U.S. COVID-19 Deaths: The Weekend-Effect "Mystery"

Keith Gandal and Neil Gandal[1]

July 20, 2020

Abstract

In this paper, we examine U.S. COVID-19 deaths by day of the week. Mysteriously, the same pattern has repeated every single week of the pandemic: deaths rise from Tuesday-Friday and come down Saturday-Monday, hitting a nadir on Sunday or Monday. We show that such deaths are substantially higher during the Tuesday to Friday period than they are during the Saturday to Monday period. Controlling for time trends, deaths during the Tuesday to Friday period are at least 40 percent higher than the Saturday to Monday period.

The weekend effect does not obtain in New York City. Without New York City, controlling for time trends, deaths during the Tuesday to Friday period in the U.S. are 50 percent higher than the Saturday to Monday period. This is much larger than the "weekend" effect for the rest of the world (approximately 20 percent.) We provide some preliminary thoughts as to why this obtains in the case of COVID-19 in the U.S. Further research is encouraged.

1. Introduction:

In this paper, we examine U.S. COVID-19 deaths by day of the week. We show that such deaths are substantially higher during the Tuesday to Friday period than they are during the Saturday to Monday period. Controlling for time trends, deaths during the Tuesday to Friday period are at least 40 percent higher than the Saturday to Monday period.

The weekend effect does not obtain in New York City. Without New York City, controlling for time trends, deaths during the Tuesday to Friday period in the U.S. are 50 percent higher than the Saturday to Monday period. This is much larger than the "weekend" effect for the rest of the world (approximately 20 percent.) We provide some preliminary thoughts as to why this obtains in the case of COVID-19 in the U.S. Further research is encouraged.

In the discussion section, we provide some preliminary thoughts as to why this obtains in the case of COVID-19. Further research is encouraged.

The rest of us this section surveys the literature.

Freemantle et al (2012) has a finding about hospitals deaths occurring on weekends. Using data from UK National Health Care Service (NHS), they show that for every 100 deaths among patients in a hospital on Wednesday, there are 92 deaths among similar patients in the hospital on a Sunday. But the difference they find is "only" eight percent, that is, there are eight percent fewer deaths in hospitals on Sunday than there are Wednesday.[2]

---

[2] Perhaps because this is a secondary finding, they do not speculate as to why this is the case. Official mortality data from Israel from the Israel Central Bureau of Statistics shows, that controlling for other factors, deaths during the weekend (which is Friday and Saturday in Israel) are three percent lower than during the week for the period from January 1, 2000 through the end of May 2020. This result comes from Steinberg (work in progress 2020.)

To the best of our knowledge, there is no research on day of the week effects for deaths that occur outside of hospitals. Public media reports that deaths due to COVID-19 among long-term care residents account for 42% of all COVID-19 deaths in the U.S.[3] In many of these cases, nursing care residents died on site and not in hospitals.[4] Thus many U.S. deaths from COVID-19 occurred outside of hospitals.[5]

Finally, there is virtually no difference in the number of deaths, from all causes combined, by day of the week in the United States. According to Livescience,[6] based on data from the U.S. Centers for Disease Control, there was very little difference in deaths by day of the week in the United States. Based on the "CDC Wonder database," which contains data on all deaths in the U.S. from 1999 to 2014, "Livescience" reports the following: Sunday, which was the "low day" of the week for deaths, had 5.6 million total deaths during the 1999-2014 period, while Saturday, the "high day," had 5.7 million total deaths during the same period. This is a very small (1.7 percent) difference from the trough to the peak. The same pattern (very small percent differences by day of the week) obtains for specific diseases as well.[7]

2. Data

Perhaps surprisingly, it is not easy to get daily data on U.S. deaths from COVID-19. This is likely due to the fact that the U.S. has many different official reporting jurisdictions, such as counties and states. *The Atlantic* discusses some of the

[3] See https://www.nytimes.com/interactive/2020/us/coronavirus-nursing-homes.html
[4] https://www.washingtonpost.com/business/2020/06/16/nursing-home-deaths-coronavirus-hospital-transfers/?arc404=true
[5] Neil Gandal et al (2020) provide evidence that (controlling for other risk factors,) long-term care facilities are a risk factor for death from COVID-19 both in the U.S. and Europe. The research does not examine, however, what features of such settings (communal living area, multiple residents in a room, care provided by multiple caregivers to multiple care recipients, etc.) increase the chances of death from COVID-19, and whether any of the features would affect death by day of the week.
[6] See LiveScience, "The Deadliest Day of the Week," by Sara G. Miller April 18, 2016, available at: https://www.livescience.com/54429-deadliest-day-of-the-week.html
[7] Ibid.

difficulties.[8] According to that article, "data from the COVID Tracking Project have been used by Johns Hopkins University, governors and members of Congress, and the White House." Hence, we employ data from the COVID Tracking Project.

According to their website, the COVID Tracking Project collects data on "COVID-19 testing and patient outcomes from all 50 states, 5 territories, and the District of Columbia. Our dataset is currently in use by national and local news organizations across the United States and by research projects and agencies worldwide. Our data API (which allows sites and apps to import our dataset automatically) receives about two million requests per day."[9] These data are updated between 4:00 and 5:00 Eastern time.

But, in order to insure that our results are robust, we employ a second data source as well. The second data source is Wikipedia data reported by Google. According to Google support, the data "comes from sources like Wikipedia, government health ministries, The New York Times, and other authoritative sources, which may be added over time with attribution. Cases are constantly updated from resources around the world. Daily situation reports are also available on the World Health Organization site." [10] These data are apparently updated at midnight.

The data in the Tables and the Regression analysis come from these two different sources: Nevertheless, the key results are virtually unchanged regardless of which data source we use. Indeed, with the exception of one daily observation, the correlation between the daily death rates between the two sources is 0.99.

---

[8] See "State and Federal Data on COVID-19 Testing Don't Match Up," by Robinson Meyer and Alexis Madrigal, May 17, 2020, available at https://www.theatlantic.com/health/archive/2020/05/cdc-publishing-covid-19-test-data/611764/

[9] The COVID Tracking Project: https://covidtracking.com/data/download . Quote from https://covidtracking.com/about and https://covidtracking.com/about-data/faq.

[10] Quote from https://support.google.com/websearch/answer/9814707?p=cvd19_statistics&hl=en-IL&visit_id=63730777304984544-3822379242&rd=1.

Finally, we also examined a third data source: Worldometers. See
https://www.worldometers.info/coronavirus/country/us/. Although they have
slightly fewer day observations, the results are again virtually unchanged.

3.   Analysis:

Figure 1 is graph charting daily deaths in the U.S. from COVID during the duration of
the pandemic in the U.S., from February 29 through July 15 (which is a Thursday.)[11]
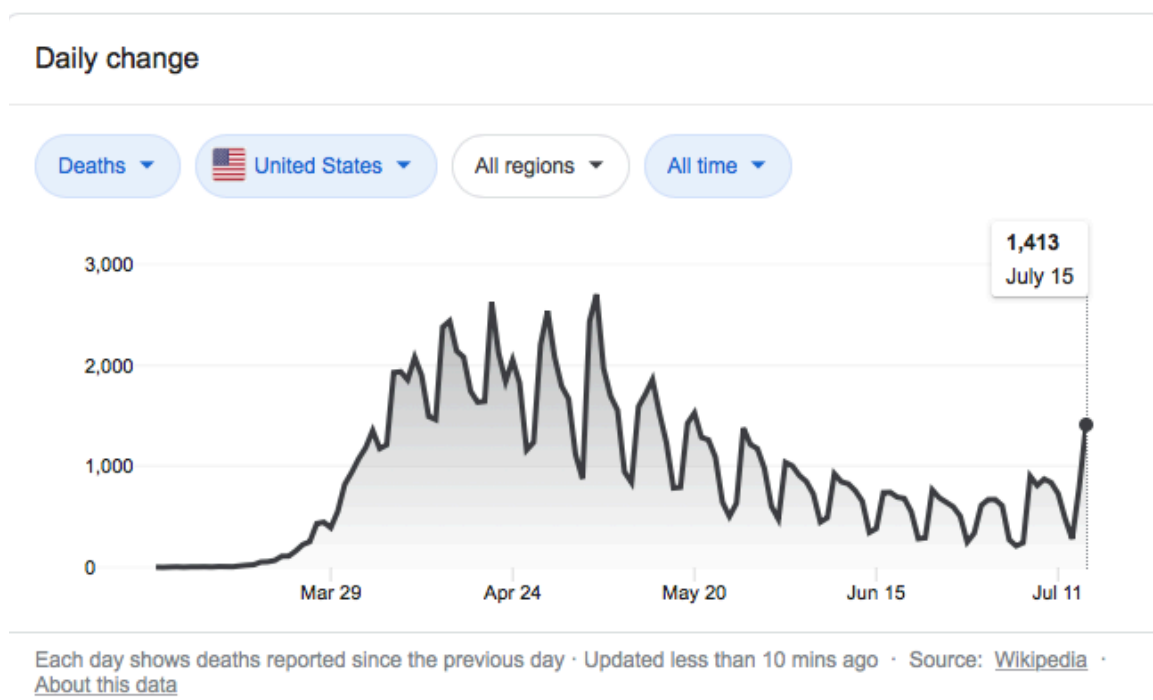

Figure 1. U.S. Daily Deaths

The frequency of the pattern is strikingly regular. Every week the deaths go up and
come down. Some weeks go higher than others. Remarkably, the period of the wave

---

[11] The Figures 1-3 data are from the second source: Wikipedia, available at
https://www.google.com/search?sxsrf=ALeKk03ZuTzprRsLY9j2HtXINCBtGtcybg%3A15947382398
64&source=hp&ei=P8YNX_jkMd2EytMPno2QoAg&q=coronavirus+totals&oq=co&gs_lcp=CgZwc3ktY
WIQARgAMgQIIxAnMgQIIxAnMgQIIxAnMggIABCxAxCDATIFCAAQsQMyCAgAELEDEIMBMggIABCxA
xCDATICCAAyBQgAELEDMggIABCxAxCDAVCkBFikBWCKHWgAcAB4AIABOIgBbZIBATKYAQCgAQGq
AQdnd3Mtd2l6&sclient=psy-ab

is exactly a week. The same pattern has repeated *every single week of the pandemic*: deaths rise from Tuesday-Friday and come down Saturday-Monday, hitting a nadir on Sunday or Monday.

But it is not just that the deaths go up and down. The percentage difference within the week is staggering as Table 1 shows. Table 1 delineates the U.S. COVID-19 according to the day of the week. The second and third columns in Table 1 (for the two different data sources) show that on average, deaths were staggeringly higher on Tuesdays, Wednesdays, Thursdays and Friday than they were on Saturday, Sunday and Monday. Columns 4 and 5 in Table 1 calculate the percent of the average deaths per day above the Monday baseline, or trough. For example, from the raw data, on average, deaths on Tuesday through Friday were at least 60 percent above the Monday values.

Day	Ave. Deaths (Source 1)[12]	Ave. Deaths (Source 2)	% above Monday (Source 1)	% above Monday (Source 2)
Saturday	901.4	910.8	34.7	47.2
Sunday	682.4	636.4	2.0	2.8
Monday	669.1	618.9	0.0	0.0
Tuesday	1118.9	1157.9	67.2	87.1
Wednesday	1130.2	1159.3	68.9	87.3
Thursday	1128.2	1065.9	68.6	72.2
Friday	1032.6	1035.9	54.3	67.4

Table 1: Daily COVID-19 Deaths through July 15 2020.

---

[12] Data from the first source from June 25 (a Thursday) is likely not correct regarding the number of deaths that occurred on that day. It may be an error, as source 1 provides no explanation for an entirely incongruous number; it may also be that previously uncounted deaths were belatedly added in, en masse, on that day. That was the case with New York City on May 5, as reported by data source 2; see below. Hence, we replace this one observation with the June 25 observation from the second source. The results are qualitatively unchanged if we simply remove that observation.

Table 2 delineates U.S. COVID-19 deaths according to "the week" vs "the weekend," the latter of which is in fact what Americans call a "long weekend." We define the week to be Tuesday through Friday, and the "weekend" is defined to be Saturday through Monday.

We do because Monday numbers are essentially the same as Sunday and extremely different from every other weekday. What we are calling "the weekend effect" starts Saturday and carries on through Monday. Why the "weekend effect" should persist into Monday requires further research. But there is no question that, when it comes to U.S. COVID-19 deaths, the weekly wave pattern is *not simply* a matter of reporting lags, as New York City data do not share this regular wave pattern. (See below.)

The second column (raw data) in Table 2 shows that, on average, deaths were staggeringly higher during the week in the U.S. Column 3 shows the results from the regression analysis with a 3rd degree polynomial time trend included. (The regression analysis is in the Appendix.)

- In the case of data for the entire U.S., controlling for the 3rd degree polynomial time trend, the regression analysis shows that weekday deaths were on average 42-45% above the weekend rates.
- When we exclude New York City (NYC) data, controlling for the 3rd degree polynomial time trend, the regression analysis shows that weekday deaths were on average 48-53% above the weekend rates in the U.S.

Period	% above Weekend Raw Data[13]	% above Weekend Regression Analysis
All US Data	47% (53%)	42% (45%)
US Without NYC	58% (67%)	48% (53%)
NYC only	-3%	-2%
Rest of the World	25%	20%

Table 2. Week vs. Weekend Effect

---

[13] For U.S. data, we report from results from the two sources as described above. The second source numbers are in parentheses.

The Rest of the World:

Using Worldometer worldwide data,[14] we can repeat the regression analysis we conducted for the United States for the rest of the world. We compute data for the rest of the world by subtracting the U.S. data (from the COVID Tracking Project) from the world totals.[15] We find that there is indeed a weekend effect worldwide, but it is much smaller. Controlling for the 3rd degree polynomial time trend, this effect is approximately 20 percent versus approximately 50 percent for the United States without NYC. So there is a very large difference. The 20 percent is much closer to the 8 percent weekend effect that Freemantle et al (2012) found.

4.   New York City

New York City (NYC) daily death data are available from the NYC government site at https://www1.nyc.gov/site/doh/covid/covid-19-data.page.

NYC COVID deaths basically climb fast then decrease slowly, with minor dips and rises that don't conform to the U.S. weekly pattern. There is, in short, no regular wave pattern by day of the week. See Figure 2. When we repeat the regression analysis for NYC, the estimated coefficient on the variable "week" is -0.02 with a standard error of 0.10. Deaths are higher on the weekend by approximately 2 percent but this effect is not statistically significant. Hence, in NYC, there is no weekend effect at all.

Why might this be the case? Possibly because in NYC, between mid-March and the end of May, every day seemed the same, as in the movie "Groundhog Day." Except it was Coronavirus Day. Each day, you woke up to disbelief, dread, even horror, and

---

[14] https://www.worldometers.info/coronavirus/coronavirus-death-toll/
[15] The results are virtually unchanged if we use the Worldometer data for the United States. But again, we are missing some observations for the Worldometer United States data.

soon enough, you heard the wail of ambulances.[16] White hospital tents dotted the East Meadow in Central Park; the scene was like something out of a Civil War photograph. During that period, the electronic kiosks on the streets, which usually present a variety of ads, headlines, drawings, photographs, and fun facts about NYC, ran COVID-19-related information 24 hours a day, 7 days a week. The familiar rhythms of the American week were simply wiped away. There was no time off and no weekends in the sense that there were no bars, restaurants, or theaters to go to. No sports to watch. People did not get together with family and friends that they weren't living with. No one was on the streets. Even Times Square was empty. The sirens didn't stop at night. For almost everyone in NYC, it was impossible to avoid worrying, to stop seeing the news, to relax.
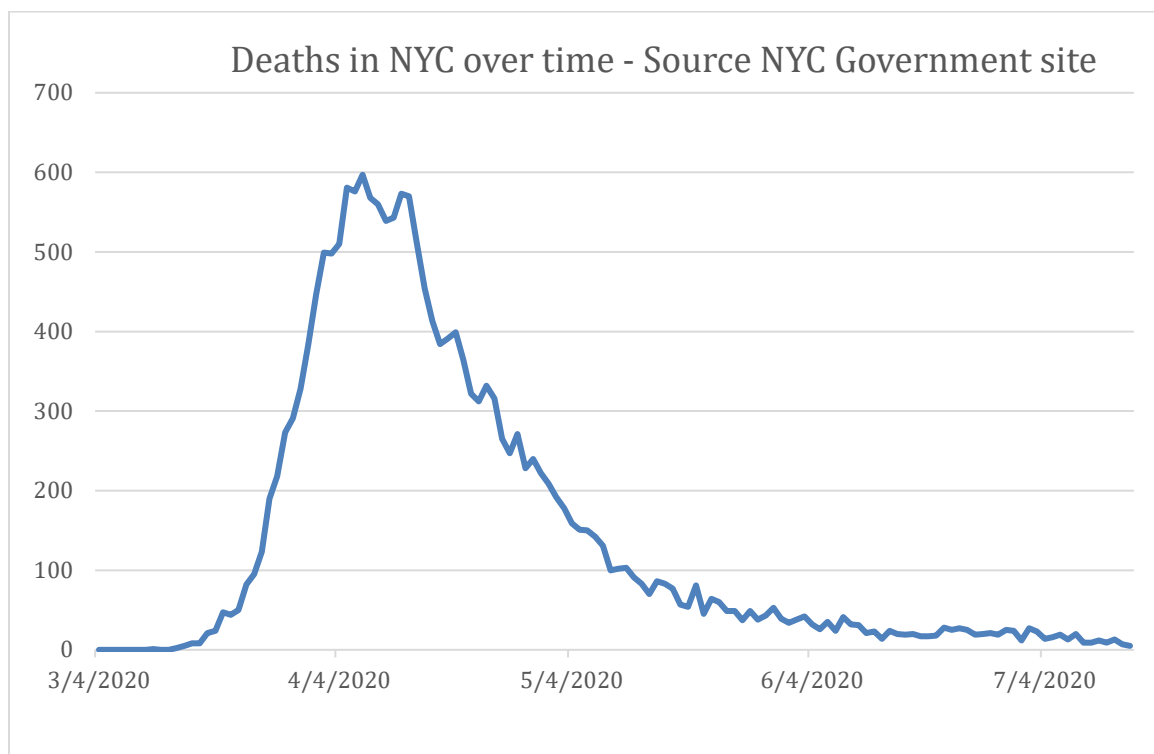

Figure 2: New York City deaths over time from COVID-19.

---

[16] I (Keith Gandal) was in NYC on a weekly work schedule during this period (working remotely), but I nonetheless had trouble knowing what day it was. Other people observed this phenomenon too.

5.   Discussion

Why would there be such a large regular weekly pattern to COVID-19 deaths in the U.S.? The large difference in deaths in the U.S. by week vs weekend cannot likely be explained simply as a lag or delay in reporting of weekend deaths.   Even if there is a consistent 10 percent underreporting of deaths in the weekend (which seems like a lot) across the various U.S. jurisdictions from which the data are calculated, underreporting of deaths cannot explain most of this difference.

Do rhythms at hospitals explain some of this? Hospitals tend to be less staffed during the weekend, or staffed with less senior doctors, and there tends to be less availability of diagnostics.[17] Since this is generally the case,[18] one might think that hospital deaths would then go up on the weekends because less experienced doctors are running things with less diagnostic assistance. But Freemantle et al (2012) show that deaths from all causes actually go down slightly on the weekends in hospitals.

It seems to us that it is likely that something *social* or *cultural* is going on with overall U.S. COVID-19 deaths, corresponding, in America, to differing behaviors and attitudes tied to different parts of the week. We do not have the answers, but we throw out some possibilities here:

Perhaps people tend to relax more on the weekends, even in hospitals or long-term care facilities, even when they are not allowed visitors (as has usually been the case during the U.S. COVID-19 pandemic). Fewer senior doctors and less diagnostic activity on weekends -- a weekend slowdown missing in NYC -- may mean a more relaxed atmosphere inside hospitals.

---

[17] Freemantle et al (2012) also makes this point.
[18] That was not true in NYC and other places as well during the height of the COVID-19 death toll, as doctors across the country heroically worked incredibly long shifts day after day in order to minimize deaths.

Outside of hospitals, people socialize with family and friends. What don't they do on weekends that they do during the week? They probably don't work as much, or, if unemployed, they likely don't tend to worry as much about it. And perhaps they don't watch as much news as during the week. In any case, in American life, weekends are *supposed to be* for fun, relaxation, and religious spirituality. The weekend is a deeply-rooted and powerful social practice shared from coast to coast. Could worrying, watching the frightening news coverage of the pandemic, and ultimately panicking about being sick with COVID-19 be increasing the death toll? We leave this for future research.

References:

Freemantle, N., Richardson, M., Wood, J., Ray, D., Khosla, Shahian, D., Roche, W., Stephens, I., Keogh, B., and Pagano, D., 2012, "Weekend hospitalization and additional risk of death: An analysis of inpatient data," J R Soc Med 2012: 105: 74–84. DOI 10.1258/jrsm.2012.120009.

Gandal, N., M. Yonas, M. Feldman, A. Pauzner and A. Tabbach (2020), "Long-Term Care Facilities as a Risk Factor for Death Due to COVID-19", CEPR Discussion Paper 14844.

Appendix

	Week vs. Weekend[19] 3rd order polynomial time-trend	
	US Data (Source 1) Coefficients (Std. Errors)	US Data Source 2) Coefficients (Std. Errors)
Week	0.42*** (0.072)	0.45*** (0.068)
Time Trend	0.35*** (0.01)	0.35*** (0.009)
Time Trend Squared	-0.0047*** (0.00017)	-0.0047*** (0.00015)
Time Trend Cubed	0.000016*** (7.9E-07)	0.000018*** (7.4E-07)
R^2	0.947	0.954
Adjusted R^2	0.945	0.952
N	134	134

Dependent Variable: Natural Logarithm of daily deaths

Independent Variables:

- Time trend based on Days from the beginning of the pandemic in the U.S. For the time trends, Day 1 = 1, Day 2 =2, etc.
- Binary "Dummy" variable for week as defined in the paper

*** Significant at 99% level of confidence, ** significant at the 95% level of confidence.

---

[19] Using Worldometer data, we have 124 observations, since their data starts a bit later. The estimated coefficient on week is 0.47 (std. error = 0.062.) It is significant at the 99% level of confidence. The other regressions discussed in table 2 are available from the authors upon request.