Early COVID-19 Interventions Failed to Replicate St. Louis vs. Philadelphia
Outcomes in the United States

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ABSTRACT

The Coronavirus disease 2019 (COVID-19) pandemic has elicited an abrupt pause in the United States in multiple sectors of commerce and social activity. As the US faces this health crisis, the magnitude, and rigor of their initial public health response was unprecedented. As a response, the entire nation shutdown at the state-level for the duration of approximately one to three months. These public health interventions, however, were not arbitrarily decided, but rather, implemented as a result of evidence-based practices. These practices were a result of lessons learned during the 1918 influenza pandemic and the city-level non-pharmaceutical interventions (NPIs) taken across the US. During the 1918 pandemic, two model cities, St. Louis, MO, and Philadelphia, PA, carried out two different approaches to address the spreading disease, which resulted in two distinctly different outcomes. Our group has evaluated the state-level public health response adopted by states across the US, with a focus on New York, California, Florida, and Texas, and compared the effectiveness of reducing the spread of COVID-19. Our assessments show that while the states mentioned above benefited from the implementations of early preventative measures, they inadequately replicated the desired outcomes observed in St. Louis during the 1918 crisis. Our study indicates that there are other factors, including health disparities that may influence the effectiveness of public health interventions applied. Identifying more specific health determinants may help implement targeted interventions aimed at preventing the spread of COVID-19 and improving health equity.
INTRODUCTION

As the first wave of Coronavirus Disease 2019 (COVID-19) pandemic began to sweep through the United States (US) in March 2020, multiple public health measures were enforced across the nation in an unprecedented manner. However, by the end of June 2020, the US remained one of the largest COVID-19 epicenters in the world, with more than 2.5 million confirmed cases and the number of new daily cases reaching highs in certain states and the US (CDC, 2020b). Now, faced with the renewed threat of experiencing prolonged second wave, many states are reintroducing partial shutdown measures, which are examples of non-pharmaceutical interventions (NPIs). During the first wave of this pandemic, the US strictly implemented multiple NPIs to help mitigate the spread of the disease, and reduce the number of COVID-19-related deaths. Herein we discuss the successes and failures of the implemented evidence-based public health practices amid a nationwide public health crisis that abruptly brought the nation and its economy to a screeching halt.

As of February 2020, while China, Italy, and Spain experienced the turmoil of being the epicenters for the COVID-19 pandemic, the US had only about 50 confirmed cases, and the national populace was nearly unaffected. No one could have anticipated how life was about to change in the ensuing months. In March 2020, different states started to sound the alarms, and place their respective constituencies under states of emergency. After that, increasingly rigorous preventative measures that affected the function and dynamics of societal interaction were implemented. These interventions, aimed at facilitating social distancing and preventing the spread of COVID-19, can be categorized into four broad measures (Galbadage et al., 2020b; Wilder-Smith and Freedman, 2020). These are (1) screening and testing, (2) prevention of mass gatherings, (3) stay at home orders, and (4) the use of face masks. In the US, 44 states of the 50 states
implemented statewide stay at home orders at the early stages of the COVID-19 pandemic, paralleling other measures listed above (Figure 1, Supplemental Table 1). The mean duration of stay at home orders for all US states was 49.5 days (SD ± 16.5) (median 50 days, range 25 to 81 days).

While seemingly sudden and societally intrusive, historical precedent and evidence-based practices have guided these measures. For example, a century ago, the world experienced a devastating toll on lives caused by the 1918 influenza pandemic. In response to this pandemic, health officials implemented a broad range of NPIs according to the then available understanding of disease transmission (Mills et al., 2004; Ferguson et al., 2005; Markel et al., 2006). Furthermore, studies comparing public health measures implemented by several cities across the United States and other nations such as England further illustrated how these measures helped reduce the spread of the 1918 influenza pandemic and decrease mortality rates (Ferguson et al., 2006; Bootsma and Ferguson, 2007; Handel et al., 2007; Hatchett et al., 2007).

Studies on the 1918 influenza pandemic have focused on contrasting NPIs implemented by two US cities, St. Louis, MO, and Philadelphia, PA. St. Louis imposed strict preventative interventions early on, while Philadelphia minimally applied restrictions at a much later date. Accordingly, St. Louis had a milder outbreak, whereas Philadelphia experienced significantly higher mortality rates (Hatchett et al., 2007). These outcomes observed in the 1918 influenza pandemic helped guide the widely-adopted rigorous public health measures against COVID-19. Hatchett et al. (2007) also identified four critical factors that helped determine the success of the control of the pandemic dissemination. These factors were (1) implementation of early and rapid interventions, (2) duration the responses, (3) multiple concurrent interventions, and (4) the intensity of the interventions implemented.
Other studies supported these conclusions while emphasizing the effectiveness of early interventions, but also noted that stringent preventative measures could leave many more susceptible individuals once these NPIs are relaxed (Kalnins, 2006; Bootsma and Ferguson, 2007). During the 1918 pandemic, most of the US cities maintained preventative measures for about two to eight weeks (Hatchett et al., 2007). However, cities that relaxed NPIs earlier experienced increased case numbers resulting in second wave resurgences. An inverse relationship between the intensity of the first and second waves of the pandemic was also observed. These observations were partly due to the smaller proportion of susceptible populations present in cities after a strong first wave of the disease (Bootsma and Ferguson, 2007; Hatchett et al., 2007).

Here we compare and contrast public health interventions implemented in the US during the first wave of the COVID-19 pandemic, focusing on four states: New York, Florida, Texas, and California. These states comprised some of the most populous counties in the US and were affected sharply by the COVID-19 pandemic. In addition, our group studied the case rates of COVID-19 before, during, and after these measures were implemented, and then compared it to the outcomes of St. Louis, and Philadelphia, during the 1918 influenza pandemic (Figure 2). While variation in the timing and the intensity of the public health measures applied was observed, all four states implemented very similar interventions. Our comparisons show that the early evidence-based interventions implemented by the US were not adequately able to replicate the desired outcomes of St. Louis vs. Philadelphia and curtail the COVID-19 pandemic.
METHODS

Evaluating the State and County Level Public Health Response

We documented public health responses and actions taken between January 1st and June 30th at the state- and county-level were found using the state and county public health department and government websites. More specifically, we examined press releases and executive orders issued by the state, and the counties were used to determine the public health response. This information collected was organized in an Excel worksheet by date and type of response. We used four broad categories to distinguish between the types of responses. They were (1) screening and testing, (2) prevention of mass gatherings, (3) stay at home orders, and (4) the use of face masks. To have only the most relevant and quantifiable data, we distilled public health responses to critical interventions. Besides, the first positive cases of COVID-19 in each county were also noted. Office Timeline Online was used to create timelines to illustrate this information visually.

Determining the Case Rates and Mortality Rates

COVID-19 Cases and deaths are presented as seven-day averages from data provided by Johns Hopkins University and the City of New York (Dong et al., 2020). Case rates were calculated as new confirmed COVID-19 cases per 100,000 population in the respective counties. Death rates were calculated as new COVID-19 related deaths per 1,000,000 people in the individual counties. We calculated the case rates and mortality rates in the six most populous counties in the states of New York (Kings, Queens, New York, Suffolk, Bronx, and Nassau), California (Los Angeles, San Diego, Orange, Riverside, San Bernardino, and Santa Clara), Florida (Miami-Dade, Broward, Palm Beach, Hillsborough, Orange, and Pinellas, and Texas (Harris, Dallas, Tarrant, Bexar, Travis, and Collin). We then overlayed the duration statewide stay-at-home orders that were implemented by each state (Grey boxes) to evaluate the ensuing case and mortality rates.
RESULTS

Public Health Response to COVID-19

As mentioned earlier, responses to earlier pandemics in the US included school closures, restaurant restrictions, emergency declarations, gathering restrictions, stay at home orders, and non-essential business closures (Gupta et al., 2020). The COVID-19-related responses have been mainly relegated to state-level decision making and based on necessity and intensity within each state.

Screening and Testing

Targeted screening for COVID-19 began in California and New York with Los Angeles (LAX), San Francisco (SFO), and New York (JFK) airports for travelers coming from Wuhan, China, starting on January 17th (CDC, 2020e). The first reported case in the United States occurred on January 26th in California. New York, Florida, and Texas all had initial cases within the first week of March (Figure 1c). State-funded testing sites for all four states implemented utilized drive-through and walk-up options to reduce numbers of potentially infected individuals from seeking assistance at healthcare facilities. Early in the pandemic, testing was limited, and priority was given to high-risk individuals, including symptomatic patients, healthcare workers, first responders, essential workers, and individuals in contact with other high-risk individuals. As more tests were readily available, fewer restrictions were placed on who was able to get tested (Florida Department of Health, 2020; State of California, 2020b; State of New York, 2020a; Texas Department of State Health Services, 2020). In addition to walk-up and drive-through sites, mobile testing sites were also deployed in Florida and New York to increase the number of tests administered (City of New York, 2020; Florida Division of Emergency Management, 2020). Each state also implemented contact tracing to identify potentially exposed individuals (CDC, 2020c).
**Mass Gatherings**

The next primary public health intervention implemented across all four states was the cancellation of mass gatherings of 250 individuals, followed by 50 individuals per location (Supplemental Tables 2-5). These orders followed shortly after initial cases were identified in each state. Events that brought in large amounts of attendance, such as concerts, sporting events, and festivals were canceled first. Next, the states incrementally decreased the number of people allowed to gather in one location until, eventually, the state recommended that people should only interact with those who were within the same household.

**Stay at Home Orders**

One of the most rigorous measures utilized during COVID-19 was the stay at home orders. California was under stay at home order for 50 days (March 19th to May 7th) (State of California, 2020a). The stay at home order in California was implemented more rigorously at the county level because the state-level order acted more as a recommendation (Supplemental Table 3). The NY State on PAUSE plan stay at home order was enforced for 68 days (March 22nd to May 28th) before the state started its Phase one reopening plan (Cuomo, 2020; State of New York, 2020b; c). Florida state stay at home order was in effect for 27 days (April 3rd to April 29th) (State of Florida, 2020). Texas implemented stay at home orders for 29 days before relaxing these measures statewide (April 2nd to April 30th) (Abbott, 2020).

Many US states enacted stay at home orders very early on in the COVID-19 transmission. States with early COVID-19 cases placed these measures before April 29th (cluster 1) and did so with a statewide case count of fewer than 2000 cases, while states that put stay at home orders after April 29th did so before reaching 5000 cases (cluster 2) (Figure 1a, Supplemental Table 1). When adjusted to the county population, these measures were implemented with case rates of
below 50 cases per 10,000 (Figure 1b). The only exception was New York, which implemented these measures after 11,700 cases were confirmed. (Figure 1a).

**Cloth Face Masks**

On April 3rd, the Centers for Disease Control and Prevention (CDC) released its recommendation for all individuals to use cloth face masks when in public (CDC, 2020a). The goal of this recommendation was to reduce the viral transmission from asymptomatic carriers that may unknowingly spread to disease to susceptible individuals (Esposito et al., 2020; Galbadage et al., 2020b). While the extent to which the effectiveness of this measure is debatable, it helps bring more awareness to the public and help curtail the person-to-person transmission of the virus (Eikenberry et al., 2020). California was the first to implement this statewide on April 1st, which was two days before the CDC’s recommendation (Figure 1c). New York also implemented this measure as a state-level order, but it happened two weeks after the CDC’s recommendation. Florida and Texas only recommended face coverings at the state-level but was mandated in most counties (supplemental Tables 4 and 5).

**Differences in Statewide Responses to COVID-19**

The public health interventions implemented across the four states, New York, California, Florida, and Texas, were very similar. Any differences stem from the relative time of implementation and the intensity of measures taken. Unfortunately, New York was one of the first states severely affected by COVID-19 and was likely too late to implement these preventative measures (Figure 1a and b, Figure 2 and b). The initial wave of COVID-19 in New York, therefore, resembled that of Philadelphia during the 1918 pandemic. California, on the other hand, initiated precautionary measures early and seemed to follow the outcomes of St. Louis, at least in the initial
stages (Figure 2, c, and d). Regulations in both of these states were more stringent, and often had
consequences such as fines and jail time tied to not adhering to them.

In Texas and Florida, the implementation of specific public health interventions was less
rigorous as compared to California and New York. In Texas, for example, the regulations were not
implemented as quickly or as firmly at the state-level. Some public health interventions, such as
the ban on gathering, stay at home orders, and wearing cloth face masks, may have been perceived
as violations of individual liberties and disrupting businesses. In many ways, the small-government
philosophy of these states left essential decisions and actions to be made at the county-level.

Around the time many states went into shut down mode, spring break activities remained open in
Florida. The decision to not shut down before spring break was made in support of the state’s
economy. It was only after large tourist attractions, including Universal Studios and Disney World,
decided to close were more rigorous measures put in place in Florida.

The Spread of COVID-19 Across States and Counties

During the first months of COVID-19, the disease spread rapidly across the United States.
In New York, the number of positive cases grew exponentially over the first month of the
pandemic, especially in the New York City area and surrounding boroughs. However, unlike other
states, the number of daily cases in New York has decreased consistently since the end of April.
In California, Florida, and Texas, the number of daily cases has continued to increase over time at
a slower rate compared to New York. To better understand the dynamics of COVID-19 spread in
each of these states, we reviewed the number of cases and deaths in the six most populous counties
in each of these states (Figure 2).

In New York, the most populous counties all experienced a similar first wave of COVID-
19, with a peak of about 100 cases per 10,000 people in early April (Figure a). Most counties in
the state of California continued to have a relatively slow, but steady rise in the number of cases, making it difficult to distinguish between a first and a second wave (Figure 2c). We observed a similar pattern in the counties in Florida and Texas, except Miami-Dade County in Florida, which showed a peak case rate of about 15 cases per 10,000 people in early April (Figure 2c, e, g). Among these states, it is clear that New York experienced a robust first wave and a negligible second wave of the COVID-19 pandemic. While California, Florida, and Texas were spared from a significant first wave with cases rate peaking at less than 20 cases per 10,000, they are now facing a much higher risk for a prolonged second wave of the disease.

**US COVID-19 Interventions Failed to Replicate 1918 Pandemic Outcomes**

In the COVID-19 pandemic, the goal of effective public health preventative measures implemented was to mitigate and contain the spread of the disease. In the US, for the most part, public health interventions followed the principles of effective NPIs. They were implemented early on in the pandemic, using multiple preventative measures, with high intensity and for average durations longer than 45 days (Figure 1, Supplement Table 1). The exception to this was New York, which delayed the initiation of these measures (Figure 1a and b). This caused New York to experience a peak first wave, with hospitals reaching their capacity and a peak number of deaths occurring during mid-April (Figure 1b). However, New York enforced its preventative measures for close to three months, which in turn helped them bring their daily case rates to less than 5 cases per 10,000 by the end of June.

In contrast to New York, most other states followed the evidence-based recommendations, as stated above (Figure 1). This helped states “flatten the curve” to various degrees and control the initial spread of COVID-19 within their states. However, these public health interventions seemed to have only prolonged the transmission potential of the COVID-19 as states, including California,
Florida, and Texas, were experiencing new daily highs in confirmed cases by the end of June 2020 (CDC, 2020b). While the general expectation was that US states would follow the outcome of St. Louis during the 1918 pandemic, they have fallen short of replicating this desired outcome. On the contrary, by the end of June 2020, many such states were reimplementing statewide partial shutdown measures to prevent a potential second wave of COVID-19.

**DISCUSSION**

While the United States is now moving toward increased testing, there were some differences between how individual states responded to COVID-19 compared to countries that have already returned to pre-COVID-19 societal normality. In Iceland, for example, when cases were identified, public health officials implemented the following strategies, 1) quarantine requirements for international travelers coming and going, 2) high tracing of infection, 3) ban on gatherings larger than 20 persons, school closures with limited openings of elementary and preschools, defining areas of higher risk, and constant communication with the general public (Iceland Directorate of Health, 2020). New Zealand, another island nation with great success, was a bit more rigorous in the process by modifying and intensifying pre-existing plans for the management of influenza pandemics from previous outbreaks (Baker et al., 2020). These methods included the declaration of a national emergency, locking down the country, closing non-essential locations of work, banning social gatherings, extreme restrictions on travel, and closure of all schools. Furthermore, as part of this intensified strategy, border security was highly controlled. However, there are some distinct differences between Iceland, New Zealand, and the United States. For one, Iceland and New Zealand are small island nations with much smaller populations, making it much easier to implement stringent preventative measures, including better travel restrictions.
Another aspect to bear in mind is the fact that with Iceland and New Zealand, orders were also able to be carried out more consistently, unlike the US, which has delegated authority to individual states.

Many other factors can play a role in explaining why the US was not able to effectively replicate the outcomes of St. Louis vs. Philadelphia in the 1918 pandemic. A primary consideration is the level of adherence to these implemented measures. Regardless of the effectiveness of these measures, if people do not consistently comply, then outcomes can undoubtedly change. As an important note to add, numerous risk factors have been identified for COVID-19 and its clinical outcomes. These include advanced age, sex, immune-compromised status, and comorbidities, including chronic respiratory diseases, diabetes, and hypertension (Galbadage et al., 2020a; Li et al., 2020; Richardson et al., 2020). Genetic factors or social behaviors can also influence the spread of the disease. American Indian and African Americans have been reported to be five times more likely to be hospitalized for COVID-19, and Hispanic individuals are four times more likely to be hospitalized when compared to non-Hispanic whites (CDC, 2020d). Other social determinants of health, such as access to healthcare, insurance status, employment, poverty, education, and density of residential population, can also contribute to the disparities observed in COVID-19 transmission. Potential clusters of these risk factors and health determinates present in different geographic regions can lead to a disproportionate spread of the Coronavirus. These can make it more difficult to predict the outcomes of COVID-19 preventative measures implemented.
Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

AJ analyzed the US public health response and helped with the figure preparation, writing, and editing of the manuscript. BP aided in intervention comparative analysis and helped with the writing and editing of the manuscript. TG aided in disease spread, and comparative analysis, and helped with the figure preparation, writing and editing of the manuscript.

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Supplementary Material

The Supplementary Material for this article can be found below.
Abbott, G.G. (2020). Executive Order GA14 (Relating to statewide continuity of essential services and activities during the COVID-19 disaster) [Online]. Available: https://lrl.texas.gov/scanned/govdocs/Greg%20Abbott/2020/GA-14.pdf [Accessed June 26, 2020].

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Figure 1. State and county-level public health interventions to contain the spread of COVID-19. (a) The number of lab-confirmed COVID-19 cases at the start of the stay-at-home orders implemented by each state (Dong et al., 2020). Arkansas, Iowa, Nebraska, North Dakota, South Dakota, and Wyoming did not issue statewide stay-at-home orders and are not included. Cluster 1 - states that implemented stay-at-home orders before March 29th, 2020, and Cluster 2 - states that implemented these orders after March 29th. (b) Case rates of lab-confirmed COVID-19 patients at the start of the stay-at-home orders implemented by each state. Case rates are the number of cases per 10,000 of the county population. (c) Timeline of public health response (non-pharmaceutical interventions) in the states of New York (NY), California (CA), Florida...
(FL) and Texas (TX). These interventions included screening and testing, a ban on mass gatherings, stay at home orders, requirements for face masks in public locations, and other state-specific measures. In NY contained a one-mile containment effort around hotspot New Rochelle in Westchester County. In FL airport and roadway, screening was implemented for travelers coming to FL from the tri-state region as well as other regions with a high prevalence of COVID-19. In TX Airport and roadway, screening was implemented mainly for travelers coming into TX from the tri-state area and Louisiana, where the prevalence of COVID-19 was high. TX did not enforce mandatory use of cloth facemasks at the state level. Travis (4/13), Harris (4/13), Bexar (4/16), Dallas County (4/18) ordered mandatory facemasks.
Figure 2. United States COVID-19 cases and mortality in the six most populous counties in the states of New York, California, Florida, and Texas. COVID-19 Cases and deaths are presented as seven-day averages from data provided by Johns Hopkins University and the City of New York (Dong et al., 2020). Grey boxed areas are the duration statewide stay-at-home orders that were implemented by each state: New York (NY) March 22nd to May 28th (68 days), California (CA) March 19th to May 7th (50 days), Florida (FL) April 3rd to April 29th (27 days), and Texas (TX) April 2nd to April 20th (29 days). (a, c, e, g) Case rates are new confirmed COVID-19 cases per 100,000 population in the respective counties. (b, d, f, h) Death rates are new COVID-19 related deaths per 1,000,000 population in the individual counties. (a, b) Six most populous counties in the state of NY: KN-NY - Kings, QE-NY - Queens, NY-NY - New York, SF-NY - Suffolk, BR-NY - Bronx, and NS-NY - Nassau. (c, d) Six most populous counties in the state of CA: LA-CA - Los Angeles, SD-CA - San Diego, OR-CA - Orange, RV-CA - Riverside, SB-CA - San Bernardino, and SC-CA - Santa Clara. (e, f) Six most populous counties in the state of FL: MD-FL - Miami-Dade, BW-FL - Broward, PB-FL - Palm Beach, HB-FL - Hillsborough, OR-FL - Orange, and PN-FL - Pinellas. (g, h) Six most populous counties in the state of TX: HR-TX - Harris, DL-TX - Dallas, TR-TX - Tarrant, BX-TX - Bexar, TV-TX - Travis, and CL-TX - Collin.