

The first teams rushed to date the Moon rocks. On 7 October, one reported an age of 1.96 billion years (give or take 57 million years) for the basalts¹. Less than two weeks later, another team, including Li, corroborated those dates, estimating the age to be two billion years (give or take four million years)².

The results confirmed that the Moon was still volcanically active almost one billion years after activity was thought to have peaked, according to analysis of the rocks from Apollo. But working out what fuelled this activity has proved tricky.

One leading theory, based on satellite observations, suggested that heat-producing radioactive elements such as potassium and thorium found in the lunar mantle might have driven the volcanism. But when another team at the IGG examined the lunar basalts, they determined that high levels of these elements³ were not the source.

Another possibility was that the mantle contained enough water to reduce the temperature at which materials melt; this would have made it easier for the magma to erupt. But Lin Yangting, a planetary scientist at the IGG, and his colleagues found that the lunar rocks probably came from a relatively dry source⁴.

Flummoxed

The question of the volcano's heat source has flummoxed scientists. "This is a very big science problem," says Weibiao Hsu, a planetary geochemist at Purple Mountain Observatory in Nanjing, China, because it reveals how much there is to learn about the Moon's evolution.

Hsu wonders whether a closer look at the basalts might reveal that they do actually come from a source rich in heat-producing elements, because the study by Lin and his colleagues was conducted on soil samples that contain many materials. Hsu has found that the rocks contain high levels of titanium, which suggests they came from deep in the mantle.

"We're exploring all possibilities," says Ming Tang, a geochemist at Peking University in Beijing, who received two tiny grains of basaltic rock and will analyse them to better understand the pressure and temperature in which they were created. The samples are a first for Tang, who previously studied magma from volcanoes on Earth. "It's a good opportunity for me and many other Chinese scientists interested in stretching their field," says Tang.

Hsu says there will be a lot of groups trying to solve the mystery. This year, his laboratory received more applications from students keen to join its graduate programme than it could accommodate. "This has never been the case before."

1. Che, X. *et al.* *Science* **374**, 887–890 (2021).
 2. Li, Q.-L. *et al.* *Nature* **600**, 54–58 (2021).
 3. Tian, H.-C. *et al.* *Nature* **600**, 59–63 (2021).
 4. Hu, S. *et al.* *Nature* **600**, 49–53 (2021).

COVID'S TRUE DEATH TOLL: MUCH HIGHER THAN OFFICIAL FIGURES

Modelling suggests that by the end of 2021, some 18 million people had died because of the pandemic.

By David Adam

The number of people who have died because of the COVID-19 pandemic could be roughly three times higher than official figures suggest, according to a new analysis.

The study, published on 10 March, says that the true number of lives lost to the pandemic by 31 December 2021 was close to 18 million (COVID-19 Excess Mortality Collaborators *Lancet* <https://doi.org/gpnw46>; 2022). That far outstrips the 5.9 million deaths that the study says were reported to official sources for the same period. The difference is down to steep undercounts in official statistics, owing to delayed and incomplete reporting and a lack of data in dozens of countries.

The loss of life "is much higher than simply assessed by reported COVID-19 deaths in most countries", says study co-author Haidong Wang, a demographer and population-health researcher at the Institute for Health Metrics and Evaluation (IHME) in Seattle, Washington.

The study uses a measure called excess mortality to overcome variation in the ways that countries identify and record deaths from SARS-CoV-2 infection. Researchers estimate excess mortality by comparing the total deaths reported in a region, from all causes, with how many deaths would be expected, given recent trends. Excess deaths are a good indicator of

COVID-19 mortality, Wang says, citing studies from Sweden and the Netherlands suggesting that the disease caused most of the excess deaths during the pandemic. But he stresses that research is needed to separate deaths caused directly by COVID-19 from those that are indirect results of the pandemic.

The IHME team collected data on deaths from all causes in 74 countries and territories. For countries that do not produce such data, the authors used a statistical model to produce mortality estimates. The analysis indicates that between 1 January 2020 and 31 December 2021, reported deaths from COVID-19 totalled 5.9 million, but excess deaths might have totalled 18.2 million (see 'COVID's true toll').

Grim statistics

The IHME's figure for global excess deaths is the first to appear in a peer-reviewed journal. Its central estimate is similar to that of *The Economist* magazine in London (see go.nature.com/3d5bpc3), which arrived at some 18 million excess deaths by the end of 2021. But the error bars on the IHME's analysis are notably narrower: *The Economist* has a 95% uncertainty interval of 12.6 million–21.0 million; the IHME's is just 17.1 million–19.6 million.

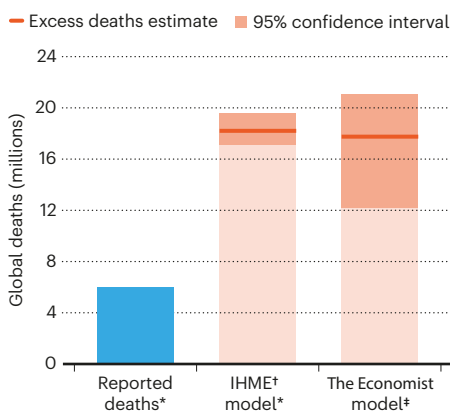
Other researchers in the field have previously criticized the IHME's COVID-19 mortality estimates. Ariel Karlinsky, an economist at the Hebrew University of Jerusalem in Israel, says the new study's central estimate of 18 million is reasonable, but that some of the IHME's numbers for excess deaths in individual countries are significantly out of step with other sources. "They still have their ludicrous estimate for Japan at over 100,000 excess deaths, which is over six times the reported deaths," he says.

The IHME model contains some "bizarre features", adds Jonathan Wakefield, a statistician at the University of Washington in Seattle, who leads the World Health Organization's COVID-19 global death toll project. The IHME's approach leads him to doubt the validity of its uncertainty intervals and other statistical features of the modelling.

Different models and techniques will produce different results and uncertainty levels, Wang responds. For example, the IHME model uses 15 variables to estimate a country's excess deaths, whereas *The Economist's* model employs more than 100.

COVID'S TRUE TOLL

The number of confirmed deaths (blue bar) caused by COVID-19 is much smaller than tallies of 'excess deaths' (pink bars), which are those above what is expected, during the pandemic.



*Up to 31 December 2021; †Institute for Health Metrics and Evaluation; ‡up to 27 December 2021.