Coronavirus Disease-2019 Case, Death, and Testing Rates in the United States and Worldwide: Primary Data and Review

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Short Title. COVID-19 Testing

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ABSTRACT

Coronavirus disease-2019 (COVID-19), due to the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), has been associated with a world-wide pandemic, with the United States (US) having the largest total number of cases and deaths (>7 million and >200,000, respectively) at this time. We assessed data as of September 1, 2020 from our combined laboratories and as reported for selected states and countries for case, death, and testing rates per 1 million in the population. Our goal was to elucidate potential causes for the large rate differences observed. SARS-CoV-2 naso-pharyngeal (NP) RNA swab testing in 985,219 US subjects referred to our laboratories by healthcare providers revealed an overall 10.1% positive rate, comparable to the 7.3% rate reported nationwide. In a small subset of 91 subjects, all of whom had been positive for SARS-CoV-2 RNA in NP swabs 2-4 weeks earlier, NP swab testing was twice as likely to be positive (58.6%) as saliva samples (21.5%), based on paired sampling. Our positive rates per state agreed reasonably well with reported Centers for Disease Control and Prevention (CDC) data (r=0.609, P<0.0001) based on 19,898 cases, 593 deaths, and 271,637 tests, all per 1 million in the US population. Louisiana had the highest case rate; New Jersey had the highest death rate; and Rhode Island had the highest testing rate. Of 47 countries, including all countries with populations >50 million, Qatar had the highest case rate; Peru had the highest death rate; and Israel had the highest testing rate for SARS-CoV-2 infection. Correlations between case rates and death rates as well as testing rates were 0.473 and 0.398 for US states and 0.488 and 0.395 for the various countries, respectively (all P<0.0001). In conclusion, outpatient saliva testing is not as sensitive as NP testing for SARS-CoV-2 RNA detection. While testing is important, without adequate public health measures, it is unlikely that we will get this pandemic under adequate control until vaccines become available.

Key Words. SARS-CoV-2, COVID-19, swab RNA testing

Abbreviations

CDC, Centers for Disease Control and Prevention

COVID-19, coronavirus disease-2019

EUA, emergency use authorization

FDA, Food and Drug Administration

N gene, nucleocapsid gene

NP, naso-pharyngeal

OP, oro-pharyngeal

PCR, polymerase chain reaction

RT-PCR, reverse transcriptase polymerase chain reaction

SARS-CoV-2, severe acute respiratory syndrome coronavirus-2

S gene, spike glycoprotein gene

INTRODUCTION

Coronavirus disease-2019 (COVID-19) is caused by the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), which is now associated with a world-wide pandemic (>30 million cases and >1 million deaths). The diagnosis is made by SARS-CoV-2 RNA detection in naso-pharyngeal (NP) swabs, nasal swabs, oro-pharyngeal (OP) swabs, or saliva.[1-4] The greatest number of deaths/1 million in the population has been reported in the densely populated northeastern states of the United States (US). Up to 50% of SARS-CoV-2 positive patients can remain symptomatic; however, such individuals can spread infections.[5-7] The average onset of symptoms after infection is about 5 days (range 2-14 days). COVID-19 fatality is substantially higher in the elderly, and in those with cardiovascular disease, diabetes, obesity, hypertension, and lung disease.

COVID-19 disease symptoms include fever, fatigue, cough, loss of smell and taste, gastro-intestinal symptoms, and shortness of breath. The virus spreads between people mainly via respiratory droplets generated by talking, singing, coughing, and/or sneezing. Severe complications include severe acute respiratory distress due to pneumonia (which may require a ventilator), and potentially death from overwhelming infection and inflammation.[1-4] The virus is highly contagious, with about 50% of infected people being asymptomatic.[5,6] While testing is critical for diagnosis and documentation of potential immunity, public health measures (e.g. face masks, shields, social distancing, and hand washing) are critical for prevention of new cases until a vaccine becomes available. Subjects that are positive for SARS-CoV-2 RNA based on NP swabs may not have transmissible virus over time, but only viral fragments.[7] Our goals were to assess our own data as well as available US and worldwide data in terms of cases, deaths, and testing per 1 million in the population, in order to examine potential causes for the large rate differences observed between states and countries.

METHODS

Populations studied

A total of 985,219 subjects (58.2% female; age range 1-101 years; median [IQR] age 49.0 [35.0-6.0] years; 18.2% ≥65 years of age) were assessed in physician offices, clinics, and hospitals. These subjects had NP, OP, or nasal swab samples collected by healthcare providers at various sites throughout the United States, placed in viral transport media, and submitted by overnight express courier service for SARS-CoV-2 RNA detection to Boston Heart Diagnostics (Framingham, MA) beginning on April 17, 2020, Diatherix (Huntsville, AL) beginning on March 16, 2020, and/or Viracor (Lee's Summit, MO) beginning on March 13, 2020. For this analysis, data assessment was ended as of September 1, 2020. Table 1 presents data from hospitals, clinic sites, and healthcare provider offices in 38 states with more than 100 results for samples sent to these laboratories.

For this research, patient data were extracted from medical records without name or identification number and were analyzed as anonymized data. In our view, this research is exempted from requirement for human institutional review board approval as per exemption 4, as listed at https://grants.nih.gov/policy/ humansubjects.htm and at the open education resource (OER) website for research involving human subjects. This exemption "involves the collection or study of data or specimens if publicly available or recorded such that subjects cannot be identified". At the request of the preprint server medRxiv, we had this designation and our research reviewed by the Advarra Institutional Review Board (Columbia, MD) and their determination on September 26, 2020 was that "had the request for exempt determination been submitted prior to initiation of research activities, the research would have met the criteria for exemption from institutional review board review under 45 CFR 46.104(d) (4). Therefore, they agreed that this research did not require institutional review board approval.

The paired NP swab and saliva samples were collected from previously positive convalescent plasma donors (n=91, mean age 53 years, 53% female) using a protocol and written informed consent form approved by the human institutional review board of Trinity Health of New England (Hartford, CT). These subjects had all been positive 2-4 weeks earlier for SARS-CoV-2 RNA based on NP swabs. The

saliva was collected in viral transport media kits obtained from Strategic Laboratory Partners (Nashville, TN).

We also examined Centers for Disease Control and Prevention (CDC) data from various states for comparison. We included Rhode Island because of the high case and death rates observed for this state. To obtain information on COVID-19 data for the states in the US and world-wide data, we accessed the CDC website on September 1, 2020, https://www.cdc.gov/covid-data-tracker/index.html#testing, as well as the website https://www.worldometers.info/coronavirus/? and the World Health Organization website https://www.covid19.who.int/.

SARS-CoV-2 viral detection

Detection of SARS-CoV-2 RNA in NP, OP, nasal swabs or saliva was performed using reverse transcriptase polymerase chain reaction methods as previously described for the Viracor assay.[8] Viracor was among the first US laboratories to offer SARS-CoV-2 RNA testing as of March 13, 2020. Viral detection and quantification in plasma was performed using a reverse transcriptase polymerase chain reaction (RT-PCR) method which targets two regions of the SARS-CoV-2 nucleo-capsid (N) gene using TaqMan chemistry. This assay is a modification of an assay approved by the Food and Drug Administration (FDA) under emergency use authorization (EUA) guidelines for qualitative detection of SARS-CoV-2 in respiratory samples. Nucleic acid extraction was performed using the ThermoFisher KingFisher FLEX instrument with MagMAX Viral/Pathogen Nucleic Acid Isolation reagents. Amplification was performed using the Applied Biosystems™ 7500 Fast Real-Time PCR Systems (SDS v1.5.1) with TaqPath 1-step RT-qPCR master mix CG reagents. A total of 15 µL nucleic acid was amplified in a 30 µL reaction volume. The thermocycling protocol was as follows: 25˚C for 2:00 (1 cycle), 50˚C for 15:00 (1 cycle), 95˚C for 2:00 (1 cycle), 95˚C for 0:03, 60C for 0:30 (45 cycles). For quantification, a standard curve was used by amplifying 10-fold serial dilutions (75 copies/mL to 7.5 x 10^7 copies/mL) of *in vitro* transcribed RNA prepared from the full SARS-CoV-2 N gene. The copies/mL value for each sample which generated a cycle threshold value was calculated using the slope and y-

intercept derived from linear regression of the standard curve results.

The Boston Heart Diagnostics SARS-CoV-2 RNA assay is very similar to the Viracor assay except that this assay uses Thermo-Fisher TaqPath COVID-19 Combo kits (Waltham, MA) and targets a region in the N gene, a region in the spike (S) glycoprotein gene, and a region in the ORF1 gene. Positive values are those detected at a cycle threshold values of ≤37 cycles. Boston Heart Diagnostics began offering its testing as of April 17, 2020.

Diatherix began offering SARS-CoV-2 RNA testing as of March 16t, 2020, based on nested, end-point PCR technology that allows SARS-CoV-2 detection through target enrichment and amplification. The reaction process includes enrichment and tagging of the target, followed by traditional PCR amplification. First, nucleic acid is extracted from the sample. SARS-CoV-2 is amplified by low concentration nested gene-specific primers that are designed to enrich the targets during the initial PCR cycles. Inside nested primers have a unique tag sequence complementary to proprietary SuperPrimers (Fs and Rs), which are included in the primer mix. The universal SuperPrimers are used to amplify all targets by annealing to the complementary tag sequence on the inside nested primers. The reverse primer of the SuperPrimer set is labeled with biotin, which is incorporated into the resultant PCR product. In the procedure, universal SuperPrimers (Fs and Rs) are used to amplify all targets. The Rs primer is labeled with biotin for subsequent detection. Following PCR, amplicons are hybridized onto a Diatherix microarray in which a detection probe specific to the assay target is attached. Hybridization is followed by incubation with streptavidin-phycoerythrin (SA-PE), which binds to the biotinylated amplicon and emits fluorescence upon excitation. Results for SARS-CoV-2 are reported as 'Detected' or 'Not Detected' based on fluorescence intensity above background. The Diatherix SARS-CoV-2 assay has been validated to be used with the KingFisher Flex System (Thermo Fisher Scientific, Waltham, MA) utilizing extraction reagents from either Qiagen (ClearMag) or Omega Bio-tek (MagBind Viral DNA/RNA). RT-PCR reactions have been validated on and can be performed on the Applied Biosystems (ABI) GeneAmp 9700 or the Veriti 96-well Thermal Cycler (Thermo Fisher Scientific). Postamplification hybridization washes are performed using a Wellwash Versa Microplate Washer (Thermo Fisher Scientific).

Fluorescence signals are analyzed on the SensoSpot Fluorescence Low Density Microarray Analyzer (Sensovation AG, Radolfzell, Germany. The RNA assays in all three laboratories have received EUA approval from the FDA and have excellent sensitivity, reproducibility, and reliability.

Statistical Analysis

All statistical analyses were performed using R software, version 3.6.0 (R Foundation, Vienna, Austria) for comparisons between rates, and the statistical significance of differences between groups was assessed using the nonparametric Kruskal-Wallis method. Pearson correlation analysis was also performed using R.

RESULTS

Of 985,219 subjects having NP, OP, or nasal swabs done between March 13 and September 1, 2020 at various sites in 43 states, 10.1% were positive for SARS-CoV-2 RNA. The data from 38 states in which at least 100 swabs were submitted for testing are presented in Table 1. When we first tabulated these data on June 1, 2020, New York State had by far the highest percentage of positive subjects (43.5%); this rate decreased to 4.6%, when we included 104,195 tests done for health screening and for nursing home employees who had much lower positive rates of <4.0%. When a subset of 91 subjects, who served as convalescent plasma donors and had been positive for SARS-CoV-2 RNA based on NP swabs 2-4 weeks earlier, had repeat NP swabs and saliva collected, 58.6% were still positive based on NP swabs; but only 21.5% were positive based on saliva collection. These differences were statistically significant $P<0.01$). In our total study population, 18.2% were ≥65 years of age, of whom 6.9% were positive compared to 10.5% in the <65-year age group. Therefore, in the population we tested, older people did not have a higher positivity rate; in fact, it was lower ($P<0.0001$), even though it has been well documented that elderly subjects have a significantly higher case fatality rate than younger subjects.

When we compared our data with CDC state-wide data, for the 38 states where we had >100 cases/state, we noted a significant correlation for the percentage of positives (r=0.609, $P<0.0001$). We added Rhode Island to the data set because it is in the very high mortality, densely-populated northeast corridor of the US. As of September 1. 2020, the top ten states in the United States for cases/1 million were Louisiana, Mississippi, Arizona, Alabama, Georgia, Tennessee, South Carolina, Texas, New York, and Iowa (Table 1). However, the top ten US states in terms of deaths/1 million were New Jersey, New York, Massachusetts, Connecticut, Louisiana, Rhode Island, Mississippi, Arizona, Michigan, and Illinois. In terms of testing per 1 million, the top ten states were Rhode Island, New York, Louisiana, Connecticut, Illinois, Massachusetts, New Jersey, Tennessee, Michigan, and California.

In Figure 1, we have plotted the relationship between death and case rates per million by state (Panel A). These data are based on 19,898 cases/1 million and 593 deaths/1million in the US as of September 1, 2020, as well as 271,637 tests/1 million in the US population. As can be clearly seen in

Figure 1, the northeastern states of New Jersey, New York, Massachusetts, Connecticut, and Rhode Island (red circles) had the highest death rates per case, while the southern states (orange circles) of Louisiana, Mississippi, Alabama, and Georgia, and one western state Arizona had higher case rates, but generally much lower mortality rates. Western states (blue circles), especially Oregon, Wyoming, Washington, Colorado, Utah, and California, had the lowest mortality rates and also relatively low case rates. The overall correlation between deaths/1 million and cases/1million was 0.473 (P<0.0001). In Panel B, we plotted tests/1 million versus cases/1 million, and here we see a similar positive relationship with a correlation coefficient of 0.398 (P<0.0001). Clearly higher testing rates are not associated with lower case rates, but in fact, with higher case rates. Louisiana had the highest case rate as well as a high testing rate, while the converse was true for Oregon. Overall, the highest testing rates were observed in Rhode Island, New York, and Louisiana, all states with among the highest case rates.

We carried out a similar analysis for all countries in the world with populations >50 million, as well as other selected countries. This analysis included 47 countries. Of these, 3 countries were in Asia and Oceania; 11 countries were in Europe; 5 countries were in North America; 7 countries were in South America; 7 countries were in the Middle East; and 4 countries were in Africa (Table 2). As for US states, we also plotted these relationships in Panel A and B of Figure 2. The correlations between cases/1 million and deaths/1 million were similar to US states at 0.488 (P<0.0001), as were the correlations between cases/1 million and tests/1 million at 0.395 (P<0.0001). However, these relationships had to be plotted on log scales instead of linear scales because of the very large variability in rates between countries. Countries with the highest death rates generally also had the highest case rates and testing rates. These countries were all in Europe (Belgium, Spain, United Kingdom, Italy, Sweden, and France), North America (United States, Mexico, and Panama), and South America (Peru, Brazil, Chile, Columbia, and Argentina). The converse was true for many countries in Asia and Oceania (Vietnam, Myanmar, Thailand, China, South Korea, Japan, Australia, and New Zealand), and Africa (Nigeria, Kenya, and Ethiopia), with South Africa being an exception. Middle Eastern countries (Qatar, Israel, Iraq, Saudi Arabia, and Turkey) tended to have intermediate death rates, but high case and testing rates. Other very

populous Asian countries (India, Bangladesh, Pakistan, and the Philippines) had intermediate case rates, as well as fairly low death and testing rates. Similar relationships between case rates and testing rates were observed. As for US states, high testing rates were generally associated with high case rates.

DISCUSSION

The rapid spread of SARS-CoV-2 viral infection has been in large part due to its very contagious nature and the fact that many infected people are asymptomatic. Although the pandemic started in China, its spread there as well as in other countries in Asia, such as Thailand, Vietnam, Myanmar, South Korea, and Japan, has been quite well controlled. In these countries case rates have been <100/1 million and death rates have been <10/1 million. One cannot attribute this excellent infection control to testing, but rather to excellent public health measures including isolation of cases, contact tracing, social distancing, and the wearing of face masks. It is interesting that even in countries such as India, Bangladesh, the Philippines, and Australia, all with >1,000 cases/1 million, death rates have been <60/1 million. In contrast, subjects in Europe, North America, and South America have fared far worse with case rates generally >5,000/1 million and death rates >500/1 million, despite a large amount of testing. In the northeastern and southern US states, case rates have generally exceeded 15,000/1 million; and death rates have been >1,000/1 million, despite a lot of testing.

Rates in the United States (19,898 cases and 593 deaths per million) and Brazil (19,919 cases and 609 deaths per million) were comparable in cases and deaths, due to limited public health measures. In contrast, Japan (579 cases and 11 deaths per million), South Korea (430 cases and 7 deaths per million), China (59 cases and 3 deaths per million), and Thailand (50 cases and < 1 death per million) had much lower rates, presumably due to significantly better public health measures. Many European countries had case rates lower than the United States, but comparable death rates. The importance of public health measures may best be exemplified by comparing Sweden, which did not introduce such measures, to its neighbors Norway and Finland, which did introduce such measures. Sweden had case and death rates of 8,555/1 million and 578/1 million, respectively, while Norway and Finland had case and death rates of <2,500/1 million and <65/1 million, respectively. These great differences occurred despite the fact that these countries had fairly equivalent testing rates.

There may be some other potential causes of the large variability in case and death rates between countries. One such possibility is mutations in the virus. The D614G amino acid substitution in the S

glycoprotein encoded by the SARS-CoV-2 S gene has been reported to result in a form of the virus that is more infective and virulent than the original Wuhan strain.[9-13] This variant has been found in over 90% of United States strains. Another possibility is human genetic variation. Genome-wide association studies have identified a 3p21.31 DNA locus as being associated with a significant 1.77-fold increased risk for respiratory failure in hospitalized COVID-19 patients.[14] This genetic variant, apparently inherited from Neanderthals, is not present in subjects indigenous to China, Japan, or Sub-Saharan Africa, and has a frequency of ~5–8% in North America and western Europe and ~20% in India.[15] Therefore, both viral and human genetic variation may play a role in country differences with regard to SARS-CoV-2 cases and mortality rates.

Recently, there has been a significant increase in SARS-CoV-2 RNA testing in the United States in an effort to control the pandemic in the absence of vaccines. There have also been efforts to find easier ways to carry out such testing. Despite data from Yale New Haven Medical Center indicating that self-collected saliva samples yielded similar or better results than did NP swabs in terms of detecting SARS-CoV-2 positive hospitalized patients based on 44 paired samples, our data in previously positive outpatients did not support these findings. Our data indicated that saliva analysis only found about half as many positive cases than did NP swab analysis. Moreover, data has indicated that rapid antigen testing for SARS-CoV-2 protein is not nearly as sensitive or accurate as RNA testing. Our overall data strongly supports the benefits of public health measures in preventing spread of SARS-CoV-2 infection. In our view the major reason for the very high cases and mortality rates in the United States has been the consistent lack of such measures, due to failures of government and public agency leadership.

CONCLUSIONS

Our data indicate that 1) outpatient saliva testing is not as sensitive as NP testing in detecting SARS-CoV-2 RNA; 2) the marked variability in the case and death rates between states and countries is due mainly to differences in public health measures; 3) variation in SARS-CoV-2 genetics and human genetics may also play a role in such differences; and 4) these difference are least likely to be due to lack of adequate testing.

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FIGURE LEGENDS

FIGURE 1 COVID-19 death and testing rates relative to case rates in the United States as of September 1, 2020. The reported cases of COVID-19 per 1 million people are presented by state versus the reported deaths due to COVID-19 (Panel A) and versus the reported tests for COVID-19 (Panel B). Red circles indicates states in the Northeast; green circles, states in the upper Midwest; purple circles, states in the lower Midwest; orange circles, states in the South; and blue circles, states in the West. Linear scales were used.

FIGURE 2 COVID-19 fatality and testing rates relative to case rates world-wide as of September 1, 2020. The reported cases of COVID-19 per 1 million people are presented by country versus the reported deaths due to COVID-19 (Panel A) and versus the confirmed tests for COVID-19 (Panel B). Blue circles represent Asia; gold circles, Europe; red circles, North America; orange circles, South America, purple circles, Africa; and green circles, the Middle East. Log scales were used.

TABLE 1 SARS-CoV-2 RNA positive rates by states with >100 tests (Eurofins testing)

	Centers for Disease Control and Prevention*				US Eurofins Laboratories	
State	Cases/1 M	Deaths/1M	Tests/1M	% Positive†	Tests Done	% Positive†
Alabama	27,648	469	213,913	12.9%	80,122	11.3%
Arizona	28,439	724	212,248	13.4%	666	11.3%
Arkansas	22,137	311	263,827	8.4%	15,858	8.4%
California	19,026	357	313,574	6.1%	13.537	3.3%
Colorado	10,451	344	132,079	7.9%	7,867	5.3%
Connecticut	15,172	1,256	366,654	7.0%	461	3.9%
Delaware	18,964	630	263,614	7.2%	4,994	4.9%
Florida	18,152	257	149,698	16.8%	114,777	16.2%
Georgia	27,231	584	266,430	16.2%	138,058	16.2%
Illinois	20,306	668	361,094	5.6%	9,814	6.1%
Indiana	15,187	507	235,365	9.0%	10,469	8.5%
Iowa	23,059	383	218,251	10.6%	1,506	6.7%
Kansas	16,618	173	151,516	9.1%	21,102	6.9%
Kentucky	12,260	232	211,175	5.8%	39,801	8.9%
Louisiana	33,343	1,110	432,281	7.7%	12,132	9.2%
Maryland	17,925	633	307,528	5.8%	1,150	7.3%
Massachusetts	18,976	1,330	351,991	5.4%	2,559	8.8%
Michigan	12,101	690	334,024	3.6%	27,113	10.2%
Mississippi	29,963	897	226,010	13.3%	4,007	20.7%
Missouri	14,584	294	188,111	7.8%	53,657	3.6%
Nebraska	19,320	222	203,857	9.5%	9,807	12.3%
New Jersey	22,394	1,817	350,550	6.4%	2,513	8.6%
New York	24,419	1,702	435,364	5.6%	175,814	4.6%
North Carolina	17,233	285	240,448	7.2%	62,627	7.8%
Ohio	11,481	373	212,462	5.4%	20,810	10.9%
Oklahoma	11,956	221	249,515	4.8%	9,122	12.7%
Oregon	6,794	118	141,121	4.8%	1,551	8.5%
Pennsylvania	11,507	618	139,516	8.3%	9,216	4.5%

	Centers for Disease Control and Prevention*				US Eurofins Laboratories	
State	Cases/1 M	Deaths/1M	Tests/1M	% Positive†	Tests Done	% Positive†
Rhode Island	19,518	1,007	512,898	3.8%	–	–
South Carolina	24,587	587	213,327	11.5%	23,399	13.0%
South Dakota	11,818	200	213,327	5.5%	1,496	2.5%
Tennessee	24,635	291	349,723	7.0%	60,992	10.0%
Texas	23,520	490	313,574	7.5%	17,249	18.5%
Utah	17,473	134	274,732	6.4%	1,487	4.5%
Virginia	15,423	318	218,274	7.1%	2,938	12.6%
Washington	10,637	261	209,850	5.1%	2,683	3.6%
West Virginia	6,793	147	263,104	2.2%	1,158	3.9%
Wisconsin	14,548	205	228,483	6.4%	1,918	5.0%
Wyoming	7,255	73	222,787	3.3%	995	5.2%

As of September 1, 2020, there were 19,898 cases/1M, 593 deaths/1M, and 271,637 tests/1M in the United States, for a 7.3% positive rate. Eurofins data based on PCR testing of 985,219 subjects in 47 states (39 of which with >100 cases are reported above) had a 10.1% positive rate.

*Testing as reported on the following websites: https://www.cdc.gov/covid-data-tracker/index.html#cases and www.worldometersinfo/coronavirus.

†Pearson correlation between total reported state positive rates and US Eurofins Laboratories positive rates was r = 0.609 (P<0.001).

1M, 1 million people.

TABLE 2 SARS-CoV-2 cases, deaths, and testing per million in the population

Country	Cases/1 M	Deaths/1M	Tests/1M	% Positive	Case Fatality Rate
ASIA AND OCEANIA					
China	59	3	111,163	0.01%	5.09%
India	3,331	56	39,127	8.5%	1.68%
Bangladesh	2,029	28	10,331	19.6%	1.38%
Pakistan	1,355	29	12,989	10.4%	2.14%
South Korea	430	7	41,645	1.0%	1.63%
Japan	579	11	13,150	4.4%	1.90%
Thailand	50	0.8	10,728	0.4%	1.60%
Vietnam	11	0.4	10,349	0.1%	3.64%
Myanmar	48	0.3	3,519	13.6%	0.63%
Philippines	2,303	37	27,334	8.4%	1.61%
Indonesia	770	31	9,418	8.2%	4.03%
Australia	1,049	33	280.640	0.3%	3.15%
New Zealand	362	5	177.869	0.2%	1.38%
EUROPE					
Russia	7,207	126	273,473	2.6%	1.75%
Spain	11,851	635	213,594	5.5%	5.36%
Italy	4,712	589	159,706	3.0%	12.50%
Belgium	7,808	855	218,293	3.6%	10.95%
United Kingdom	5,270	612	259,284	2.0%	11.61%
France	5,420	472	153,134	3.5%	8.71%
Germany	3,095	112	160,267	1.9%	3.62%
Sweden	8,555	578	123,669	6.9%	6.76%
Norway	2,219	49	158,419	1.4%	2.21%
Finland	1,544	61	144,425	1.1%	3.95%
Ukraine	3,406	70	40,712	8.4%	2.06%
NORTH AMERICA					
United States	19,898	593	271,637	7.3%	2.98%

Country	Cases/1 M	Deaths/1M	Tests/1M	% Positive	Case Fatality Rate
Canada	3,569	242	158,162	2.3%	6.78%
Mexico	5,049	539	11,462	44.1%	10.68%
Panama	23,041	491	88,850	25.9%	2.13%
Guatemala	4,467	162	15,020	29.7%	3.63%
SOUTH AMERICA					
Brazil	19,919	609	68,148	29.2%	3.06%
Peru	21,478	918	104,573	20.5%	4.27%
Columbia	13,624	437	60,070	22.7%	3.21%
Argentina	11,578	243	33,436	34.6%	2.10%
Chile	22,484	619	143,814	15.6%	2.75%
Bolivia	10,612	605	22,779	5.7%	5.70%
Ecuador	6,398	607	18,875	33.9%	9.49%
MIDDLE EAST					
Iran	4,724	272	41,662	11.3%	5.76%
Turkey	3,389	82	97,177	3.5%	2.42%
Iraq	6,893	193	42,536	16.2%	2.80%
Israel	16,152	119	284,859	5.7%	0.74%
Saudi Arabia	9,291	121	161,668	5.7%	1.30%
Qatar	43,196	73	242,408	17.8/%	0.17%
Egypt	979	54	1,314	74.5%	5.52%
AFRICA					
South Africa	10,839	257	64,983	16.7%	2.37%
Ethiopia	553	9	9,791	5.7%	1.63%
Nigeria	270	5	2,092	12.9%	1.85%
Kenya	666	11	8,926	7.5%	1.65%

As of September 1, 2020, there were 28,649,518 cases (3,675/1M) and 919,517 deaths (118/1M) worldwide.

Data as reported on the following websites: https://www.who.org and www.worldometersinfo/coronavirus.

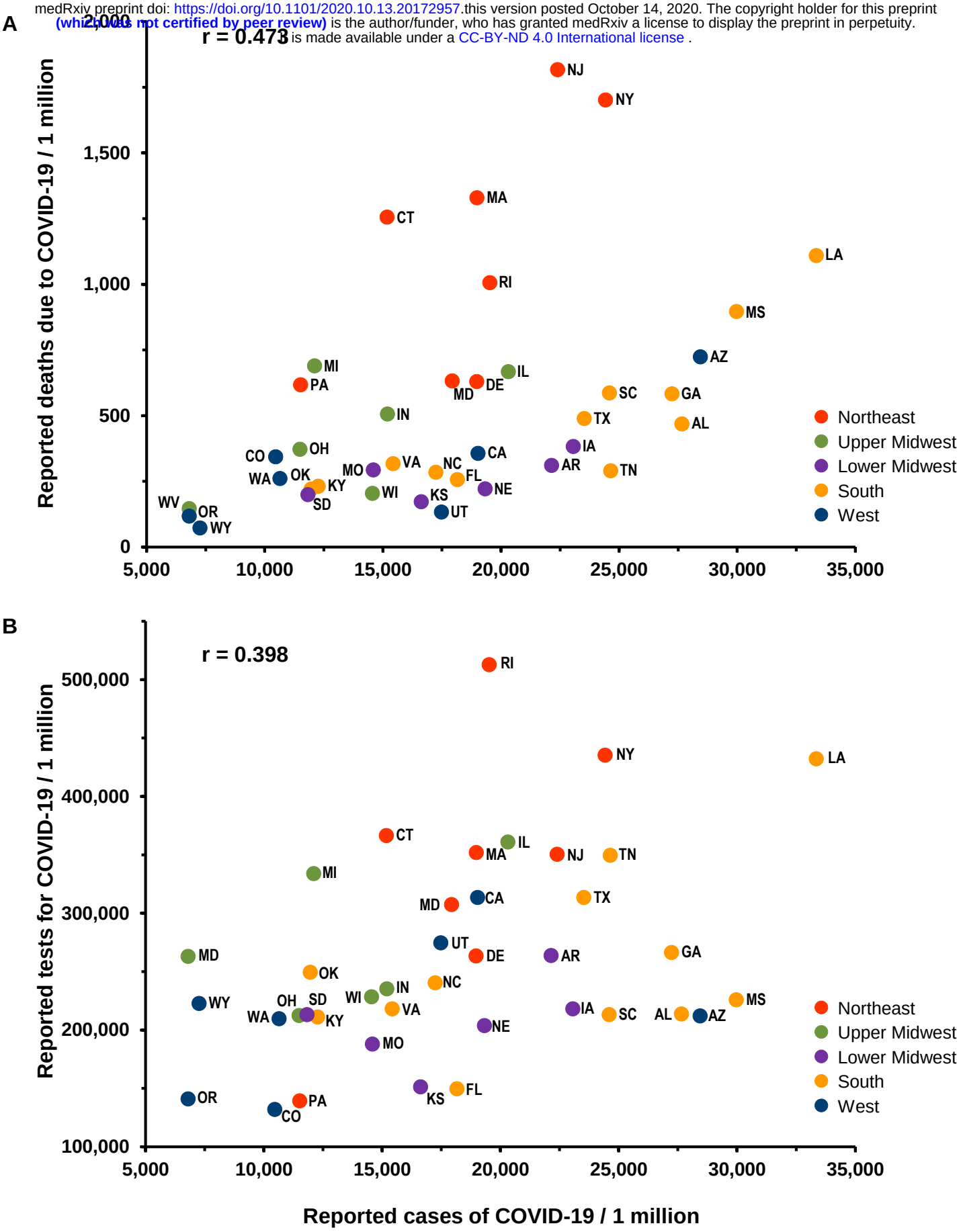

FIGURE 1 COVID-19 death and testing rates relative to case rates in the United States as of September 1, 2020. The reported cases of COVID-19 per 1 million people are presented by state versus the reported deaths due to COVID-19 (Panel A) and versus the reported tests for COVID-19 (Panel B). Red circles indicate states in the Northeast; green circles, states in the upper Midwest; purple circles, states in the lower Midwest; orange circles, states in the South; and blue circles, states in the West. Linear scales were used.

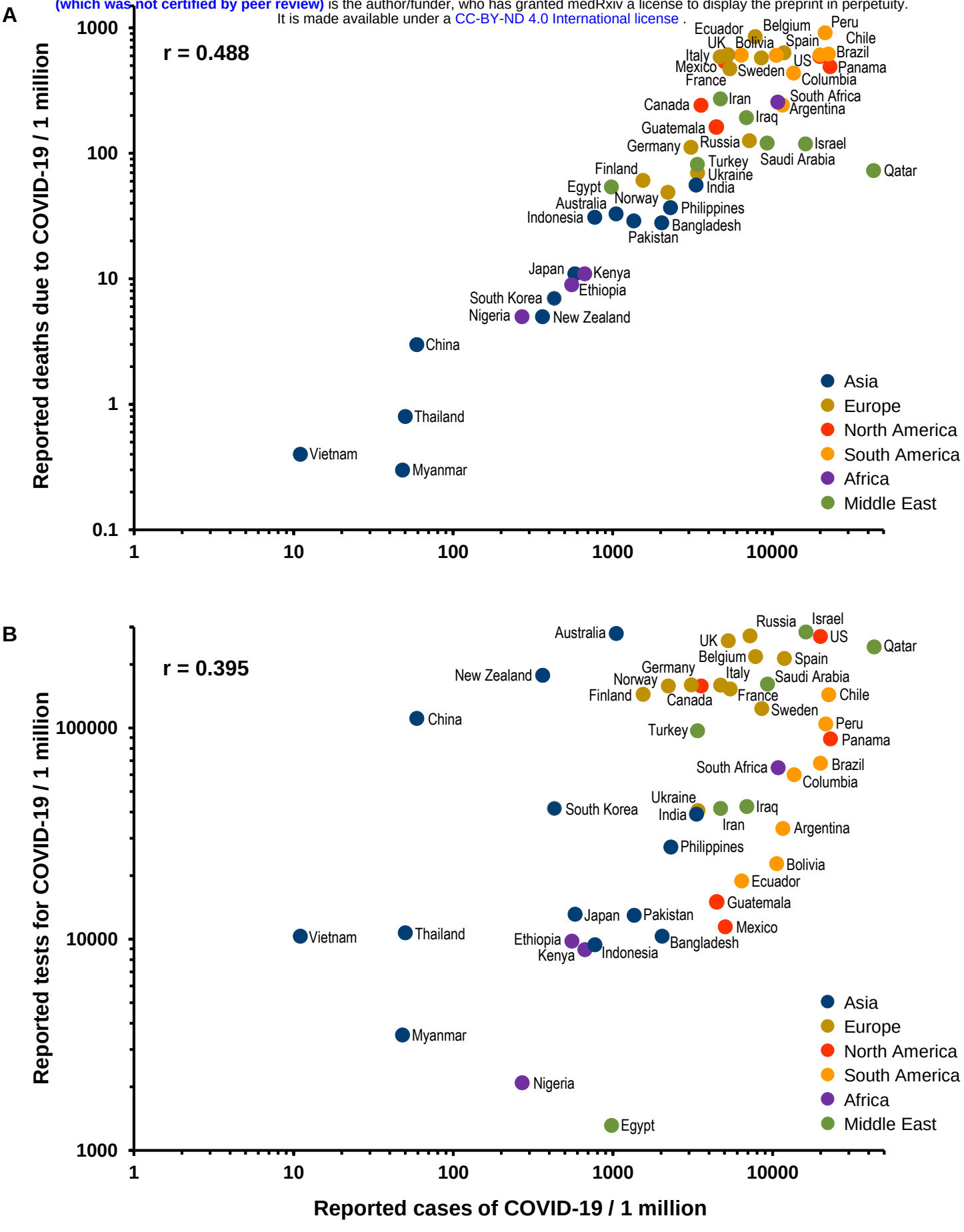

FIGURE 2 COVID-19 fatality and testing rates relative to case rates world-wide as of September 1, 2020. The reported cases of COVID-19 per 1 million people are presented by country versus the reported deaths due to COVID-19 (Panel A) and versus the confirmed tests for COVID-19 (Panel B). Blue circles represent Asia; gold circles, Europe; red circles, North America; orange circles, South America, purple circles, Africa; and green circles, the Middle East. Log scales were used. UK, United Kingdom, US, United States.