Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

biased, especially in the initial part of an outbreak, and converge once all cases are closed". During and after the epidemic peak, patient denominators correspond to the best estimates of people presenting with clinical COVID-19 because of access to diagnostic testing and stabilisation of the number of new daily cases. At that time, we consider that patients were screened close to symptom onset. According to reports from WHO,[5] the time from symptom onset to death ranges from 2 to 8 weeks. In our estimates, we chose to use the minimum time between symptom onset and death so not to overestimate mortality rates. Another factor that is still unknown and could bias the model is the number of asymptomatic cases, as acknowledged in our Correspondence. Most asymptomatic patients are not captured by screening, leading to underestimates in the denominator. We presented our model as a mortality rate estimate among people presenting with clinical COVID-19—that is, symptomatic cases. In our experience, patients are mostly interested in knowing mortality rates when symptomatic, and less so of asymptomatic carriers.

There are other limitations that would apply to any statistical method, such as the possible change in testing frequency due to a shortage of tests. In some places, patients might even die before being tested. In the extreme, the mortality rate would reach 100% if only patients who had died were tested, whereas mortality rates would significantly drop if the entire population was to be tested. Thus, ideally, estimates should be adjusted according to test availability. Another consideration is that mortality in this epidemic is highly age-dependent, and so will vary according to the number of older individuals in the population. In high-income countries, the demographic pyramid is such that there are higher proportions of older individuals in the population. With larger numbers of vulnerable individuals exposed, one will observe higher overall mortality rates. In addition, mortality will vary across communities depending on access to tertiary medical centres and well equipped critical care units.

For the time being, in Europe, we are still in the early epidemic period, with a rapid increase in the number of cases; additional data are needed for the assessment of cumulative mortality rates due to confirmed COVID-19 cases over time.[6] Thus, the goal of our publication was to share our vision of the potential impact of COVID-19 using a model that integrated the viral incubation period and the time to death following diagnosis. As with every model, estimates will improve as the number of cases increase.

We declare no competing interests.

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1 Kim DD, Goel A. Estimating case fatality rates of COVID-19. *Lancet Infect Dis* 2020; published online March 31. https://doi.org/10.1016/S1473-3099(20)30234-6.
2 Spychalski P, Błażyńska-Spychalska A, Kobiela J. Estimating case fatality rates of COVID-19. *Lancet Infec Dis* 2020; published online March 31. https://doi.org/10.1016/S1473-3099(20)30246-2.
3 Lipsitch M. Estimating case fatality rates of COVID-19. *Lancet Infect Dis* 2020; published online March 31. https://doi.org/10.1016/S1473-3099(20)30245-0.
4 Baud D, Qi X, Nielsen-Saines K, Musso D, Pomar L, Favre G. Real estimates of mortality following COVID-19 infection. *Lancet Infect Dis* 2020; published online March 12. https://doi.org/10.1016/S1473-3099(20)30195-X.
5 WHO. Report of the WHO–China Joint Mission on Coronavirus Disease 2019 (COVID-19). Feb 16–24, 2020. https://www.who.int/publications-detail/report-of-the-who-china-joint-mission-on-coronavirus-disease-2019-(covid-19) (accessed March 22, 2020).
6 WHO. Coronavirus disease 2019 (COVID-19). Situation Report–57. March 17, 2020. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200317-sitrep-57-covid-19.pdf?sfvrsn=a26922f2_2 (accessed March 22, 2020).

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The many estimates of the COVID-19 case fatality rate

Since the outbreak of coronavirus disease 2019 (COVID-19) began in December, a question at the forefront of many people's minds has been its mortality rate. Is the mortality rate of COVID-19 higher than that of influenza, but lower than that of severe acute respiratory syndrome (SARS)?

The trend in mortality reporting for COVID-19 has been typical for emerging infectious diseases. The case fatality rate (CFR) was reported to be 15% (six of 41 patients) in the initial period,[1] but this estimate was calculated from a small cohort of hospitalised patients. Subsequently, with more data emerging, the CFR decreased to between 4·3% and 11·0%,[2,3] and later to 3·4%.[4] The rate reported outside China in February was even lower (0·4%; two of 464).[5]

This pattern of decreasing CFRs is not surprising during the initial phase of an outbreak. Hard outcomes such as the CFR have a crucial part in forming strategies at national and international levels from a public health perspective. It is imperative that health-care leaders and policy makers are guided by estimates of mortality and case fatality.

However, several factors can restrict obtaining an accurate estimate of the CFR. The virus and its clinical course are new, and we still have little information about them. Health care capacity and capability factors,

including the availability of health-care workers, resources, facilities, and preparedness, also affect outcomes. For example, some countries are able to invest resources into contact tracing and containing the spread through quarantine and isolation of infected or suspected cases. In Singapore, where these measures have been implemented, the CFR of 631 cases (as of March 25, 2020) is 0·3%. In other places, testing might not be widely available, and proactive contact tracing and containment might not be employed, resulting in a smaller denominator and skewing to a higher CFR. The CFR can increase in some places if there is a surge of infected patients, which adds to the strain on the health-care system and can overwhelm its medical resources.

A major challenge with accurate calculation of the CFR is the denominator: the number of people who are infected with the virus. Asymptomatic cases of COVID-19, patients with mild symptoms, or individuals who are misdiagnosed could be left out of the denominator, leading to its underestimation and overestimation of the CFR.

A unique situation has arisen for quite an accurate estimate of the CFR of COVID-19. Among individuals onboard the Diamond Princess cruise ship, data on the denominator are fairly robust. The outbreak of COVID-19 led passengers to be quarantined between Jan 20, and Feb 29, 2020. This scenario provided a population living in a defined territory without most other confounders, such as imported cases, defaulters of screening, or lack of testing capability. 3711 passengers and crew were onboard, of whom 705 became sick and tested positive for COVID-19 and seven died,[6] giving a CFR of 0·99%. If the passengers onboard were generally of an older age, the CFR in a healthy, younger population could be lower.[7]

Although highly transmissible, the CFR of COVID-19 appears to be lower than that of SARS (9·5%) and Middle East respiratory syndrome (34·4%),[8] but higher than that of influenza (0·1%).[9,10]

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1 Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020; **395:** 497–506.
2 Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet* 2020; **395:** 507–13.
3 Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA* 2020; published online Feb 7. DOI:10.1001/jama.2020.1585.
4 WHO. WHO Director-General's opening remarks at the media briefing on COVID-19. March 3, 2020. https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---3-march-2020 (accessed March 11, 2020).
5 Johns Hopkins Center for Systems Science and Engineering. Coronavirus COVID-19 global cases. 2020. https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6. (accessed March 11, 2020)
6 CNA. Diamond Princess passenger dies, bringing ship's death toll to seven. March 8, 2020. https://www.channelnewsasia.com/news/asia/coronavirus-covid19-japan-diamond-princess-deaths-12513028 (accessed March 11, 2020).
7 Pappas S. How deadly is the new coronavirus? March, 2020. https://www.livescience.com/is-coronavirus-deadly.html (accessed March 11, 2020)
8 Munster VJ, Koopmans M, van Doremalen N, van Riel D, de Wit E. A novel coronavirus emerging in China—key questions for impact assessment. *N Engl J Med* 2020; **382:** 692–94.
9 de Wit E, van Doremalen N, Falzarano D, Munster VJ. SARS and MERS: recent insights into emerging coronaviruses. *Nat Rev Microbiol* 2016; **14:** 523–34.
10 Fauci AS, Lane HC, Redfield RR. Covid-19—navigating the uncharted. *N Engl J Med* 2020; published online Feb 28. DOI:10.1056/NEJMe2002387.

COVID-19 and medical education

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The coronavirus disease 2019 (COVID-19) outbreak has rapidly transitioned into a worldwide pandemic. This development has had serious implications for public institutions and raises particular questions for medical schools. Frequent rotations between departments and hospitals make medical students potential vectors for COVID-19. Equally, as trainee doctors we stand to learn a tremendous amount and can contribute to the care of patients. More immediate concerns among medical students centre on the impact of COVID-19 on medical education.

A substantial number of medical students are in the process of preparing for or undertaking assessments that require clinical exposure. The effect of COVID-19 on medical education could therefore be considerable. Several teaching hospitals in the UK have reported cases of COVID-19, with some hospitals suspending medical and observership students from attending clinical attachments. This suspension might extend to more hospitals as the COVID-19 pandemic continues to develop, which could lead to clinical medical students receiving reduced exposure in specific specialties, causing a detrimental effect to exam performance and competency as foundation year 1 doctors.

The situation is more complex for some final year medical students who are in the process of sitting their final assessments. Some medical schools have reduced clinical exposure in the weeks coming up to their final exams to reduce the risk of contracting the virus. Many electives could also be cancelled because of the global prevalence of COVID-19. This situation would not only cause financial losses for students, but also lead to a missed opportunity of working in a health-care system outside of the UK. At this stage, it is difficult to predict what will