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Associations of Stay-at-Home Order Enforcement With COVID-19 Population Outcomes: An Interstate Statistical Analysis

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In the United States, state governors initially enacted coronavirus diseases 2019 (COVID-19)-mitigation policies with limited epidemiologic data. One prevailing legislative approach, from March to May 2020, was the implementation of "stay-at-home" (SAH) executive orders. Although social distancing was encouraged, SAH orders varied between states, and the associations between potential legal prosecution and COVID-19 outcomes are currently unknown. Here, we provide empirical evidence on how executive enforcement of movement restrictions may influence population health during an infectious disease outbreak. A generalized linear model with negative binomial regression family compared COVID-19 outcomes in states with law-enforceable stay-at-home (eSAH) orders versus those with unenforceable or no SAH orders (uSAH), controlling for demographic factors, socioeconomic influences, health comorbidities, and social distancing. COVID-19 incidence was less by 1.22 cases per day per capita in eSAH states compared with uSAH states (coefficient = −1.22, 95% confidence interval (CI): −1.83, −0.61; $P < 0.001$), and each subsequent day without an eSAH order was associated with a 0.03 incidence increase (coefficient = 0.03, 95% CI: 0.03, 0.04; $P < 0.001$). Daily mortality was 1.96 less for eSAH states per capita (coefficient = −1.96, 95% CI: −3.25, −0.68; $P = 0.004$). Our findings suggest allowing the enforcement of public health violations, compared with community education alone, is predictive of improved COVID-19 outcomes.

communicable disease; coronavirus; disease outbreaks; policy; public health

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease 2019; eSAH, law-enforceable stay-at-home order; SAH, stay-at-home order; SDI, social distancing index; uSAH, unenforceable stay-at-home order.

To stop the initial transmission of coronavirus disease 2019 (COVID-19) within the United States, infectious disease experts and epidemiologists recommended enacting public health policy to mitigate community transmission (1). Municipalities and local governments became the first to implement public health policies such as gathering restrictions. Subsequently, mitigation efforts became more unified as states imposed comprehensive restrictions within their borders (2). State governments first imposed individual mobility and social distancing regulations on March 19, 2020, with California issuing a stay-at-home order (SAH). By April 7, 2020, 49 states had enacted public health interventions aimed at curbing person-to-person transmission of COVID-19. Often, such policies included language directing citizens to remain in the safety of their homes (3). While heterogeneous on a national scale, statewide measures conferred a greater level of parity between local municipalities, many of which previously implemented contrasting regulations. In the absence of an overarching federal mandate, each state could incorporate additional stipulations, such as enforcement guidelines, within their directives (4).

All 50 states declared a state of emergency during the initial transmission of COVID-19 within the United States in March 2020, but the extent to which governors enacted further mobility restrictions varied (5). A prevalent strategy for mitigating COVID-19 spread was the implementation of SAH executive orders, which outlined regulations for individual movement outside of the home and stipulated the temporary closure of nonessential businesses. SAH orders delineated the occasions citizens were permitted to leave their residences, listing only instances deemed "essential" by the order, such as doctor appointments or acquiring groceries. Multiple states made infringing on SAH guidelines an unlawful offense with penalties ranging from misdemeanor to civil charges. In contrast, a minority of governors implemented SAH orders but did not instruct for their enforcement. Other states opted for more lenient approaches by electing not to issue a SAH order or instead allowing local municipalities to impose mandates as they saw fit. The societal ramifications of these enforcement guidelines remain the subject of ongoing political and legal debate (6, 7).

Although previous studies have examined the implied effectiveness of SAH orders and mobility restrictions, to our knowledge none have examined the associations of government-enforcement strategies and COVID-19 population outcomes (8–14). For example, prior studies using the COVID-19 Tracking Project (11, 14) and smartphone data (12, 13) suggested that mobility restrictions and SAH orders were successful at mitigating adverse COVID-19 outcomes; however, these investigations do not report quantitative incidence comparisons between states with differing SAH legal enforcement policies. Additional studies suggested that SAH orders were effective alongside other public health interventions such as face masks (14) and local municipal SAH orders (12, 14); however, the degree to which mobility restrictions and COVID-19 incidence and mortality were influenced by their enforcement was not considered (11–14). Furthermore, such studies either did not utilize nationwide data sets or did not adequately control for confounding demographic, epidemiologic, and health variables between states (8–14). Thus, the association of SAH enforcement policy with COVID-19 population outcomes remains under investigation (4).

We investigated whether statewide SAH orders that included written language for legal prosecution of offenders were associated with decreased COVID-19 incidence and mortality rates when controlling for state demographic factors, mobility data, socioeconomic factors, and underlying health comorbidities. This controlled interstate statistical investigation has the potential to provide relevant data to governments and public health experts as the United States continues to navigate through the enduring COVID-19 pandemic. Furthermore, analysis of how written policy correlates to epidemiologic outcomes in the context of an infectious disease outbreak may guide legislative response in future epidemics.

METHODS

Documenting government actions

The extent of each state's policy response to the coronavirus pandemic was recorded directly from official executive orders, which were made public to their constituents (Web Table 1, available at https://doi.org/10.1093/aje/kwab267). The authors (K.S.H. and J.M.) thoroughly reviewed language within executive orders implemented after the declaration of a state of emergency in each corresponding state and characterized their policy response, if any. SAH orders were classified based on prior accepted definitions: specifically, language compelling constituents to remain in their homes unless for certain vital activities necessary to sustain life (15, 16). The first SAH executive order that included jurisdiction of all statewide counties was selected for our investigation. The identified executive orders in Web Table 1 were cross-validated with other available databases and were found to be in agreement, suggesting that the orders reviewed were directly those specifying SAH policy and not other related emergency public health measures (17). Next, these policies were screened for written guidelines for penalties that could be brought against violators by law enforcement officials. Together, these criteria defined an enforceable stay-at-home order (eSAH), where legal ramifications were used to compel citizens to obey the public health measure (Web Figure 1).

State policies were categorized as unenforceable (uSAH) if their orders outlined recommended actions rather than required instructions, if states delegated public health policy to local governments, or if they opted not to provide formal SAH directives. Although somewhat varied in their policy response, all uSAH states continued to emphasize the gravity of the pandemic and urged their constituents on prudence via emergency declarations and official rhetoric; however, uSAH states did not legally oblige all constituents to cease nonessential travel, which is the divergent characteristic in our analysis. uSAH states instead relied upon public education and the independent judgment of their citizens to reduce mobility outside of the home.

States with movement restrictions that varied by county or local municipality were classified into the uSAH category. Although some local governments in these states implemented SAH orders that were enforceable by law, the heterogeneity of movement restrictions in their neighboring regions may have enabled constituents to circumvent regulations by traveling to these surrounding jurisdictions (18).

COVID-19 data collection

Daily positive COVID-19 cases, hospitalizations, and associated deaths were documented from each state's first case through May 20, 2020. May 4 was the average date states began to relax eSAH restrictions. The May 20 endpoint encompasses this period and any potential residual COVID-19 cases that occurred late within the SAH period. Because the time of COVID-19 result reporting corresponds to when cases were reported positive, not the date of test administration, a lag time was implemented from May 4. The COVID-19 incubation period occurs by day 11 in 97.5% of individuals, and a 5-day leeway was given for testing turnaround (19).

The COVID Tracking Project at *The Atlantic* magazine is a publicly available database that collects historical state-level COVID-19 health outcome information (20). The COVID Tracking Project compiles information on daily positive tests and deaths sourced directly from official state-level public health data and is accessible via the Creative

Commons Attribution-NonCommercial 4.0 International License. The database has been utilized to model projections for COVID-19 scenarios within the United States, and positive tests are strongly aligned with available US Centers for Disease Control and Prevention data for COVID-19 incidence and deaths (21, 22).

State epidemiologic characteristics

Epidemiological characteristics were collected for each state to aid in the regression model. Population density, age, race, sex, Census region, and educational status of those over 25 years of age were recorded from 2018 American Community Survey data, via the US Census Bureau (23). Average household income and percentage of the population under the poverty line were recorded from the US Census Bureau Small Area Income and Poverty Estimates program (24).

Several common health comorbidities were stratified by state and entered into the regression model. Chronic disease indicators measured by the US Centers for Disease Control and Prevention, Division of Population Health, were used as health comorbidity variables. State health comorbidities that were examined include the age adjusted prevalence of people over age 18 who smoke, with asthma, medicated hypertension, diabetes mellitus, hypercholesterolemia, chronic obstructive pulmonary disease, chronic kidney disease, or obesity. Age-adjusted incidence of mortality from "diseases of the heart" was utilized as a marker of cardiovascular disease prevalence within each state (25). Emerging data suggests that these conditions may be associated with higher rates of death in patients with COVID-19 and should be controlled for to determine the associations of SAH order enforcement (26). The full description of each state's epidemiologic characteristics and comorbidities can be seen in Web Table 2.

Social distancing index

To account for the intrinsic degree of social distancing and community interaction within a given state, the authors utilized the social distancing index (SDI) from the University of Maryland's COVID-19 Impact Analysis Platform for use in the regression model (27). The SDI utilizes deidentified cellular and vehicular movement data to calculate 6 different mobility metrics, such as the reduction of nonwork trips, the percentage of the community staying home, and the reduction of travel distance, among others, to determine the degree of movement within a state (28). Mobility metrics are then entered into a previously validated algorithm, which determines the SDI (27). The SDI is scaled from 0 to 100, with 0 being the least and 100 being the maximum value, suggestive of absent and maximal social distancing, respectively. For states that utilized eSAH orders ($n = 37$) or made SAH recommendations ($n = 5$), the SDI was indexed from the date of each state's first confirmed COVID-19 case until the date of SAH order recommendation or implementation. The date of SAH order implementation was chosen as the end index date to avoid the simultaneous influence of SAH orders on COVID-19 outcomes and the SDI. For states that did not issue statewide SAH orders ($n = 6$) or relied on local ordinances ($n = 2$), the SDI was indexed from the date of each first confirmed case until March 27, the average date of SAH implementation nationwide. The values of each state's SDI can be seen in Web Table 2.

Statistical analysis

A generalized linear model (GLM) with multivariable random effects using penalized quasi-likelihood was used in the statistical analysis. Due to the nonnormal distribution and overdispersed count outcome variables (incidence per day per capita and mortality per day per capita), a negative binomial regression distribution was used. A random-effects model was employed to account for within-state variability, an autocorrelation structure with time-lag adjustment was utilized to adjust the model for the correlated error terms over time, and state population per square mile was used as an offset variable. The model adjusted for previously mentioned state demographic data via multivariable stepwise regression, in which the variables selected showed statistical significance in the univariate models (Web Figure 2). Results were depicted as β-coefficients represented with their corresponding 95th percentile confidence intervals (CIs). Covariates of regression included days from when SAH was issued (or May 20, 2020, for uSAH), race, age, sex, income, Census region, and age-adjusted prevalence of the aforementioned comorbid conditions (19). Figures were created by plotting the median incidence and mortality each day for each group (eSAH and uSAH). Statistical analyses were performed using R, version 3.6.1 (R Foundation for Statistical Computing. Vienna, Austria), and STATA, release 15 (StataCorp LLC, College Station, Texas). *P* values were 2-sided and values of <0.05 were considered statistically significant. R package "glmmPQL" was utilized to run the analyses, while STATA was used to plot median COVID-19 incidence and mortality.

RESULTS

Two cohorts were formed based on the enforceable order inclusion criteria: eSAH states and uSAH states (Figure 1). In total, 37 states met the inclusion criteria for an enforceable statewide SAH order (eSAH). The remaining 13 states were classified in the uSAH group. Of the 13 states in the uSAH group, 5 issued SAH orders that served only as recommendations, 2 opted for regional approaches, and the remaining 6 did not issue any SAH orders of any kind. Oklahoma and Utah implemented local ordinances while the governors of Connecticut, Kentucky, Massachusetts, New Mexico, and Virginia issued an SAH executive order but did not allow for lawful enforcement in their writing. The states who made no such statewide SAH orders and did not have any significant regional SAH orders during the study period were Arkansas, Iowa, Nebraska, North Dakota, South Dakota, and Wyoming.

Multivariable negative binomial regression indicated that, on average, the number of cases per day per capita (100,000 people) was 1.22 less in states with a law-enforceable SAH order (eSAH) compared with those without such an order

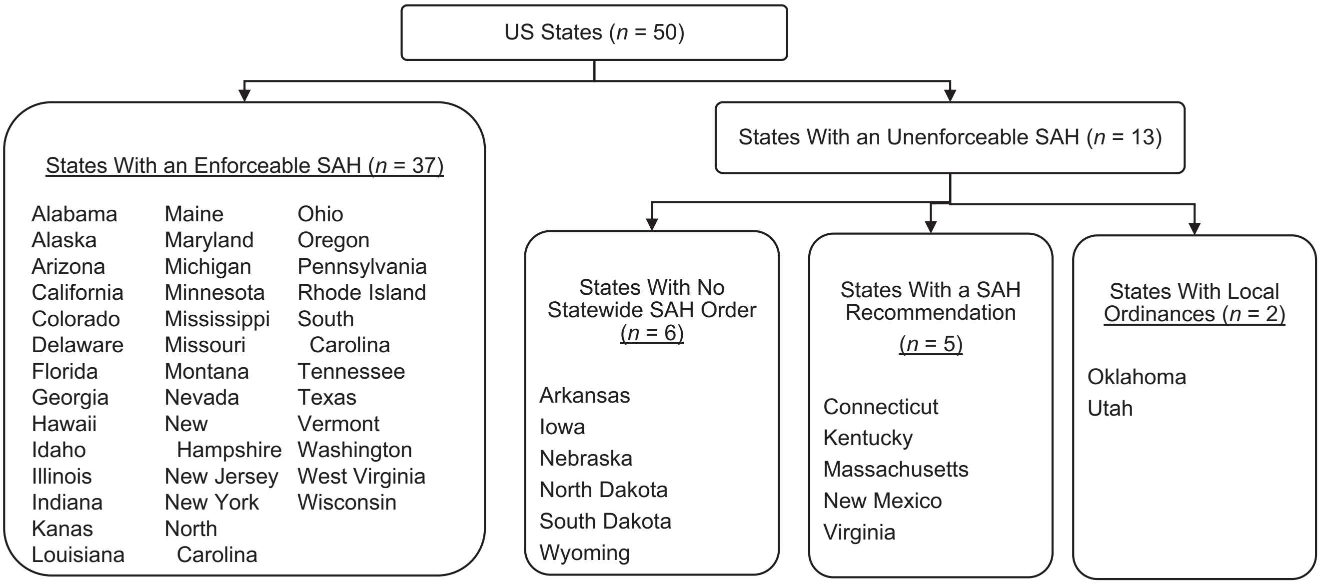

Figure 1. Categorization of states into 2 cohorts for linear regression analysis based upon the inclusion criteria for law-enforceable stay-at-home orders (SAH), United States, March 2020 to May 20, 2020.

(coefficient = −1.22, 95% CI: −1.83, −0.61; $P < 0.001$) (Table 1 and Figure 2). Additionally, each subsequent day after a state's first case that they withheld issuing an eSAH order was predictive of a 0.03 rise in incidence per capita (coefficient = 0.03, 95% CI: 0.03, 0.04; $P < 0.001$). For every percent increase in the population over 18 years of age who have asthma (age-adjusted prevalence), there were 44.48 (coefficient = 44.48, 95% CI: 2.84, 86.12; $P = 0.037$) more positive cases per day per capita respectively. Although it did not reach the significance threshold set by our study, for every percent increase in the population of African-American and Black individuals there were 8.51 more COVID-19 cases per day per capita (coefficient = 8.51, 95% CI: −1.58, 18.60, $P = 0.097$).

The multivariable negative binomial regression model indicated that, on average, the number of deaths per day per capita was 1.96 less for eSAH states compared with uSAH states (coefficient = −1.96, 95% CI: −3.25, −0.68; $P = 0.004$) (Table 2 and Figure 3). Additionally, a higher percentage of female population (compared with male) was predictive of 284.46 fewer deaths per day per capita (coefficient = −284.46, 95% CI: −481.16, −87.77; $P = 0.006$). For every percent increase in the population of individuals who were under 19 years old, there were 98.42 fewer deaths per day per capita (coefficient = −98.42, 95% CI: −184.81, −12.04; $P = 0.027$). A higher percentage of individuals with obesity or who were overweight was also predictive of COVID-19 mortality (coefficient = 51.00, 95% CI: 14.49, 87.50, $P = 0.008$).

DISCUSSION

Previous investigations have demonstrated the effectiveness of social distancing, but the association of statewide SAH enforcement policies on population outcomes has not been extensively studied. Throughout the COVID-19 pandemic in the United States, states often enacted heterogeneous public health policies that continue to undergo constant modification and revision. Our findings suggest that written enforcement guidelines included within SAH restrictions are predictive of lower COVID-19 incidence and mortality, compared with governments that did not stipulate legal guidelines for statewide nonessential travel.

Within the states with enforceable SAH orders, prosecution guidelines varied. Some governors, such as those in Oregon and Vermont, publicly prioritized education before law enforcement of their SAH order (29, 30). Other states, such as New Jersey, openly proclaimed their desire for strong enforcement, with State Attorney General Gurbir Grewal announcing that "the time for warnings is over" (31). Despite differences in enforcement strategy, all eSAH states had in common the ability to lawfully punish violators, if they so choose. In contrast, citizens of uSAH states did not have the risk of legal consequences to weigh prior to public interaction. In Massachusetts, a state with a recommended SAH order, Governor Charlie Baker declared "I do not believe I can or should order U.S. citizens to be confined to their home for days on end" (32, p. 2).

However, independent of enforcement strategy, all 50 states emphasized the gravity of the COVID-19 pandemic via a State of Emergency declaration and implored their citizens to exercise prudence (5). Despite this, our analysis predicted that the forewarning of legal prosecution, or lack thereof, played a more significant role in predicting improved public health outcomes than the message alone. As a whole, the eSAH group achieved these associations despite varying levels of substantive enforcement. It is yet to be determined whether this association is based upon the direct

Table 1. Multivariable Regression Analysis of Per-Capita Daily Incidence of Coronavirus Disease 2019, United States, March 2020 to May 20, 2020

Variable	Value (SE)	95% CI	*P* Value
Enforceable SAH order	−1.22 (0.3)	−1.83, −0.61	<0.001[a]
Days from SAH issued (or May 20, 2020, if uSAH)	0.03 (0)	0.03, 0.04	<0.001[a]
Social distancing and community mobility			
Social distancing index	0.02 (0.03)	−0.05, 0.09	0.530
% Of age group			
Ages 20–64	Base		
Ages ≥65	34.37 (22.13)	−10.50, 79.24	0.130
Ages <19	27.07 (20.14)	−13.77, 67.91	0.188
% Of race/ethnicity group			
Other	Base		
White	1.95 (2.48)	−3.07, 6.98	0.436
Black/African-American	8.51 (4.98)	−1.58, 18.60	0.097
Hispanic or Latino	0.97 (2.67)	−4.45, 6.39	0.719
Social and health determinants			
Median household income ($)	0 (0)	0, 0	0.450
Female sex, %	−64.61 (45.89)	−157.67, 28.45	0.168
Adults (≥18 years) who smoke (2018)[b]	7.73 (11.98)	−16.56, 32.02	0.523
Adults (≥18 years) who have asthma (2018)[b]	44.48 (20.54)	2.84, 86.12	0.037[a]
Adults (≥18 years) who have hypercholesterolemia (2017)[b]	−5.94 (11.78)	−29.83, 17.95	0.618
Adults (≥18 years) who have COPD (2018)[b]	−23.12 (22.46)	−68.67, 22.43	0.311
Adults (≥18 years) who are overweight or obese (2018)[b]	4.62 (8.51)	−12.64, 21.88	0.591
Adults (≥18 years) who have CKD (2018)	−43.10 (46.22)	−136.82, 50.63	0.358
Intercept	−2.83 (23.23)	−48.28, 42.62	0.903

Abbreviations: CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; SAH, stay-at-home order; SE, standard error; uSAH, unenforceable stay-at-home order.
[a] Indicates statistical significance ($P < 0.05$).
[b] Indicates age-adjusted prevalence.

threat of legal action or an increase in the implied seriousness of the pandemic that is conveyed with a statewide SAH order. Further studies should examine potential COVID-19 outcome differences within the eSAH group based on the degree of enforcement.

Secondary covariates that were determined to be significant predictors of COVID-19 incidence by our model included asthma, while the secondary covariates that were found to be significant predictors of COVID-19 mortality by our model were the percentage under 19 years old, percentage female residents, and the percentage of individuals who were overweight or obese. Notably, our statistical analysis is designed as a predictive model, and significant covariates identified are only associated with the outcome rather than direct causations. Nevertheless, prior analysis of secondary covariates have found them to directly influence COVID-19 outcomes themselves (33). For example, a large meta-analysis suggested that male sex was a risk factor for severe COVID-19 and intensive-care-unit admission (34). By designing our model in this manner, we controlled for the influence of these parameters on our primary outcome, government enforcement. Due to our inability to imply causation, additional studies that directly examine the associations of these covariates with COVID-19 outcomes should be utilized before designing public health policy based around these secondary estimates.

Furthermore, our secondary covariates may have additional confounding for which we are unable to control. For example, the SDI may be strongly influenced by the political leanings of its constituents, as the issue of social distancing and mask wearing became highly politicized during the pandemic (35). Many diseases tend to occur in clusters, such as diabetes, obesity, and cardiovascular diseases, which cannot be controlled for with the population health metrics used by our study (36). Given the wealth of data suggesting that COVID-19 outcomes are worse for those with chronic diseases, our data indirectly signifies the importance of a healthy populace in reducing COVID-19 mortality (37).

Our study relies on accurate reporting of COVID-19 outcomes, which have been suggested to be underreported (38). Challenges arose with the timely reporting of new COVID-19 cases as each state was independently tasked with the

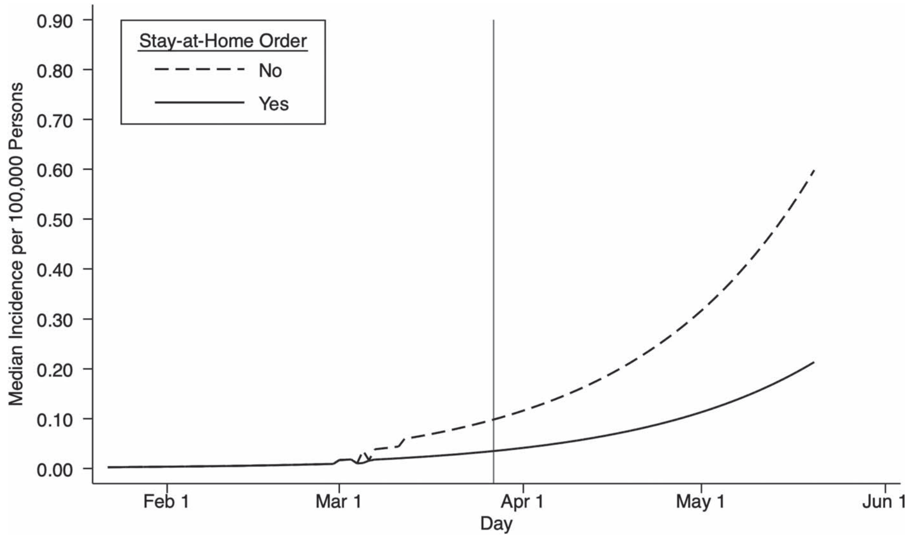

Figure 2. Coronavirus disease 2019 (COVID-19) daily median incidence according to presence of enforceable stay-at-home order (SAH), United States, March 2020 to May 20, 2020. Differences are statistically significant ($P < 0.001$). Dashed line, states without a law-enforceable statewide SAH order; solid line, states with an enforceable SAH order; vertical line is the average date of SAH order implementation.

complex logistical undertaking (39). Potential politicization of outcomes data reporting may have confounded the accurate reporting of COVID-19 incidence, as was alleged within at least one state's public health department (40). Additionally, each state took different actions at different times, including other social distancing measures such as school closures, businesses closures, and/or bans on public gatherings, which may similarly affect COVID-19 incidence and mortality (41). These factors were individually unaccounted for in our model. Within the eSAH group, enforcement strategies varied. Some states opted for more aggressive enforcement while many others emphasized warnings and fines. We are unable to account for differential changes in enforcement within our study.

Socioeconomic considerations

We have previously found that health-care disparities targeting minority populations have led to unequal COVID-19 population outcomes, although it is currently unclear how

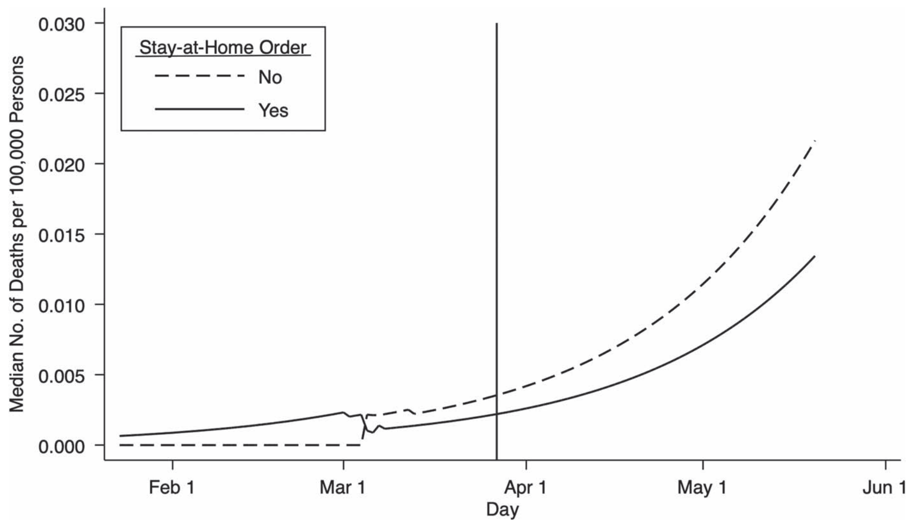

Figure 3. Coronavirus disease 2019 (COVID-19) daily median mortality according to presence of enforceable stay-at-home order (SAH), United States, March 2020 to May 20, 202. Differences are statistically significant ($P < 0.001$). Dashed line, states without a law-enforceable statewide SAH order; solid line, states with an enforceable SAH order; vertical line is the average date of SAH order implementation.

Table 2. Multivariable Regression Analysis of Per-Capita Daily Deaths From Coronavirus Disease 2019, United States, March 2020 to May 20, 2020

Variable	Value (SE)	95% CI	*P* Value
Enforceable SAH order	−1.96 (0.63)	−3.25, −0.68	0.004[a]
Days from SAH issued (or May 20, 2020 if uSAH)	0.03 (0)	0.03,0.04	<0.001[a]
Social distancing and community mobility			
Social distancing index	0.06 (0.07)	−0.08, 0.20	0.388
% Of age group			
Ages 20–64	Base		
Ages ≥65	−18.47 (−46.80)	−113.37, 76.42	0.696
Ages <19	−98.42 (46.60)	−184.81, −12.04	0.027[a]
% Of race/ethnicity group			
Other	Base		
White	2.20 (5.26)	−8.48, 12.87	0.679
Black/African American	13.64 (10.54)	−7.72, 35.01	0.204
Hispanic or Latino	0.40 (5.66)	−11.07, 11.88	0.944
Social and health determinants			
Median household income ($)	0 (0)	0, 0	0.679
Female sex, %	−284.46 (97.00)	−481.16, −87.77	0.006[a]
Adults (≥18 years) who smoke (2018)[b]	−23.52 (25.37)	−74.96, 27.91	0.360
Adults (≥18 years) who have asthma (2018)[b]	28.14 (43.42)	−59.90, 116.18	0.512
Adults (≥18 years) who have hypercholesterolemia (2017)[b]	−14.42 (24.91)	−64.92, 36.09	0.567
Adults (≥18 years) who have COPD (2018)[b]	−36.95 (47.47)	−133.21, 59.31	0.442
Adults (≥18 years) who are overweight or obese (2018)[b]	51.00 (18.00)	14.49, 87.50	0.008[a]
Adults (≥18 years) who have CKD (2018)	53.05 (97.72)	−145.09, 59.31	0.591
Intercept	124.33 (49.13)	28.22, 220.44	0.011

Abbreviations: CI, confidence interval; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; SAH, stay-at-home order; SE, standard error; uSAH, unenforceable stay-at-home order.

[a] Indicates statistical significance ($P < 0.05$).

[b] Indicates age-adjusted prevalence.

SAH orders may have contributed to unequal outcomes in these groups (42). Additionally, health-care disparities are well known to exist in rural states, which also happen to be the majority of states that did not issue SAH orders (43). This may have deterred the citizens in these states from seeking COVID-19 tests, lowering the apparent incidence.

Importantly, the SAH orders and their enforcement have consequences that extend beyond COVID-19 outcomes. For example, an estimated 41% of adults delayed seeking medical care during the pandemic, and many routine procedures were canceled during SAH orders (44). Furthermore, one report suggested that COVID-19-related SAH orders had adverse impacts on mental health and physical activity, which may predispose the population to obesity or other adverse health outcomes (45). Crime, namely domestic violence, also increased during the lockdown period (46). Socioeconomic impacts of SAH are substantial and cannot be discounted (47). Future analysis should compare these associations against the potential benefit of SAH orders and their enforcement on preventing COVID-19 outcomes.

Conclusions

This investigation highlighted a significantly smaller daily COVID-19 case incidence and mortality within states that enacted enforceable stay-at-home orders compared with those that did not. Analyses controlled for demographic, comorbid, and socioeconomic factors to isolate the influence of SAH enforcement. Our results provide evidence that enforceable state-level guidelines predict improved public health intervention outcomes, irrespective of actual punishment administered. As states relaxed their original SAH orders, COVID-19 cases have steadily increased with the resumption of person-to-person contact. Similar to the initial COVID-19 spread in the United States, governors are reevaluating the most appropriate steps to mitigate transmission. One popular intervention is recommending the use of facial coverings while in public or social settings, because of their efficacy in reducing respiratory droplet transmission (48–50). Future analysis is warranted to evaluate whether issuing enforcement guidelines for mask mandates and similar public health efforts may parallel our findings on stay-at-home orders.

Further analysis is needed to examine whether it is the threat of enforcement or the strength of a message that is more impactful for mitigating transmission of COVID-19. It is also important not to discount the potential for harm, whether economic, social, or medical, that may occur with the implementation of such policies. Nevertheless, our study suggests that executive enforcement of public health policy is predictive of improved population-based COVID-19 outcomes. This association may help policy makers curtail future waves of COVID-19 transmission in the United States and properly respond to future infectious disease outbreaks.

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The data underlying this article are available in the article and in its online supplementary material.

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