



Exploring the Gap Between Excess Mortality and COVID-19 Deaths in 67 Countries

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Introduction

During the SARS-CoV-2 pandemic, a surge in overall deaths has been recorded in many countries, most of them likely attributable to COVID-19. However, COVID-19 confirmed mortality (CCM) is considered an unreliable indicator of COVID-19 deaths because of national health care systems' different capacities to correctly identify people who actually died of the disease.^{1,2} Excess mortality (EM) is a more comprehensive and robust indicator because it relies on all-cause mortality instead of specific causes of death.³ We analyzed the gap between the EM and CCM in 67 countries to determine the extent to which official data on COVID-19 deaths might be considered reliable.

Methods

In this cross-sectional study, we retrieved aggregated country-level data on population and COVID-19 overall confirmed cases, deaths, and testing as of December 31, 2020, from Our World in Data. Data on countries' overall deaths from 2015 to 2020 were obtained from the World Mortality Data set (eAppendix in the [Supplement](#)). This research was based on public use datasets that do not include identifiable personal information and, per the Common Rule, was exempt from Institutional Review Board review and approval. For the same reason, no informed consent was required. This study follows the Strengthening the Reporting of Observational Studies in Epidemiology ([STROBE](#)) reporting guideline.

Negative binomial regression models were used to estimate projected deaths in 2020 using mortality data from 2015 to 2019. Two-sided 95% CIs for country-specific projected deaths were calculated applying the normal approximation to the Poisson distribution. EM in the pandemic period (ie, February 26 to December 31, 2020) was estimated as the difference between cumulative observed deaths and projected deaths. Countries' testing capacity was assessed with their cumulative test-to-case ratio (eAppendix in the [Supplement](#)). The association between country-specific cumulative CCM and EM per 100 000 population of 2020 was displayed using a scatterplot, in which the identity line discriminates countries with EM exceeding CCM from those with EM lower than CCM. A color was assigned to countries based on their decile of testing capacity. All analyses were performed using R version 4.0.4 (R Project for Statistical Computing). Details on the analytic approach are available in the eAppendix in the [Supplement](#).

Results

Most of the 67 countries experienced an increase in mortality during 2020 ([Table](#)). Among countries with increased mortality (ie, those located above 0 on the y-axis in the [Figure](#)), a small number appeared under the identity line, showing lower-than-expected mortality after subtracting COVID-19 deaths. Countries located above the identity line can be visually classified into 2 groups: 1 with several Latin American and East European countries, which exhibit a large gap between EM and CCM (eg, Mexico, 212 excess deaths vs 96 COVID-19 deaths per 100 000 population); the other, more heterogeneous group showed a moderate EM beyond CCM (eg, Greece, 57 excess deaths vs 45 COVID-19 deaths per 100 000 population). Countries with negative EM also had very low CCM and

+ Supplemental content

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Table. Excess Deaths and Test-to-Case Ratio, February 26 to December 31, 2020, 67 Countries

| Country | Observed deaths | Projected deaths (95% CI) | Ratio of observed to projected | Excess deaths per 100 000 | Total COVID-19 deaths | COVID-19 deaths per 100 000 | Excess deaths attributed to COVID-19, % ^a | Test to case ratio |
|-----------------|-----------------|---------------------------------|--------------------------------|---------------------------|-----------------------|-----------------------------|--|--------------------|
| Albania | 23 400 | 18 154 (17 572-18 736) | 1.29 | 182.29 | 1181 | 41.04 | 23 | 4.24 |
| Australia | 119 924 | 124 531 (121 707-127 355) | 0.96 | -18.07 | 909 | 3.56 | NA | 396.15 |
| Austria | 75 588 | 67 431 (66 021-68 841) | 1.12 | 90.57 | 6059 | 67.27 | 74 | 10.63 |
| Belgium | 108 160 | 89 308 (87 083-91 533) | 1.21 | 162.66 | 19 361 | 167.05 | 103 | 10.77 |
| Bolivia | 69 752 | 44 655 (44 586-44 724) | 1.56 | 215.00 | 9165 | 78.51 | 37 | 2.59 |
| Brazil | 1 385 572 | 1 139 346 (1 135 039-1 143 653) | 1.22 | 115.84 | 194 949 | 91.72 | 79 | 1.42 |
| Bulgaria | 105 383 | 88 056 (86 220-89 892) | 1.20 | 249.37 | 7405 | 106.57 | 43 | 5.68 |
| Chile | 109 238 | 95 428 (92 487-98 369) | 1.14 | 72.24 | 16 488 | 86.25 | 119 | 10.59 |
| Colombia | 255 360 | 210 524 (208 704-212 344) | 1.21 | 88.12 | 42 620 | 83.76 | 95 | 4.93 |
| Costa Rica | 22 135 | 21 321 (20 940-21 702) | 1.04 | 15.98 | 2185 | 42.89 | 268 | 2.53 |
| Croatia | 47 865 | 42 092 (41 322-42 862) | 1.14 | 140.62 | 3795 | 92.44 | 66 | 4.83 |
| Cyprus | 5256 | 4994 (4842-5146) | 1.05 | 29.91 | 117 | 13.36 | 45 | 47.12 |
| Czechia | 109 308 | 93 318 (91 664-94 972) | 1.17 | 149.31 | 11 302 | 105.54 | 71 | Missing |
| Denmark | 45 582 | 45 673 (44 789-46 557) | 1.00 | -1.57 | 1226 | 21.17 | NA | 64.20 |
| Ecuador | 102 468 | 63 902 (63 241-64 563) | 1.60 | 218.59 | 14 001 | 79.36 | 36 | 3.30 |
| Estonia | 13 356 | 12 858 (12 610-13 106) | 1.04 | 37.54 | 221 | 16.66 | 44 | 22.81 |
| Finland | 46 142 | 45 369 (44 587-46 151) | 1.02 | 13.95 | 550 | 9.93 | 71 | 69.39 |
| France | 561 871 | 507 513 (497 166-517 860) | 1.11 | 79.76 | 64 203 | 94.21 | 118 | Missing |
| Georgia | 41 771 | 37 461 (36 571-38 351) | 1.12 | 108.04 | 2505 | 62.79 | 58 | Missing |
| Germany | 822 155 | 793 924 (775 602-812 246) | 1.04 | 33.69 | 32 267 | 38.51 | 114 | 21.20 |
| Greece | 107 886 | 101 976 (100 065-103 887) | 1.06 | 56.70 | 4730 | 45.38 | 80 | 24.36 |
| Guatemala | 81 804 | 71 611 (71 075-72 147) | 1.14 | 56.89 | 4781 | 26.69 | 47 | 4.43 |
| Hungary | 118 424 | 105 853 (103 646-108 060) | 1.12 | 130.13 | 9292 | 96.19 | 74 | 6.91 |
| Iceland | 1889 | 1903 (1860-1946) | 0.99 | -4.10 | 29 | 8.50 | NA | 41.96 |
| Israel | 40 261 | 37 288 (36 438-38 138) | 1.08 | 34.35 | 3292 | 38.03 | 111 | 19.81 |
| Italy | 630 694 | 521 949 (511 176-532 722) | 1.21 | 179.86 | 73 019 | 120.77 | 67 | 12.62 |
| Japan | 1 131 879 | 1 171 088 (1 154 918-1 187 258) | 0.97 | -31.00 | 3286 | 2.60 | NA | 19.03 |
| Kazakhstan | 139 904 | 109 835 (108 318-111 352) | 1.27 | 160.14 | 2761 | 14.70 | 9 | 27.53 |
| Kyrgyzstan | 33 995 | 27 135 (27 045-27 225) | 1.25 | 105.15 | 1355 | 20.77 | 20 | Missing |
| Latvia | 23 869 | 23 159 (22 643-23 675) | 1.03 | 37.64 | 603 | 31.97 | 85 | 21.44 |
| Lithuania | 36 750 | 30 847 (30 277-31 417) | 1.19 | 216.84 | 1695 | 62.26 | 29 | 11.57 |
| Luxembourg | 3960 | 3664 (3565-3763) | 1.08 | 47.29 | 489 | 78.12 | 165 | 35.58 |
| Malaysia | 145 604 | 150 442 (150 192-150 692) | 0.97 | -14.95 | 471 | 1.46 | NA | 29.59 |
| Malta | 3311 | 3032 (2928-3136) | 1.09 | 63.19 | 215 | 48.69 | 77 | 40.51 |
| Mauritius | 9250 | 9595 (9540-9650) | 0.96 | -27.13 | 10 | 0.79 | NA | Missing |
| Mexico | 898 733 | 625 345 (616 114-634 576) | 1.44 | 212.04 | 123 845 | 96.05 | 45 | 2.40 |
| Moldova | 34 043 | 29 276 (28 381-30 171) | 1.16 | 118.17 | 2985 | 74.00 | 63 | Missing |
| Mongolia | 13 258 | 14 554 (14 494-14 614) | 0.91 | -39.53 | 1 | 0.03 | NA | 492.61 |
| Montenegro | 6141 | 5455 (5319-5591) | 1.13 | 109.22 | 677 | 107.79 | 99 | Missing |
| Netherlands | 141 911 | 126 826 (124 163-129 489) | 1.12 | 88.04 | 11 305 | 65.98 | 75 | 6.69 |
| New Zealand | 27 643 | 29 907 (29 211-30 603) | 0.92 | -46.95 | 25 | 0.52 | NA | 650.26 |
| North Macedonia | 21 622 | 16 537 (16 197-16 877) | 1.31 | 244.07 | 2503 | 120.14 | 49 | 4.83 |
| Norway | 33 544 | 33 460 (32 815-34 105) | 1.00 | 1.55 | 433 | 7.99 | 515 | 56.91 |
| Oman | 9072 | 7782 (7726-7838) | 1.17 | 25.26 | 1499 | 29.35 | 116 | Missing |
| Panama | 20 313 | 17 527 (17 305-17 749) | 1.16 | 64.57 | 4022 | 93.21 | 144 | 5.28 |
| Paraguay | 28 707 | 27 376 (27 239-27 513) | 1.05 | 18.66 | 2262 | 31.71 | 170 | 5.19 |
| Peru | 192 215 | 107 608 (106 057-109 159) | 1.79 | 256.60 | 37 525 | 113.81 | 44 | 3.43 |

(continued)

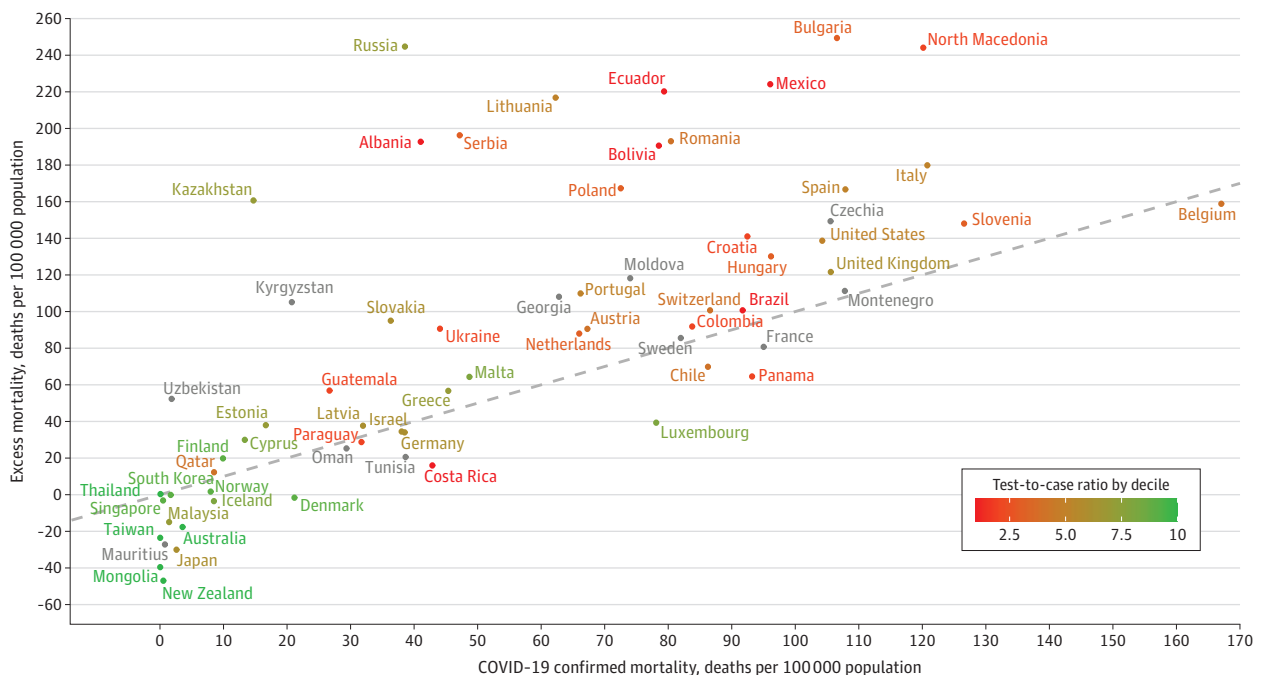
Table. Excess Deaths and Test-to-Case Ratio, February 26 to December 31, 2020, 67 Countries (continued)

| Country | Observed deaths | Projected deaths (95% CI) | Ratio of observed to projected | Excess deaths per 100 000 | Total COVID-19 deaths | COVID-19 deaths per 100 000 | Excess deaths attributed to COVID-19, % ^a | Test to case ratio |
|----------------|-----------------|---------------------------------|--------------------------------|---------------------------|-----------------------|-----------------------------|--|--------------------|
| Poland | 407 017 | 343 727 (337 185-350 269) | 1.18 | 167.23 | 27 454 | 72.54 | 43 | 5.36 |
| Portugal | 104 427 | 90 907 (88 257-93 557) | 1.15 | 132.59 | 6751 | 66.21 | 50 | 13.73 |
| Qatar | 2237 | 1882 (1869-1895) | 1.19 | 12.32 | 245 | 8.50 | 69 | 8.63 |
| Romania | 251 366 | 214 243 (209 476-219 010) | 1.17 | 192.97 | 15 469 | 80.41 | 42 | 7.61 |
| Russia | 1 817 225 | 1 460 074 (1 433 045-1 487 103) | 1.24 | 244.73 | 56 271 | 38.56 | 16 | 29.14 |
| Serbia | 97 126 | 83 772 (82 148-85 396) | 1.16 | 196.25 | 3211 | 47.19 | 24 | 6.80 |
| Singapore | 18 157 | 18 382 (18 363-18 401) | 0.99 | -3.85 | 29 | 0.50 | NA | 92.71 |
| Slovakia | 49 240 | 44 053 (43 267-44 839) | 1.12 | 95.01 | 1983 | 36.32 | 38 | 18.10 |
| Slovenia | 20 034 | 17 033 (16 630-17 436) | 1.18 | 144.35 | 2631 | 126.56 | 88 | 5.55 |
| South Korea | 252 127 | 252 686 (249 165-256 207) | 1.00 | -1.09 | 869 | 1.69 | NA | 65.46 |
| Spain | 417 857 | 339 985 (332 077-347 893) | 1.23 | 166.55 | 50 442 | 107.89 | 65 | 11.77 |
| Sweden | 80 125 | 71 487 (69 939-73 035) | 1.12 | 85.53 | 8279 | 81.98 | 96 | Missing |
| Switzerland | 64 126 | 55 415 (54 275-56 555) | 1.16 | 100.65 | 7493 | 86.58 | 86 | 8.13 |
| Taiwan | 142 272 | 147 889 (145 095-150 683) | 0.96 | -23.58 | 6 | 0.03 | NA | 158.93 |
| Thailand | 414 555 | 414 290 (412 595-415 985) | 1.00 | 0.38 | 63 | 0.09 | 24 | 228.14 |
| Tunisia | 61 509 | 59 078 (57 198-60 958) | 1.04 | 20.57 | 4570 | 38.67 | 188 | Missing |
| Ukraine | 516 097 | 476 463 (466 623-486 303) | 1.08 | 90.63 | 19 281 | 44.09 | 49 | 5.19 |
| United Kingdom | 576 821 | 494 271 (481 999-506 543) | 1.17 | 121.60 | 71 675 | 105.58 | 87 | 21.06 |
| United States | 2 870 292 | 2 419 814 (2 387 664-2 451 964) | 1.19 | 136.09 | 344 730 | 104.15 | 77 | 12.70 |
| Uzbekistan | 150 808 | 133 298 (128 228-138 368) | 1.13 | 52.32 | 614 | 1.83 | 4 | Missing |

Abbreviation: NA, not applicable.

^a Excess deaths attributable to COVID-19 calculated by dividing COVID-19 deaths per 100 000 by excess deaths per 100 000.

Figure. Scatterplot of COVID-19 Confirmed Mortality vs Excess Mortality in 67 Countries, February 26 to December 31, 2020



The dashed diagonal line represents the equality between the number of excess deaths and of COVID-19 reported deaths. The 0 marker on the y-axis indicates no excess mortality. Countries are colored according to their decile of the test-to-case ratio. Countries appearing in gray had unavailable or incomplete data on testing.

were mainly located in East Asia. The lowest figures of EM and CCM generally belonged to countries with higher testing capacity (in green) and the largest differences between EM and CCM to countries with poorer testing capacity (in red).

Discussion

This comparison of CCM and EM revealed the different national health systems' capacity to test and diagnose COVID-19 and their responsiveness to the health crisis. Underreporting of COVID-19 deaths because of strained health care systems' capacity might explain our findings for countries where EM exceeded CCM.^{2,4} In contrast, the effects of nonpharmaceutical interventions on populations' main causes of deaths, such as the decrease in work and road accidents, could be responsible for the reduction in overall mortality in countries where CCM exceeded EM.⁵ Notably, most of the countries that presented reduced overall mortality during 2020 had extremely high testing capacity and were praised for their effective response measures against the pandemic.⁶

Limitations of our analysis include the lack of stratification by age and sex, the underrepresentation of some areas of the world, and not considering nonpharmaceutical interventions. Despite these drawbacks, our findings corroborate the evidence that in many countries the accuracy in quantifying the death toll of COVID-19 is still a missed target. The global action against the pandemic is being conditioned by diverse responses to the crisis, but reliable evidence should be the pillar on which effective prevention measures are built.

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SUPPLEMENT.**eAppendix.** Supplemental Methods