# COVID19 Time Series Analysis, Worldwide and U.S.

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*28 March 2020*

Source data: 2019 Novel Coronavirus COVID-19 (2019-nCoV) Data Repository by Johns Hopkins CSSE; https://github.com/CSSEGISandData/COVID-19

Source code: https://github.com/opencedar/covid19

The visualizations in this document are heavily indebted to Edward Tufte and his use of sparklines—small, clutter-free time series lines—to show how many different panels or categories of data are changing through time; check out https://www.edwardtufte.com/bboard/q-and-a-fetch-msg?msg_id=0001OR.

## Worldwide

### Worldwide Summary

Sorted by total number of cases. Percent growth in total cases in the past seven days is last column.

Table 1: Worldwide Summary

| Country_Region | days_50 | conf | deaths | new_conf | conf_lag7 | l7_rate |
|---|---|---|---|---|---|---|
| US | 33 | 101657 | 1581 | 17821 | 19101 | 432% |
| Italy | 35 | 86498 | 9134 | 5909 | 47021 | 84% |
| China | 66 | 81897 | 3296 | 115 | 81250 | 0% |
| Spain | 27 | 65719 | 5138 | 7933 | 20410 | 220% |
| Germany | 28 | 50871 | 342 | 6933 | 19848 | 156% |
| France | 29 | 33402 | 1997 | 3851 | 12632 | 164% |
| Iran | 33 | 32332 | 2378 | 2926 | 19644 | 64% |
| United Kingdom | 17 | 14745 | 761 | 2933 | 4014 | 268% |
| Switzerland | 25 | 12928 | 231 | 1117 | 5294 | 144% |
| Korea, South | 37 | 9332 | 139 | 91 | 8652 | 8% |
| Netherlands | 23 | 8647 | 547 | 1179 | 3003 | 188% |
| Austria | 22 | 7657 | 58 | 748 | 2388 | 220% |
| Belgium | 23 | 7284 | 289 | 1049 | 2257 | 224% |
| Turkey | 10 | 5698 | 92 | 2069 | 359 | 1,488% |
| Canada | 21 | 4682 | 54 | 640 | 943 | 396% |
| Portugal | 17 | 4268 | 76 | 724 | 1020 | 320% |
| Norway | 24 | 3755 | 19 | 386 | 1914 | 96% |
| Brazil | 16 | 3417 | 92 | 432 | 793 | 332% |
| Australia | 24 | 3143 | 13 | 333 | 791 | 296% |
| Sweden | 23 | 3069 | 105 | 229 | 1639 | 88% |
| Israel | 18 | 3035 | 12 | 342 | 705 | 332% |
| Czechia | 17 | 2279 | 9 | 354 | 833 | 172% |
| Denmark | 19 | 2200 | 52 | 177 | 1337 | 64% |
| Malaysia | 24 | 2161 | 26 | 130 | 1030 | 108% |
| Ireland | 15 | 2121 | 22 | 302 | 683 | 212% |
| Chile | 14 | 1610 | 5 | 304 | 434 | 272% |
| Luxembourg | 14 | 1605 | 15 | 152 | 484 | 232% |
| Ecuador | 11 | 1595 | 36 | 192 | 367 | 336% |
| Japan | 41 | 1468 | 49 | 81 | 963 | 52% |

| Country_Region | days_50 | conf | deaths | new_conf | conf_lag7 | l7_rate |
|---|---|---|---|---|---|---|
| Poland | 15 | 1389 | 16 | 168 | 425 | 228% |
| Pakistan | 13 | 1373 | 11 | 172 | 501 | 176% |
| Romania | 15 | 1292 | 26 | 263 | 308 | 320% |
| South Africa | 13 | 1170 | 1 | 243 | 202 | 480% |
| Thailand | 21 | 1136 | 5 | 91 | 322 | 252% |
| Saudi Arabia | 15 | 1104 | 3 | 92 | 344 | 220% |
| Indonesia | 15 | 1046 | 87 | 153 | 369 | 184% |
| Finland | 17 | 1041 | 7 | 83 | 450 | 132% |
| Russia | 14 | 1036 | 4 | 196 | 253 | 308% |
| World | 22 | 569662 | 26728 | 60913 | 262983 | 116% |

## Ln (Seven-Day-Moving-Average New Cases) Impact on Ln (New Cases)

In other words, elasticity. How does this elasticity change through time, from days since the 50th case?

An elasticity under 1 indicates that over a seven-day period, new cases are decreasing.

The black line shows the best curve fit for elasticity changing over time. All countries generally are moving to cap the rate of exponential growth. Countries above the line are doing worse than average, and those below the line are doing better than average. A rate below 1 indicates that new cases are declining over an average 7-day period.
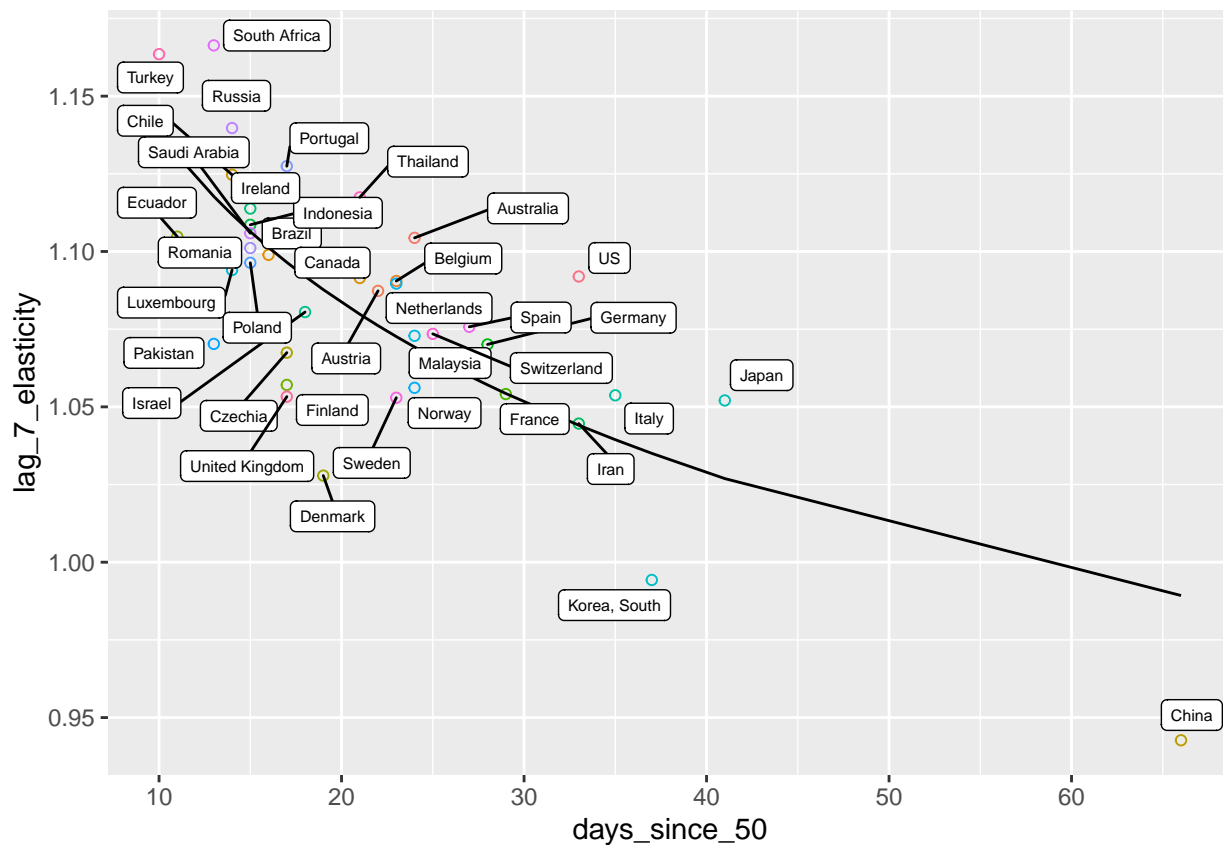
Table 2: Countries by Predicted vs. Actual Lag 7 New Case Elasticity on Today's Cases

| country | days_since_50 | lag_7_elasticity | prediction | residual |
|---|---|---|---|---|
| Turkey | 10 | 1.16 | 1.14 | 0.03 |
| Ecuador | 11 | 1.10 | 1.13 | -0.03 |
| Pakistan | 13 | 1.07 | 1.12 | -0.05 |
| South Africa | 13 | 1.17 | 1.12 | 0.05 |
| Luxembourg | 14 | 1.09 | 1.11 | -0.02 |
| Chile | 14 | 1.12 | 1.11 | 0.01 |
| Russia | 14 | 1.14 | 1.11 | 0.03 |
| Poland | 15 | 1.10 | 1.11 | -0.01 |
| Romania | 15 | 1.10 | 1.11 | -0.01 |
| Saudi Arabia | 15 | 1.11 | 1.11 | 0.00 |
| Indonesia | 15 | 1.11 | 1.11 | 0.00 |
| Ireland | 15 | 1.11 | 1.11 | 0.01 |
| Brazil | 16 | 1.10 | 1.10 | 0.00 |
| United Kingdom | 17 | 1.05 | 1.10 | -0.04 |
| Finland | 17 | 1.06 | 1.10 | -0.04 |
| Czechia | 17 | 1.07 | 1.10 | -0.03 |
| Portugal | 17 | 1.13 | 1.10 | 0.03 |
| Israel | 18 | 1.08 | 1.09 | -0.01 |
| Denmark | 19 | 1.03 | 1.09 | -0.06 |
| Canada | 21 | 1.09 | 1.08 | 0.01 |
| Thailand | 21 | 1.12 | 1.08 | 0.04 |
| Austria | 22 | 1.09 | 1.08 | 0.01 |
| Sweden | 23 | 1.05 | 1.07 | -0.02 |
| Netherlands | 23 | 1.09 | 1.07 | 0.02 |
| Belgium | 23 | 1.09 | 1.07 | 0.02 |
| Norway | 24 | 1.06 | 1.07 | -0.01 |
| Malaysia | 24 | 1.07 | 1.07 | 0.00 |
| Australia | 24 | 1.10 | 1.07 | 0.04 |
| Switzerland | 25 | 1.07 | 1.07 | 0.01 |
| Spain | 27 | 1.08 | 1.06 | 0.02 |
| Germany | 28 | 1.07 | 1.06 | 0.01 |
| France | 29 | 1.05 | 1.05 | 0.00 |
| Iran | 33 | 1.04 | 1.04 | 0.00 |
| US | 33 | 1.09 | 1.04 | 0.05 |
| Italy | 35 | 1.05 | 1.04 | 0.01 |
| Korea, South | 37 | 0.99 | 1.04 | -0.04 |
| Japan | 41 | 1.05 | 1.03 | 0.03 |
| China | 66 | 0.94 | 0.99 | -0.05 |

## Sparklines

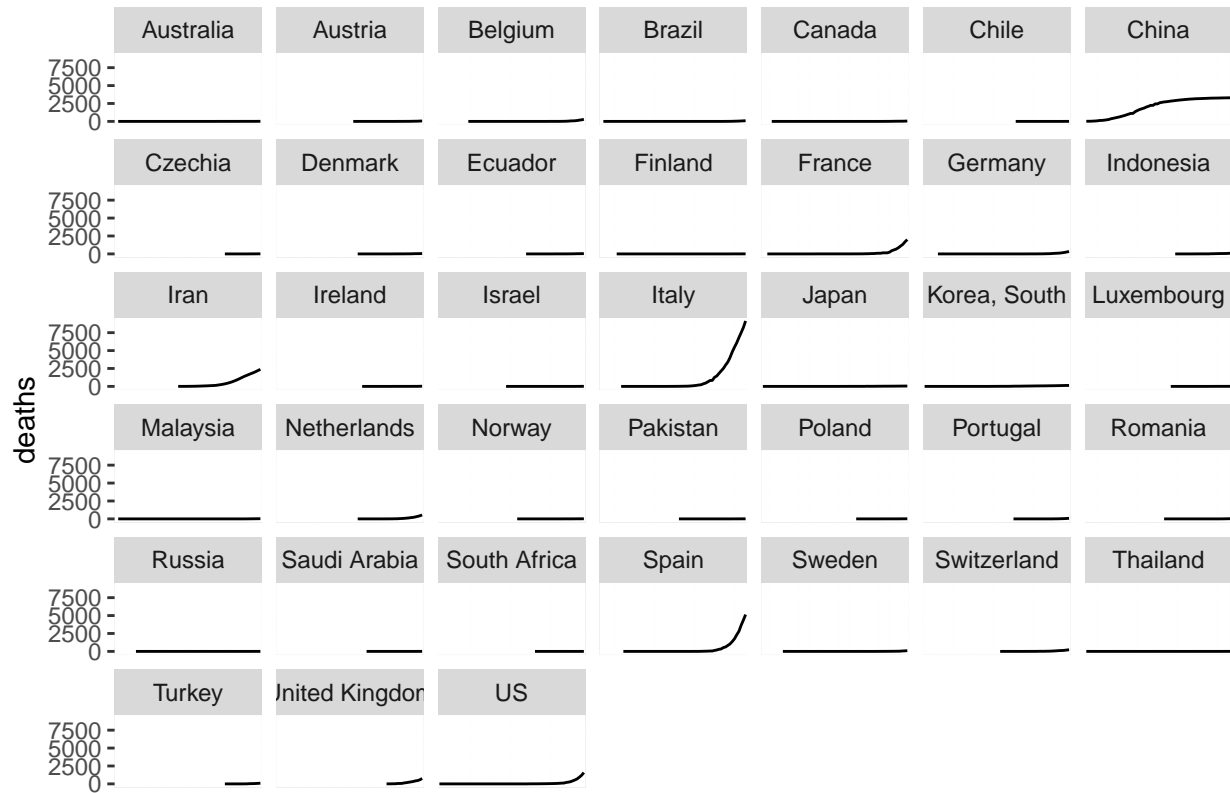### Confirmed Cases



Confirmed COVID19 Cases Through 28 March 2020
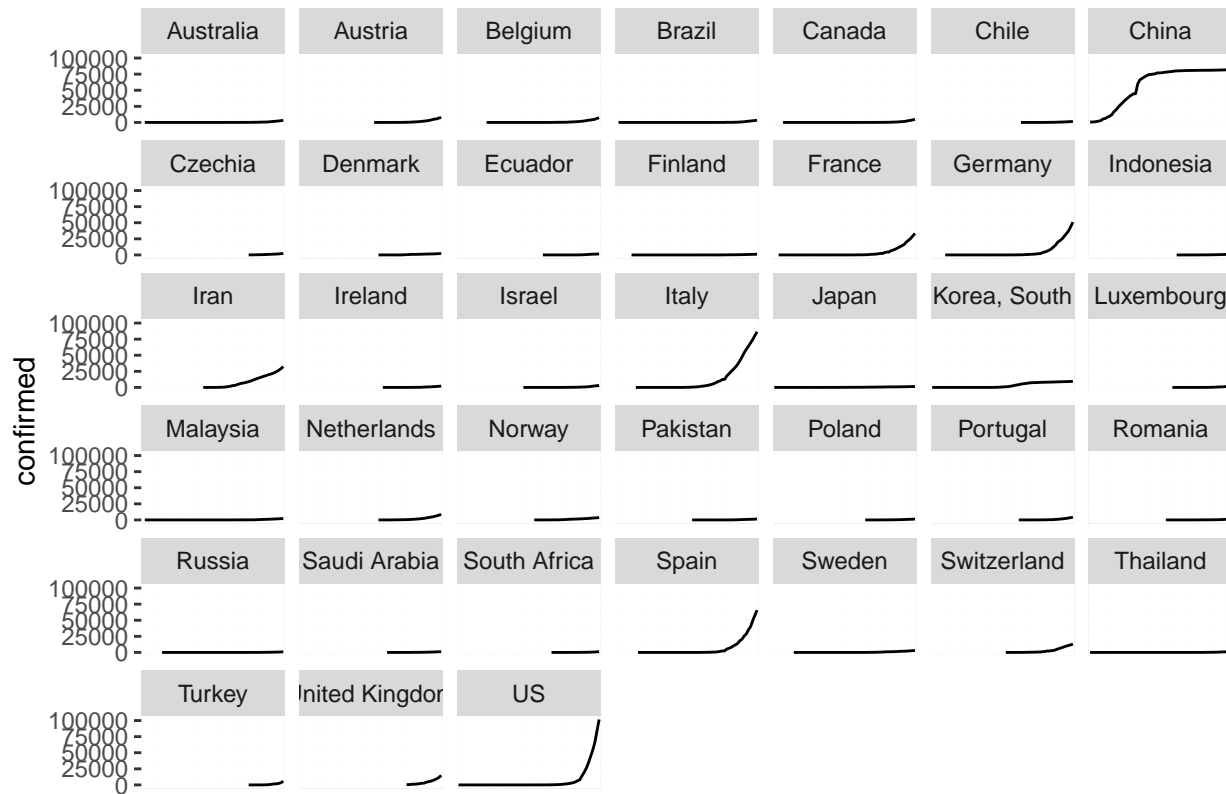
**Deaths**

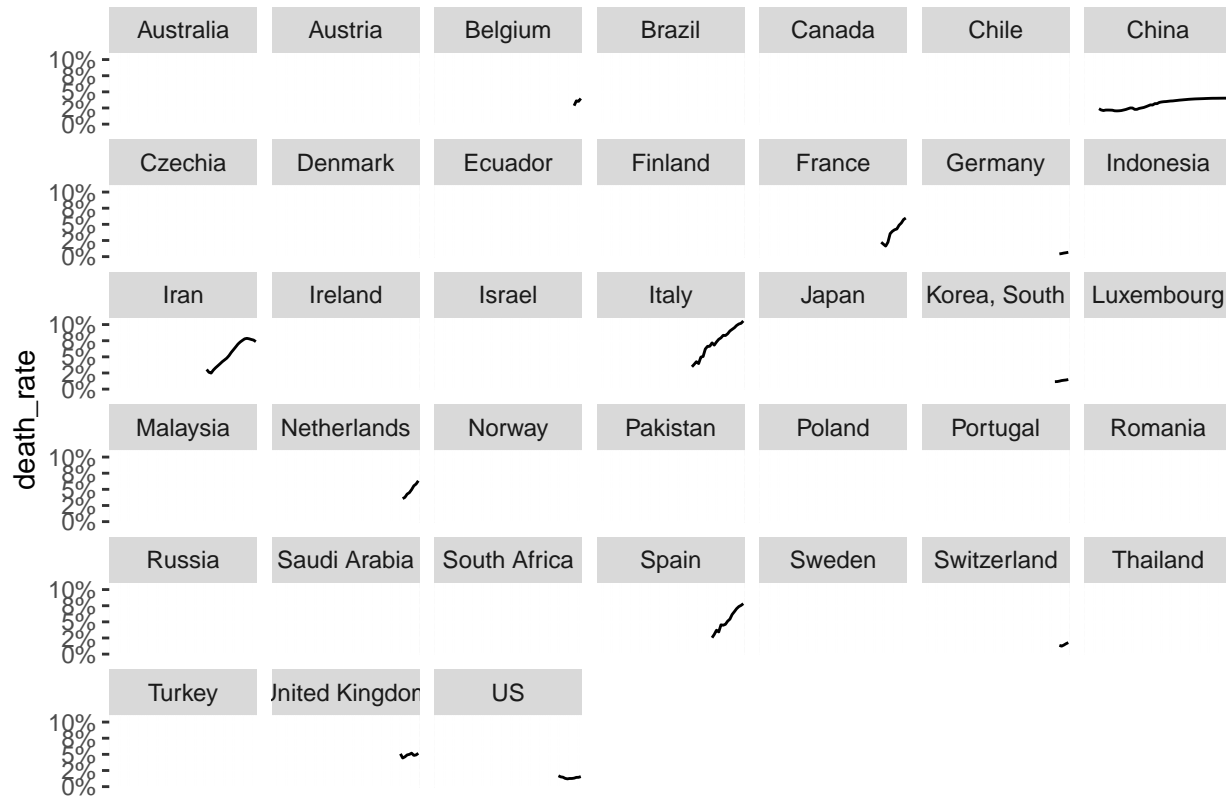## Cumulative COVID19 Deaths Through 28 March 2020



deaths

## 5–Day MA Confirmed Growth Rate Through 28 March 2020
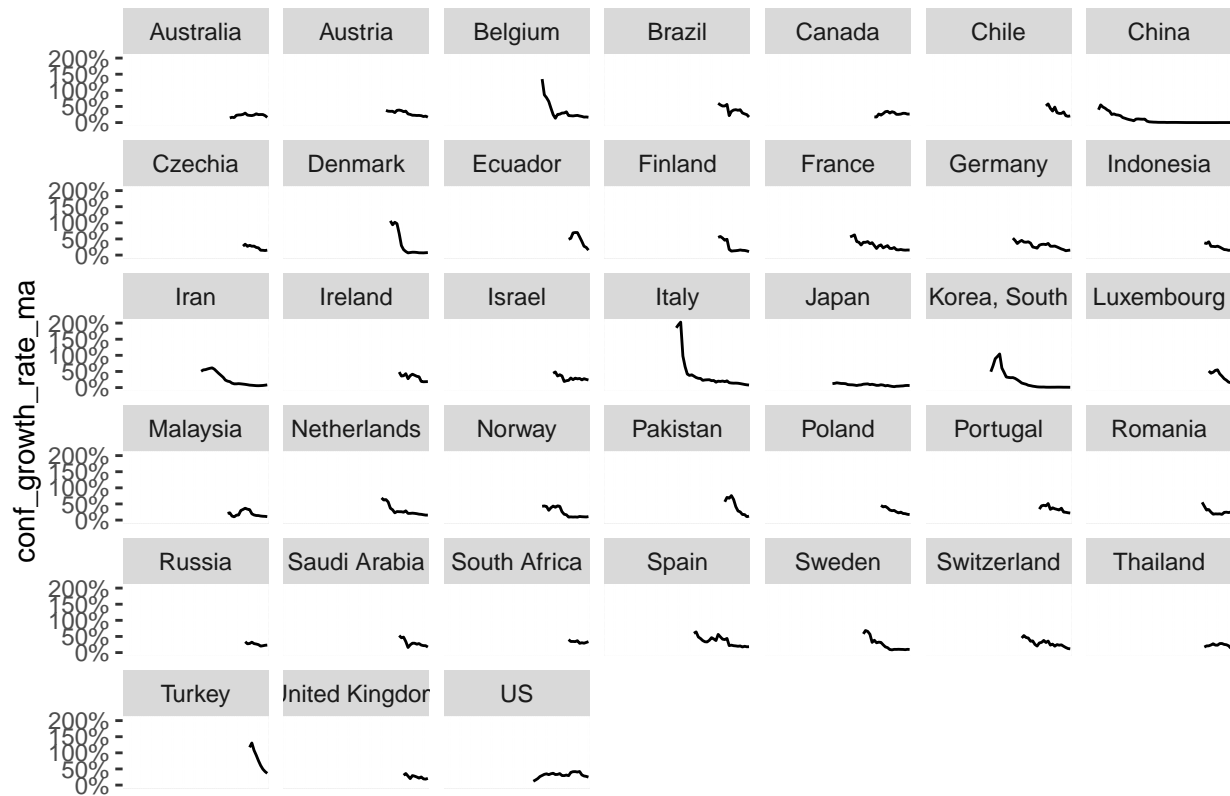
**Death Rate**

## Death Rate Through 28 March 2020



# U.S. Analysis

## State Summary

Sorted by total number of cases. Percent growth in total cases in the past seven days is last column.

Table 3: State-by-State Summary

| Province_State | days_50 | conf | deaths | new_conf | conf_lag7 | l7_rate |
|---|---|---|---|---|---|---|
| New York | 21 | 44876 | 527 | 6999 | 8310 | 440% |
| New Jersey | 14 | 8825 | 108 | 1949 | 890 | 892% |
| California | 23 | 4657 | 94 | 758 | 1177 | 296% |
| Michigan | 12 | 3634 | 92 | 789 | 552 | 560% |
| Washington | 23 | 3477 | 157 | 270 | 1524 | 128% |
| Massachusetts | 18 | 3240 | 35 | 823 | 413 | 684% |
| Illinois | 14 | 3024 | 34 | 486 | 585 | 416% |
| Florida | 15 | 2900 | 35 | 543 | 563 | 416% |
| Louisiana | 14 | 2744 | 119 | 440 | 538 | 412% |
| Pennsylvania | 13 | 2345 | 22 | 550 | 303 | 672% |
| Georgia | 14 | 2000 | 64 | 475 | 420 | 376% |
| Texas | 14 | 1937 | 26 | 374 | 394 | 392% |
| Colorado | 14 | 1433 | 27 | 3 | 363 | 296% |
| Tennessee | 12 | 1318 | 6 | 221 | 233 | 464% |
| Connecticut | 11 | 1291 | 27 | 279 | 194 | 564% |

| Province_State | days_50 | conf | deaths | new_conf | conf_lag7 | l7_rate |
|---|---|---|---|---|---|---|
| Ohio | 12 | 1137 | 19 | 269 | 173 | 556% |
| Indiana | 9 | 979 | 25 | 334 | 86 | 1,040% |
| Wisconsin | 11 | 926 | 14 | 198 | 207 | 348% |
| North Carolina | 11 | 887 | 4 | 149 | 172 | 416% |
| Maryland | 11 | 775 | 5 | 192 | 149 | 420% |
| Missouri | 8 | 666 | 9 | 146 | 53 | 1,156% |
| Arizona | 8 | 665 | 13 | 157 | 78 | 752% |
| Virginia | 11 | 607 | 10 | 141 | 122 | 396% |
| Alabama | 9 | 587 | 4 | 70 | 83 | 608% |
| Mississippi | 9 | 579 | 8 | 94 | 80 | 624% |
| South Carolina | 9 | 542 | 13 | 118 | 126 | 332% |
| Nevada | 11 | 536 | 10 | 116 | 114 | 372% |
| Utah | 11 | 472 | 1 | 76 | 78 | 504% |
| Oregon | 11 | 416 | 12 | 100 | 114 | 264% |
| Minnesota | 12 | 396 | 4 | 52 | 115 | 244% |
| Arkansas | 9 | 381 | 3 | 46 | 96 | 296% |
| Oklahoma | 7 | 322 | 8 | 74 | 49 | 556% |
| Kentucky | 7 | 301 | 7 | 54 | 47 | 540% |
| District of Columbia | 8 | 271 | 3 | 40 | 71 | 280% |
| Iowa | 7 | 235 | 3 | 56 | 45 | 424% |
| Kansas | 7 | 206 | 4 | 34 | 44 | 368% |
| Idaho | 5 | 205 | 3 | 59 | 23 | 792% |
| Rhode Island | 8 | 203 | 0 | 38 | 54 | 276% |
| Vermont | 6 | 184 | 10 | 26 | 29 | 536% |
| Maine | 9 | 168 | 1 | 13 | 56 | 200% |
| Delaware | 6 | 163 | 2 | 33 | 38 | 328% |
| New Hampshire | 7 | 158 | 1 | 21 | 44 | 260% |
| New Mexico | 6 | 136 | 1 | 23 | 43 | 216% |
| Montana | 4 | 109 | 1 | 19 | 15 | 628% |
| Hawaii | 6 | 106 | 0 | 11 | 26 | 308% |
| US | 11 | 101019 | 1571 | 17718 | 18889 | 436% |

## Ln (Seven-Day-Moving-Average New Cases) Impact on Ln (New Cases)

In other words, elasticity. How does this elasticity change through time, from days since the 50th case?

An elasticity under 1 indicates that over a seven-day period, new cases are decreasing.

The black line is the best fit for elasticity for the states that have had 50 cases as they progress. Above the line: worse than average; below-the-line: better than average.

The blue line is the best fit for elasticity for countries across the world. It's apparent that the U.S. is not doing as well as the rest of the world in containing exponential growth–probably due to initial testing failures.
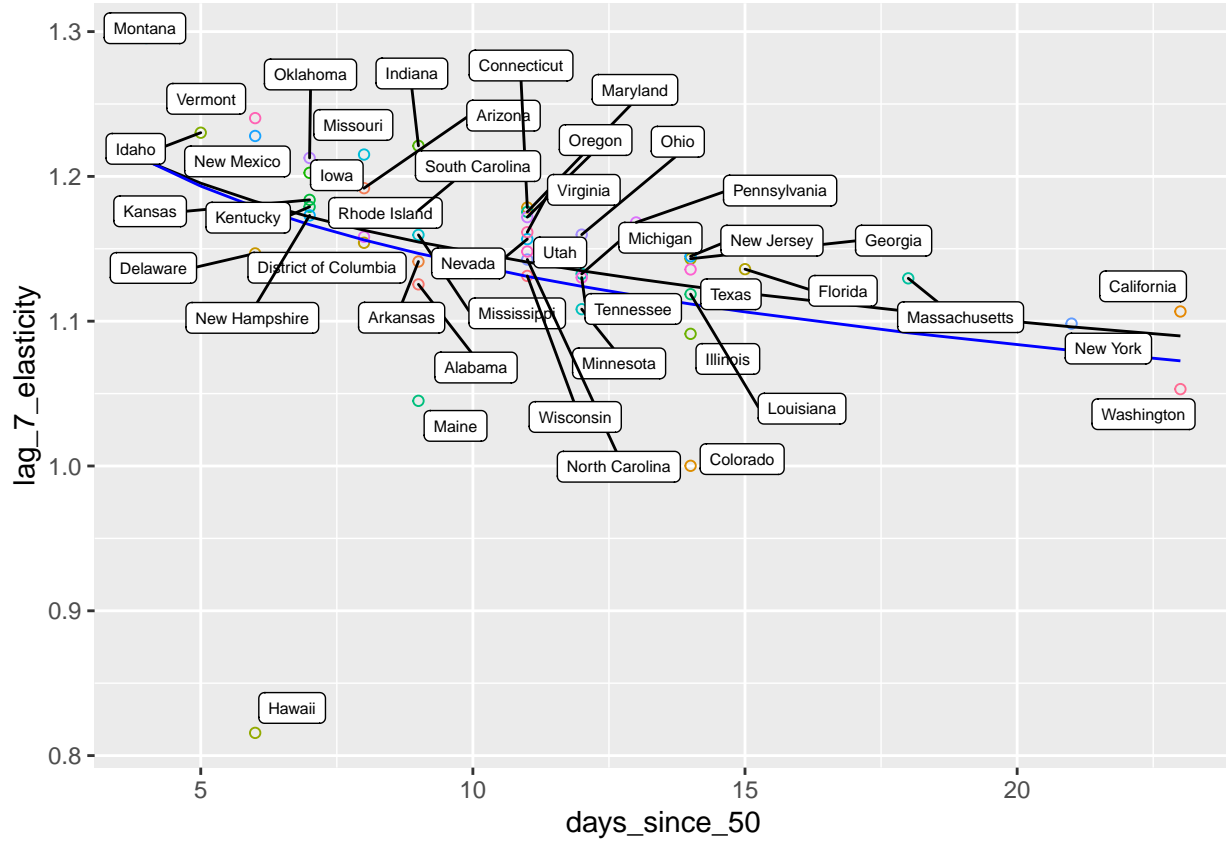
**Comparisons with U.S. and worldwide averages**

Some states are doing better than worldwide averages when taking into account days since 50th case. Most are doing worse.

Table 4: States by Predicted vs. Actual Lag 7 New Case Elasticity on Today's Cases

| state | days_since_50 | lag_7_elasticity | prediction_us | prediction_ww | us_residual | ww_residual |
|---|---|---|---|---|---|---|
| Montana | 4 | 1.30 | 1.21 | 1.21 | 0.08 | 0.08 |
| Idaho | 5 | 1.23 | 1.20 | 1.19 | 0.03 | 0.04 |
| Hawaii | 6 | 0.82 | 1.18 | 1.18 | -0.37 | -0.36 |
| Delaware | 6 | 1.15 | 1.18 | 1.18 | -0.04 | -0.03 |
| New Mexico | 6 | 1.23 | 1.18 | 1.18 | 0.05 | 0.05 |
| Vermont | 6 | 1.24 | 1.18 | 1.18 | 0.06 | 0.06 |
| New Hampshire | 7 | 1.17 | 1.17 | 1.17 | 0.00 | 0.01 |
| Kentucky | 7 | 1.18 | 1.17 | 1.17 | 0.01 | 0.01 |
| Kansas | 7 | 1.18 | 1.17 | 1.17 | 0.01 | 0.02 |
| Iowa | 7 | 1.20 | 1.17 | 1.17 | 0.03 | 0.04 |
| Oklahoma | 7 | 1.21 | 1.17 | 1.17 | 0.04 | 0.05 |
| District of Columbia | 8 | 1.15 | 1.16 | 1.16 | -0.01 | 0.00 |
| Rhode Island | 8 | 1.16 | 1.16 | 1.16 | 0.00 | 0.00 |
| Arizona | 8 | 1.19 | 1.16 | 1.16 | 0.03 | 0.04 |
| Missouri | 8 | 1.22 | 1.16 | 1.16 | 0.05 | 0.06 |
| Maine | 9 | 1.05 | 1.15 | 1.15 | -0.11 | -0.10 |
| Alabama | 9 | 1.13 | 1.15 | 1.15 | -0.03 | -0.02 |
| Arkansas | 9 | 1.14 | 1.15 | 1.15 | -0.01 | -0.01 |

| state | days_since_50 | lag_7_elasticity | prediction_us | prediction_ww | us_residual | ww_residual |
|---|---|---|---|---|---|---|
| Mississippi | 9 | 1.16 | 1.15 | 1.15 | 0.00 | 0.01 |
| South Carolina | 9 | 1.18 | 1.15 | 1.15 | 0.02 | 0.03 |
| Indiana | 9 | 1.22 | 1.15 | 1.15 | 0.07 | 0.07 |
| Wisconsin | 11 | 1.13 | 1.14 | 1.13 | -0.01 | 0.00 |
| North Carolina | 11 | 1.14 | 1.14 | 1.13 | 0.00 | 0.01 |
| Utah | 11 | 1.15 | 1.14 | 1.13 | 0.01 | 0.02 |
| Nevada | 11 | 1.16 | 1.14 | 1.13 | 0.02 | 0.03 |
| Virginia | 11 | 1.16 | 1.14 | 1.13 | 0.02 | 0.03 |
| Oregon | 11 | 1.17 | 1.14 | 1.13 | 0.03 | 0.04 |
| Maryland | 11 | 1.18 | 1.14 | 1.13 | 0.03 | 0.04 |
| Connecticut | 11 | 1.18 | 1.14 | 1.13 | 0.04 | 0.05 |
| Minnesota | 12 | 1.11 | 1.13 | 1.12 | -0.03 | -0.02 |
| Tennessee | 12 | 1.13 | 1.13 | 1.12 | 0.00 | 0.01 |
| Michigan | 12 | 1.13 | 1.13 | 1.12 | 0.00 | 0.01 |
| Ohio | 12 | 1.16 | 1.13 | 1.12 | 0.02 | 0.04 |
| Pennsylvania | 13 | 1.17 | 1.13 | 1.12 | 0.04 | 0.05 |
| Colorado | 14 | 1.00 | 1.12 | 1.11 | -0.12 | -0.11 |
| Illinois | 14 | 1.09 | 1.12 | 1.11 | -0.03 | -0.02 |
| Louisiana | 14 | 1.12 | 1.12 | 1.11 | -0.01 | 0.01 |
| Texas | 14 | 1.14 | 1.12 | 1.11 | 0.01 | 0.02 |
| Georgia | 14 | 1.14 | 1.12 | 1.11 | 0.02 | 0.03 |
| New Jersey | 14 | 1.14 | 1.12 | 1.11 | 0.02 | 0.03 |
| Florida | 15 | 1.14 | 1.12 | 1.11 | 0.02 | 0.03 |
| Massachusetts | 18 | 1.13 | 1.11 | 1.09 | 0.02 | 0.04 |
| New York | 21 | 1.10 | 1.10 | 1.08 | 0.00 | 0.02 |
| Washington | 23 | 1.05 | 1.09 | 1.07 | -0.04 | -0.02 |
| California | 23 | 1.11 | 1.09 | 1.07 | 0.02 | 0.03 |

## Forecast New Cases by State

We estimate new cases by date, to see when states will peak, based on the worldwide curve fit. The reasoning is that testing rates increasing wildly recently in the U.S. have falsely inflated elasticity.

Table 5: Forecast Peak New Cases by State

| state | total_cases | peak_new_cases | date | population | perc_pop_infected |
|---|---|---|---|---|---|
| Minnesota | 3,131 | 67 | 2020-03-23 | 5,420,380 | 0.1% |
| Colorado | 3,025 | 409 | 2020-03-26 | 5,268,367 | 0.1% |
| Illinois | 20,530 | 673 | 2020-03-26 | 12,882,135 | 0.2% |
| Washington | 10,511 | 616 | 2020-03-26 | 6,971,406 | 0.2% |
| New York | 641,819 | 15,925 | 2020-04-15 | 19,651,127 | 3.3% |
| Louisiana | 49,042 | 1,086 | 2020-04-17 | 4,625,470 | 1.1% |
| Wisconsin | 15,879 | 328 | 2020-04-17 | 5,742,713 | 0.3% |
| Tennessee | 26,133 | 543 | 2020-04-20 | 6,495,978 | 0.4% |
| Michigan | 111,186 | 2,525 | 2020-04-21 | 9,895,622 | 1.1% |
| California | 99,721 | 2,013 | 2020-04-23 | 38,332,521 | 0.3% |
| North Carolina | 26,305 | 521 | 2020-04-24 | 9,848,060 | 0.3% |
| Utah | 14,764 | 269 | 2020-04-27 | 2,900,872 | 0.5% |
| Texas | 82,802 | 1,677 | 2020-04-28 | 26,448,193 | 0.3% |
| Florida | 175,719 | 3,620 | 2020-04-30 | 19,552,860 | 0.9% |
| Massachusetts | 248,437 | 5,076 | 2020-05-02 | 6,692,824 | 3.7% |
| Georgia | 154,661 | 3,119 | 2020-05-03 | 9,992,167 | 1.5% |

| state | total_cases | peak_new_cases | date | population | perc_pop_infected |
|---|---|---|---|---|---|
| Nevada | 30,693 | 565 | 2020-05-03 | 2,790,136 | 1.1% |
| New Jersey | 1,772,870 | 40,280 | 2020-05-05 | 8,899,339 | 19.9% |
| Virginia | 53,600 | 1,003 | 2020-05-07 | 8,260,405 | 0.6% |
| Ohio | 180,703 | 3,576 | 2020-05-10 | 11,570,808 | 1.6% |
| Oregon | 64,805 | 1,195 | 2020-05-16 | 3,930,065 | 1.6% |
| Maryland | 350,874 | 7,054 | 2020-05-20 | 5,928,814 | 5.9% |
| Pennsylvania | 3,399,764 | 75,341 | 2020-05-22 | 12,773,801 | 26.6% |
| Connecticut | 1,563,785 | 33,588 | 2020-05-23 | 3,596,080 | 43.5% |

## Sparklines

We only look at states with more than one hundred cases today. For moving average growth rates, we only look at states with deaths and recoveries over 25.

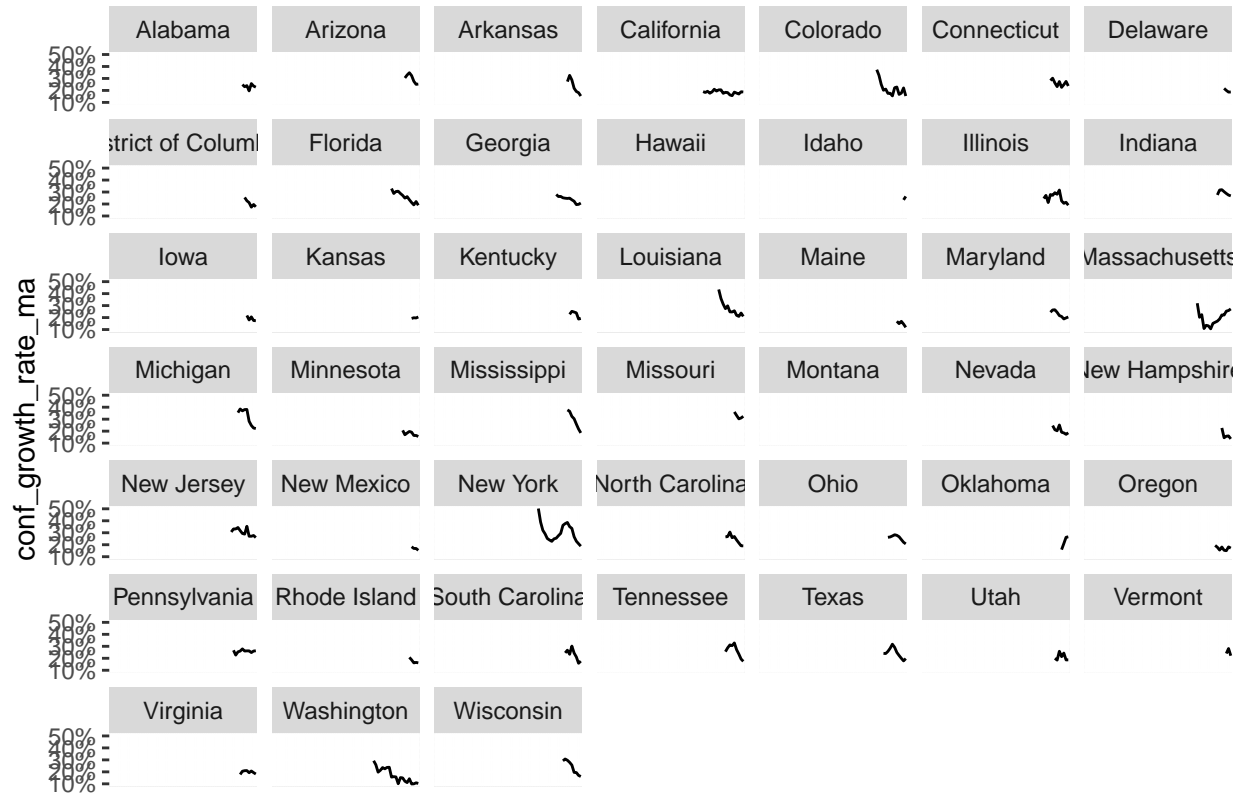### Confirmed Cases



Confirmed COVID19 Cases Through 28 March 2020
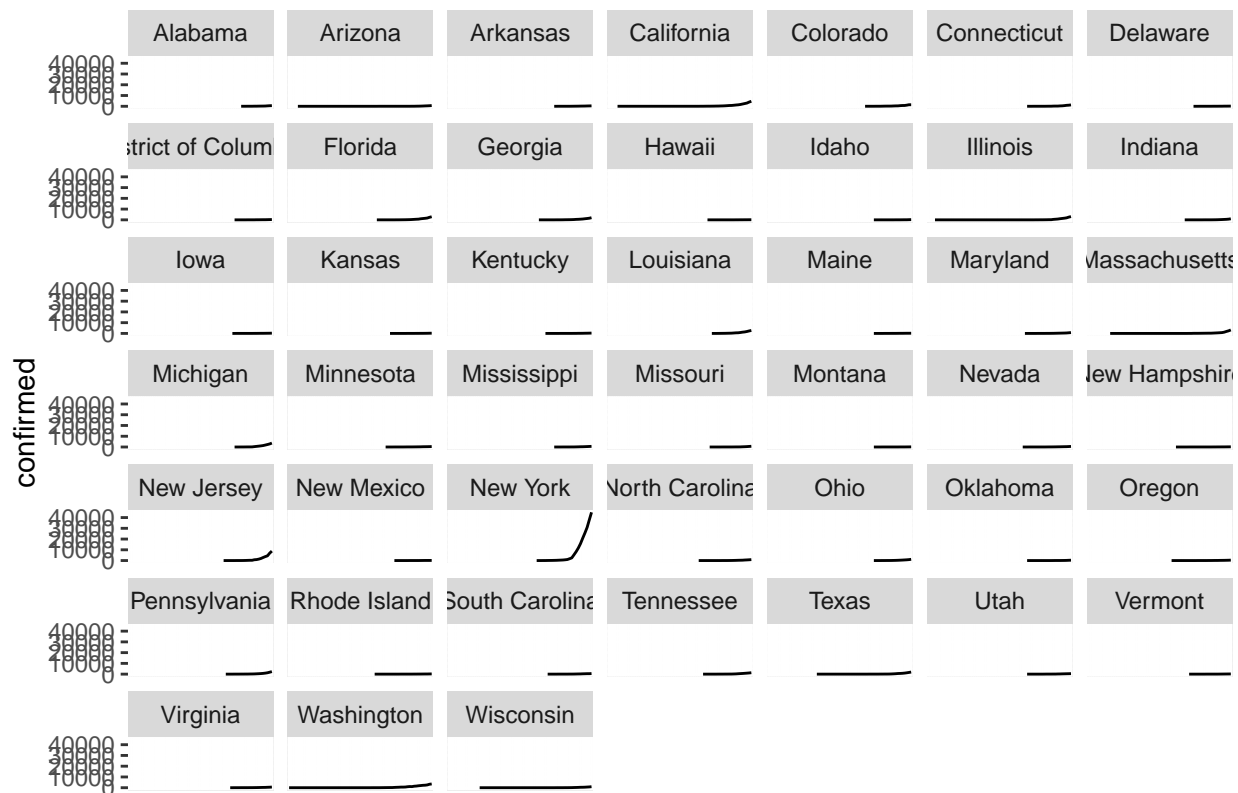
## Cumulative COVID19 Deaths Through 28 March 2020

**Confirmed Growth Rate 5-Day Moving Average**



Confirmed Growth Rate Through 28–1 March 2020

**Death Rate 5-Day Moving Average**

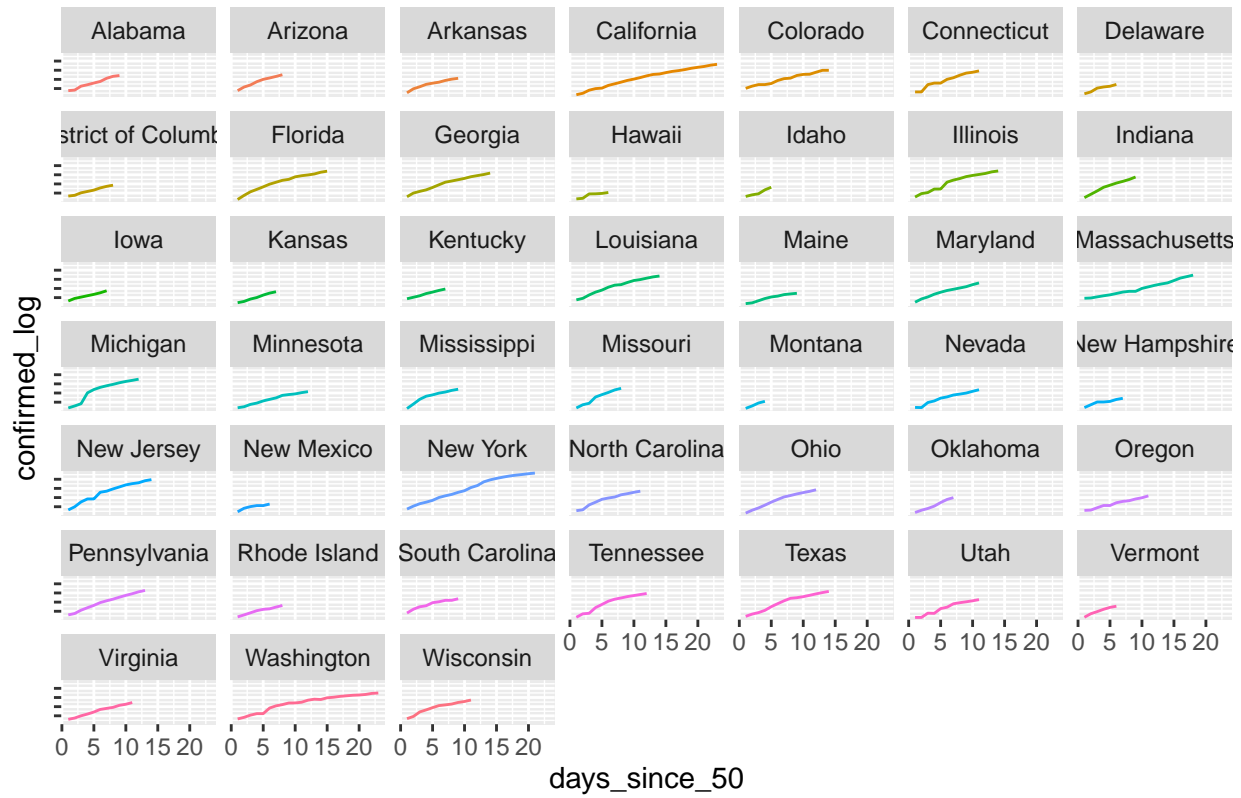Only states with >25 deaths are shown

# Death Rate Through 28–1 March 2020

| Alabama | Arizona | Arkansas | California | Colorado | Connecticut | Delaware |
|---|---|---|---|---|---|---|
| District of Columbia | Florida | Georgia | Hawaii | Idaho | Illinois | Indiana |
| Iowa | Kansas | Kentucky | Louisiana | Maine | Maryland | Massachusetts |
| Michigan | Minnesota | Mississippi | Missouri | Montana | Nevada | New Hampshire |
| New Jersey | New Mexico | New York | North Carolina | Ohio | Oklahoma | Oregon |
| Pennsylvania | Rhode Island | South Carolina | Tennessee | Texas | Utah | Vermont |
| Virginia | Washington | Wisconsin | | | | |

death_rate_ma

12%
10%
8%
6%
4%
2%

Log−10 of Confirmed Cases Since 50th Case by State as of 28 March 2020

**Confirmed Cases**

## Confirmed COVID19 Cases by State Through 28 March 2020