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Analyzing COVID-19 Deaths by Weekday: A Four-Year Statistical Review (2020–2023)

Haftanın Günlerine Göre COVID-19 Ölümlerinin Analizi: Dört Yıllık İstatistiksel Bir İnceleme (2020–2023)

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ABSTRACT

Background: Earlier studies have suggested that the mortality rate of Coronavirus Disease-2019 (COVID-19) may vary by day of the week, possibly due to variations in healthcare system workflows or reporting delays. This study aimed to assess whether such day-of-week effects exist in COVID-19 death data from 2020 to 2023 in the United States.

Materials and Methods: We extracted nationwide United States COVID-19 mortality data from the Centers for Disease Control and Prevention WONDER database, grouping deaths by weekday for each year from 2020 to 2023. Negative binomial regression and Tukey's Honest Significant Difference test were used to assess differences in daily death counts. Additional comparisons were made between aggregated weekday (Monday–Friday) and weekend (Saturday–Sunday) totals.

Results: No statistically significant differences were observed in the number of deaths across individual weekdays in any year analyzed (p = 0.905 for all years combined). Post-hoc testing confirmed that all pairwise comparisons between weekdays were non-significant. Sub-analyses of early (2020–2021) and late (2022–2023) pandemic periods also showed no significant variation (all p-values >0.05). The average number of deaths was slightly higher on weekdays throughout the study period in the weekday-versus-weekend analysis; however, the combined difference did not reach statistical significance (p = 0.947).

Conclusion: Official COVID-19 mortality data from 2020 to 2023 in the United States show no evidence of a "weekend effect," indicating that the day of the week did not significantly influence reported deaths.

Keywords: Coronavirus Disease-2019, COVID-19, SARS-COV-2, mortality, weekend effect

ÖZ

Amaç: Önceki çalışmalar, Koronavirüs Hastalığı-2019 (COVID-19) mortalitesinin haftanın günlerine göre değişebileceğini; bunun da sağlık sistemi iş akışları veya bildirim gecikmelerinden kaynaklanabileceğini öne sürmüştür. Bu çalışmanın amacı, 2020–2023 yılları arasında Amerika Birleşik Devletleri'ne ait COVID-19 ölüm verilerinde haftanın gününe bağlı bir etkinin olup olmadığını değerlendirmektir.

Gereç ve Yöntemler: Amerika Birleşik Devletleri genelindeki COVID-19 mortalite verileri Hastalık Kontrol ve Önleme Merkezleri WONDER veri tabanından elde edilmiş ve 2020–2023 yıllarının her biri için ölümler haftanın günlerine göre gruplandırılmıştır. Günlük ölüm sayılarındaki farklılıkları değerlendirmek için negatif binom regresyonu ve Tukey'nin Dürüstçe Anlamlı Fark testi kullanıldı. Ayrıca, hafta içi (Pazartesi–Cuma) ve hafta sonu (Cumartesi–Pazar) toplamları arasında karşılaştırmalar yapılmıştır.

Bulgular: İncelenen hiçbir yılda haftanın bireysel günleri arasında ölüm sayıları açısından istatistiksel olarak anlamlı bir fark saptanmamıştır [tüm yıllar birleştirildiğinde (p = 0,905)]. Post-hoc analizler, haftanın günleri arasındaki tüm ikili karşılaştırmaların anlamsız olduğunu doğrulamıştır. Pandeminin erken (2020–2021) ve geç (2022–2023) dönemlerine yönelik alt analizlerde de anlamlı bir değişkenlik gözlenmemiştir (tüm p-değerleri >0,05). Hafta içi–hafta sonu karşılaştırmasında, çalışma dönemi boyunca ortalama ölüm sayılarının hafta içi günlerde hafif düzeyde daha yüksek olduğu gözlenmiş; ancak toplam fark istatistiksel anlamlılığa ulaşmamıştır (p = 0,947).

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ÖZ

Sonuç: Amerika Birleşik Devletleri'nde 2020–2023 yıllarına ait resmi COVID-19 mortalite verileri, haftanın gününe bağlı bir "hafta sonu etkisi" olduğuna dair kanıt sunmamaktadır. Bu bulgular, bildirilen ölüm sayılarının haftanın günlerinden anlamlı düzeyde etkilenmediğini göstermektedir.

Anahtar Kelimeler: Koronavirüs Hastalığı-2019, COVID-19, SARS-CoV-2, mortalitesi, hafta sonu etkisi

Introduction

Understanding the temporal distribution of mortality due to Coronavirus Disease-2019 (COVID-19) is critical for effective public health planning and response (1). Epidemiologists and health authorities have relied extensively on mortality data to track disease progression, allocate healthcare resources, and evaluate the impact of interventions such as vaccination campaigns and preventive (even restrictive) measures (2). However, fluctuations in reported deaths are shaped not only by the biological course of COVID-19 but also by administrative practices and the timing of data collection and reporting. Consequently, determining whether observed trends in mortality reflect genuine epidemiological patterns or are artifacts of reporting and operational cycles is essential (3).

The influence of the day of the week on reported COVID-19 deaths is a frequently examined aspect. Although viral transmission is not expected to follow a weekly rhythm, healthcare and reporting systems often do. Many hospitals and public health institutions operate on weekends with reduced staffing levels, which can delay diagnoses and treatments and potentially increase mortality rates. This operational pattern has been associated with the so-called "weekend effect"—a phenomenon where patients admitted during weekends experience worse outcomes, potentially due to limited access to specialized care, diagnostics, or senior medical staff. In 2018, Honeyford et al. (4) published a meta-analysis encompassing 39 studies and 57 separate analyses and found a 7% increased risk of death for weekend admissions (odds ratio [OR]: 1.07; 95% confidence interval [CI]: 1.03–1.12). Similarly, a subsequent meta-analysis by Chen et al. in 2019, which included 68 studies and over 640 million hospital admissions, reported an even greater weekend-associated mortality risk of 16% (odds ratio [OR]: 1.16; 95% confidence interval [CI]: 1.10–1.23), with the highest effect observed among patients undergoing elective surgical procedures (OR: 1.70; 95% CI: 1.08–2.52) (5).

In the context of COVID-19, care-seeking behavior delays during weekends could intensify disease outcomes, contributing to variations in mortality data. Evaluating whether such temporal effects are observable at a population level can offer insights for optimizing healthcare delivery and preparedness in future pandemics. Accordingly, this study aimed to assess whether statistically significant differences exist in the number of reported COVID-19 deaths by day of the week, including distinctions between weekdays and weekends, in the United States between 2020 and 2023.

Materials and Methods

Mortality data for COVID-19 were obtained from the United States Centers for Disease Control and Prevention (CDC), National Center for Health Statistics. National Vital Statistics System, Mortality 2018–2023 on CDC Wide-Ranging, Online Data for Epidemiologic Research Online Database, released in 2024 (6). These data were extracted from the latest available Multiple Cause of Death Files at the time of our search (years 2018–2023), as compiled from records provided by 57 vital statistics jurisdictions through the Vital Statistics Cooperative Program. Data extraction was performed on June 20, 2025. The search criteria used for this analysis included selecting the "Multiple Cause of Death, 1999–2023" database and filtering for the underlying cause of death coded as U07.1, which corresponds to COVID-19. The data were grouped by year and weekday to capture the total number of deaths recorded on each day of the week—Monday through Sunday—for 2020, 2021, 2022, and 2023. No age adjustment or demographic stratification was applied because such variables are not available in the dataset when mortality data are grouped by day of the week. The extracted results provided the raw death counts.

To evaluate differences in the total number of deaths across individual weekdays, a negative binomial regression was conducted for each year, after normality was verified using the Shapiro–Wilk test. Tukey's Honest Significant Difference (HSD) test was used as a post-hoc method to assess pairwise differences between all weekday combinations. Separate negative binomial regression and Tukey HSD tests were performed to compare aggregate weekday (Monday through Friday) and weekend (Saturday and Sunday) data, assessing broader temporal patterns.

Statistical Analysis

All statistical analyses were performed using the scipy.stats and statsmodels libraries in Python version 3.11 (Python Software Foundation, Wilmington, United States of

America). Because the CDC WONDER is a publicly available, anonymized, and freely searchable database, this study was exempt from approval by the ethics committee.

Results

Table 1 summarizes the total number of COVID-19 deaths recorded on each day of the week across the first four pandemic years. Visual inspection suggests relatively consistent totals across weekdays in each year. No obvious or systematic peak or flex is apparent on any specific day, even in years with higher overall deaths (e.g., 2020 and 2021). Although there was a slight trend toward reduced death counts on weekends (Saturday and Sunday), this pattern was neither pronounced nor consistent across years.

Figure 1 shows an improved visualization of data, showing the proportion of weekday deaths relative to the total weekly deaths for each year, expressed as percentages.

A negative binomial regression was applied to weekday totals for each year to assess whether any day of the week was significantly associated with different death totals compared to others, yielding a p-value of 0.905. Although the negative binomial regression did not reveal significant differences, the Tukey's honestly significant difference test was performed to explore potential pairwise differences between individual weekdays. The test results confirmed that none of the day-to-day comparisons were statistically significant, as all pairwise comparisons yielded adjusted p-values well above the threshold of 0.05, and no confidence intervals for mean differences were excluded. The largest observed mean difference (e.g., between Fridays and Sundays) was not statistically significant. Notably a sub-analysis with negative binomial regression limited to weekly data on a monthly basis of the individual pandemic years also yielded non-statistically significant differences across the different days of the week, as follows: 2020: p = 1.000; 2021: p = 1.000; 2022: p = 1.000; and 2023: p = 1.000.

To explore broader temporal contrasts, in a secondary analysis, total deaths were averaged across weekdays (Monday through Friday) and weekends (Saturday and Sunday) (Table 2).

The data revealed that weekdays were generally associated with slightly higher average deaths in all years. However, these differences were minimal and non-statistically significant, as confirmed by the negative binomial regression comparing the two groups across the four-year period, which again yielded a non-statistically significant difference (p = 0.947).

A negative binomial regression limited to monthly data for the individual pandemic years also yielded a non-statistically significant difference between weekdays and weekends, as follows: 2020: p = 0.895; 2021: p = 0.937; 2022: p = 0.986; and 2023: p = 0.985. Figure 2 shows a visual comparison of annual death counts on weekdays and weekends, expressed as percentages of the weekly total deaths.

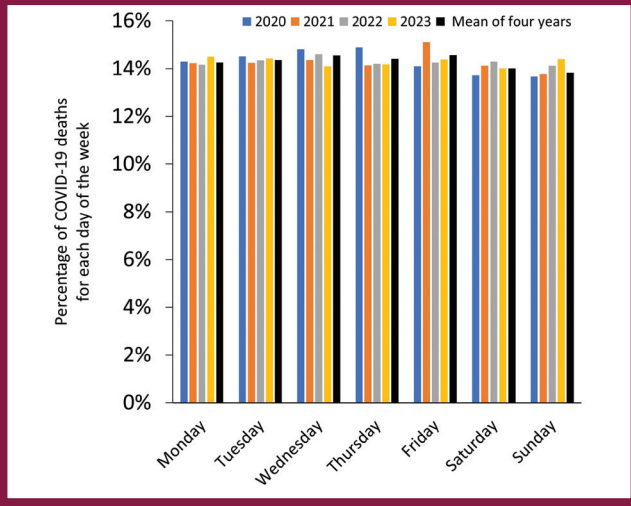

Figure 1. Deaths due to COVID-19 (% of all weekly deaths) recorded on each day of the week across the first four pandemic years in the United States.
COVID-19, Coronavirus Disease-2019.

Table 1. Total number of deaths from COVID-19 recorded on each day of the week across the first four years of the pandemic in the United States.

Year	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2020	50,156	50,922	51,973	52,255	49,476	48,127	47,922
2021	59,353	59,359	59,890	58,928	62,998	58,922	57,441
2022	26,433	26,760	27,244	26,512	26,590	26,668	26,345
2023	7,239	7,203	7,041	7,083	7,183	6,995	7,188
Total	143,181	144,244	146,148	144,778	146,247	140,712	138,896

COVID-19, Coronavirus Disease-2019.

Table 2. Total deaths from COVID-19 averaged across weekdays (Monday through Friday) and weekends (Saturday and Sunday).

Year	Weekdays (average)	Weekends (average)
2020	50,956	48,024
2021	60,106	58,182
2022	26,708	26,507
2023	7,150	7,092
Total	144,920	139,804

COVID-19, Coronavirus Disease-2019.

Figure 2. Deaths due to COVID-19 (% of all weekly deaths) recorded during weekdays or weekends across the first four pandemic years in the United States.
COVID-19, Coronavirus Disease-2019.

Discussion

The results of our study, encompassing both a detailed weekday-level analysis and a comparative assessment between weekdays and weekends, reveal no statistically significant differences in the total number of COVID-19 deaths by day of the week across the analyzed pandemic years (2020–2023). These findings suggest that the temporal pattern of COVID-19 mortality has remained consistent across weekdays and weekends in the United States across the first four years of the pandemic despite potential variations in healthcare resource availability, institutional workflows, or potential reporting delays. This consistency supports the hypothesis that the day of the week may not have a meaningful impact on the mortality rates of COVID-19 patients.

Our results do not align with those reported by Manzoor and Redelmeier (7), who analyzed COVID-19 mortality data from the World Health Organization database across 10 countries between March 7, 2020, and March 7, 2022. Their analysis identified a modest but significantly higher average daily death count on weekends (Saturdays and Sundays) than on weekdays (8,532 vs. 8,083; $p < 0.001$), corresponding to an approximately 6% relative increase. The largest absolute differences were observed in the United States (+22%) and Brazil (+29%), with such a "weekend effect" persisting throughout various pandemic phases. Consistent with these findings, Aly surveyed COVID-19-related deaths in the United States using Worldometer data from March to October 2020 (8) and found that weekends (Saturdays and Sundays) were associated with lower COVID-19 mortality than the rest of the week ($Z = 3.527$, $p = 0.0004$). However, these findings are challenged by data published by Bergman et al. (9), who demonstrated that the reporting artifacts in several studies may have substantially influenced the apparent oscillations in United States COVID-19 mortality. In their analysis, the "weekend effect" disappeared when COVID-19 death data were organized by episode rather than by report date, thus confirming the potential influence of uncontrolled confounding factors on the epidemiology of COVID-19 (10). An additional retrospective observational study by González-Gancedo et al. (11) investigated nearly 2,000 patients with COVID-19 admitted to the emergency departments of a private Spanish hospital network between February and April 2020. Although this study reported a significant association between the day of admission and survival—indicating lower survival rates for patients admitted on weekends—the authors defined the weekend as Friday, which is not considered a weekend day. Consequently, their findings are not directly comparable to those of other studies because the definition of "weekend" was different.

Conclusion

This nationwide analysis of COVID-19 mortality data from 2020 to 2023 in the United States reveals no statistically significant differences in death counts by day of the week or between weekdays and weekends. Despite prior studies suggesting a "weekend effect," our findings indicate a consistent mortality pattern across weekdays and weekends, even during peak pandemic periods. These results support the interpretation that temporal fluctuations in reported deaths are not indicative of systematic disparities in care or outcome but are more likely attributable to logistics of reporting. Our work aligns with prior analyses that identified reporting artifacts as important drivers of perceived variation in mortality, underscoring the importance of methodological rigor in epidemiological surveillance. When evaluating temporal patterns in health outcomes, future analyses should prioritize episode-based datasets and carefully account for administrative confounders.

Ethics

Ethics Committee Approval: Ethical approval was not required due to the use of publicly available web resources.

Informed Consent: Not required.

Footnotes

Authorship Contributions

Concept: G.L., C.M., Design: G.L., Data Collection or Processing: G.L., Analysis or Interpretation: G.L., C.M., Literature Search: G.L., Writing: G.L., C.M.

Conflict of Interest: No conflict of interest was declared by the author(s).

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