Understanding Elementary Statistics on COVID-19: What do they measure? & How to use them?

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The Statistics and What They Measure

1) IR= Infection rate = total or cumulative # of Covid-19 cases per million persons in the population

IR measures how many persons have contracted the virus relative to its total population at a point in time.

Usefulness, comparing any two countries (or areas) at similar times after identification of the first few cases. For instance, 30 days after the first case. It measures the rate of spread of the virus at a given distance in time from its arrival.

2) TR = Testing rate= cumulative # of COVID -19 tests performed per million persons in the population

TR measures the number of COVID-19 tests performed at any point in time relative to the number of persons in the population.

Usefulness, not much by itself. Essential in conjunction with the infection rate to generate.

3) POR = Positivity Rate = IR/TR= total # of COVID-19 cases relative to the number of tests given.

POR measures how fast COVID-19 is spreading in a country at a point in time, especially accurate when multiple tests to same person excluded from TR. It is still useful as an estimate even if multiple tests to same person not excluded, because we know it biases positivity rate downwards.

Comments based on use experience since August 5. First, it is a very useful leading indicator of the state of the pandemic with respect to the transmission of the infection within any spatial unit. Second, by using the cumulative figures for both infections and testing evaluated every two weeks, it is a very robust indicator of the actual state of the pandemic spread at that point in time, in contrast to daily comparisons or even weekly moving average comparisons. Third, the results show that keeping this rate substantially below 1% as well as stable or decreasing was the most effective tool in preventing the worst welfare outcome of the pandemic, namely deaths per capita. This was true for the analysis focusing on Australia and New Zealand relative to the US, the UK and Canada between September 4 and December 11 and corroborated by other experiences such as China relative to Europe and, to a lesser extent, even relative to Japan and South Korea.

4) DR= Death Rate = cumulative number of COVID-19 deaths per million persons in the population.

DR measures how many people have died from the virus relative to a country's total population at a point in time.

Usefulness, comparing most damaging unsuccessful outcome between countries or, more generally, spatial units at any point in time.

Comments based on use experience since August 5. First, it is a very useful indicator of the most damaging direct welfare consequence of the pandemic at any point in time for any spatial unit. Second, it is a robust indicator of this welfare consequence of the pandemic across spatial units at the same

points in time relative to the beginning of the pandemic. For instance, at the end of the pandemic or at the start and end of first or second waves, however defined, as long as the definitions keep the time-period of evaluation fixed such as weekly or biweekly. Third, it generates observable characteristics identifying population subgroups experiencing different incidence of this important welfare consequence in the population. The latter is useful for both health, social and economic policy purposes. Finally, it is a very useful lagging indicator of the state of the pandemic.

5) $\%\Delta DR = [(DR_t - DR_{t-1})/DR]100$ = percentage change in the cumulative death rate per capita over the last two- week period.

% ΔDR measures the state of the pandemic in the last two- week period by looking at the growth rate in its main lagging indicator.

Usefulness, it provides a dynamic measure (every two weeks) of the evolution of the state of the pandemic in a spatial unit at a point in time as a result of prior spread, behavior and policy actions wrt to implementation of both Non-Pharmaceutical Interventions (NPI's) and/or Pharmaceutical interventions (PI's).

Comments based on use experience since August 5. I found the earlier statistic (HSPR = DR/IR) mechanically useful but interpretatively almost useless because it was affected by too many variables. First, it would depend on the basic determinants of the rate of spread such as time of introduction into the spatial unit, population size and density, as well as spatial distribution of virus mutations within the spatial unit (Ives & Bozzuto 2020, p.19 and p. 28; https://doi.org/10.1101/2020.06.18.20134700). Incidentally, the latter reference relies on the death rate per capita across US counties as its basic data in estimating the rate of spread of the virus in its original state, i.e., prior to any intervention by either the population or policy makers. Second, it would also depend on policies implemented to deal with the pandemic, quality of medical facilities and personnel as well as on habits and attitudes of the population wrt to masks, social distancing, testing and contract tracing. Explaining variations in this statistic would be far more appropriate for a professional research project than for an educational one.

Starting on November 11, I began to notice that variations in the percentage change of two- week per capita deaths (% ΔDR) were useful in understanding the state of the pandemic at a point in time in different countries, especially in conjunction with the change in the two- week positivity rates. Thus, I decided to change to this indicator as a far more useful elementary statistic in the context of an educational memo and in view of the looming introduction of experimental vaccines and treatments as pharmaceutical interventions in the pandemic.

Additional Comments on How to Use Them.

The earlier biweekly comments on how to use the positivity rates and the death rates are still valid, applicable and available on the development section of my home page at (http://econweb.umd.edu/~betancourt/development.htm) in the file titled "Understanding Elementary Pandemic Statistics.Final Form.Sept/Dec.2020". The data source continues to be the same, Worldometer; the basic countries analyzed in detail continue to be the same (US, UK, Canada, Australia and New Zealand). The additional 13 countries added for robustness to check the analysis as well as the two US states (MD and FLA) continue to be the same. The main change henceforth is that the third statistic reported every biweekly period in the table is the percentage change in the last two weeks of

cumulative deaths per million persons in the population of the spatial unit, % ΔDR as defined above. In order to preserve continuity, I have replaced the HSPR measure with the %ΔDR in the first two tables of the earlier file (starting whenever feasible from the prior data) and included them here. The detailed new analysis here starts with the two- week period ending on December 25. The data for that date starts on the third table.

Main Insights of August to December Analysis Useful for the Design of Future Exercises or Projects.

1. The use of cumulative infection and testing rates to construct positivity rates provides a robust elementary statistic to evaluate the effectiveness of policies during the evolution of the pandemic. In the relative early stages covered by the period March-December, it shows the superiority (in keeping deaths per capita low) of a vigorous approach to prevent spread by keeping the positivity rate substantially below unity and stable or decreasing. Moreover, the main policies to prevent spread during these early stages are NPI's.
2. The use of cumulative deaths per capita provides a robust elementary statistic to evaluate the main direct welfare outcome of the pandemic across spatial units during the evolution of the pandemic. In the relatively early stages covered by this period, it shows that positivity rates above unity generate a variety of possible trends for this important outcome variable that include reversals of fortune across countries with respect to its level.
3. The use of percentage changes in cumulative deaths per capita levels over the last two- week period provides a dynamic elementary statistic to evaluate the effectiveness of policies during the evolution of the pandemic that should yield new insights in two different ways. First, by itself, it shows the recent impact on the main direct outcome of the pandemic of prior policies of all types and a population's behavioral responses to these policies at a point in time. Second, in conjunction with the trend of prior positivity rates, it suggests acceleration or deceleration in the state of the pandemic through its own trends due to its role as a lagging indicator of the state of the pandemic. The latter might yield insights on the direct and indirect impact of treatments and vaccines during the evolution of the pandemic.

What do we learn from the December 25 updates in the context of this major revision and recent pandemic related developments?

First, something we already knew that is worth reiterating more explicitly. The statistics presented here based on cumulative data are complementary not substitutes for the ones presented in the media based on current new infections, hospitalizations, testing and deaths per capita. The cumulative ones are relevant to evaluate strategies or broad policies during the evolution of the pandemic; the current ones are relevant for evaluation of tactics or crisis management actions at a particular point in time. While there are plenty of good news in the medium to long-term future, the news in the short-term future are less attractive.

In the USA, the effects of cold weather and Thanksgiving (November 26) become evident in the Table data. The positivity rate starts from a high of 7.5% on September 4; it decreases steadily to a low of 6% by October 30; and it increases steadily to a new high of 7.9% on December 25. The two- week deaths per capita growth rate increases steadily from a low of 4.7% on October 16 to a high of 12.4% by December 25. That increase implies a doubling of per capita deaths about every 11 weeks if maintained,

which is unlikely. Yet, deviation of this possibility from actual behavior is a direct measure of the ability to engage in collective action by the inhabitants of the spatial unit.

In the UK, the main news is a virus mutation discovered in September that epidemiologists consider as probably more contagious but not necessarily more virulent than the original. It appears with increasing frequency in London and the Southeast area of England in current data. This interpretation of the new mutation is consistent with our results for the whole country. The positivity rate in the UK remains the same until October 16 when it increases to 2.3% and continues to increase every two weeks to reach 4.2% on December 25. On the other hand, the two-week growth rate of deaths per capita has slowed down recently. Starting at a low of 0.5% on September 18, it reaches a maximum of 11.9% on November 27 and is at 10.4% on December 25.

Canada's experience differs from both the USA and the UK. By October 16, its positivity rate is the same as the UK at 2.3%, despite a much higher start on September 4 of 7% relative to the UK's 1 .9%. Since then, however, Canada's positivity rate remains below the UK's, ending at 4% on December 25. It does much better than the UK (or the US) in mitigating the worst welfare outcome of the pandemic, experiencing death rates at or below 40% of those of the UK until December25. The increase in the two-week deaths per capita growth rate resembles that of the USA instead of the UK in that it is increasing while in the UK it is decreasing since November 27. It is worth noting that the Canadian Thanksgiving, which is associated with harvest time, took place on October 12 and the Canadian winter started earlier than in the US because Canada lies at higher latitudes than the US except for Alaska. Thus, despite better NPI practices and policies, having to go inside seems to have had a substantial negative impact on Canadian welfare outcomes as measured by this lagging indicator. The trends for Australia and New Zealand remain as before despite isolated outbreaks especially in Australia.

The results for Europe are quite similar to the previous two-week period. Spain and France improved their situations by lowering the growth of deaths per capita substantially and keeping positivity rates the same or lower although still at high levels. Italy, Germany, and Denmark experienced increases in their positivity rates while growth in per capita deaths over the two week- period remained substantially above 10 %. In Germany and Denmark, which were starting from a low level of death rates per capita, these increases should be worrisome since they exceeded 20% per two-week period.

In the next set of spatial units, Japan and Korea are experiencing increasing positivity rates since October 30 and November 13, respectively. Not surprisingly, their death rates per capita are starting to grow, especially in Japan which has had a positivity rate at least thrice as high as Korea during the eight two-week periods. China and Cuba remain stable, just as before, while Jamaica continues to experience a decrease in the two-week growth rate of deaths per capita while maintaining the same level of its positivity rate as in the previous period.

Finally, in the last set of spatial units, Chile continues its previous trend with respect to declining positivity rates and low growth rates in two-week per capita deaths. Maryland shows increasing positivity rates since November 13 and increases in the growth of two-week per capita deaths since October 16. This pattern is similar to the overall USA pattern as well as consistent with recent lockdown measures imposed throughout the state, e.g., restrictions on inside dining in restaurants. Florida is likely to face difficult circumstances in a month or two due to the following considerations. Slightly increasing positivity rates from an 8% level since October 30; high and since November 13 growing levels of deaths

per capita; and a governor that de-emphasizes NPI's, e.g., Florida has a testing rate that is only 89% of Maryland's as of December 25 but a population 3.6 times larger than Maryland!

What do we learn from the January 08 updates in the context of recent pandemic developments?

Among recent pandemic developments in the press, the new more contagious mutation from the UK has spread in Europe and it has already appeared in several US states. In addition, a new variant also believed to be more contagious appeared in South Africa. On the positive side, three vaccines from Western sources have moved into the actual vaccination process worldwide. Similarly, one vaccine from Russia and two from China are into the vaccination process beyond their borders. Vaccines, however, minimize impact on a person but their impact on contagion is not clear in general until reaching herd immunity. Incidentally, today I witnessed a very smooth well-organized and efficient vaccination process for category 1a vaccine candidates at a community center in Maryland. It took 35 minutes from arrival 10 minutes before appointment time to returning to the car, including a 15-minute waiting period for side effects observation. Caveats. 1) While this is just one vaccination center, it took place in a state not known for its logistical competence (ranked 8th from the bottom this week). 2) We have yet to see what happens with the second dose in four weeks. The latter outcome might be subject to the risks of a change in policy with uncertain benefits and costs at the federal level (delaying the second dose to reach more persons) from a new administration that may be impossible to impose consistently at the local levels for a wide variety of medical, logistical and even political reasons.

The USA figures reveal a continuation of an increasing trend in positivity rates at already high levels, but at least the increasing two- week death rate peaked for the time being. What the Christmas holiday effects will be on the latter will become clear over the next four weeks. In the UK, there was an acceleration of the persistently increasing positivity trend in the last two weeks as well as an acceleration of the two- week death rate beyond its Thanksgiving peak. Thus, it provides further support for the need of stricter lockdown measures recently introduced. In Canada, both the positivity rates and the two- week death rates exhibit persistently increasing trends, which suggests that Canada may eventually need to supplement their earlier more relaxed NPI policies with more aggressive ones such as increased testing or stricter lockdowns. Four weeks ago, the ratio of deaths per capita for the UK/Canada comparison was 2.68; today it is 2.64. Since deaths are increasing in both countries, they are doing so faster in Canada. Infections have increased in Australia and New Zealand recently but the increase in testing (not shown in the table) was 5% higher in Australia, which decreased the positivity rate. There were no changes in death rates.

In Europe, lockdown restrictions have managed to restrain the rate of increase in positivity rates and to decrease the two-week percentage change in the death rate substantially in Spain, Italy and France but not in Germany and Denmark. In the next set of spatial units, Japan and South Korea have experiences similar to Germany and Denmark. It has led to a stricter lockdown announcement in Japan. China has an increase in infection rates, which fails to show in the positivity rate at this level of aggregation. There are no reported changes in the death rate. Cuba experiences observable increases in positivity rates and percentage death rates over the last two weeks. Jamaica 's positivity rate oscillates between October 30 and January 8 whereas the two-week percentage change in the death rate steadily decreases during this period. Finally, with respect to countries, Brazil continues to exhibit very high positivity rates by any standard together with oscillating and single digit two-week percentage changes in death rates. Chile continues to decrease its positivity rate and exhibits oscillating percentage change in two-week death

rates. El Salvador exhibits increasing positivity rates and increasing percentage changes in two-week death rates over the last four weeks. In terms of US states, both Maryland and Florida exhibit increasing positivity rates over the last four weeks as well as percentage change decreases from previous peaks in their two-week death rates. Since Florida's positivity rates are about 60% higher than Maryland's and its testing rate 77% lower, the possibilities of a dramatic surprise from the Christmas effect in the next two to four weeks are also higher.

Parenthetically, the frequency of updates differs for different items in Worldometer's data tables for the same country. For instance, death rates updates often take place more than once within the same day, at least for the USA, but population updates occur every several days. If you are calculating ratios, this can generate different results than updating all items with the same frequency. Moreover, the frequency of updates can also differ across countries. Indeed, pandemic data availability depends on a country's health authorities decisions not on any data source. The latter simply decide when to report what is available, which is probably as soon as possible. I have only found three peculiarities that may be due to this feature and reported them wherever relevant, either in a table footnote or in the text.

What do we learn from the January 22 update in light of recent developments?

First, examples of the good news. As of January 20, the USA has a new President who takes responsibility for addressing COVID-19 effectively. On this date, he made mask wearing and social distancing mandatory in all federal properties. On the next day, he issued 10 additional executive orders on the topic. In Germany and Austria masks (surgical or N95) became required in some public places. Second, examples of the bad news. The current waves of the pandemic are in full force in the USA and elsewhere due to winter, new varieties, failures in vaccine production and/or distribution, remnants of previous waves, or all of the above considerations. While in the USA a promise of 20 million vaccines by the end of December 2020 was made by the Trump administration, it led to only 14 million actually administered by January 19 2021 (Washington Post, January 21, 2021, page A4, "Biden is inheriting a disaster…"). In Europe, the European Commission failed to secure an adequate supply of the first two available vaccines. Ironically, a German company that jointly developed one of them explained the problem in terms of failures to order in time due to the Commission assuming all vaccines would be available at the same time (https://www.theguardian.com/world/2021/jan/01/france-to-step-up-covid-jabs-after-claims-of-bowing-to-anti-vaxxers). That is, trying to prevent market failure generated government failure. Impact of vaccines will take many weeks if not months to materialize.

Meanwhile, the positivity rate continued to increase in the USA and the two-week per capita death rate resumed increasing at a higher rate than the previous two-digit one. The latter probably reflects the lagged consequences of holiday travels and family reunions. Similarly, the positivity rates in the UK continue their increasing trend since early October and the two- week per capita death rates exhibit a substantially increasing trend since Christmas. The latter is probably due to the lagged consequence of the dominance of the new UK variant. In the last two weeks, Canada has been able to stop its increase in the positivity rate and to decrease its two-week per capita death rate. One measure instituted on January 7 2021 was a requirement for passengers 5 years old and older to show a negative COVID-19 test result using one of two approved tests (which exclude antigen tests) 72 hours prior to boarding flights into Canada. Within Canada, some territories discourage non-essential travel into or out of the territory, e.g., British Columbia. In Australia and New Zealand, infection rates have increased but not

enough to impact positivity rates at this level of aggregation or even the death rate per capita at any level of aggregation.

In Europe, lockdown restrictions have helped Italy, France and Denmark to decrease or maintain their positivity rates but failed to do so in Germany and Spain, which raises the need for further actions in both of these countries and especially in Spain. The lagged consequences of previous efforts at containment and mitigation have increased the two-week per capita death rate in Spain and France, left Italy's unchanged (all at levels below 10%), and decreased Germany's and Denmark's (the latter two still remain at levels over 20%). Among the next set of spatial units, Japan experienced significant increases in its positivity rate and in its two-week per capita death rate, which begins to raise doubts about the summer Olympics. South Korea was able to lower both its positivity rate and two-week per capita death rate. China's infection rate increased but not enough to affect its positivity rate or two-week per capita death rate. Cuba's positivity rate and two-week per capita death rate increased substantially, suggesting the need for more restrictive measures. Jamaica maintained its positivity rate constant at a high level and, not surprisingly, experienced a significant increase in its two- week per capita death rate. Brazil, Chile and El Salvador continued earlier patterns. Steady improvements for Chile and steady deterioration for Brazil and El Salvador. Similarly, Maryland and Florida continued earlier trends. Both were unable to lower spread by decreasing positivity rates but Maryland was able to continue mitigating outcomes by lowering the two-week per capita death rate while Florida continue to experience increases, reaching double digit rates for the first time.

What do we learn from the February 05 2021 update in light of recent developments?

*First, the Good News on Recent Developments***:** On vaccines, President Biden has assumed responsibility for production and distribution of the available vaccines into people's arms. Besides Moderna and Pfizer, a Johnson & Johnson vaccine may receive Emergency Use Authorization by FDA in the USA soon. The EU has approved AstraZeneca-Oxford. Other available vaccines seem effective (Sputnik, the 2 Chinese ones and one from India). Only one vaccine (from Merck) under trial failed to provide sufficient immunity at this stage of the pandemic. On variants, it seems the available vaccines are effective against the variants, especially the UK one, but extent of effectiveness, especially for others, is not yet clear. *Second, the Bad News*: On vaccines, while the production phase seems under control, the distribution phase has been very chaotic and is not under control, at least in most Western advanced economies. In the case of vaccines in the US, distribution issues are hard to address due to two factors on the supply side and two others on the demand side. The former are the refrigeration needs for the two widely available vaccines (limits location sites) and the need for qualified personnel to administer the vaccine into persons' arms. The latter are misinformation and distrust for vaccines affecting behavior of citizens and state and local governments' limitations or ineptitude in providing reliable services (appointment allocations) under tight budget constraints, local supply uncertainty and incompetence in reconciling conflicting objectives (efficiency and equity in distribution). On variants, the UK one is widespread in Europe, as well as in half of US states and especially in Florida. At least two confirmed cases of the South Africa variant are already in South Carolina, and three in Maryland; a confirmed case of the Brazil variant is in Minnesota.

General Observations: 1) Incompetence in service delivery at the state and local level provides advocates of centralized alternatives to democracy with attractive arguments. Survey evidence suggests this issue is relevant for young age cohorts in Australia as a result of the pandemic as noted by John Lee in a January 29, 2021 seminar on 'The Future of Democracy in Asia '

(https://www.brookings.edu/events/the-future-of-democracy-in-asia/). 2) lock-down restrictions in the US are not as severe as in other countries that have brought the virus under control. For example, in Australia or Singapore approved international travelers have to quarantine at least for 14 days after arriving into the country in addition to taking a COVID test upon arrival. In Singapore, if you are coming in from the UK or South Africa, you have to do so for 21 days rather than for 14 due to the spread of the new variants. Interestingly, recent empirical evidence suggests that the drop in economic activity during the initial lock-down restrictions in the US was due to behavior change in response to fear of the virus rather than to lock-down restrictions imposed at the time (https://www.nber.org/papers/w27432).

Positivity rates in all five Anglophone countries are either stable or declining, albeit at very different levels. In the USA, stability takes place at the highest rate observed for the country during the period (8.6%) whereas in Australia it takes place at its lowest (0.2%). The declines range from relatively small in the UK and New Zealand (less than 5% without the rounding in the table for New Zealand) to substantial for Canada (over 20%). The percentage rate of growth of two-week per capita deaths declines in three countries (USA, UK and Canada) and remains stable at zero in two of them (Australia and New Zealand). In the first two declining ones, however, it is still at the second highest level since we started measuring in September of 2020. By contrast, in Canada it is lower than all rates experienced after November 27. Thus, Canadians have successfully addressed the main lagged consequence of the recent holiday surge. Vaccine penetration is still low in all three countries. For instance, February 2 2021 estimates of persons in the population receiving at least one dose: 2.6 per 100 (Canada); 10.6per 100 (USA); and 15.5 per 100 (UK). (https://ourworldindata.org/covid-vaccinations). In addition, vaccines are unlikely to have had an effect yet on death rates due to the lag between infections and outcomes. Moreover, it is not clear what their effect would be on positivity rates for two reasons. It is unknown what effect they have on transmission medically and it is unknown if people's ex-post social behavior changes after receiving the vaccine.

In Europe, positivity rates decreased in Italy, France and Denmark, remained stable in Germany and increased in Spain. Not surprisingly, the percentage decrease in the two-week per capita death rates were substantial in Italy and Denmark as well as the increase in Spain. In France, there was an increase in the two-week per capita death rate. While in Germany the stabilization in the positivity rate coincides with a decrease in the death rate, the latter at 19% is still higher than any other experienced before November 11 although lower than all the other ones experienced since that date. In the next set of spatial units, positivity rates stabilize for Japan and South Korea but at very different levels that lead to a dramatic decrease in the growth of two-week per capita deaths in the latter country and a barely noticeable one in the former one. This required an affirmation of the plan to hold the Olympics in Japan this summer. China's data remains the same this period. Cuba and Jamaica both experienced increases in their positivity rates but Cuba's two-week growth of per capita deaths increases to 25% while Jamaica's decreases to 7.1%. In the last set of spatial units, Brazil, Chile and El Salvador continue in their earlier paths with respect to the positivity rate. Chile also did so with respect to increasing growth in two- week death rates per capita. Brazil stabilized the latter while El Salvador was able to decrease it.

Maryland stabilized its positivity rate at a level substantially below the US average and Florida continued to increase its rate at a level above the US average. With respect to the two-week growth in deaths per capita, Maryland continued to decrease its rate while Florida continued to increase its rate, increasing the spread from 0.9% to 2.6%.

What do we learn from the February 19 2021 update in light of recent developments?

The Good News: Stabilization or declining trends in positivity rates observed in the previous two-week period continue to hold in all but three countries and Florida in our sample of spatial units. Administration of vaccines into people's arms has made progress although obstacles to widespread distribution remain (nature- made, man- made and combinations of both). Moreover, there is wide variation in progress across countries. For instance, as of February 15, the UK is at 23.33 doses administered per 100 persons; the US at 15.81; and Canada at 3.33. Surprisingly, Chile is at 11.23 and China at 2.82. Of course, note that China has offered some of its vaccines to other countries but the extent and especially its implementation is unknown at this time. *The Bad News*: Variants continue to spread everywhere. Moreover, given the limit on vaccine supply, vaccine nationalism and vaccine hesitancy, our achievable objectives as earthlings citizens of anyone country are now more limited. Namely, it only makes sense to aim for attaining herd immunity as soon as possible through vaccinations and NPI measures while preparing for COVID-19 as an endemic but much less lethal condition. The latter will probably require booster shots for some current vaccines and vaccine development for children under 18. Both are currently at the experimental stage.

Positivity rates in Anglophone countries decline for the USA and the UK and remain stable for the other three countries. Moreover, the two-week percentage growth in deaths per capita is now below 10% in the first three countries and remains at zero in the other two Anglophone countries. High levels of vaccine penetration in the UK and US as well as lockdown restrictions and NPI's in the other three countries are working. In Europe, four of the five countries experience decreases in their positivity rate while France's remains the same. Perhaps more important, the two- week percentage growth in per capita deaths decreases in all five countries and more substantially in the two with growth rates above 10% in the prior two weeks. Even low levels of vaccine penetration with substantial lockdown restrictions and NPI's are effective in their impact on lowering positivity rates and the growth of deaths per capita.

Japan decreases both its positivity rate and its growth in per capita deaths over the last two-week period although the latter remains high at 18.8%. Positivity rates are stable in South Korea and China and increase in Cuba and Jamaica. Not surprisingly, growth in deaths per capita over the last two weeks decrease in South Korea and are reported stable at zero in China but increase in Cuba and Jamaica and substantially so in Cuba which is the only country where it is observed above 20% in this two-week period. Chile's performance resembles that of advanced countries in lowering positivity rates and growth of death per capita for reasons similar to the Anglophone countries. El Salvador's performance of stable positivity rates and lower growth of death per capita resembles France without the benefit of any significant level of vaccine penetration. Brazil is again an outlier with a higher positivity rate due to an unexplained suspicious decrease in the testing rate and lower growth in per capita deaths.

Maryland and Florida have lower positivity rates and growth in deaths per capita just as the US average and for the same reasons. While Maryland maintains its relative difference to the US average in both dynamic indicators, Florida increases its distance above the US average with respect to the positivity rate while decreasing it substantially and becoming equal to the US average with respect to the growth in deaths per capita. Florida's result is not surprising given its governor's negative attitude toward lockdowns and NPI's, positive attitudes toward vaccinations regardless of CDC guidelines, and vaccine penetration having its main impact on suppressing the most severe effects of COVID-19.

What do we learn from the March 05 2021 update in light of recent developments?

Good News. First, in the USA, FDA approved the Johnson and Johnson one dose vaccine under EUA. Distribution in the US started the first week of March 2021. One advantage of this vaccine for the world at large, besides being a one-dose vaccine and increasing available quantity of vaccines, is that its refrigeration storage requirements are far easier to meet than the ones developed by Moderna or Pfizer. Its authorization reported it to be equally effective in preventing the most severe outcomes of the disease, i.e., those leading to hospitalizations and deaths, as the previous two. Second, there is now preliminary evidence from two early studies in Israel and one in the UK that the vaccine employed has reduced transmission, in addition to preventing infection. Third, vaccine penetration has proceeded rapidly in countries able to obtain supplies of vaccines. For instance, from February 2 to February 26 single dose of vaccinations administered per 100 persons in the population have almost doubled in the UK (to 30.3), in the USA (to 21.77) and in Canada (to 4.71). In Chile, it has grown by over 50% in the last two weeks (to 17.57). *Bad News*. First, in many advanced countries those who want vaccinations are likely to have them by late summer. Yet, that accomplishment may not be sufficient to attain herd immunity if vaccine hesitancy is too widespread among their populations. Second, many poor countries will not have been able to make much if any progress on vaccinations due to vaccine nationalism, despite COVAX. Third, new variants continue to appear (e.g., in the US we now have a California and a New York variant).

Summing up, to get to the endemic stage where COVID-19 becomes like the seasonal flu we need to get beyond the pandemic stage as soon as possible, which will require substantial vaccination progress in all countries. For an insightful discussion of this issue see, for example, the Brookings discussion on" Fast Track to Recovery: US-China Collaboration on COVID-19 Prevention and Treatment," https://www.brookings.edu/events/fast-track-to-recovery-us-china-collaboration-on-covid-19-finall, prevention-and-treatment/ . Finally, for some perspective on the wisdom of the masses behavior with respect to their politicians' pronouncements, e.g., the Texas governor 100% capacity opening of restaurants, see general observation 2 in the February 05 2021 update.

Not surprisingly, Anglophone countries with substantial vaccine penetration (USA, UK and Canada) experience substantial declines in their two-week growth of per capita deaths, ranging from 37% to over 50%. Similarly, their cumulative positivity rates decline, albeit more modestly, for the USA and the UK, and remain stable for Canada, which has a much smaller rate of vaccine penetration. Moreover, for both outcomes the declines are associated positively with the vaccine penetration rates. Thus, it provides additional evidence on the beneficial impact of vaccines on transmission. For the two Anglophone countries that pursued successful virus suppression strategies (Australia and New Zealand) and have hardly any vaccine penetration, the results remain as before. The patterns in Maryland and Florida resemble the US pattern, probably due to vaccine penetration, but the levels remain as different as they were in the last update, probably due to differences with respect to their NPI policies.

In Europe, there are substantial declines in all five countries in the growth of per capita deaths over the last two-weeks and modest declines in cumulative positivity rates, except for Germany where this positivity rate remains constant. Vaccine penetration in these countries ranges between 7.13 (France) and 11.28 (Denmark) per 100 persons administered at least one dose as of March2/3 2021. This range starts higher than Canada's (5.54) but ends well below the US (24.08) for these same dates. Japan and South Korea have not experienced substantial vaccine penetration and their outcomes continue the

patterns of the previous updates, namely decreases in positivity rates and per capita death rates for Japan and stability in positivity rates with declines in per capita deaths for South Korea. China, which also pursued a successful suppression strategy and has very little vaccine penetration (3.65 per 100 persons as of February 28 2021), remains the same as before.

Developing countries vary quite widely with respect to outcomes, policies and vaccine penetration. Cuba experiences a significant increase in its cumulative positivity rate as well as a significant decrease in the growth of its per capita deaths. Nonetheless, the latter rate is the highest of any spatial unit in the Table. While Cuba currently has little vaccine penetration, it is trying to develop its own vaccine, Soberana. Jamaica and Brazil experience substantial increases in both their positivity rates and growth in per capita deaths. The levels of the former in Brazil are quite worrisome, since they represent primarily increases in the infection rate and the possibility that its new variant is leading to reinfection increases. While Chile and El Salvador experience decreases in both outcomes, the results for Chile represent a long-term trend in the positivity rate and a recent one with respect to the death rate that is likely to continue. For, Chile has a penetration rate (20.72) higher than the five European countries in the Table on March 2/3 2021. On the other hand, El Salvador's positivity rate is a small decrease from the last update's recent peak as well a significant one from its highest peak per capita death rate on January 22 2021 without significant vaccine penetration.

What do we learn from the March 19 2021 update in light of recent developments?

Good News: First, "I can wait to…" Countries where vaccination penetration is proceeding more rapidly and reliably are developing more optimistic outlooks towards returning to some form of normalcy, even before the end of the summer. This outlook varies positively with the rate of vaccine penetration. For instance, the latter stands as of March 14 in terms of doses administered per 100 members of the population as: UK, 37.98 (March 13); USA, 32.01; Canada 8.02, That is, around 25%, 47%, and 70%, respectively, in terms of growth in the last two weeks for the three Anglophone countries that were unable to suppress the virus. Second, not only is the US contributing money to the COVAX program but it agreed to support additional vaccine production in India aimed at global herd immunity as an outcome of the QUAD meeting with India, Japan, and Australia. Similarly, it also signed agreements with Mexico and Canada providing them access to vaccines currently stored in the US and authorized for emergency use in these countries but not in the US. Third, the Johnson & Johnson vaccine has now been administered into people' arms in the US for three weeks without major incidents reported in the popular press.

Bad News: First, use of the AstraZeneca vaccine has been paused out of an abundance of caution in several European countries due to a few adverse events (blood clots) for some who received the vaccine. Association does not mean causation. Hence, one hopes further research establishes that it was unrelated to the vaccine. Even if it were, some or many might conclude that the benefits outweigh the risks. Indeed, the European Union authority equivalent to the FDA just did by authorizing resumption of vaccinations. Second, vaccine hesitancy continues to exist in many places. Nonetheless, at least in the US, addressing vaccine hesitancy is ongoing in various ways that seem promising. I suspect some of these approaches, if proven successful, will also be useful elsewhere. Third, some political leaders continue to disparage vaccines. Yet, some who have badmouthed vaccines in general as well as specific vaccines in particular, e.g., Bolsonaro with Pfizer, have made complete turnarounds and have sought to

purchase sizable amounts of the badmouthed vaccine. Indeed, Brazil's vaccination rate is already at 5.37 administered per 100 members of the population based on the initial purchase of a Chinese vaccine.

In sum, the longer a substantial number of people remain unvaccinated, the greater the possibility of a new variant emerging that is insensitive to the vaccines. Thus, calls for continued restraint in behavior, especially among the unvaccinated, continue to make sense as well as additional efforts in speeding vaccinations.

Anglophone countries with substantial and increasing vaccine penetration (UK, USA, and Canada) experience declines in their positivity rates and in their death rates per capita growth that are positively associated in magnitudes with their levels of vaccine penetration. Not surprisingly, the association is stronger for the latter (the direct effect of vaccines) than for the former (the indirect effect). The results for Australia and New Zealand remain as before. The patterns in Maryland and Florida are consistent with the USA pattern of stronger improvements (declines) in death rates per capita than in positivity rates. Nonetheless, the levels continue to reflect different NPI policies. Vaccine penetration rates are similar in both states, e.g., about one fifth of the population has received at least one dose.

In Europe, the rate of vaccine penetration has slowed down for reasons discussed earlier, primarily lack of supply (see January 22 update). Thus, in the last two weeks Canada's rate of vaccine penetration has increased from 49 % to 56% of Denmark's rate. The latter is the country with the highest penetration rate in the five country European group at 14.4% (March 13). Spain and Denmark have decreased their positivity rates as well as their per capita death rates. In the other countries, the positivity rates remain the same. Death rates per capita, however, decline in France and Germany while increasing in Italy. Japan and South Korea experience improvements similar in pattern to those in the Anglophone countries without their substantial vaccine penetration while China remains the same as before which we also found for Australia and New Zealand.

Once again, developing countries exhibit wide variations in outcomes. Cuba's death rate per capita decreases although it remains above 10% while its positivity rate increases. Jamaica experiences increases in both death rate per capita and positivity rates. Moreover, it reaches levels above 10 % in both dimensions. Brazil has a similar experience (and much higher levels of both) despite a higher rate of vaccine penetration than the other developing countries except Chile. El Salvador experiences improvements in both dimensions, and especially substantial in terms of a decline in per capita death rates. Finally, Chile's steady progress with respect to positivity rates slows down and stabilizes at a relative high level (.088) while its death rate per capita goes up despite having a rate of vaccine penetration higher than the US in terms of doses administered per 100 persons at 34.48 (March 14).

Final Comment

As an educational memo, this project has reached the end of the line with respect to the provision of biweekly updates. Hence, I will not be providing them in the future. An initial objective in August 2020 was to help focus discussion on per capita deaths, as opposed to absolute numbers of deaths, and subsequently (after December 25 2020) on its rate of growth or decline. A second objective was to move the discussion in the direction of more reliable or robust statistical measures than the ones available in the popular press for educational purposes. At this point, there are two major uncertainties in the evolution of the pandemic. One is the emergence or non-emergence of a mutation that renders current vaccines ineffective in preventing infection. Another is the length of time vaccines protect

against the virus. Our cumulative statistics are unlikely to shed much, if any additional light on these two issues relative to the seven- day averages available from CDC in the popular press. While the data and commentary gathered here could be useful for other worthwhile purposes, these purposes would involve research activities somewhat or even far removed from an educational memo. For instance, identifying and evaluating pandemic policy 'strategies' adopted through design or default by different spatial units throughout the pandemic. The latter is an attractive research topic but only for reporting at the end of the tunnel, not while still in the tunnel.

To conclude, I urge you to read "Why the Pandemic Experts Failed: We are still Thinking about Pandemic Data in the Wrong Way," **the Atlantic**, March 15 2021 by Robinson Meyer and Alexis Madrigal. https://www.theatlantic.com/science/archive/2021/03/americas-coronavirus-catastrophe-began-with-data/618287/ . They looked at daily tests, cases, hospitalizations and deaths with the help of 550 contributors for a year to provide better data than CDC was doing. Ironically, its COVID Tracking Project ended this daily data collection last week and are closing shop at this time. They had done all they could to improve them although without completely satisfying their objective. Their main substantive conclusion: hospitalizations provide the most accurate short-term metric on the state of the pandemic.

Reading this article was reassuring for two very different reasons. First, it validated producing the cumulative statistics here as more robust alternatives to what we get in the daily averages. Second, it confirmed my experience in dealing with government bureaucracies. For instance, the US Census Bureau mismeasurement of e-commerce has been going on since 1998. It was pointed out to them in 2018 (Economics Letters, "How the U.S Census Bureau e-commerce figures over estimate output and online sales**", 172**: 157-159). Yet the basic problem remains the same as before in their latest published version of the Annual Retail Trade Survey (May 2020). I expect it to remain unfixed. Perhaps the problems identified in the Atlantic article for the CDC are far more pervasive than the authors realize. Because they stem from the nature of bureaucracies. The latter inherently provide elementary but powerful behavioral incentives for protecting organizations and back scratching among its members. Careerism and fear of labels such as 'not a team player' can easily lead to ignorance of agencies' intended objectives, i.e., in this context accurate data measurement, which require acknowledging and/or correcting errors in published data.

*Exchanges with Juan Belt, Julio Betancourt, Chris Clague, Allan Drazen, Beatriz Hardy, Tanjim Hossain, Alicia Juarrero, Luis R. Luis, Paul Meyer and José Ramón de la Torre have substantially increased my confidence in the robustness and educational usefulness of the comparison exercises explicitly illustrated here. I am grateful for these comments. Any remaining issues that may arise with the data and analysis above are the sole responsibility of the author.

Country*/State September 04- October 16, 2020, December 25 Rev.

	POR=IR/TR				DR				%ΔDR (L2wks)			% POP>65^
	9/04	9/18	10/02	10/16	9/04	9/18	10/02	10/16	9/04	9/18	10/02	10/16	'19
USA	.075	.072	.069	.067	577	610	642	672	n.a.	5.7	5.2	4.7	15
UK	.019	.019	.019	.023	611	614	621	637	n.a.	0.5	1.1	2.6	17
Canada	.070	.022	.022	.023	242	243	246	256	n.a.	0.4	1.2	4.1	16
Australia	.004	.004	.004	.003	029	033	035	035	n.a.	13.8	6.1	0.0	15
N. Zealand	.002	.002	.002	.002	005	005	005	005	n.a.	0.0	0.0	0.0	15
Spain	.053	.061	.061	.064	625	650	684	718	n.a.	0.4	5.2	5.0	17
Italy	.031	.021	.028	.029	587	590	594	602	n.a.	0.5	6.8	1.3	21
France	.040	.042	.052	.064	470	476	490	507	n.a.	1.3	2.9	3.5	18
Germany	.020	.019	.017	.019	112	113	114	117	n.a.	0.9	0.9	2.6	19
Denmark	.007	.007	.007	.008	108	110	112	117	n.a.	1.9	1.8	4.5	19
Japan	.045	.043	.040	.038	010	012	012	013	n.a.	0.2	0.0	8.3	25
S. Korea	.010	.010	.010	.010	006	007	008	009	n.a.	16.6	14.3	12.5	13
China**	.001	.001	.001	.001	003	003	003	003	n.a.	0.0	0.0	0.0	10
Cuba	.010	.010	.009	.008	009	010	011	011	n.a.	11.1	10.0	0.0	14
Jamaica	.048	.062	.083	.093	010	017	037	054	n.a.	70. 0	118.	45.9	9
Brazil	.281	.305	.271	.289	586	634	680	716	n.a.	8.2	7.3	5.3	8
Chile	.166	.149	.138	.128	597	637	669	701	n.a	6.7	5.0	4.8	10
E. Salvador	.080	.076	.073	.071	115	124	131	140	n.a.	7.8	5.6	6.9	8
Maryland	9/26→	.049	.048	.045	→	648	653	666	→	n.a.	7.7	2.0	16^
Florida	9/26→	.133	.133	.131!	→	648	673	733	→	n.a.	3.9	8.9	21^

*All country/state data taken from Worldometer; ^ World Bank data for 2019; Census Estimates 2020.

**The actual POR rates are .00053 for all dates; rounded up to.001 for ease of presentation. ! figure corrected on 10/29/2020 (from .171)

Country*/State	October 30 – December 11,				December 25 Rev.								
	POR=IR/TR				DR				%ΔDR (L2wks)				%pop.> 65^
	10/30	11/13	11/27	12/11	10/30	11/13	11/27	12/11	10/30	11/13	11/27	12/11	'19
USA	.060	.067	.071	.075	706	749	813	903	5.1	6.1	8.5	11.1	15
UK	.029	.034	.037	.038	676	749	838	927	8.9	10.8	11.9	10.6	17
Canada	.023	.028	.032	.036	266	284	312	346	3.9	6.8	9.9	10.9	16
Australia	.003	.003	.003	.003	035	035	035	035	0.0	0.0	0.0	0.0	15
N. Zealand	.002	.002	.002	.002	005	005	005	005	0.0	0.0	0.0	0.0	15
Spain	.074	.077	.075	.072	762	865	949	1,012	6.1	13.5	9.7	6.6	17
Italy	.040	.059	.071	.075	631	721	875	1,036	4.8	14.3	21.4	18.4	21
France	.082	.102	.108	.083	551	658	780	871	8.7	19.4	18.5	20.8	18
Germany	.023	.030	.036	.042	124	146	188	253	6.0	17.7	28.8	34.6	19
Denmark	.009	.010	.011	.012	123	130	140	158	5.1	5.7	7.7	12.9	19
Japan	.037	.038	.041	.043	014	015	016	020	7.7	7.1	6.7	25.0	25
S. Korea	.010	.010	.011	.012	009	009	010	011	0.0	0.0	11.1	10.0	13
China**	.001	.001	.001	.001	003	003	003	003	0.0	0.0	0.0	0.0	10
Cuba	.008	.008	.008	.008	011	012	012	012	0.0	9.1	0.0	0.0	14
Jamaica	.095	.094	.094	.093	068	076	084	091	25.9	11.8	10.5	8.3	09
Brazil	.251	.215	.283#	.264	746	771	804	843	4.2	3.4	4.3	4.9	08
Chile	.120	.112	.105	.100	736	767	794	822	5.0	4.2	3.5	3.5	10
El Salvador	.071	.071	.071	.071	149	158	170	170	6.4	6.0	7.6	7.1	08
Maryland	.043	.043	.044	.047	683	705	752	829	2.6	3.2	6.7	10.2	16^
Florida	.080	.080	.080	.081	776	809	850	912	5.9	4.3	5.1	7.3	21^

*All country/state data taken from Worldometer; ^Word Bank estimates, 2019; Census estimates, 2020.
**The actual POR rates are .00053 for all dates; rounded up to.001 for ease of presentation; #, the testing rate for Brazil in this two- week period decreases, which is peculiar and unexplained.

Country*/State	December 25 /2020 – February 05/2021												
	POR=IR/TR				DR				% ΔDR (L2wks)				%POP>65^
	12/25	01/08	01/22	02/05	12/25	01/08	01/22	02/05	12/25	01/08	01/22	02/05	'19
USA	.079	.083	.086	.086	1015	1127	1264	1406	12.4	11.0	12.2	11.2	15
UK	.042	.050	.053	.051	1023	1153	1389	1619	10.4	12.7	20.5	16.6	17
Canada	.040	.044	.044	.036	388	437	490	541	12.1	12.6	12.1	10.4	16
Australia	.003	.002	.002	.002	035	035	035	035	0.0	0.0	0.0	0.0	15
N. Zealand	.002	.002	.002	.001	005	005	035	005	0.0	0.0	0.0	0.0	15
Spain	.072	.073	.085	.087	1065	1105	1177	1300	5.2	3.8	6.5	10.5	17
Italy	.078	.081	.080	.077	1173	1279	1394	1494	13.2	9.0	9.0	7.2	21
France	.074	.074	.073	.072	953	1023	1102	1193	9.4	7.3	7.7	8.3	18
Germany	.048	.053	.056	.056	354	468	609	725	39.9	32.2	23.2	19.0	19
Denmark	.015	.016	.016	.014	192	256	329	329	21.5	33.3	28.5	14.3	19
Japan	.045	.050	.056	.056	024	030	038	048	20.0	25.0	26.7	26.3	25
S. Korea	.014	.015	.014	.014	015	021	026	028	36.4	40.0	23.8	7.7	13
China**	.001	.001	.001	.001	003	003	003	003	0.0	0.0	0.0	0.0	10
Cuba	.008	.009	.011	.015	012	013	016	020	0.0	8.3	23.1	25.0	14
Jamaica	.093	.094	.094	.096	098	103	112	120	7.7	5.1	8.7	7.1	09
Brazil	.260	.278#	.304#	.329#	891	940	1004	1072	5.7	5.5	6.8	6.8	08
Chile	.095	.094	.092	.090	849	881	922	975	3.3	3.8	4.7	5.7	10
E. Salvador	.073	.075	.078	.079	197	214	235	254	8.2	8.6	9.8	8.1	08
Maryland	.048	.050	.051	.051	931	1021	1114	1199	12.3	9.7	9.1	7.6	16
Florida	.083	.087	.089	.090	978	1047	1152	1269	7.2	7.1	10.0	10.2	21

*All country/state data taken from Worldometer; ^Countries, Word Bank estimates, 2019; US states, Census estimates, 2020; #, again the testing rate for Brazil decreases without explanation. **The POR rates are .00053 until 01/08 and .00056 after; rounded up to.001 for ease of presentation;

Country*/State February 19 /2021 – April 02

	POR=IR/TR				DR				% ΔDR (L2wks)				%POP>65^
	02/19	03/05	03/19	04/02	02/19	03/05	03/19	04/02	02/19	03/05	03/19	04/02	'19
USA	.084	.081	.079		1520	1605	1662		8.1	5.6	3.6		15
UK	.049	.045	.039		1753	1821	1848		8.3	3.9	1.5		17
Canada	.036	.036	.035		566	583	595		4.6	2.9	2.1		16
Australia	.002	.002	.002		035	035	035		0.0	0.0	0.0		15
N. Zealand	.001	.001	.001		005	005	005		0.0	0.0	0.0		15
Spain	.084	.080	.078		1426	1507	1559		9.7	5.7	3.5		17
Italy	.074	.072	.072		1571	1639	1719		5.2	4.3	4.9		21
France	.072	.071	.071		1276	1344	1402		7.0	5.3	4.3		18
Germany	.055	.055	.055		805	858	892		11.0	6.6	4.0		19
Denmark	.013	.012	.010		399	409	413		6.1	2.5	1.0		19
Japan	.054	.052	.049		057	064	069		18.8	12.3	7.8		25
S. Korea	.014	.014	.013		030	032	033		7.1	6.7	3.1		13
China**	.001	.001	.001		003	003	003		0.0	0.0	0.0		10
Cuba	.019	.022	.024		025	030	034		25.0	20.0	13.3		14
Jamaica	.107	.111	.132		129	147	172		7.5	14.0	17.0		09
Brazil	.351#	.377#	.412#		1141	1223	1347		6.4	7.2	10.0		08
Chile	.089	.088	.088		1030	1084	1143		5.6	5.2	5.4		10
E. Salvador	.079	.078	.077		273	290	301		7.4	6.2	3.4		08
Maryland	.049	.048	.047		1267	1310	1342		5.7	3.4	2.4		16
Florida	.089	.088	.082		1372	1462	1518		8.1	6.6	3.8		21

*All country/state data taken from Worldometer; ^Countries, Word Bank estimates, 2019; US states, Census estimates, 2020; #, again the testing rate for Brazil decreases without explanation. **The POR rates are .00053 until 01/08 and .00056 after; rounded up to.001 for ease of presentation;