

# Lag Between COVID-19 Cases And Subsequent Deaths

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## Research article

**Keywords:** COVID-19, epidemiology, health policy, community health, communicable disease

**Posted Date:** May 26th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-434947/v2>

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# Abstract

**Background:** Observed COVID-19 cases and deaths are frequently used as independent factors to justify the use or de-escalation of non-pharmaceutical interventions. To investigate and describe the temporal relationship between changes in epidemic curves for COVID-19 cases and deaths, a longitudinal analysis of these metrics was performed for 16 states in the United States and three countries.

**Results:** The analysis performed demonstrates a considerable, consistent lag between a surge in COVID-19 cases and the subsequent rise in attributable deaths, with approximately a month-long lag observed.

**Conclusions:** The time lag identified must be incorporated in health emergency decision making in order to avoid the pre-mature de-escalation of disease mitigation measures.

## Background

Coronavirus disease 2019 (COVID-19), caused by Severe Acute Respiratory Syndrome coronavirus 2 (SARS-CoV-2), originated in Wuhan, China in late 2019, and was declared a pandemic by the World Health Organization on March 11, 2020 [1]. As of April 5, 2021, over 131 million cases had been confirmed in 223 countries, areas, or territories, and over 2.8 million virus-associated deaths had been reported [2]. In the face of persistent consequences from the health emergency and absence of widespread vaccination, public health authorities have employed a variety of non-pharmaceutical interventions (NPIs) to control community spread of COVID-19 [3]. While effective when fully employed, these NPIs can have secondary economic and social consequences, often receiving push-back from political leaders and the public. In gauging the appropriate level of NPI response, many have focused on health system data such as active hospitalizations and deaths, without appreciating their temporal relationship [4, 5]. By reacting to deaths or hospitalizations in isolation, or expecting both to be high at the same time, actions of health systems and jurisdictions may come weeks behind changes in true disease burden that presage resultant morbidity and mortality and societal consequence. To investigate the nature of this potential relationship, we investigated the time lag between changes in COVID-19 epidemic case curves and deaths in 16 U.S. states and three countries.

## Methods

Data from the COVID Tracking Project [6] and the European Centre for Disease Prevention and Control [7] were used to identify surges in COVID-19 cases and subsequent virus-associated deaths. To minimize the impacts of variability in reporting, a surge was defined as a two-fold or greater increase in the seven-day average case or death count in a two-month period. The nadir of the seven-day average preceding the surge in cases or deaths was determined, and the inflection point was defined as the date that marked a 10 percent increase in the seven-day average of cases or deaths above the nadir. If the nadir was zero, the inflection point was defined as the next date when a seven-day average was greater than zero. When

surges in both cases and deaths were observed, the lag between them was calculated as the number of days between each of their inflection points (Fig. 1).

After surveying U.S. rates across the 50 states, we identified those that experienced a discrete surge in cases between June 1, 2020 and August 1, 2020. Sixteen states in the United States (Georgia, Idaho, Iowa, Kansas, Minnesota, Mississippi, Missouri, Montana, Nevada, New Mexico, Ohio, Oklahoma, South Dakota, Virginia, West Virginia, and Wisconsin) were analyzed, along with three countries (France, Netherlands, and the United Kingdom) incorporated for comparison. Surges occurring prior to June 1, 2020 were not included, as laboratory supply shortages in the winter and spring of 2020 hampered COVID-19 diagnostic testing [8].

## Results

The lag between the surge in COVID-19 cases and the subsequent surge in deaths ranged from 14 to 55 days, with the shortest lag observed in New Mexico and the longest lag occurring in the United Kingdom (Table 1 and Fig. 2). The median time lags were 27 and 50 days, and the means were 29 and 43 days, with standard deviations of 10 and 14 days for states and countries, respectively. Analyzed together, the median time lag was 27 days, and the mean was 31 days, with a standard deviation of 12 days.

Table 1  
 Inflection Dates for Cases and Deaths and Time Lag

| Location       | Inflection Date for Cases | Inflection Date for Deaths | Lag (Days) |
|----------------|---------------------------|----------------------------|------------|
| New Mexico     | June 20, 2020             | July 4, 2020               | 14         |
| Iowa           | June 21, 2020             | July 8, 2020               | 17         |
| Nevada         | June 4, 2020              | June 26, 2020              | 22         |
| Idaho          | June 16, 2020             | July 9, 2020               | 23         |
| Oklahoma       | June 2, 2020              | June 25, 2020              | 23         |
| Virginia       | July 4, 2020              | July 29, 2020              | 25         |
| Missouri       | June 15, 2020             | July 11, 2020              | 26         |
| Montana        | June 12, 2020             | July 9, 2020               | 27         |
| Wisconsin      | June 21, 2020             | July 18, 2020              | 27         |
| Kansas         | June 15, 2020             | July 13, 2020              | 28         |
| Mississippi    | June 7, 2020              | July 7, 2020               | 30         |
| Ohio           | June 18, 2020             | July 18, 2020              | 30         |
| Georgia        | June 4, 2020              | July 10, 2020              | 36         |
| Minnesota      | June 18, 2020             | July 29, 2020              | 41         |
| West Virginia  | June 14, 2020             | July 27, 2020              | 43         |
| South Dakota   | July 18, 2020             | September 10, 2020         | 54         |
| Netherlands    | July 13, 2020             | August 5, 2020             | 23         |
| France         | July 21, 2020             | September 9, 2020          | 50         |
| United Kingdom | July 22, 2020             | September 15, 2020         | 55         |

## Discussion

Our analysis demonstrates a considerable, consistent lag between a surge in COVID-19 cases and the subsequent rise in attributable deaths. Based upon this review, deaths as a metric of community epidemic status reflect transmission events occurring in a community more than a month prior, on average. While hospitalizations ostensibly would have a shorter lag-time and may represent a more responsive metric, accurate daily curves on real-time hospitalizations are not as readily available, can be impacted by level of hospital stress, and may not capture particularly vulnerable populations counted among deaths such as long-term care facilities. We anticipate that hospitalization data would lag case incidence data, and additional research into this is warranted.

Limitations of our analysis may include an underestimation of COVID-19 cases and deaths—both those directly and indirectly related. There is variability between jurisdictions in laboratory test availability, performance, and reporting, as well as how such results are captured. Although testing was more widely accessible in the summer of 2020 compared to the winter and spring, test availability in the United States was still unable to meet the overwhelming demand [9]. As widespread community transmission occurred, scarcity of supplies amalgamated with backlogs at laboratories responsible for processing tests [9] causing reporting shortfalls and delays that contribute to an underestimation of disease incidence. Death certification errors and delays in ascertainment as COVID-19 related are known to impact mortality statistics [10, 11]. The COVID-19 pandemic has highlighted limitations within the reporting process, as deaths attributable to COVID-19 have been assigned to other causes [12].

## Conclusions

Political jurisdictions must rely on NPIs to mitigate the impact of COVID-19 even as vaccine uptake increases; for many regions of the world, this may encompass the next year or more, as well as the prospect of subsequent waves of disease. If political and health system leaders better understand the time lag between changes in community incidence and subsequent documented deaths, they may be better prepared to make more timely decisions, responding more effectively to community epidemics. Further research should explore the trend identified in this analysis, as well as temporal relationships among other commonly used metrics such as hospitalizations.

## Declarations

Ethics Approval and Consent to Participate: Not applicable

Consent for Publication: Not applicable

Availability of data and materials: The datasets analyzed during the current study are available in the COVID Tracking Project repository, <https://covidtracking.com/data/download> and the European Centre for Disease Prevention and Control repository, <https://www.ecdc.europa.eu/en/covid-19/data>

Competing Interests: The authors declare that they have no competing interests

Funding: Not applicable

Authors' Contributions: JVL conceived the study and designed the analyses. DMB participated in study design. SD performed the analyses. All authors contributed to the writing of the manuscript.

Acknowledgments: Not applicable

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## Figures

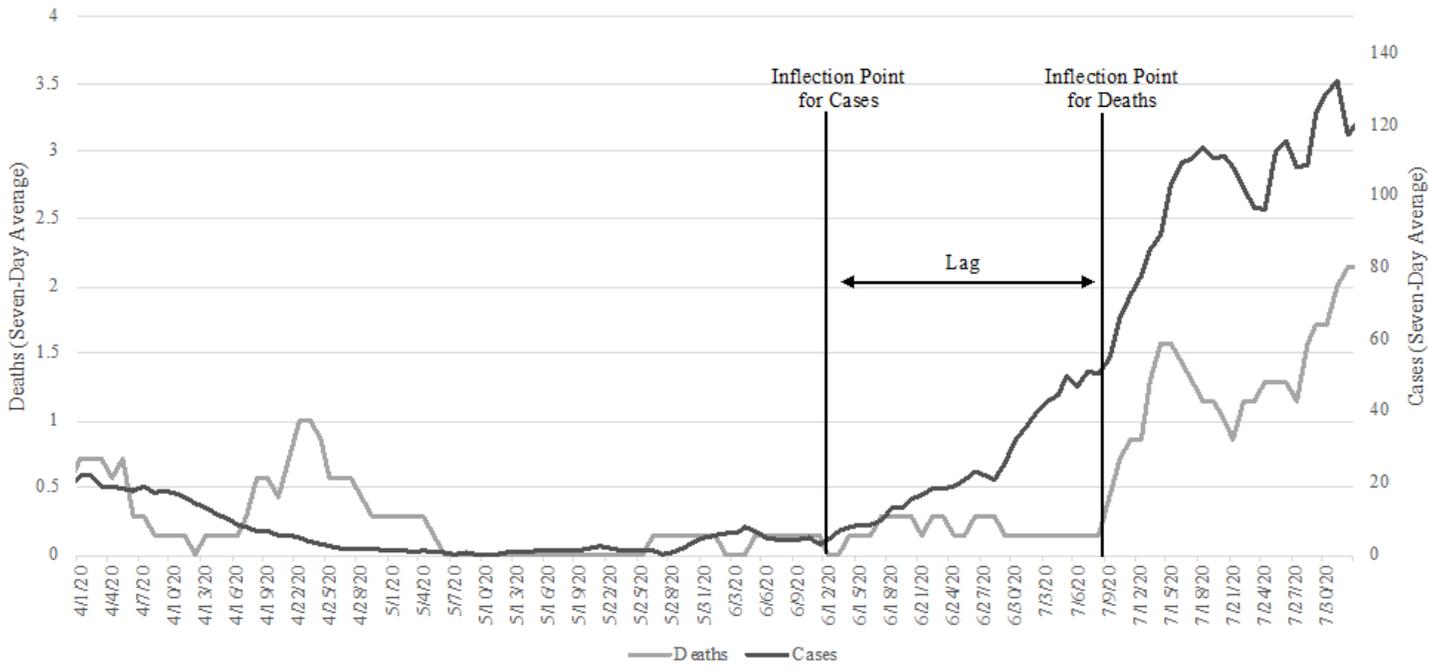


Figure 1

The Determination of Inflection Points and Calculation of Time Lag

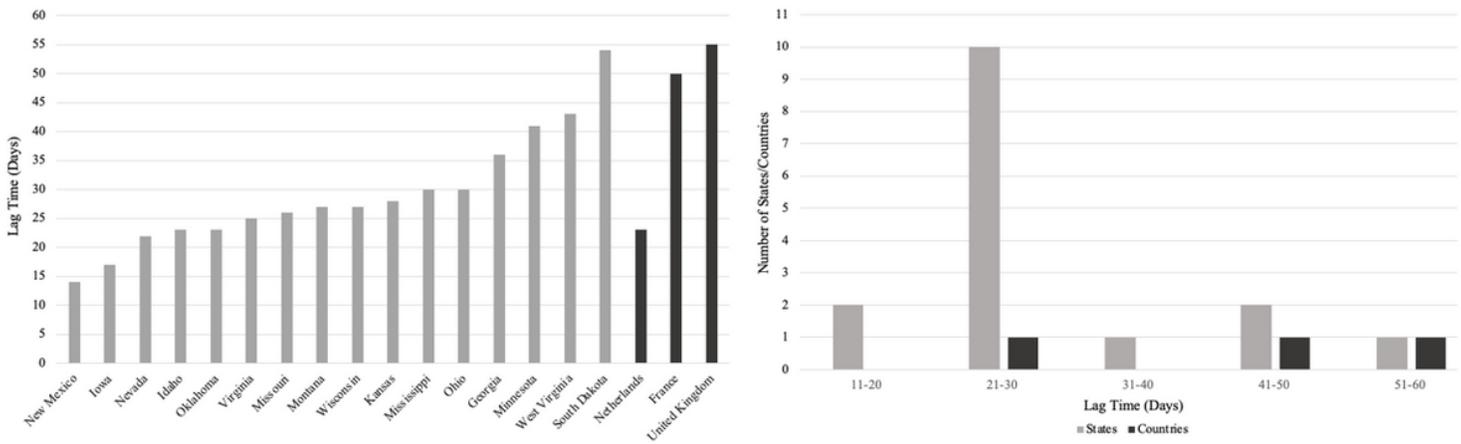


Figure 2

Time Lag for the 19 Locations Analyzed