NEWS IN FOCUS

PUTU SAYOGA/BLOOMBERG VIA GETTY

A tsunami that hit Palu in Indonesia in September was probably triggered by underwater landslides.

DISASTER

Amateur videos help track cause of Indonesian tsunami

The result highlights the power of citizen science and also exposes flaws in warning systems.

BY MICHAEL MARSHALL

A super-fast tsunami that ravaged an Indonesian island last year, killing thousands, was almost certainly triggered by underwater landslides, according to a reconstruction of the disaster generated using surveillance-camera and video footage harvested from YouTube and other social media.

The findings suggest that tsunami warning systems should be upgraded in coastal regions where there is a risk of landslide-triggered events, which can arrive much more quickly than other tsunamis. But some researchers say these events are too fast even for warning tools, and that public education is key to saving lives.

The results also highlight the power of unconventional research methods. "This is such an important example of citizen science," says geophysicist Jennifer Haase at the Scripps Institution of Oceanography in La Jolla, California, who led the study.

The Indonesian disaster occurred on 28 September, when a magnitude-7.5 earthquake struck northern Sulawesi. Shortly afterwards, a tsunami hit Palu Bay, a long, narrow and densely populated inlet. The earthquake and tsunami together killed 4,340 people.

Although a tsunami warning had been issued, it predicted only a small wave about 0.5 metres high. In fact, the wave reached 2 metres in much of Palu Bay, and reached 8 metres in some places. Eyewitnesses also said it arrived within minutes of the earthquake, rather than tens of minutes, as predicted.

The size of the tsunami surprised ▶

seismologists because it followed a 'strike-slip' tremor, in which continental plates move horizontally. Such quakes should trigger small tsunamis; large waves usually result only when tectonic plates move up and down.

UNCONVENTIONAL EVIDENCE

Many tsunami researchers suspected that the quake had triggered a submarine landslide in Palu Bay, causing the tsunami. But with limited scientific data available, geophysicist Haase and her team went hunting for another source of information.

"We started looking at different social-media platforms like YouTube, Twitter, Facebook, Instagram," says Matías Carvajal, a seismologist at the Millennium Nucleus the Seismic Cycle along Subduction Zones, a research collaboration between several universities in Chile. He found 38 amateur video and surveillance clips of the tsunami. Where possible, the team pinpointed the location of the videos on a map and synchronized them. This allowed the researchers to reconstruct how the tsunami had moved through Palu Bay.

The reconstruction shows that the tsunami inundation occurred only a few minutes after the earthquake shaking, and that successive waves came just 1–2 minutes apart. This suggests that the source was close to the shore, which is indicative of a submarine landslide, says Carvajal. The team published its findings last month (M. Carvajal *et al. Geophys. Res. Lett.* http://doi.org/c53c; 2019).

Carvajal's use of "unconventional evidence" to determine how the tsunami behaved is useful because few local data are available for this event, says Anne Socquet, a seismologist at the University of Grenoble in France, who has studied the event. This is because Indonesia has few research buoys or tide gauges.

The study offers a significant piece of evidence to support the idea that submarine landslides caused the tsunami, says Purna Sulastya Putra, a tsunami specialist at the Indonesian Institute of Sciences in Bandung.

The results suggest that tsunami warning systems need to be modified to detect landslide-triggered events, says Ignacio Sepúlveda at the Scripps Institution of Oceanography, a co-author on the study. Tsunami warning systems are typically triggered by seismometers and then verified using recorded changes in sea level. But most systems only record long-period waves that displace buoys and tide gauges for several minutes. Indonesia's systems, like most, aren't designed to detect landslide-triggered tsunamis with shorter periods.

"If you're on a coastline and feel severe shaking, run for high ground."

The Indonesian geophysics agency that issues warnings was widely criticized because it cancelled the Palu tsunami alert half an hour after it was issued. The one tide gauge in Palu Bay that the tsunami passed through didn't pick up the huge waves, says Carvajal.

Accounting for the risk of marine landslides is also difficult because there are no detailed maps of the Indonesian sea bed that could be used to pinpoint areas of loose sediment, says Putra. Coastal engineer Mohammad Heidarzadeh at Brunel University London is leading an effort to map the sea bed off Indonesia over the next three years, with the goal of forecasting tsunamis more accurately.

RISK MANAGEMENT

But even with maps, tsunamis triggered by landslides are particularly hard to predict because they usually affect a relatively small area compared with quake-triggered events, says Abdul Muhari at the Ministry of Marine Affairs and Fisheries in Jakarta. He suggests focusing on places that have experienced landslides before.

And Mika McKinnon, an independent disaster researcher in Vancouver, Canada, questions whether improved warning systems are the answer for landslide-triggered tsunamis. The best way to save lives is to ensure that people know what to do during a disaster, she says. Tsunami warning systems are useful for places far from the earthquake epicentre, where the wave is minutes away. But when the quake is closer to shore, as in Palu, the tremor itself is the warning, she says, because even an advanced warning system is unlikely to get an alert out in time. "If you're on a coastline and feel severe shaking, run for high ground." ■

VIROLOGY

How baby's first flu shapes the immune system

Two wide-ranging studies will follow children for years to monitor how their first influenza infection affects their natural immunity and vaccine response.

BY DECLAN BUTLER

The US National Institute of Allergy and Infectious Diseases (NIAID) has awarded two major grants to fund the first large-scale, long-term studies of how infants' first exposures to influenza shape their immune systems. Researchers will follow the children for several years to decipher how these early imprints affect an individual's ability to fight off different strains later in life.

The work could also help to explain why a flu vaccine administered in any given year might work well in one person but not in another, and whether a child is better protected if their first encounter is with a wild virus, rather than the weakened forms found in vaccines. It will also feed into efforts to develop a universal flu vaccine that could offer lifelong protection against most seasonal strains.

Paul Thomas, an immunologist at St. Jude Children's Research Hospital in Memphis, Tennessee, and Aubree Gordon, an epidemiologist at the University of Michigan in Ann Arbor, lead a consortium that will share a 7-year, US$35-million grant. Their team will establish infant cohorts — groups to be followed long-term — in Nicaragua, in Los Angeles, California, and in Wellington, New Zealand, with a total of 2,200–3,500 children.

A second 7-year award, of $31 million, went to a group led by Mary Allen Staat, an epidemiologist at Cincinnati Children's Hospital Medical Center in Ohio. Her team will establish cohorts in Mexico City and in Cincinnati, totalling around 1,080 infants.

Influenza viruses are constantly mutating, and a new vaccine has to be developed and administered afresh with each flu season. Current vaccines are not very effective, and the protection they offer fades within months.

But the strains to which individuals were first exposed in childhood influence how they respond in a given flu season. This imprinting confers protection for life from closely related strains, and also makes people more responsive