a city doctor who was not identified as saying it was the worst outbreak of the disease "more than 100 people have died."

The city's main hospital, said that all 100 beds were full of patients, and that the city wards were in "sanitization condition." Another doctor, Parvez Sheikh, was quoted as saying, "Patients come walking in and within minutes, they collapse and die."

In other emergency news, Delhi attorney by Prime Minister P. V. Narasimha Rao, Health Minister Prasad said that they had sent one million of tablets of the antibiotic tetracycline and hundreds of tons of DDT and other medicines to Surat and that the state health department had sent state health workers to help to save many of those in the nearby districts, while an estimated 100,000 tablets would control the flies that

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

**By DAVID E. ROSENBAUM**  
*Special to The New York Times*

WASHINGTON, Sept. 23 — Only the United States Senate with its arcane rules and members who are comfortable speaking at length to empty chambers could find itself in such a mess. Republicans kept the Senate in session all night talking about a procedural motion on campaign finance legislation. The motion was finally agreed to this afternoon, 53 to 47, and the senators recessed for the weekend.

When they reconvene on Monday, the senators will face more procedural steps, more talk and more votes on parliamentary motions — such as a thicket that it could be done or more votes to

### BILL TO REVAMP COMMUNICATIONS DIES IN CONGRESS

**INDUSTRY FEUDS BLAMED**

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

**By EDMUND L. ANDREWS**  
*Special to The New York Times*

WASHINGTON, Sept. 23 — A sweeping effort to rewrite the nation's telecommunications laws failed to permit open competition between telephone and cable television companies, collapsed today in the Senate amid friction between



In a preventive measure, a resident of the Indian city of Surat adjusted a mask over his son's face yesterday.

transfer the plague bacillus from rats.

"The situation in the affected areas is well under control and there is no cause for alarm," said M. S. Ghosh, the top civil servant at the Health Ministry.

But other accounts suggested that official statements might be intended mainly to prevent a wholesale evacuation of Surat, with the brightest risk still being posed of the disease spreading.

Surat, a textile, electrochemical and diamond-cutting center that has been one of the fastest-growing industrial sites in India in the past decade, is on the coast of the Arabian Sea, Gujarat and the adjacent state of Maharashtra, have a combined population of more than 12 million people.

Official concerns appeared to focus on Bombay, India's largest industrial center, which had an estimated population of 12.5 million. Newspa-

## Disruption to natural ecosystem

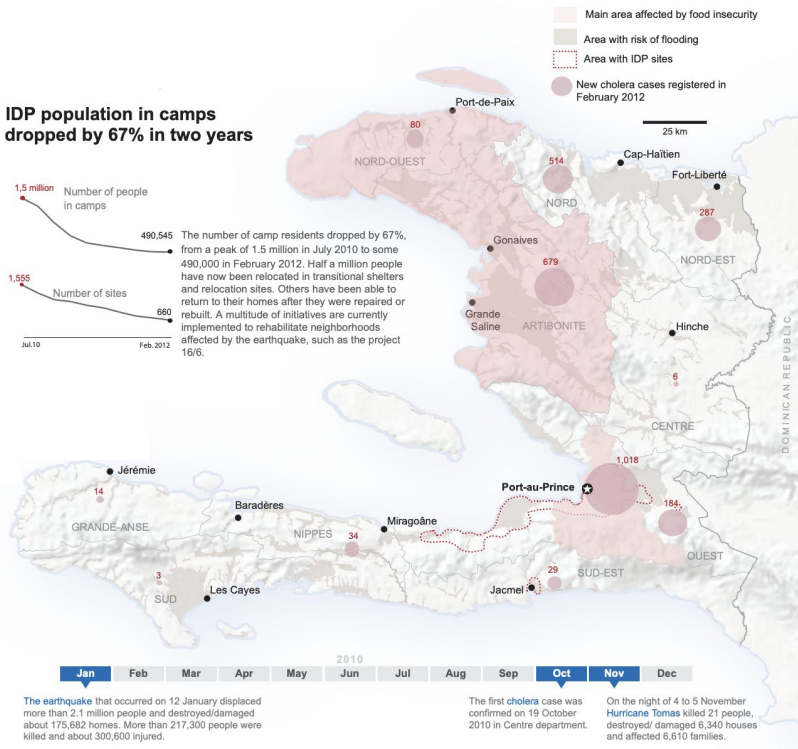
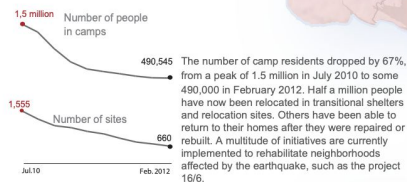
Earthquakes can cause disruption to the natural ecosystem, bringing animals in contact with human populations

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



## IDP population in camps dropped by 67% in two years



The earthquake that occurred on 12 January displaced more than 2.1 million people and destroyed/damaged about 175,682 homes. More than 217,300 people were killed and about 300,600 injured.

The first cholera case was confirmed on 19 October 2010 in Centre department.

On the night of 4 to 5 November Hurricane Tomas killed 21 people, destroyed/damaged 6,340 houses and affected 6,610 families.

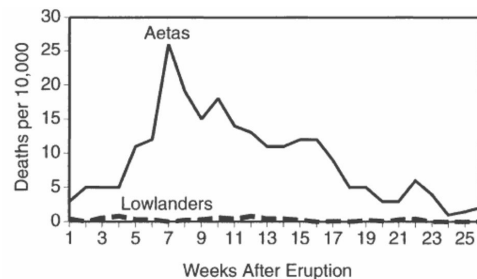
## Worsened response due to overwhelmed sanitation and healthcare infrastructure

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



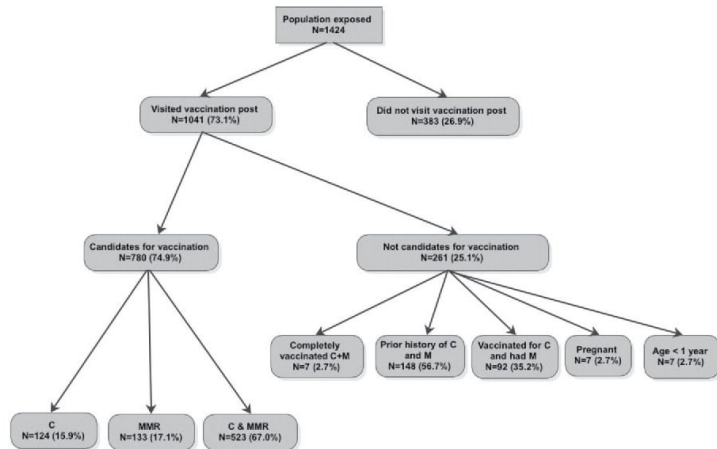
Surmieda, Maria Ruth S., et al. "Surveillance in Evacuation Camps After the Eruption of Mt. Pinatubo, Philippines." *Morbidity and Mortality Weekly Report: Surveillance Summaries*, vol. 41, no. SS-4, 1992, pp. 9–12. JSTOR, [www.jstor.org/stable/24675587](http://www.jstor.org/stable/24675587).

## 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

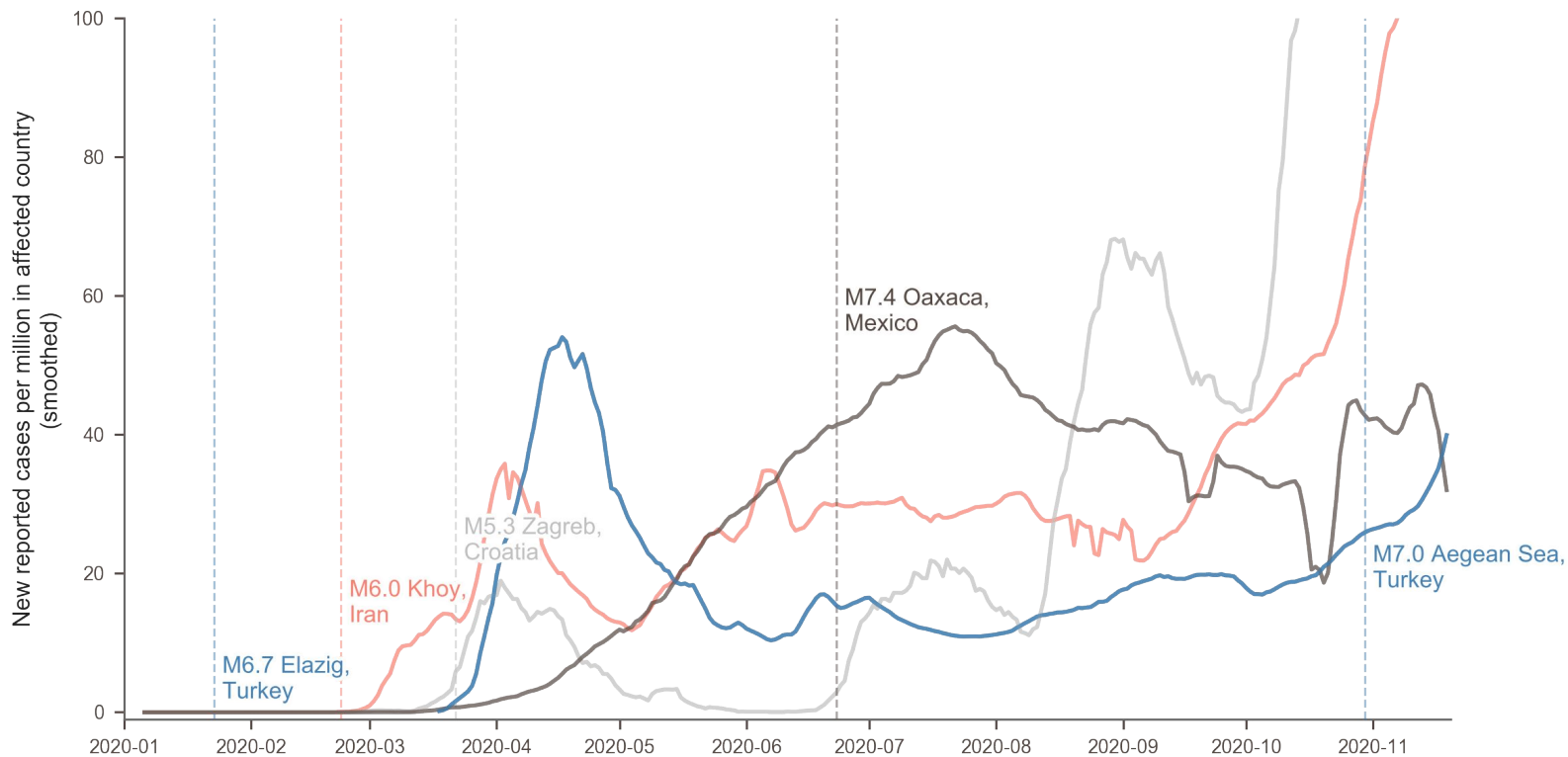
Examples include the 1991 Mount Pinatubo eruption (measles) and the 2011 Lorca earthquake in Spain (chickenpox)



Jaime 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.*

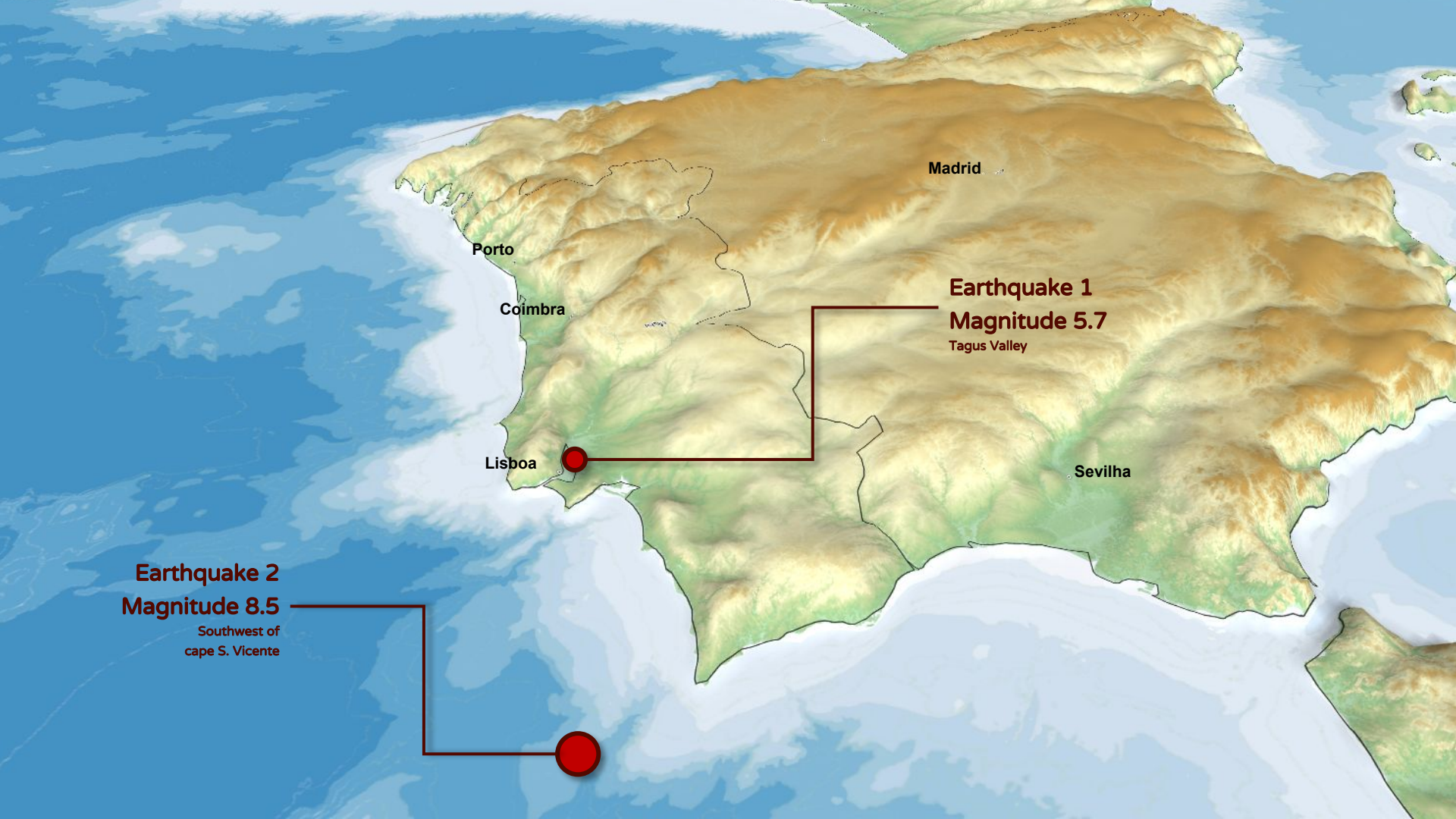


# Simulating spread of COVID-19 due to earthquakes

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Madrid

Porto

Coimbra

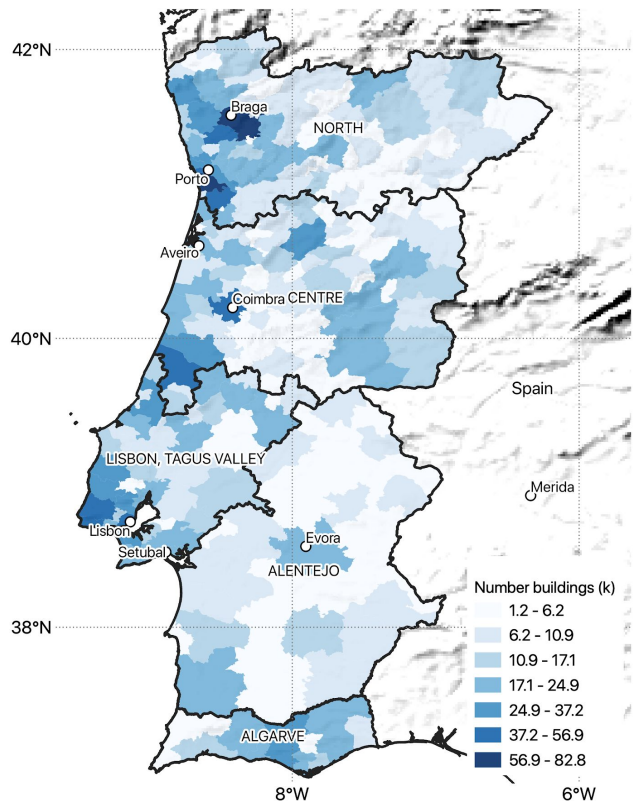
Lisboa

**Earthquake 1**  
**Magnitude 5.7**  
Tagus Valley

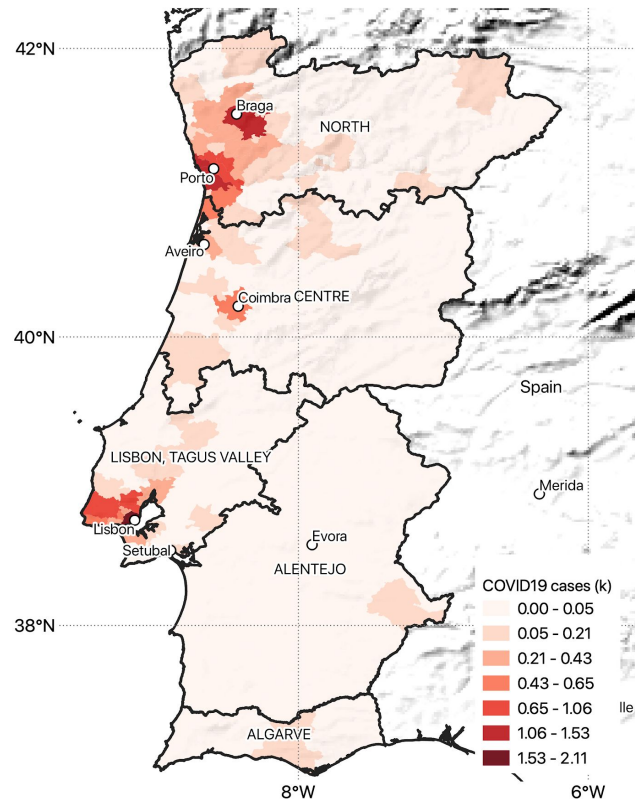
Sevilha

**Earthquake 2**  
**Magnitude 8.5**  
Southwest of  
cape S. Vicente

# Simulating spread of COVID-19 due to earthquakes

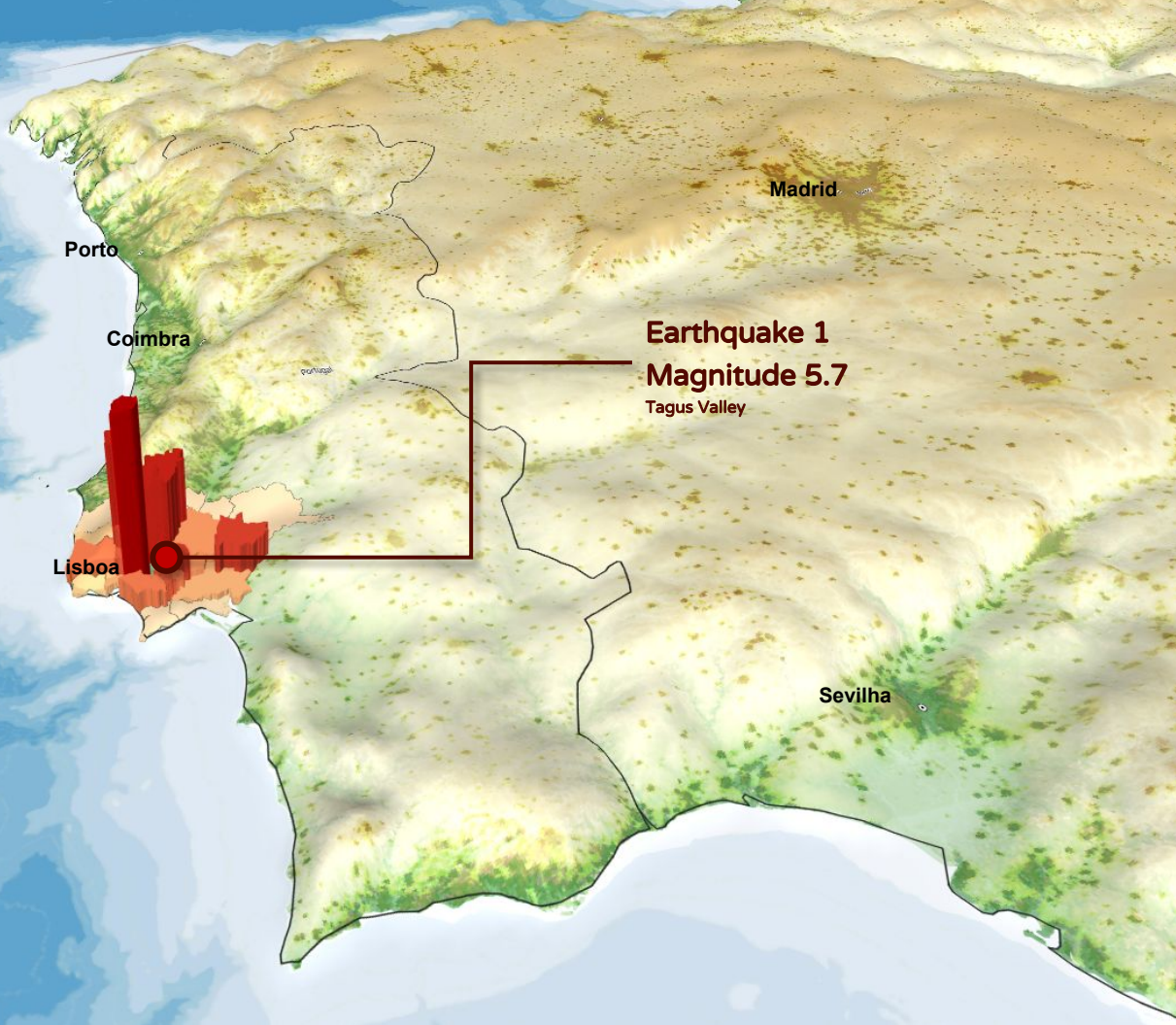


Silva V, Crowley H, Pinho R, Varum H. (2014). Seismic Risk Assessment for mainland Portugal. Bulletin of Earthquake Engineering, 13(2):429-457.



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

**Population left  
homeless or injured**



**Earthquake 1**  
**Magnitude 5.7**  
Tagus Valley

Porto

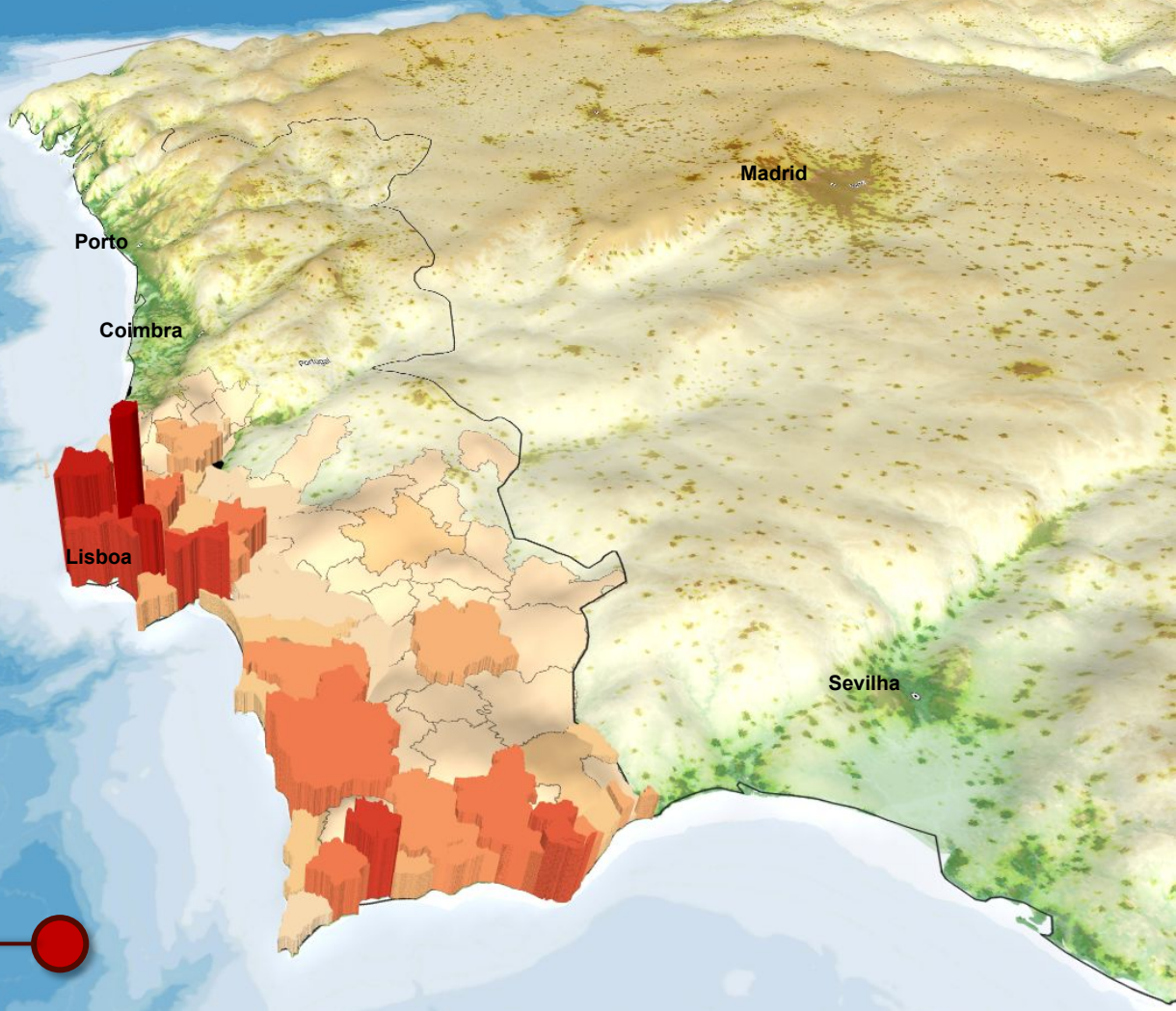
Coimbra

Lisboa

Madrid

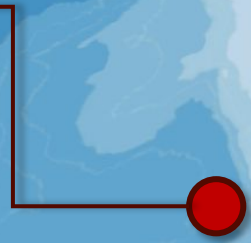
Sevilha

**Population left  
homeless or injured**

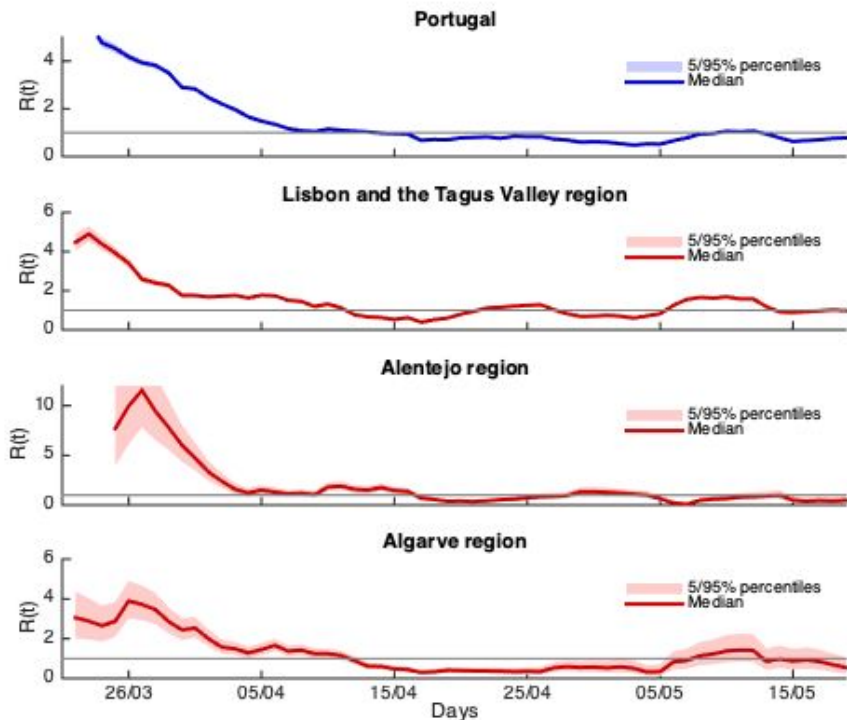


**Earthquake 2  
Magnitude 8.5**

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:

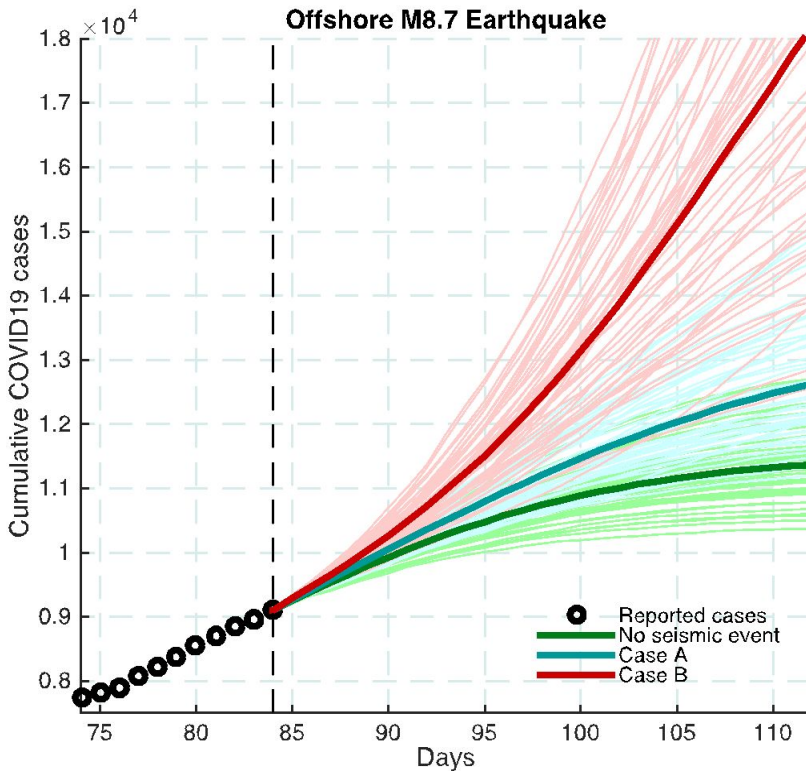
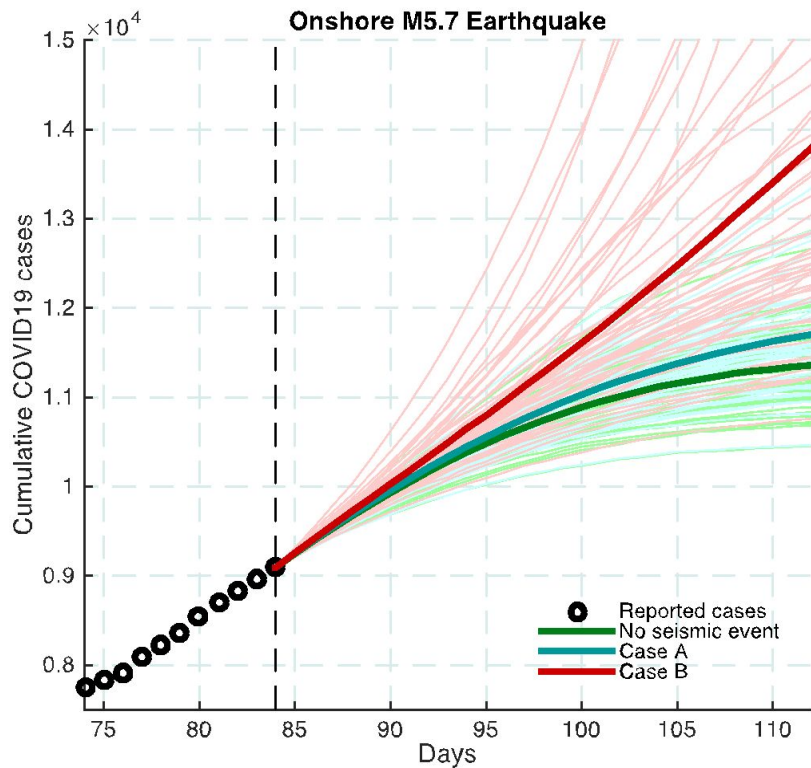
## A. Optimistic

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

## B. Pessimistic

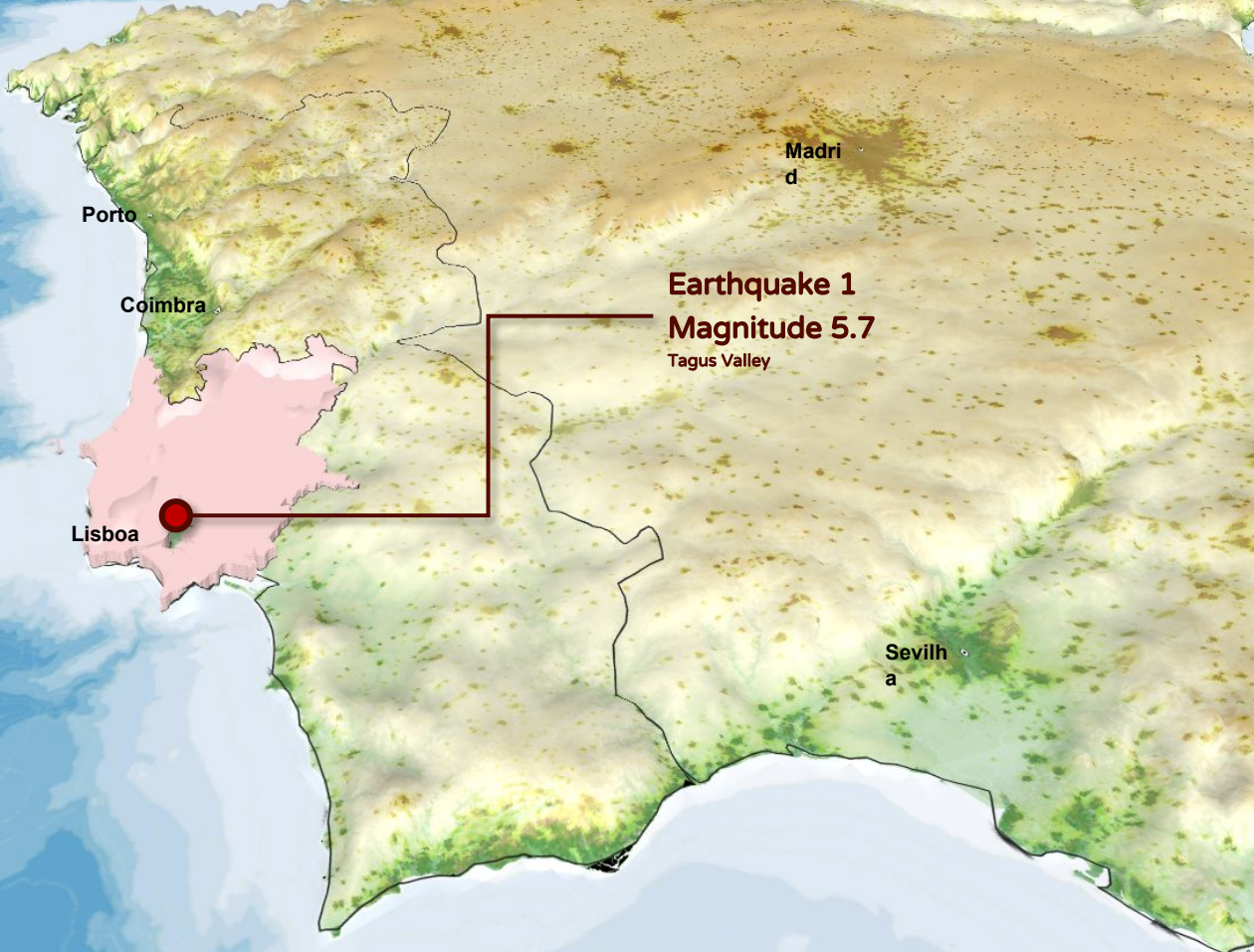
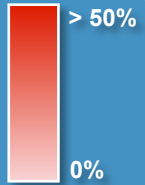
$R_t$  sharply increases after the seismic event ( $\sim 4.1$ ), the value registered by Portugal during the peak of infection

# Simulating spread of COVID-19 due to earthquakes



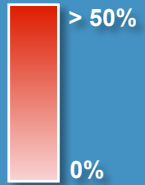
# Case A - Optimistic

Increase in the number of COVID-19 cases



# Case B - Pessimistic

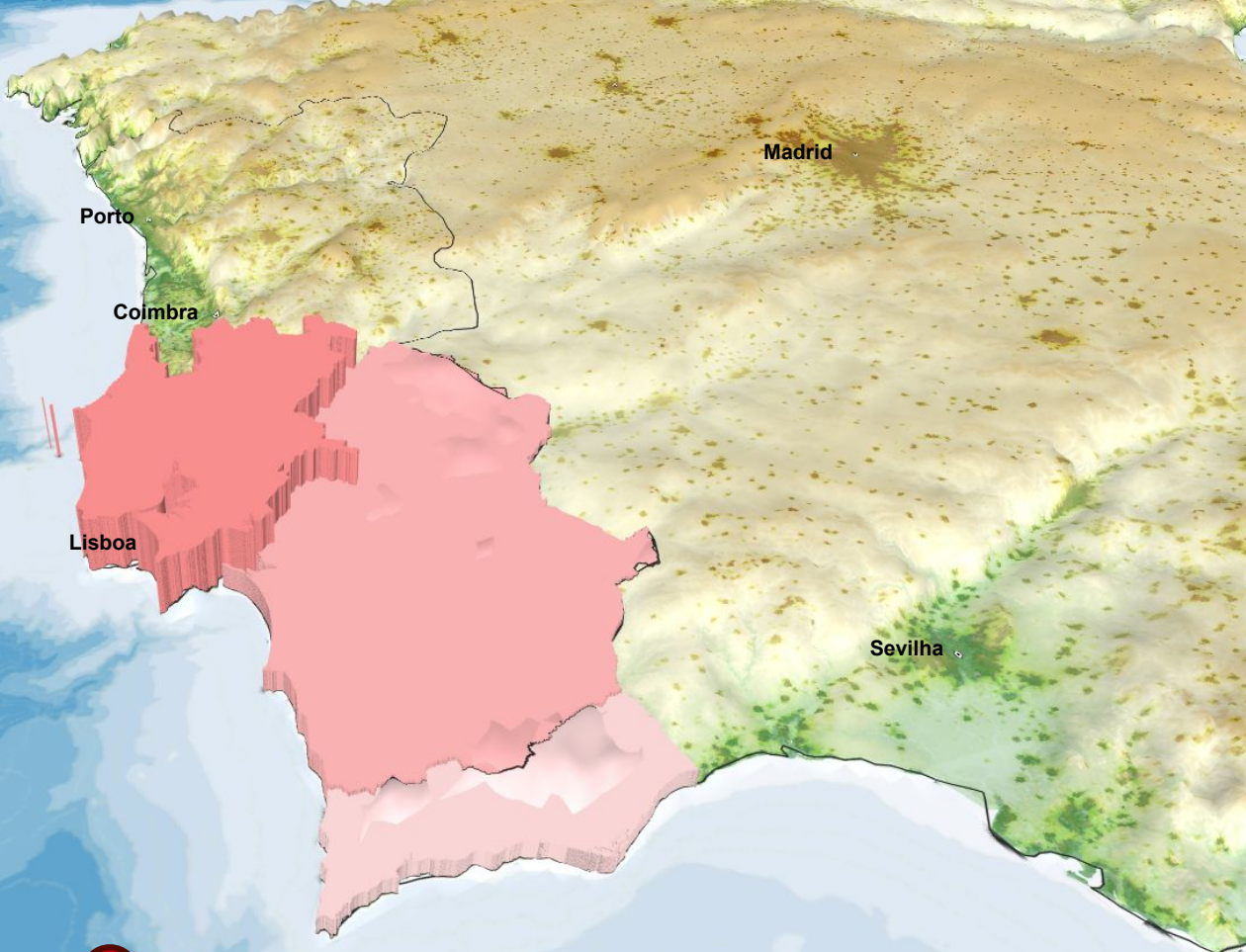
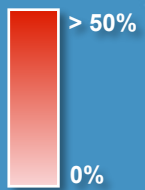
Increase in the number of COVID-19 cases





# Case A - Optimistic

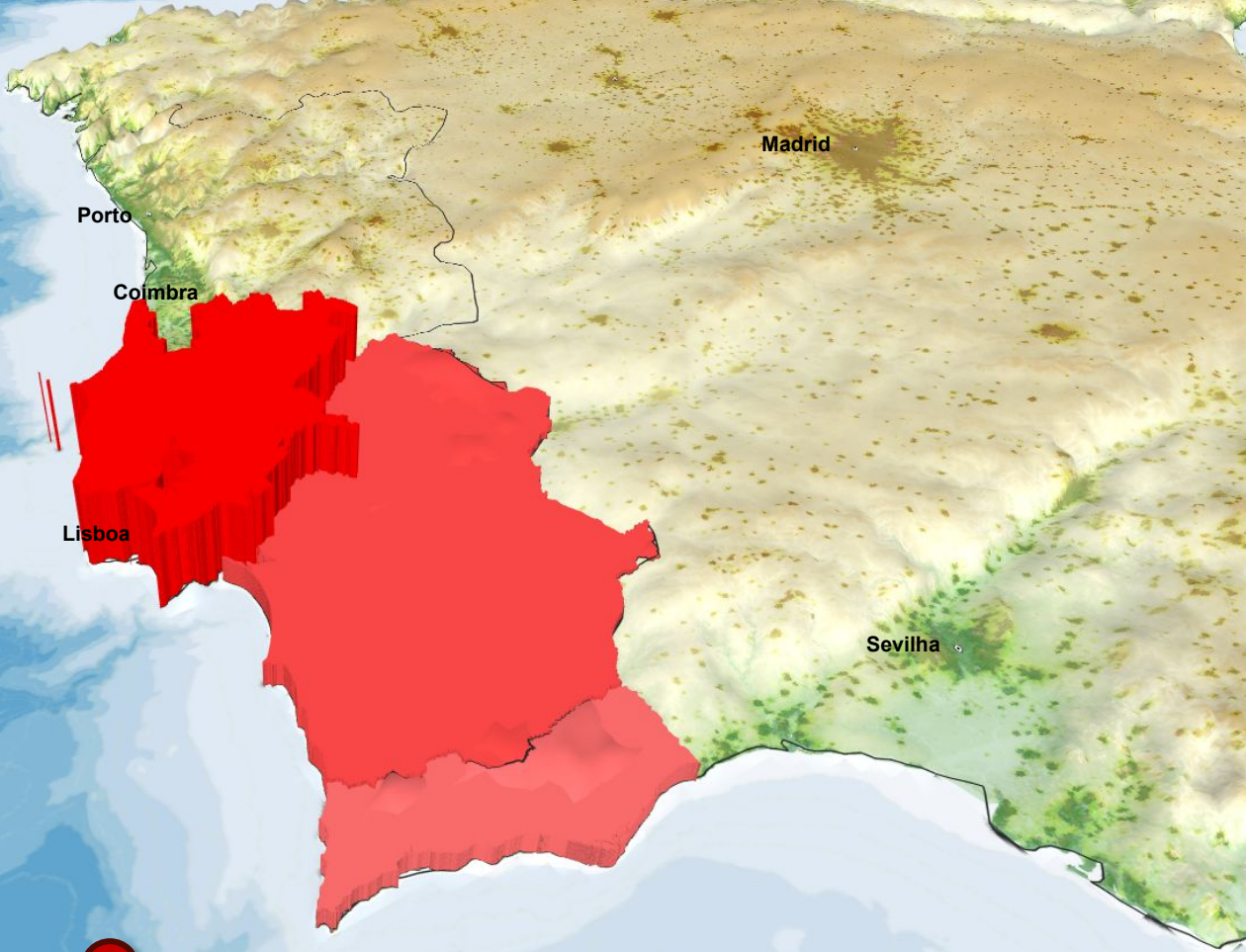
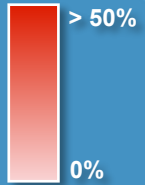
Increase in the number of COVID-19 cases



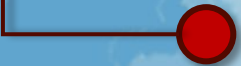
**Earthquake 2**  
**Magnitude 8.5**  
Southwest of  
cape S. Vicente

# Case B - Pessimistic

Increase in the number of COVID-19 cases



**Earthquake 2**  
**Magnitude 8.5**  
Southwest of  
cape S. Vicente



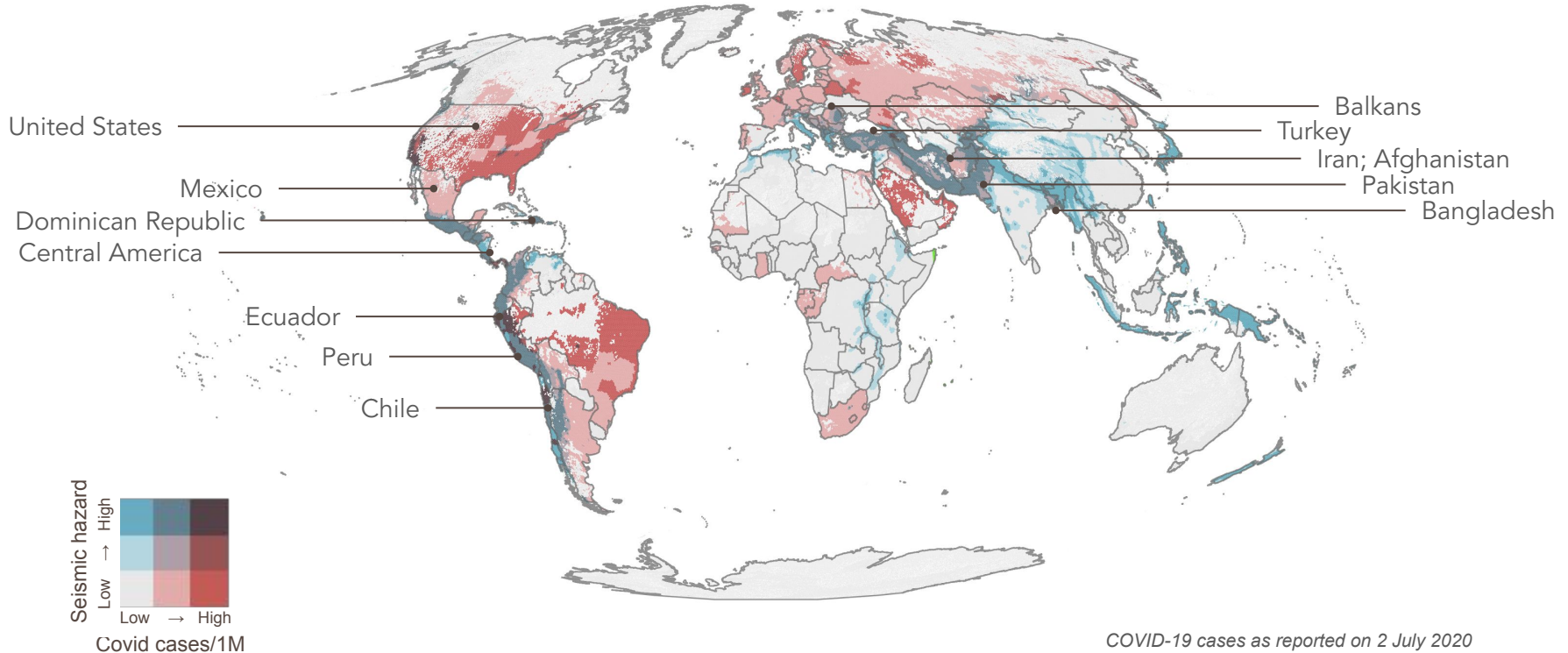
# Estimating additional fatalities due to earthquake

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
	$M_r = 4.3\%$	$M_r = 11.5\%$		$M_r = 4.3\%$	$M_r = 11.5\%$	
<b>A:</b> $R_t \sim 2.5$	52	138	1,729	0.6	1.6	292
<b>B:</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

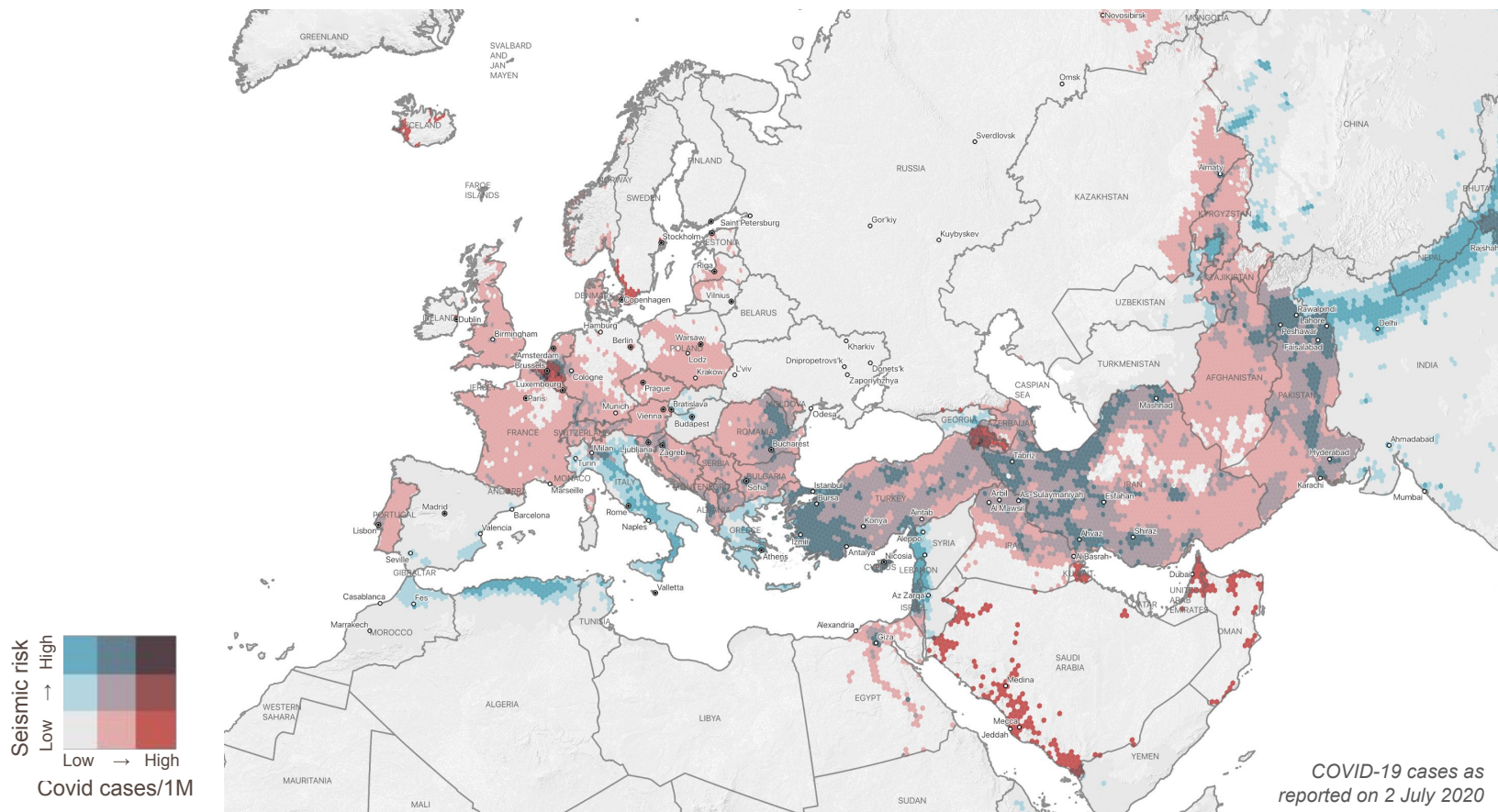


# Combined seismic hazard and COVID-19 cases globally



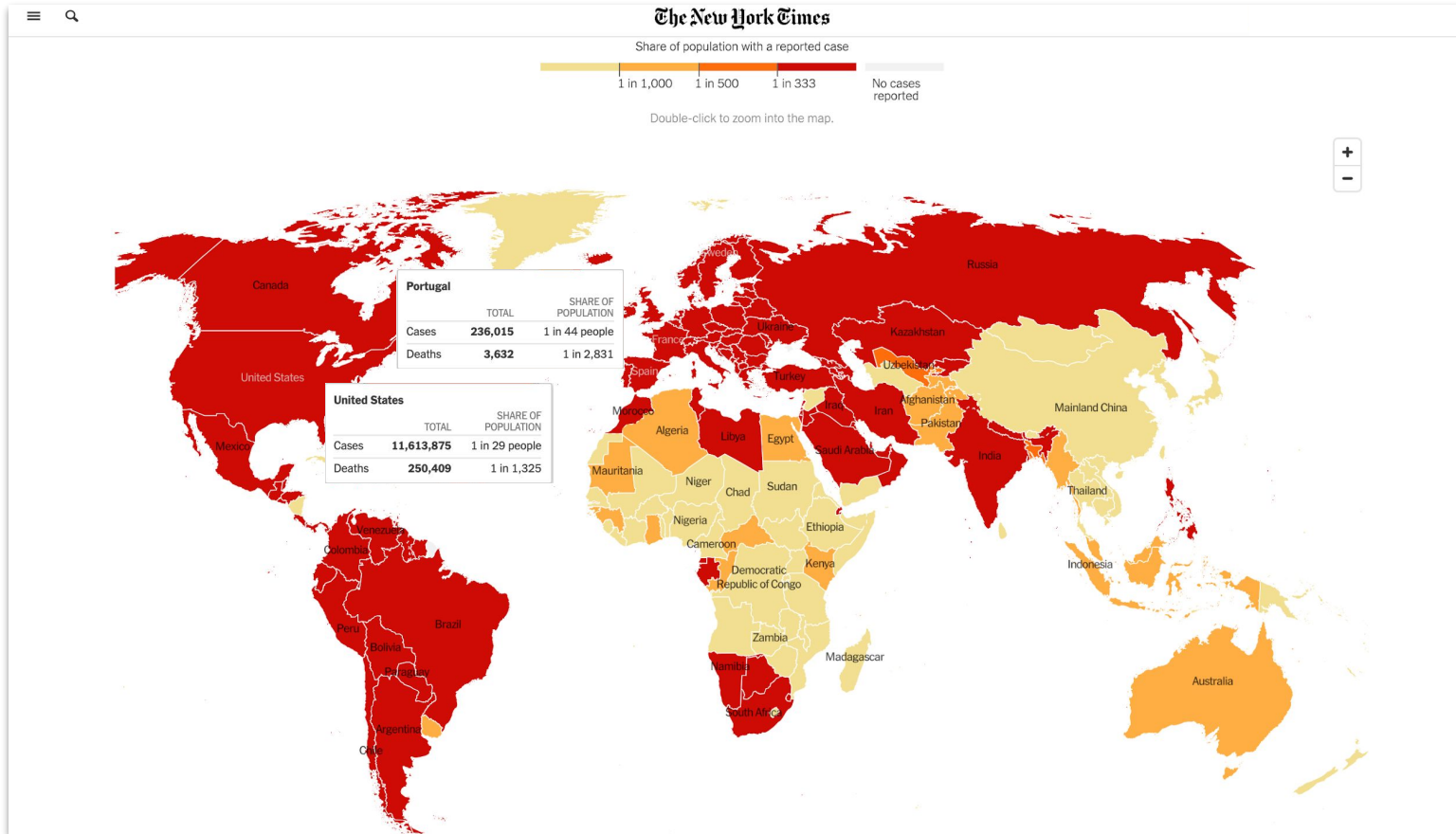


# Combined seismic and COVID-19 risk in Europe & Asia



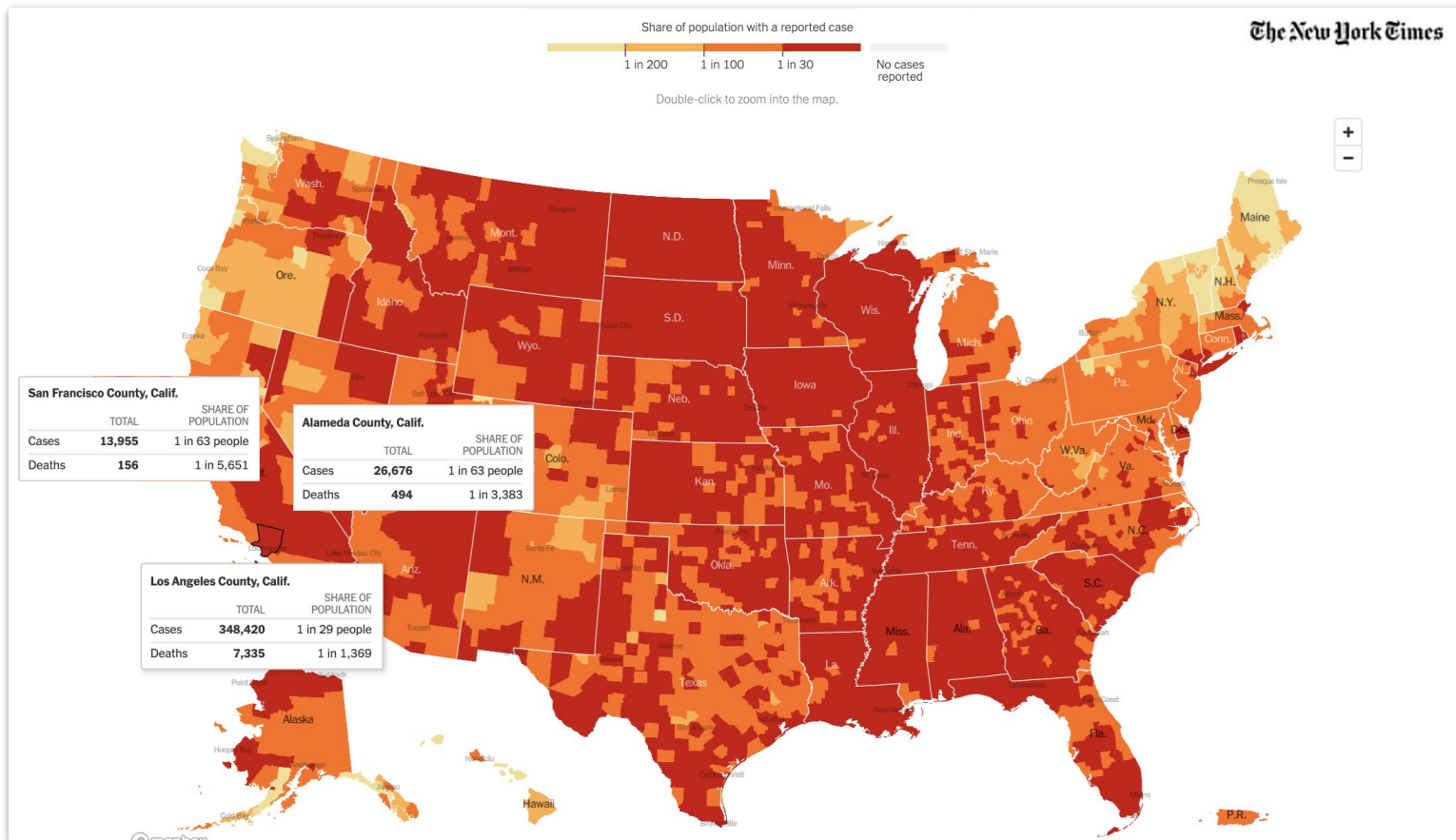


# Current state of COVID-19 pandemic





# Current state of COVID-19 pandemic



# Thank you!

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