COVID-19 Counts in Washington State and Select Other Locations

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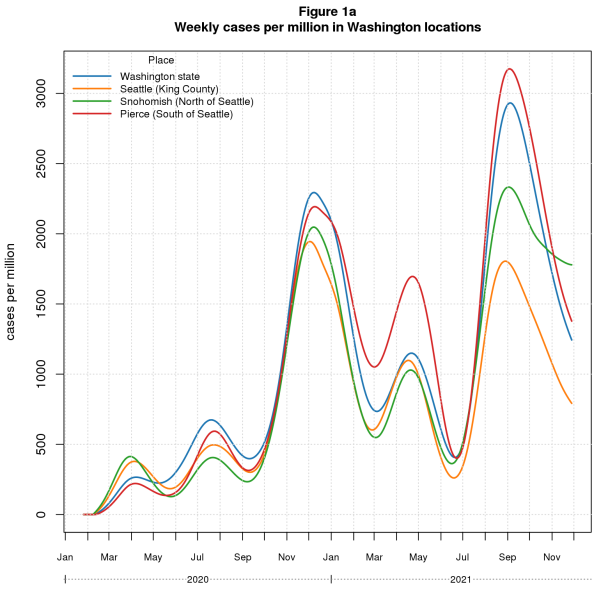
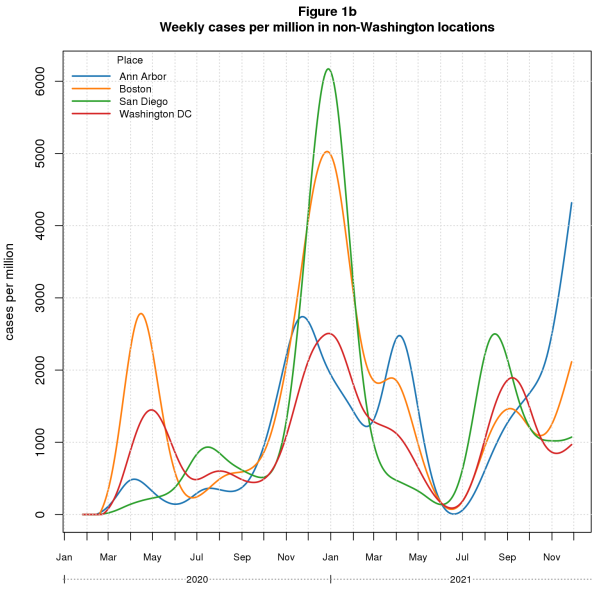
Counts of cases, hospital admissions, and deaths are key metrics of COVID-19 prevalence and burden, and are the basis for model-based estimates and predictions of these statistics. I present here graphs showing these metrics over time in Washington state and a few other USA locations of interest to me. I update the graphs and this write-up weekly. Previous versions are here. See below for caveats and technical details.

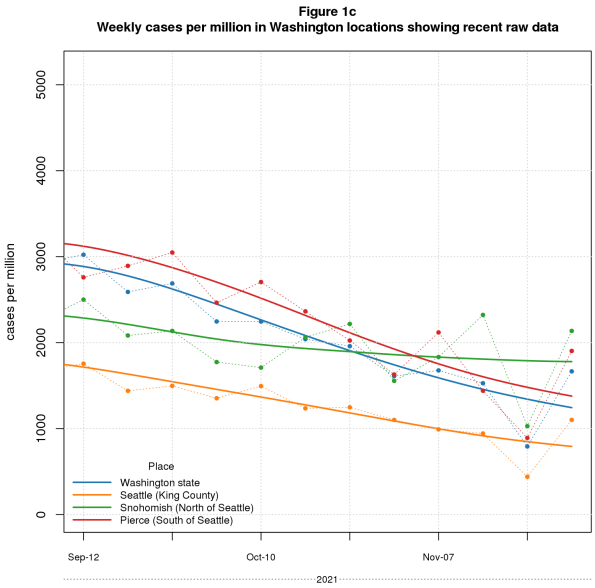
The first several figures (1a-2d) show *case* and *death* counts per million for several Washington and non-Washington locations using data from Johns Hopkins Center for Systems Science and Engineering (JHU), described below. The Washington locations are the entire state, the Seattle area (King County) where I live, and the adjacent counties to the north and south (Snohomish and Pierce, resp.). The non-Washington locations are Ann Arbor, Boston, San Diego, and Washington DC.

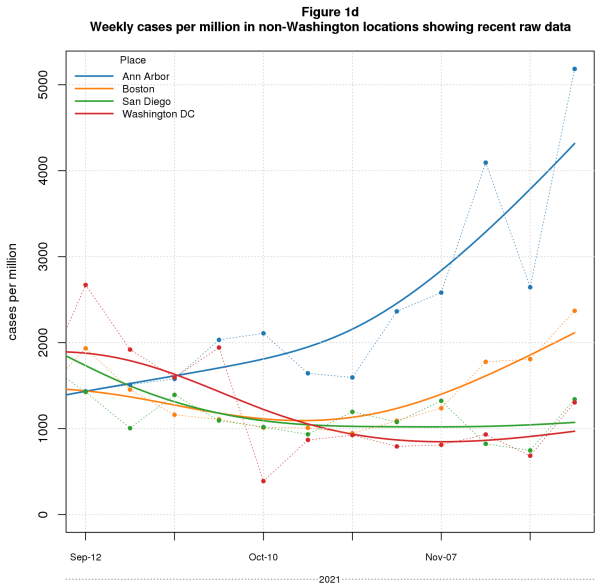
Figures 1a-b (the top row) show smoothed *case* counts (See below for details on the smoothing method). Figures 1c-d (the bottom row) overlay raw data onto the smoothed for the latest 12 weeks to help explain recent trends.

When comparing the smoothed Washington and non-Washington graphs (Figures 1a-b), please note the difference in y-scale; the graphs with raw data (Figures 1c-d) have the same y-scale and may be better for comparing Washington and non-Washington locations. The current raw counts for Washington locations are about 1100-2150 per million; non-Washington raw counts are about 1300-5200 per million.







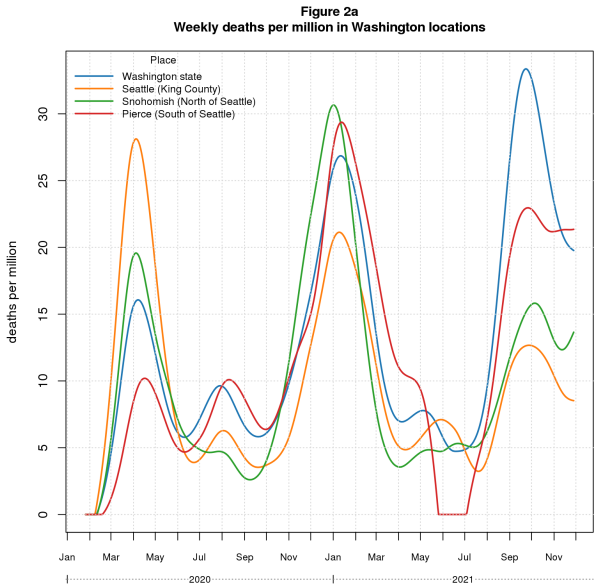


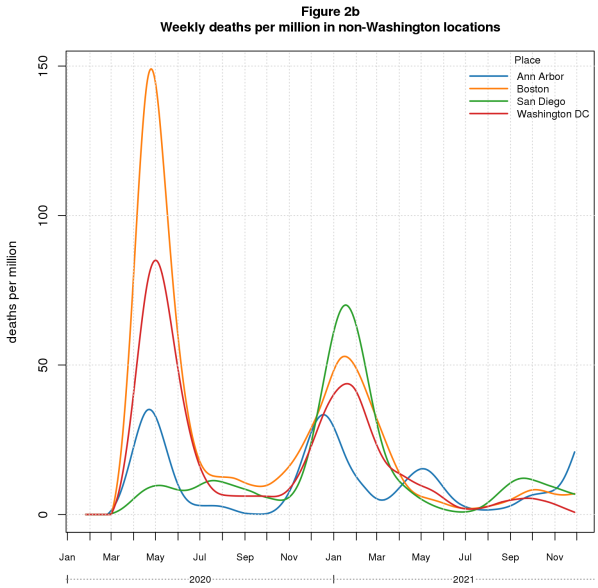
The smoothed graphs for Washington locations (Figure 1a) show rates decreasing everywhere. The raw data (Figure 1c) and trend analysis suggest that the recent trend is flat in all locations; looking back 8 weeks, the downward trend is clear everywhere except Snohomish. Rates in all Washington locations are well below their recent peaks and as well as their previous highs in winter 2020-21 (Figure 1a). Compared to spring 2020, counts are lower in Seattle and Snohomish, but higher statewide and in Pierce. Compared to peaks early in the pandemic (spring and summer 2020), counts remain well above in all locations.

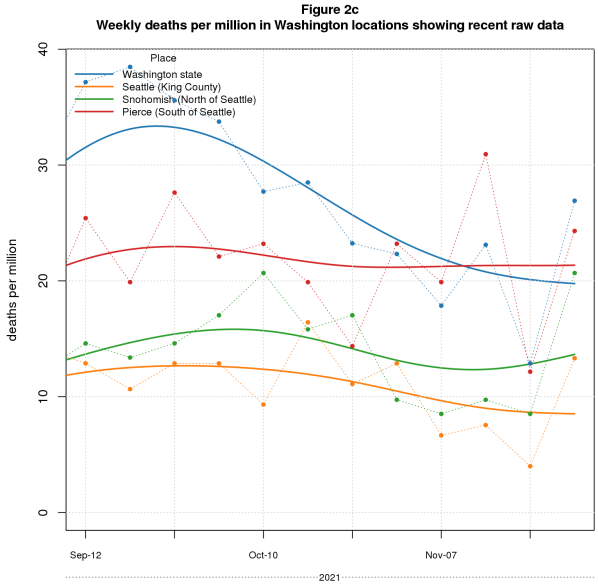
The smoothed graphs for non-Washington locations (Figure 1b) show rates increasing sharply in Ann Arbor and Boston, starting to climb in Washington DC, and flat in San Diego. The raw data (Figure 1d) and trend analysis concur with the increase in Boston. In Ann Arbor, data for the most recent 4 weeks is too variable for the software to be confident in the direction, but looking back 6 or 8 weeks, the upward direction is clear. For San Diego and Washington DC, the trend looks flat. Ann Arbor has soared above its previous peak in winter 2020-21 (Figure 1b), but all other non-Washington locations remain well below their winter 2020-21 peaks.

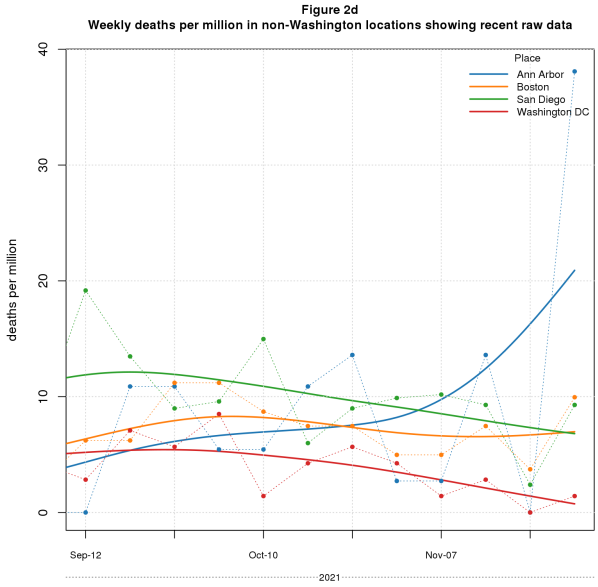
Figures 2a-d show *deaths* per million for the same locations. As with the *cases* graphs, the top row (Figures 2a-b) show smoothed data (see details below) and the bottom row (Figures 2c-d) overlays raw data onto the smoothed for the latest 12 weeks.

As with the cases data, the graphs with raw data (Figures 2c-d) are probably more useful when comparing the Washington and non-Washington graphs, as they have the same y-scale. The current Washington rates are 13-27 per million and non-Washington rates are 1-38 per million. The '38' seems anomalously high and may be an incorrect report.









The smoothed graphs for Washington locations (Figure 2a) show rates decreasing statewide and in Seattle, flat in Pierce, and heading up in Snohomish. Trend analysis and raw data (Figure 2c) suggest the trend is flat everywhere. For the state, looking back 12 weeks, the raw data suggests a pronounced decline. Rates are well below their earlier peaks in winter 2020-21 (Figure 2a). The picture is mixed compared to the peaks early in the pandemic: Seattle and Snohomish are well below the first wave (spring 2020), while the state and Pierce are above. All locations are above the second wave (summer 2020). The long flat line for Pierce in late May-June 2021 is due to negative counts for two weeks in early June: this arises when JHU discovers they overcounted previous weeks and are catching up; my software clamps the fit to zero reasoning that negative counts are meaningless.

The smoothed graphs for non-Washington locations (Figure 2b) show rates increasing in Ann Arbor but decreasing or flat everywhere else. Trend analysis and raw data (Figure 2d) suggest that rates are flat everywhere including Ann Arbor. All locations are below their peaks early in the pandemic (spring and summer 2020). All locations, except Ann Arbor, are below their peaks in spring and summer 2021.

New in this version of the document, Figures 3a-b show counts for the USA as a whole, using Washington state and Seattle for comparison. Figure 3a are *cases*; Figure 3b are *deaths*.

Figure 3a
Weekly cases per million in USA and Washington

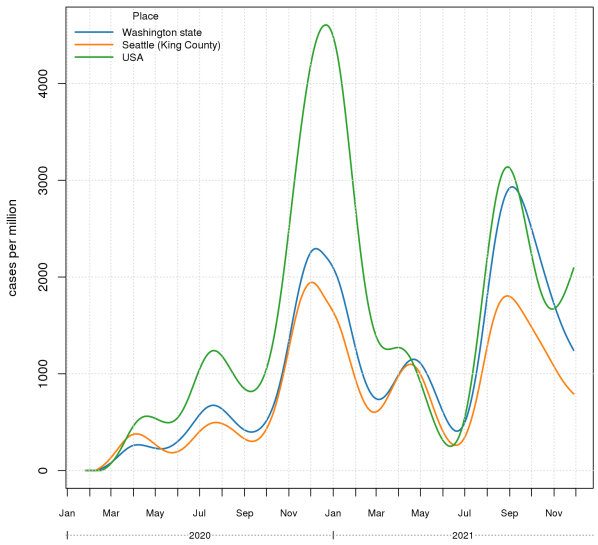
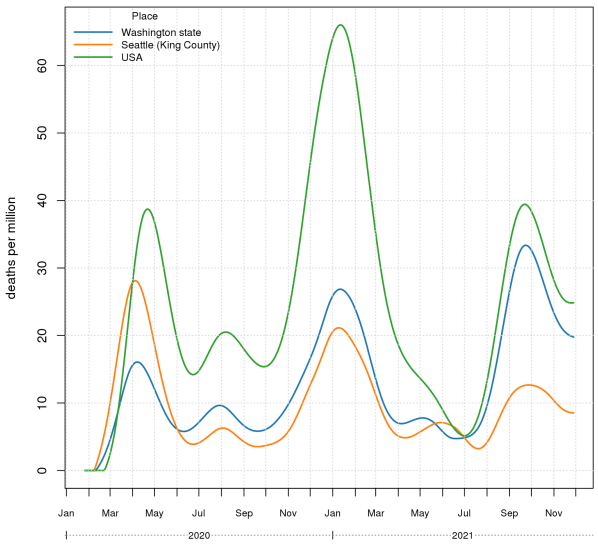


Figure 3b
Weekly deaths per million in USA and Washington



The three locations are traveling the same trajectory, indicating that the pandemic waves have played out similarly in the three locations. For most of the pandemic, USA counts are higher than Washington state, which in turn are higher than Seattle. Note also that *cases* are starting to increase again in the USA (Figure 3a). It remains to be seen where this presages a new wave in Washington state.

The next graphs show the Washington results broken down by age. This data is from Washington State Department of Health (DOH) weekly downloads, described below. An important caveat is that the DOH download systematically undercounts events in recent weeks due to manual curation. I extrapolate data for late time points to correct the undercounting as discussed below. The extrapolation worked well in past, but now seems to be erratic, making data near the end unreliable. I'm working to improve this.

Figures 4a-d are *cases*.

Figure 4a
Weekly cases per million by age in Washington state

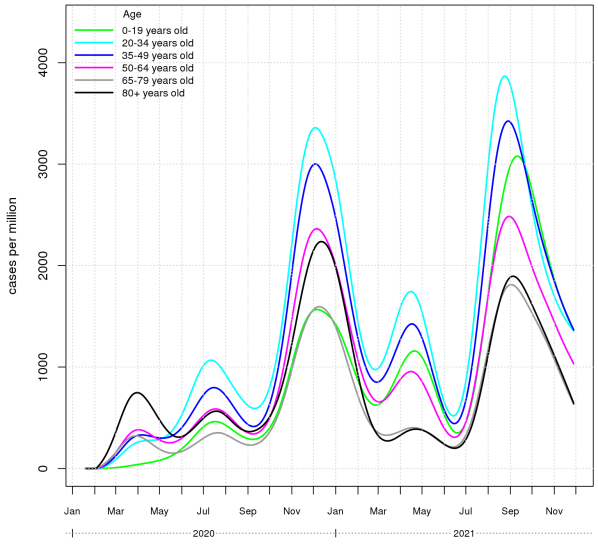
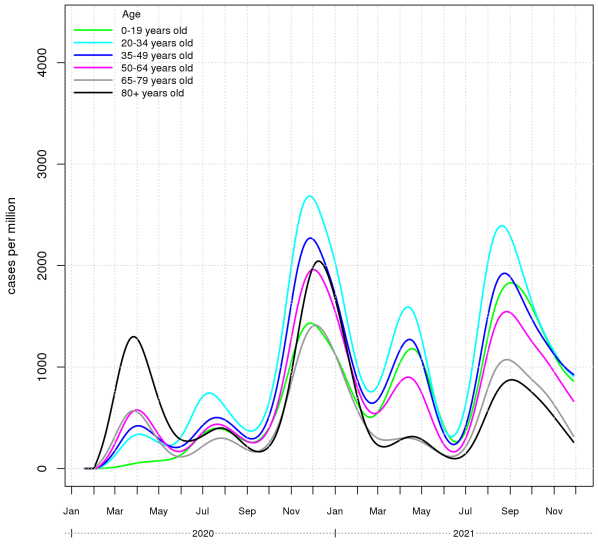
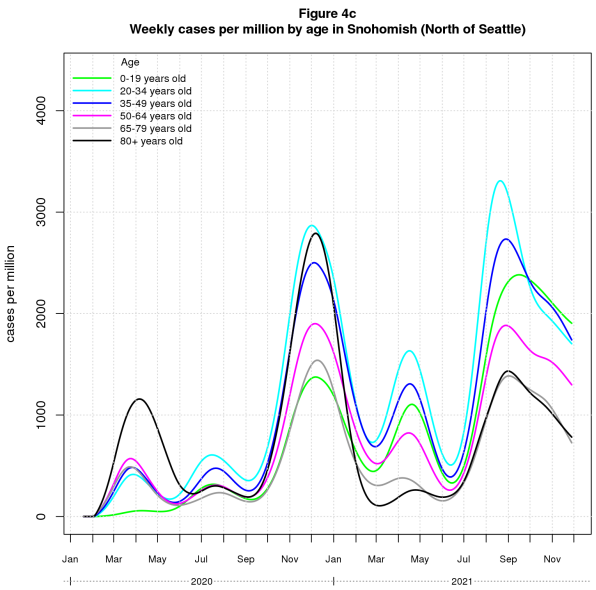
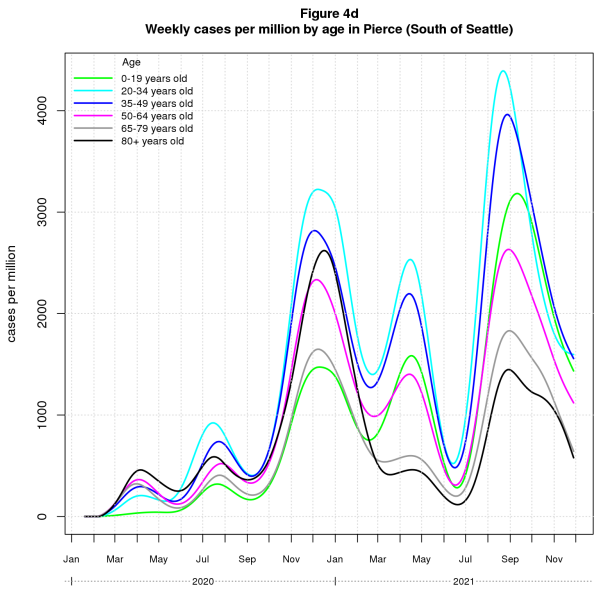


Figure 4b
Weekly cases per million by age in Seattle (King County)







Early on, the pandemic struck older age groups most heavily, but *cases* quickly spread into all age groups, even the young. Rates greatly increased in late summer and early fall 2021 but are now declining in all age groups. Statewide, the youngest group (0-19 years old) surpassed the 20-34 and 35-49 year olds in late September 2021 to take the dubious honor of being the highest group, but the three youngest groups are now essentially tied. In all locations, the youngest three groups are at the top although the ranking varies. Pre-seniors (50-64 years) are below the younger groups, followed by the two oldest age groups (65-79 and 80+ years).

The ratio between worst and best in the statewide data (Figure 4a) is about 2.1x (about 1350 for the youngest three groups (encompassing 0-49) vs. 650 for the oldest two groups (64-79 and 80+). The general pattern is similar in Seattle (Figure 4b) but the counts are a lot lower: 1.6x lower for 0-19 year olds (1350 vs. 850), 2.6x lower in the 80+ group (650 vs. 250). The Snohomish rates (Figure 4c) are worse than the state for all age groups. The Pierce rates (Figure 4d) range from 1.2x worse than the state for 20-34 years old (1350 vs. 1600) to 1.1x better for 80+ years old (650 vs. 600).

Figures 5a-d show hospital admissions (*admits*) and *deaths*.

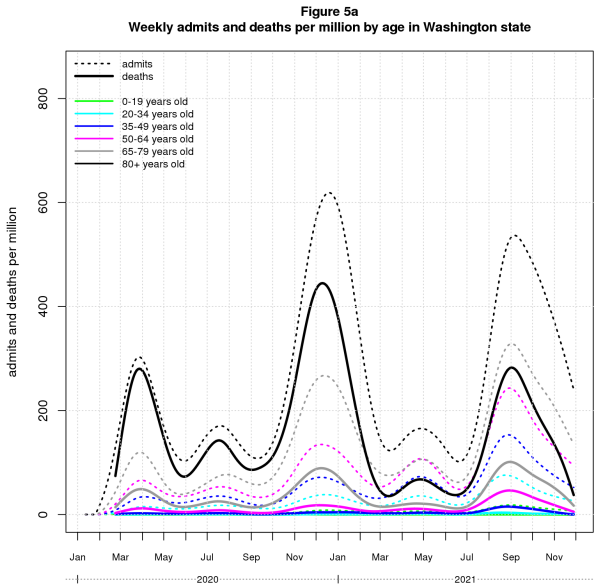


Figure 5a
Weekly admits and deaths per million by age in Washington state

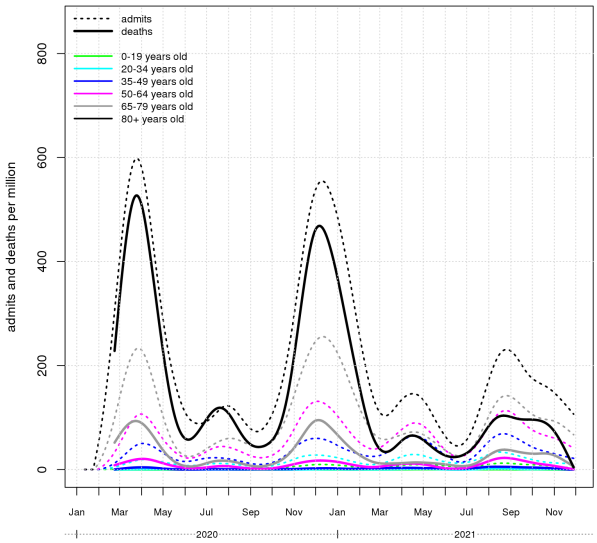


Figure 5b
Weekly admits and deaths per million by age in Seattle (King County)

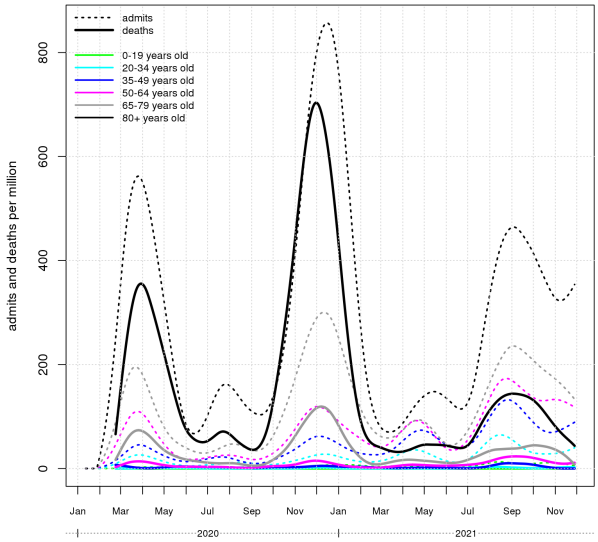


Figure 5c
Weekly admits and deaths per million by age in Snohomish (North of Seattle)

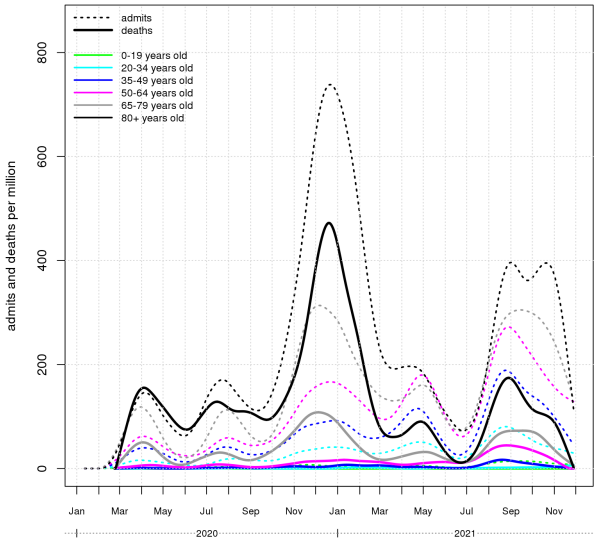


Figure 5d
Weekly admits and deaths per million by age in Pierce (South of Seattle)

Admits, like *cases*, have gone up a lot in recent weeks but are now declining in all locations for most age groups except for small bumps in Snohomish (may be artifacts of DOH undercounting and my extrapolation correcting this). As with *cases*, *admits* are much higher statewide than in Seattle (Figure 5a vs. 5b). Snohomish and Pierce (Figures 5c-d) are worse than the state in some age groups and slightly better in others. *Admit* rates vary with age groups exactly as one would expect: lowest in the young and increasing with age.

Throughout the pandemic, the *death* rate for the 80+ group was much higher than any other group. *Deaths* even in this group dropped to near zero in early summer 2021, but increased above their spring 2021 levels in all locations during the current wave, and are now falling in all locations. *Deaths* for the oldest groups are generally higher statewide (Figure 5a) than any of the individual locations (Figures 5b-d), reflecting the much higher death rate in the rural eastern part of the state (data not shown).

Deaths data near the end is especially unreliable due to DOH undercounting and my extrapolation correcting this. In the raw data (not shown), *deaths* for the 80+ group are 0 across the board in the latest data compared to 71-142 four weeks ago. I take this to indicate that reporting of *deaths* to DOH is lagging.

Caveats

1. The term *case* means a person with a detected COVID infection. In some data sources, this includes "confirmed cases", meaning people with positive molecular COVID tests, as well as "probable cases". I believe JHU only includes confirmed cases based on the name of the file I download. In past, DOH only reported confirmed cases but as of August 29, 2021 they seems to be including probable ones, too. This doesn't seem to have affected the totals much.
2. Detected *cases* undercount actual cases by an unknown amount. When testing volume is higher, it's reasonable to expect the detected count to get closer to the actual count. Modelers attempt to correct for this. I don't include any such corrections here.
3. The same issues apply to *deaths* to a lesser extent, except perhaps early in the pandemic.
4. The geographic granularity in the underlying data is *state* or *county*. I refer to locations by city names reasoning that readers are more likely to know "Seattle" or "Ann Arbor" than "King" or "Washtenaw".
5. The date granularity in the graphs is weekly. The underlying JHU data is daily; I sum data by week before graphing.
6. I truncate data to the last full week prior to the week reported here.

Technical Details

1. I smooth the graphs using a smoothing spline (R's `smooth.spline`) for visual appeal. This is especially important for the *deaths* graphs where the counts are so low that unsmoothed week-to-week variation makes the graphs hard to read.
2. The Washington DOH data (used in Figures 3 and 4 to show counts broken down by age) systematically undercounts events in recent weeks due to manual curation. I attempt to correct this undercount through a linear extrapolation function (using R's `lm`). I have tweaked the extrapolation repeatedly, even turning it off for a few weeks. The current version uses a model that combines date and recentness effects. In past, I created models for each Washington location and age group but had to change when DOH changed its age groups on March 14, 2021 (see below). I now create a single model for the state as a whole and all age groups summed together, then blithely apply that model to all locations and ages.
3. The trend analysis computes a linear regression (using R's `lm`) over the most recent four, six, or eight weeks of data and reports the computed slope and the p-value for the slope. I also compute a regression using daily data over the most recent 7-42 days. In essence, this compares the trend to the null hypothesis that the true counts are constant and the observed points are randomly selected from a normal distribution. After looking at trend results across the entire time series, I determined that p-values below 0.15 indicate convincing trends; this cutoff is arbitrary, of course.

Data Sources

Washington State Department of Health (DOH)

DOH provides three COVID data streams.

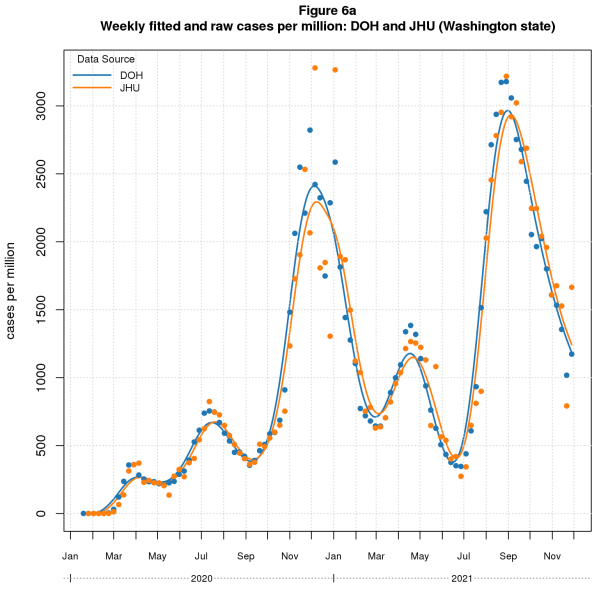
1. Washington Disease Reporting System (WDRS) provides daily "hot off the presses" results for use by public health officials, health care providers, and qualified researchers. It is not available to the general public, including yours truly.
2. COVID-19 Data Dashboard provides a web graphical user interface to summary data from WDRS for the general public. (At least, I think the data is from WDRS - they don't actually say).

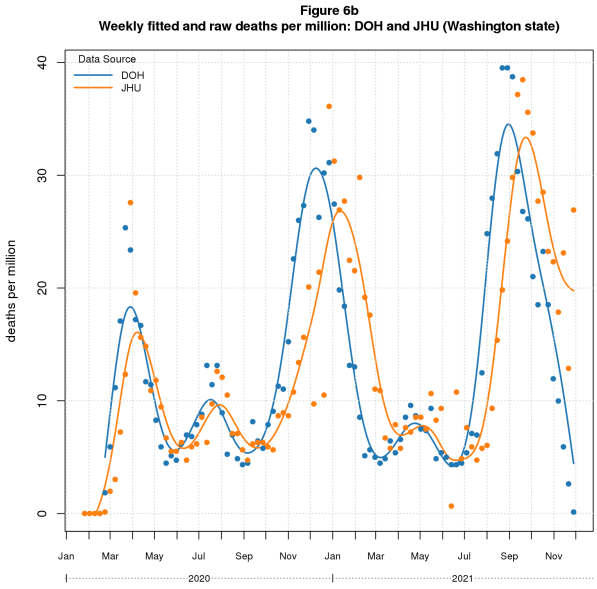
3. Weekly data downloads (available from the Data Dashboard web page) of data curated by DOH staff. The curation corrects errors in the daily feed, such as, duplicate reports, multiple test results for the same incident (e.g., initial and confirmation tests for the same individual), incorrect reporting dates, incorrect county assignments (e.g., when an individual crosses county lines to get tested).

The weekly DOH download reports data by age group. In past, the groups were 20-year ranges starting with 0-19, with a final group for 80+. As of the March 14, 2021 data release (corresponding to document version March 17), they changed the groups to 0-19, followed by several 15 year ranges (20-34, 35-49, 50-64, 65-79), with a final group for 80+. They changed age groups again in the August 29, 2021 data release (corresponding to document version September 1) and again a week later in the September 5, 2021 release (document version September 8), but I chose to map the new age groups to the previous ones to avoid difficulties in aligning DOH age groups with population data. The new groups are 0-11, 12-19, 20-34, 35-49, 50-64, 65-79, 80+; I reconstitute 0-19 by summing 0-11 and 12-19.

Issues with DOH Undercounting

Figures 6a-b compare DOH and JHU *cases* and *deaths* for Washington state to illustrate the undercount in the raw DOH data. The *cases* data matches well except for a few weeks in winter 2020 and the most recent two weeks. The *deaths* data matches less well and is presently much lower than JHU. I believe the discrepancy in the *deaths* date reflects the consistent undercount of recent DOH data.





Johns Hopkins Center for Systems Science and Engineering (JHU)

JHU CSSE has created an impressive portal for COVID data and analysis. They provide their data to the public through a GitHub repository. The data I use is from the csse_covid_19_data/csse_covid_19_time_series directory: time_series_covid19_confirmed_US.csv for *cases* and time_series_covid19_deaths_US.csv for *deaths*.

JHU updates the data daily. I download the data the same day as the DOH data (now Tuesdays) for operational convenience.

Other Data Sources

The population data used for the per capita calculations is from Census Reporter. The file connecting Census Reporter *geoids* to counties is the Census Bureau Gazetteer.

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