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.

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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.

Country*/State	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			1015	1127			12.4	11.0			15
UK	.042	.050			1023	1153			10.4	12.7			17
Canada	.040	.044			388	437			12.1	12.6			16
Australia	.003	.002			035	035			0.0	0.0			15
N. Zealand	.002	.002			005	005			0.0	0.0			15
Spain	.072	.073			1065	1105			5.2	3.8			17
Italy	.078	.081			1173	1279			13.2	9.0			21
France	.074	.074			953	1023			9.4	7.3			18
Germany	.048	.053			354	468			39.9	32.2			19
Denmark	.015	.016			192	256			21.5	33.3			19
Japan	.045	.050			024	030			20.0	25.0			25
S. Korea	.014	.015			015	021			36.4	40.0			13
China**	.001	.001			003	003			0.0	0.0			10
Cuba	.008	.009			012	013			0.0	8.3			14
Jamaica	.093	.094			098	103			7.7	5.1			09
Brazil	.260	.278#			891	940			5.7	5.5			08
Chile	.095	.094			849	881			3.3	3.8			10
E. Salvador	.073	.075			197	214			8.2	8.6			08
Maryland	.048	.050			931	1021			12.3	9.7			16
Florida	.083	.087			978	1047			7.2	7.1			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 actual POR rates are .00053 for all dates; rounded up to.001 for ease of presentation;