

Average detection rate of SARS-CoV-2 infections is estimated around six percent

On March 31st, 2020, reported case fatality rates in the countries currently most affected by the novel coronavirus disease (COVID-19) ranged from 11.7% in Italy to 1.1% in Germany (a factor of 10.6),¹ suggesting vast differences in the quality of countries' case records. In particular, (confirmed) case fatality rates may only be a very poor proxy for the true infection fatality rate if a high number of infections remain undetected. Despite such uncertainties, policy makers rely heavily on the extrapolation of past trends when planning responses to the pandemic.

A recent study,² combining data from mainland China with those of international Wuhan residents returning on repatriation flights, presented novel age-specific estimates for the infection fatality rate. As returning Wuhan expats have been subject to extensive testing, substantial underdiagnosing is unlikely, providing confidence in these numbers. We therefore treat the reported infection fatality rates as benchmark for other countries and calculate infection fatality rates for the 40 most affected countries using UN population data to correct for differences in age distributions (see Table 1).³ The same study estimates the average time from symptom onset to death to be approximately 18 days.² If we conservatively assume that individuals are tested four days after symptom onset and if countries were successful in tracing the majority of infections, dividing the cumulative number of deaths on March 31st by the cumulative number of confirmed cases by March 17th should yield case fatality rates similar to the reported infection fatality rates. This is, however, generally not the case. Instead, in all countries, the number of confirmed cases by March 17th was substantially lower than what would have been expected given the total number of deaths reported two weeks later. The average detection rate is around six percent, making the number of cases that is reported in the news on a daily basis rather meaningless. To estimate the true number of infections on March 31st, we assume for simplicity that detection rates are constant over time. We believe that this is on average a rather conservative assumption as it is getting more difficult in a growing pandemic to detect all cases despite huge efforts to increase testing capacity. Countries that started with a very low detection rate like Turkey or even the United States might be an exception to this. We calculate the estimated number of infections on March 31st dividing the number of confirmed cases on March 31st by the detection rate. While the Johns Hopkins data report less than a million confirmed cases globally at the moment this correspondence is written, we estimate the number of infections to be a few tens of millions.

Putting an end to current travel restrictions and social distancing measures will not only require a strong reduction in the transmission of new cases but also major improvements in the ability of countries to detect new infections to then adopt adequate measures for isolating infected patients and tracing potential contact persons. In absence of such measures, the virus might remain undetected again for an extended period of time and a new outbreak is likely just a matter of time.

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We have no competing interests.

References

- 1 Johns Hopkins University Center for Systems Science and Engineering (JHU CSSE). 2019 Novel Coronavirus COVID-19 (2019-nCoV) Data Repository by Johns Hopkins CSSE. Johns Hopkins University 2020. Available from: <https://github.com/CSSEGISandData/COVID-19> [accessed April 1st, 2020, 10 am CET]
- 2 Verity R, Okell LC, Dorigatti I, Winskill P, Whittaker C, Imai N, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. *Lancet Infect Dis* 2020; [https://doi.org/10.1016/S1473-3099\(20\)30243-7](https://doi.org/10.1016/S1473-3099(20)30243-7).
- 3 United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects 2019, Online Edition. Rev. 1. United Nations 2020. Available from: <https://population.un.org/wpp/Download/Standard/Population/> [accessed March 19th, 2020]

Table 1: Country records of COVID-19 deaths, number of confirmed cases and estimated number of infections

| Country | Infection fatality rate | Number of deaths (March 31 st) | Number of confirmed cases (March 17 th) | Estimated number of infections (March 17 th) | Estimated detection rate | Number of confirmed cases (March 31 st) | Estimated number of infections (March 31 st) | Share of population infected (March 31 st) |
|-------------|-------------------------|--|---|--|--------------------------|---|--|--|
| Italy | 1.38% | 12,428 | 31,506 | 899,426 | 3.50% | 105,792 | 3,020,125 | 5.00% |
| Spain | 1.21% | 8,464 | 11,748 | 701,030 | 1.68% | 95,923 | 5,723,946 | 12.24% |
| US | 0.96% | 3,873 | 6,421 | 404,390 | 1.59% | 188,172 | 11,850,950 | 3.58% |
| France | 1.20% | 3,532 | 7,715 | 294,205 | 2.62% | 52,827 | 2,014,513 | 3.09% |
| Iran | 0.43% | 2,898 | 16,169 | 672,755 | 2.40% | 44,605 | 1,855,912 | 2.21% |
| UK | 1.09% | 1,793 | 1,960 | 164,727 | 1.19% | 25,481 | 2,141,529 | 3.15% |
| Netherlands | 1.14% | 1,040 | 1,711 | 91,126 | 1.88% | 12,667 | 674,628 | 3.94% |
| Germany | 1.30% | 775 | 9,257 | 59,407 | 15.58% | 71,808 | 460,828 | 0.55% |
| Belgium | 1.14% | 705 | 1,243 | 62,019 | 2.00% | 12,775 | 637,402 | 5.50% |
| Switzerland | 1.13% | 433 | 2,700 | 38,229 | 7.06% | 16,605 | 235,107 | 2.72% |
| Turkey | 0.55% | 214 | 47 | 38,770 | 0.12% | 13,531 | 11,161,684 | 13.23% |
| Brazil | 0.59% | 201 | 321 | 33,848 | 0.95% | 5,717 | 602,838 | 0.28% |
| Sweden | 1.15% | 180 | 1,190 | 15,601 | 7.63% | 4,435 | 58,142 | 0.58% |
| South Korea | 0.96% | 162 | 8,320 | 16,818 | 49.47% | 9,786 | 19,782 | 0.04% |
| Portugal | 1.32% | 160 | 448 | 12,123 | 3.70% | 7,443 | 201,415 | 1.98% |
| Indonesia | 0.42% | 136 | 172 | 32,694 | 0.53% | 1,528 | 290,445 | 0.11% |
| Austria | 1.15% | 128 | 1,332 | 11,129 | 11.97% | 10,180 | 85,052 | 0.94% |
| Canada | 1.05% | 101 | 478 | 9,651 | 4.95% | 8,527 | 172,170 | 0.46% |
| Denmark | 1.14% | 90 | 1,025 | 7,912 | 12.95% | 3,039 | 23,459 | 0.41% |
| Philippines | 0.36% | 88 | 187 | 24,457 | 0.76% | 2,084 | 272,557 | 0.25% |
| Romania | 1.09% | 82 | 184 | 7,525 | 2.45% | 2,245 | 91,819 | 0.48% |
| Ecuador | 0.47% | 75 | 58 | 15,809 | 0.37% | 2,240 | 610,563 | 3.46% |
| Ireland | 0.84% | 71 | 223 | 8,469 | 2.63% | 3,235 | 122,852 | 2.49% |
| Japan | 1.60% | 56 | 878 | 3,490 | 25.16% | 1,953 | 7,762 | 0.01% |
| Domin. Rep. | 0.48% | 51 | 21 | 10,621 | 0.20% | 1,109 | 560,915 | 5.17% |
| Iraq | 0.23% | 50 | 154 | 21,858 | 0.70% | 694 | 98,502 | 0.24% |
| Greece | 1.34% | 49 | 387 | 3,660 | 10.57% | 1,314 | 12,428 | 0.12% |
| Egypt | 0.34% | 46 | 196 | 13,423 | 1.46% | 710 | 48,625 | 0.05% |
| Algeria | 0.43% | 44 | 60 | 10,323 | 0.58% | 716 | 123,187 | 0.28% |
| Malaysia | 0.45% | 43 | 673 | 9,495 | 7.09% | 2,766 | 39,024 | 0.12% |
| Norway | 1.01% | 39 | 1,463 | 3,874 | 37.76% | 4,641 | 12,290 | 0.23% |
| Morocco | 0.47% | 36 | 38 | 7,589 | 0.50% | 617 | 123,227 | 0.33% |
| India | 0.41% | 35 | 142 | 8,462 | 1.68% | 1,397 | 83,250 | 0.01% |
| Poland | 1.06% | 33 | 238 | 3,101 | 7.68% | 2,311 | 30,110 | 0.08% |
| Czechia | 1.09% | 31 | 396 | 2,837 | 13.96% | 3,308 | 23,696 | 0.22% |
| Peru | 0.54% | 30 | 117 | 5,585 | 2.09% | 1,065 | 50,839 | 0.15% |
| Panama | 0.54% | 30 | 69 | 5,551 | 1.24% | 1,181 | 95,016 | 2.20% |
| Mexico | 0.48% | 28 | 82 | 5,777 | 1.42% | 1,094 | 77,079 | 0.06% |
| Argentina | 0.67% | 27 | 68 | 4,024 | 1.69% | 1,054 | 62,367 | 0.14% |
| Pakistan | 0.29% | 26 | 236 | 8,911 | 2.65% | 1,938 | 73,173 | 0.03% |

Note: The infection fatality rate is calculated as weighted sum of the age specific infection fatality rates from Verity et al. (2020) weighted by the population shares of each age group from the United Nations population data. The estimated number of infections on March 17th is the number of deaths on March 31st divided by the infection fatality rate. The estimated detection rate is the number of confirmed cases divided by the estimated number of infections on March 17th. The estimated number of infections on March 31st is the number of confirmed cases on March 31st divided by the estimated detection rate.