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ORIGINAL RESEARCH

Efficacy of COVID-19 Public Health Measures in Philadelphia, New York City, Baltimore, and Chicago

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Introduction: From the early days of the pandemic, US cities have implemented a variety of public health measures to reduce the spread of COVID-19. This study investigates which policies were most effective in reducing cases of COVID-19 in four major cities: Philadelphia, New York City, Baltimore, and Chicago.

Methods: Through a cross-comparative analysis, we developed a timeline that tracked the implementation of a range of public health measures along with changes in COVID-19 cases, hospitalizations, and deaths. Data were collected from publicly available government sites and from press releases.

Results: The results from the stay-at-home orders illustrate the delayed impact it has in reducing COVID-19 cases and hospitalizations. The mask mandate led to the immediate and sustained reduction in cases across all four cities. During the spike of COVID-19 in the Fall of 2020, restrictions on indoor dining contributed significantly to reducing COVID-19 cases.

Discussion: Of all the measures that were examined, the implementation of mask mandates was most closely associated with a decline in COVID-19 cases, hospitalizations, and deaths across all four cities. Restrictions on indoor dining were also associated with a reduction in COVID-19 cases. Future studies should further investigate the adherence to different policies to better understand their impacts.

Keywords: public policy, healthcare, reform, health system, population health

Introduction

The first confirmed case of COVID-19 was identified in Wuhan, China, in December 2019.[1] In the subsequent months, the virus quickly spread across the world, arriving in the United States on January 16th, 2020.[1] On March 11th, 2020, the World Health Organization declared COVID-19 a pandemic, and cities across the world began to shut down.[2] Since the start of the pandemic, there have been over 60 million cases and over 1,000,000 COVID-19 related deaths in the United States.[3] Public health agencies have implemented a wide array of policies to reduce the spread of COVID-19 and protect the most vulnerable populations.

The COVID-19 pandemic illustrates the value of strong public health systems and the need for effective organization within and across nations. It has also brought to light the social and economic health disparities on minority populations that continue to afflict many Americans each year as well as the fragility of the US health-care system. Studies have proven that African American communities have an increased mortality and morbidity associated with COVID-19.[4] Unprecedented large-scale public health measures have been, and continue to be, deployed to help reduce the spread of the disease, with varying levels of adherence and success. This study seeks to better understand the efficacy of COVID-19 public health measures through a comparative analysis focused on four similar major US cities.

As this study took place during the pandemic, there is limited research that thoroughly analyzes the impacts of the current local city public health measures. Since the onset of the pandemic in China, much research has been conducted on the actions of Chinese cities such as Wuhan to stop the spread of coronavirus.[5–7] The global scale of the pandemic has led to the development of a variety of international studies comparing national responses across countries.[8,9] Studies analyzing the United States COVID-19 response have predominately focused on the impacts of state-wide policies.[10,11] While there have

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been some peer-reviewed studies reviewing the effects of masks and social distancing to reduce the spread of coronavirus, many of these were conducted prior to the major wave of COVID-19 that began in the winter of 2020.[12]

To understand the effectiveness of public health policies deployed after the winter 2020 wave of infections, a study was constructed to examine impact of these policies on changes in COVID-19 cases, hospitalizations, and deaths. To help control for extraneous factors in this high-level analysis, four similar urban cities in the US were selected.

Materials and Methods

Sources of Data

The study was conducted using publicly available information on government public health web sites and in press releases. Epidemiologic data on COVID-19 cases, hospitalizations, and deaths were obtained from city health department web sites, where available. Data on the implementation of public health measures were obtained from specific press releases and city government web site postings. Philadelphia policy and health metric data was collected from the City of Philadelphia Department of Public Health on June 1, 2021.[13,14] New York City policy and health metric data was collected from NYC Department of Health COVID-19 data page on June 1, 2021.[15] Baltimore policy and health metric data was collected the Baltimore COVID-19 dashboard on June 1, 2021.[16] Chicago policy and health metric data was collected from the City of Chicago COVID-19 dashboard on June 1, 2021.[17]

The public health measures that were tracked in the analysis include mask mandates, stay-at-home orders, suspension of indoor dining, and complete shutdown of restaurants and bars. These measures were chosen given the consistency in measures across all cities. These measures were coded based on the description of the order in the city mandate. An in-depth description of each policy for each city is presented in the results.

Geographic Sample

Four US cities were selected for this analysis: Philadelphia, New York City, Baltimore, and Chicago. These cities were selected based on similarities in population densities and demographics obtained through the 2020 U.S. Census (see Table 1).[18] These cities are also significant international transportation hubs determined through the Bureau of Transportation.[19] The cities all share a similar climate with warm temperatures in the summer and cooler temperatures in the winter.[20]

Analysis

Timelines were created for each city, which included COVID-19 cases, hospitalizations, deaths, and the implementation of various public health strategies. The major policies that were assessed for each city include: shutdown restaurants/bars, stay-at-home order, mask mandate, stage 1 reopening, reimplementation of COVID-19 restrictions, suspension of indoor dining, and spring reopening. These policies were selected based on their consistency across cities and similar implementation strategies. To analyze the efficacy of these strategies, the percent change in COVID-19 cases at 14,

Table 1 City Demographics

Geographic Data	Philadelphia	New York City	Baltimore	Chicago
Population				
Population Size	1,603,797	8,804,190	585,708	2,746,388
Population per square mile	11,379.5	27,012.4	7671.5	11,841.8
Age				
% Persons under 18 years	21.6	20.7	20.5	20.5
% Persons over 65 years	14.0	14.9	14.0	12.7
Economy				
Median Household Income (dollars)	49,127	67,046	52,164	62,097
% Persons in poverty	19.4	17.3	20.0	17.3

30, and 60 days after its implementation was calculated. The percent change in COVID-19 cases for similar policies was then compared across cities to reveal trends. The cross-comparisons between cities allow for a comprehensive review of each specific policy.

Results

Dates of covid-19 polices are listed in Table 2.

Philadelphia

Shutdown restaurants/bars: Began on 3/16/20 by mandate from the City of Philadelphia. This shutdown also included all non-essential businesses.

Stay-at-Home Order: Began on 3/23/20 through an emergency order by the City of Philadelphia. The order prohibited operation of non-essential businesses, detailed social distancing rules, and restricted all gatherings.

Mask Mandate: Began on 4/19/20 through executive order by the Pennsylvania Governor's Office. The Mask Mandate required employees and customers in public settings to wear face coverings.

Stage 1 Reopening: Known as "Yellow Phase" in Philadelphia, began on 6/5/20 through an emergency order by the City of Philadelphia. Permitted lower-risk activities to resume, such as retail business, outdoor parks, and childcare centers. Outdoor dining did not resume until 6/12/20.

Reimplementation of COVID-19 Restrictions: Began on 11/20/20 through an emergency order by the City of Philadelphia. The restrictions included prohibition of all public gatherings, in-person schools, indoor dining, gym attendance, and other restrictions. Retail establishments were allowed to remain open, but with capacity limits.

Suspension of Indoor Dining: Began on 11/20/20 through an emergency order by the City of Philadelphia.

Spring Reopening: Began on 2/12/21 through public announcement by the City of Philadelphia. The reopening allowed restaurants to resume indoor dining and businesses to increase capacity limits.

New York City

Shutdown restaurants/bars: Began on 3/16/20 through emergency executive order by the City of New York. This shutdown also included all entertainment venues and gyms.

Stay-at-Home Order: Began on 3/20/20 through executive order by the Governor's Office. The Stay-at-Home Order prohibited operation of non-essential businesses, detailed social distancing rules, and restricted all gatherings.

Mask Mandate: Began on 4/17/20 through executive order by the Governor's Office. The mask mandate required all residents to wear a mask or face covering in public when social distancing could not be maintained.

Stage 1 Reopening: Known as Phase 1 in New York City, reopening began on 6/8/20 through announcement by the Governor's office. Stage 1 reopening allowed for lower-risk activities, such as construction projects, wholesale manufacturing, and curbside retail pick-up to resume.

Reimplementation of COVID-19 Restrictions: Began on 11/13/20 through executive order by the Governor's office. These restrictions included: curfews on restaurants and bars, restrictions on gatherings, and curfews on gyms.

Suspension of Indoor Dining: Began on 12/14/20 through executive order by the Governor's Office.

Table 2 Dates of COVID-19 Policies

Policies	Philadelphia	New York City	Baltimore	Chicago
Shutdown restaurants/bars (SRB)	3/16/20	3/16/20	3/19/20	3/16/20
Stay-at-Home Order (SAH)	3/23/20	3/20/20	3/30/20	3/26/20
Mask Mandate (MM)	4/19/20	4/17/20	4/15/20	4/30/20
Stage 1 Reopening (S1R)	6/5/20	6/8/20	6/8/20	6/3/20
Reimplementation of COVID-19 Restrictions (RC)	11/20/20	11/13/20	11/12/20	11/16/20
Suspension of Indoor Dining (SID)	11/20/20	12/14/20	12/11/20	10/30/20
Spring Reopening (SR)	1/16/21	2/12/21	1/21/21	2/11/21

Spring Reopening: Began on 2/12/21 through executive order by the Governor's office. The reopening allowed restaurants to resume indoor dining.

Baltimore

Shutdown restaurants/bars: Began on 3/19/20 through announcement by the Mayor of Baltimore. This shutdown also included all entertainment venues and gyms.

Stay-at-Home Order: Began on 3/30/20 through executive order by the Governor's office. The Stay-at-Home Order prohibited operation of non-essential businesses, detailed social distancing rules, and restricted all gatherings.

Mask Mandate: Began on 4/17/20 through Executive Order by the Mayor's Office. The Mask mandate required all residents to wear a mask or face covering in public when social distancing could not be maintained.

Stage 1 Reopening: Known as Phase 1 in Baltimore, began on 6/8/20 through executive order by the Mayor's Office. Stage 1 Reopening loosened restrictions on barbershops, reopened childcare settings, and increased outdoor dining capacity. Outdoor dining was reopened on 5/29/20.

Reimplementation of COVID-19 Restrictions: Began on 11/12/20 through executive order by the Mayor's office. These restrictions included: capacity limits on restaurants, bars, retail businesses and gyms as well as restrictions on gatherings.

Suspension of Indoor Dining: Began on 12/11/20 through executive order by the Mayor's office.

Spring Reopening: Began on 1/21/21 through announcement by the Mayor's office. The reopening allowed restaurants to resume indoor dining and gyms to reopen.

Chicago

Shutdown restaurants/bars: Began on 3/16/20 through statewide mandate.

Stay-at-Home Order: Began on 3/26/20 through executive order by the Governor's Office. The Stay-at-Home Order restricted gatherings, detailed social distancing rules, and closed parks.

Mask Mandate: Began on 4/30/20 through Executive Order by the Governor's Office. The mask mandate advised all residents to wear a mask or face covering in public when social distancing could not be maintained.

Stage 1 Reopening: Known as Cautious Reopening in Chicago, began on 6/3/20 through announcement by the Mayor's office. Stage 1 Reopening reopened parks and loosened restrictions on businesses, gyms, and religious facilities.

Reimplementation of COVID-19 Restrictions: Began on 11/16/20 through announcement by the Mayor's office. These restrictions included: limitations on travel, non-essential business curfews, capacity limits on gyms, and restrictions on gatherings. Indoor dining was prohibited on 10/30/20.

Suspension of Indoor Dining: Began on 10/30/20 through executive order by the Governor's office.

Spring Reopening: Began on 2/11/21 in Chicago through announcement by the Mayor's office. The reopening allowed for restaurants to resume indoor dining and capacity limits to increase for businesses.

Discussion

The COVID-19 pandemic has devastated cities across the world. In the United States, cities in the East coast and Midwest were impacted by the virus to varying degrees. The cases of COVID-19 in urban regions reveal much about the importance of proactivity and caution. This study sought to investigate the effectiveness of COVID-19 public health measures through a comparative analysis across four major U.S. cities. The results of the study reveal that while some public health measures, such as mask mandates and indoor dining restrictions, resulted in a reduction in COVID-19 health metrics, other policies such as stay-at-home orders and reimplementing gathering restrictions had mixed effects on cities (see Figures 1–3 and Tables 3–5).

Stay-at-Home Order

The Stay-at-Home Order was implemented in Philadelphia on March 23, 2020, and was followed by an overall increase in cases and hospitalizations (deaths were not calculated due to lack of data). However, the rate of increase in cases began to drop by the 14-day time point, and the rate of increase had slowed considerably between 30 and 60 days. This is likely

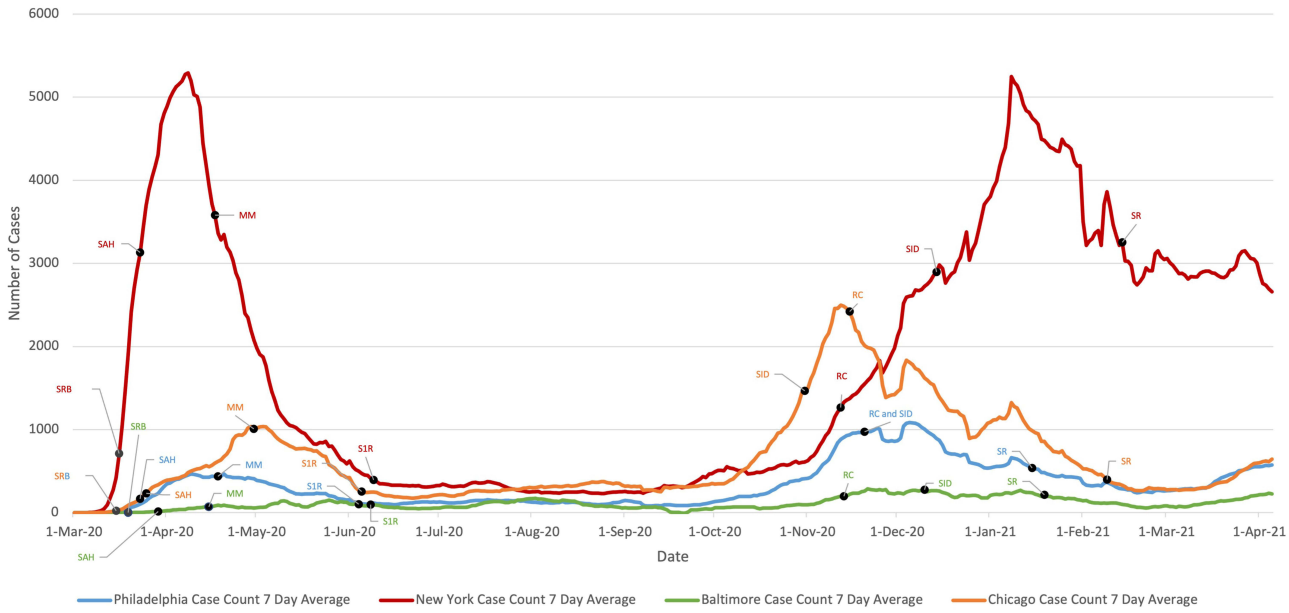

Figure 1 New COVID-19 cases 7 day average.
Abbreviations: SRB, Shutdown restaurants/bars; SAH, Stay-at-Home Order; MM, Mask Mandate; S1R, Stage 1 Reopening; RC, Reimplementation of COVID-19 Restrictions; SID, Suspension of Indoor Dining; SR, Spring Reopening.

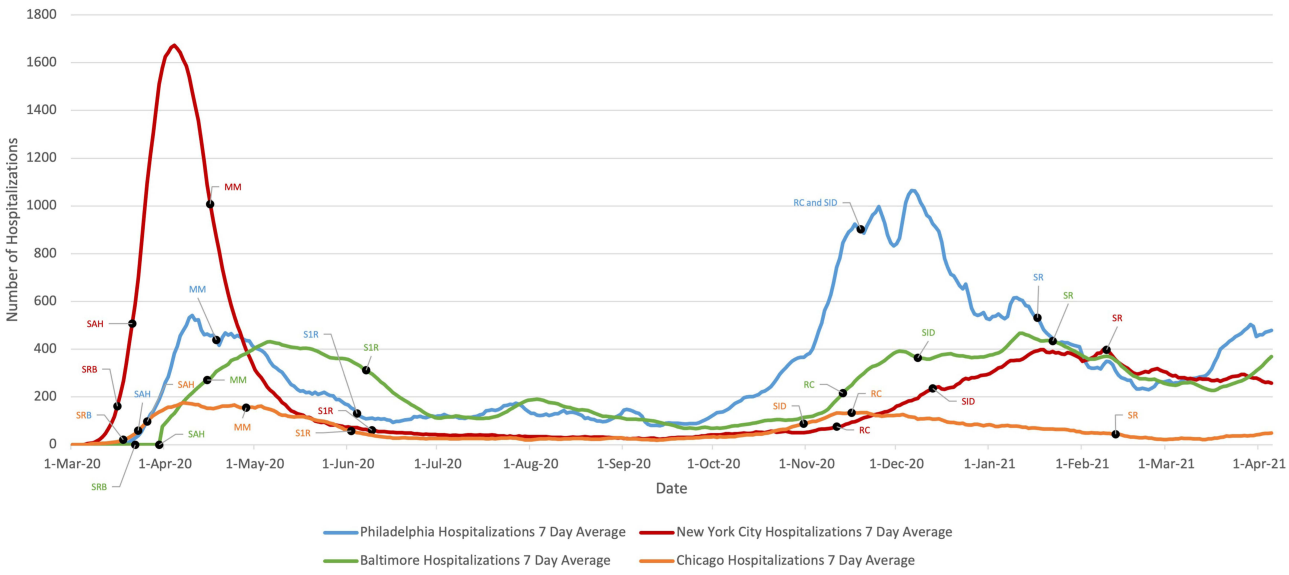

Figure 2 COVID-19 hospitalizations 7 day average.
Abbreviations: SRB, Shutdown restaurants/bars; SAH, Stay-at-Home Order; MM, Mask Mandate; S1R, Stage 1 Reopening; RC, Reimplementation of COVID-19 Restrictions; SID, Suspension of Indoor Dining; SR, Spring Reopening.

attributable to the delayed effect of the Stay-at-Home order in Philadelphia as the policy became increasingly enforced throughout the early stages of the pandemic (see Figures 4–6 and Tables 6–8).

New York City implemented its Stay-at-Home Order on March 20, 2020, resulting in a sustained decrease in cases and hospitalizations within 30 days. However, New York recorded an increase in deaths in the days and months after the SAH order went into effect. This may be attributable in part to the fact that New York was able to provide mortality rates at this stage, unlike in Philadelphia and Baltimore, and the death rate eventually reversed itself. The SAH order in New York City

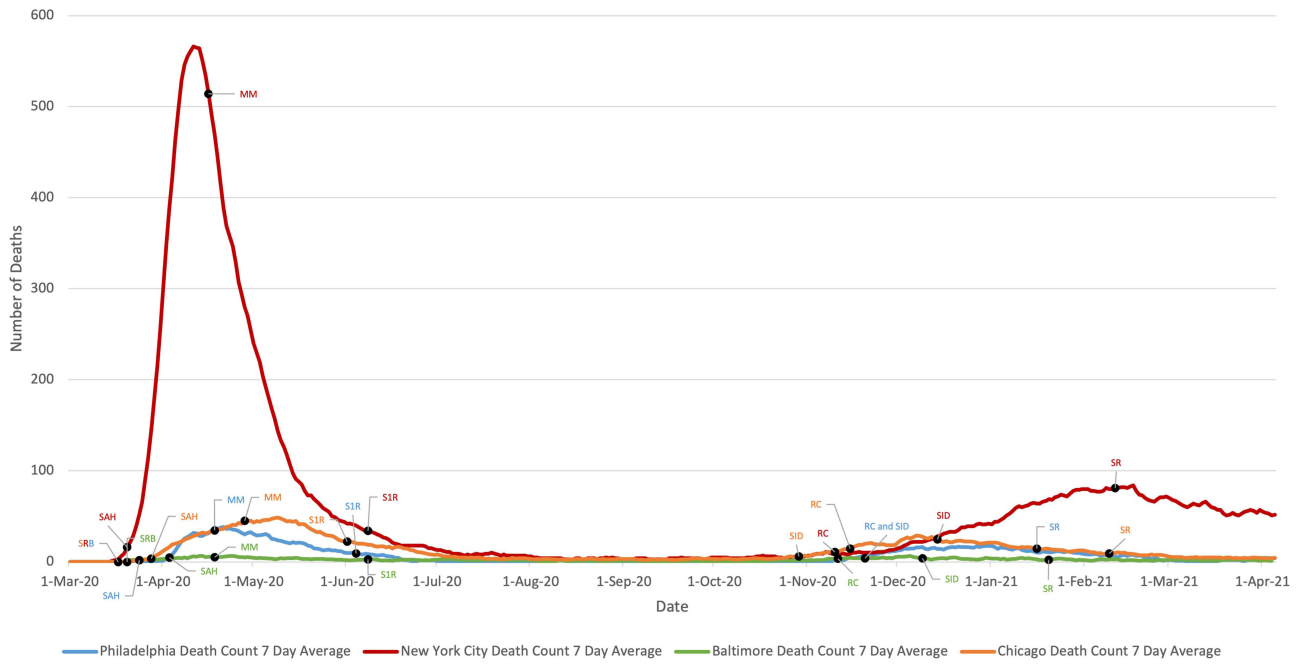

Figure 3 COVID-19 deaths 7 day average.
Abbreviations: SRB, Shutdown restaurants/bars; SAH, Stay-at-Home Order; MM, Mask Mandate; S1R, Stage 1 Reopening; RC, Reimplementation of COVID-19 Restrictions; SID, Suspension of Indoor Dining; SR, Spring Reopening.

appears to have had both a delayed and sustained impact on reducing cases and hospitalizations. The rate of increase in deaths also gradually declined following implementation of the policy (see Figures 7–9 and Tables 9–11).

Following the enactment of the Stay-at-Home Order in Baltimore on March 30, 2020, cases and hospitalizations increased across all time intervals. At the 14-day interval, cases increased by 165% and hospitalizations increased by 233%. By 60 days, cases increased by 870% and hospitalizations increased by 388%. Deaths were not calculated due to insufficient data. The results indicate the Stay-at-Home order had limited impact in reducing early COVID-19 transmission in Baltimore. The results in Baltimore may also be due to a slow number of growing cases that peaked later in the season (see Figures 10–12 and Tables 12–14).

Table 3 COVID-19 Cases % Change

Policies	Philadelphia			New York City			Baltimore			Chicago		
	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day
Shutdown restaurants/bars (SRB)	1206%	1437%	683%	189%	83%	−59%	1000%	2525%	700%	463%	710%	1144%
Stay-at-Home Order (SAH)	245%	202%	44%	41%	−41%	−75%	165%	61%	870%	39%	53%	−39%
Mask Mandate (MM)	−37%	24%	−34%	−47%	−90%	−88%	−62%	3%	−43%	−39%	−81%	−78%
Stage 1 Reopening (S1R)	−2%	−48%	−35%	−11%	−3%	−43%	−37%	6%	145%	−22%	−37%	−66%
Reimplementation of COVID-19 Restrictions (RC)	7%	−66%	−46%	54%	49%	249%	35%	39%	17%	−6%	−46%	−60%
Suspension of Indoor Dining (SID)	7%	−66%	−46%	50%	44%	−7%	−44%	2%	−70%	44%	−52%	−9%
Spring Reopening (SR)	−25%	−4%	55%	−2%	−43%	−29%	−49%	−63%	−55%	−36%	−42%	97%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 4 COVID-19 Hospitalizations % Change

Policies	Philadelphia			New York City			Baltimore			Chicago		
	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day
Shutdown restaurants/bars (SRB)	N/A	N/A	N/A	443%	154%	−64%	N/A	N/A	N/A	841%	782%	541%
Stay-at-Home Order (SAH)	674%	647%	185%	130%	−28%	−84%	233%	388%	317%	16%	−13%	−42%
Mask Mandate (MM)	−35%	−1%	−61%	−67%	−90%	−92%	37%	30%	−30%	−22%	−68%	−82%
Stage I Reopening (S1R)	2%	−30%	−2%	−19%	−45%	−61%	−48%	−60%	−41%	−44%	−46%	−59%
Reimplementation of COVID-19 Restrictions (RC)	25%	−45%	−50%	75%	154%	336%	51%	43%	92%	−15%	−44%	−63%
Suspension Of Indoor Dining (SID)	25%	−45%	−50%	34%	68%	32%	−3%	33%	4%	30%	7%	−24%
Spring Reopening (SR)	−27%	−44%	4%	−4%	−26%	−42%	−15%	−40%	−41%	−57%	−61%	45%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 5 COVID-19 Deaths % Change

Policies	Philadelphia			New York City			Baltimore			Chicago		
	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day	14 Day	30 Day	60 Day
Shutdown restaurants/bars (SRB)	N/A	N/A	N/A	3963%	5563%	975%	N/A	N/A	N/A	1100%	3000%	4800%
Stay-at-Home Order (SAH)	N/A	N/A	N/A	960%	749%	17%	N/A	N/A	N/A	1150%	1800%	1050%
Mask Mandate (MM)	−17%	−59%	−100%	−45%	−80%	−96%	−375%	−100%	−175%	13%	−48%	−83%
Stage I Reopening (S1R)	−100%	−100%	−100%	−56%	−64%	−95%	200%	200%	0%	5%	−75%	−85%
Reimplementation of COVID-19 Restrictions (RC)	133%	117%	0%	200%	400%	1360%	500%	0%	100%	−15%	−4%	−58%
Suspension Indoor Dining (SID)	133%	117%	0%	47%	123%	170%	−111%	−111%	−33%	400%	325%	425%
Spring Reopening (SR)	50%	114%	−100%	−12%	−48%	−54%	−100%	−100%	−100%	−11%	−78%	−44%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Chicago implemented its Stay-at-Home Order on March 26, 2020, and saw a reduction in hospitalizations but an increase in mortality rates. At the two-week interval, cases had increased by 39% and hospitalizations had increased by 16%. At the 60-day interval, however, cases declined by 39% and hospitalizations declined by 42%. Deaths increased at each time point, with an 1150% increase at 14 days, an 1800% increase at 30 days, and a 1050% increase at 60 days. The dichotomy of the results in cases and deaths points to the delayed impact of the policy on the community. Throughout the pandemic deaths lag cases and hospitalizations and this is likely the reason behind the increasing number of deaths (see Figures 13–15 and Tables 15–17).

In summary, the Stay-at-Home Orders were followed by a decline in cases and hospitalizations in New York City and Chicago, but an increase in cases and hospitalizations in Philadelphia and Baltimore. However, it is important to note that the rate of increase in cases and hospitalizations in Philadelphia gradually declined at each time interval. This may point to the delayed impact that stay-at-home orders have in reducing COVID-19 cases and hospitalizations. It is difficult to evaluate the impact on deaths as there was insufficient data for two of the cities.

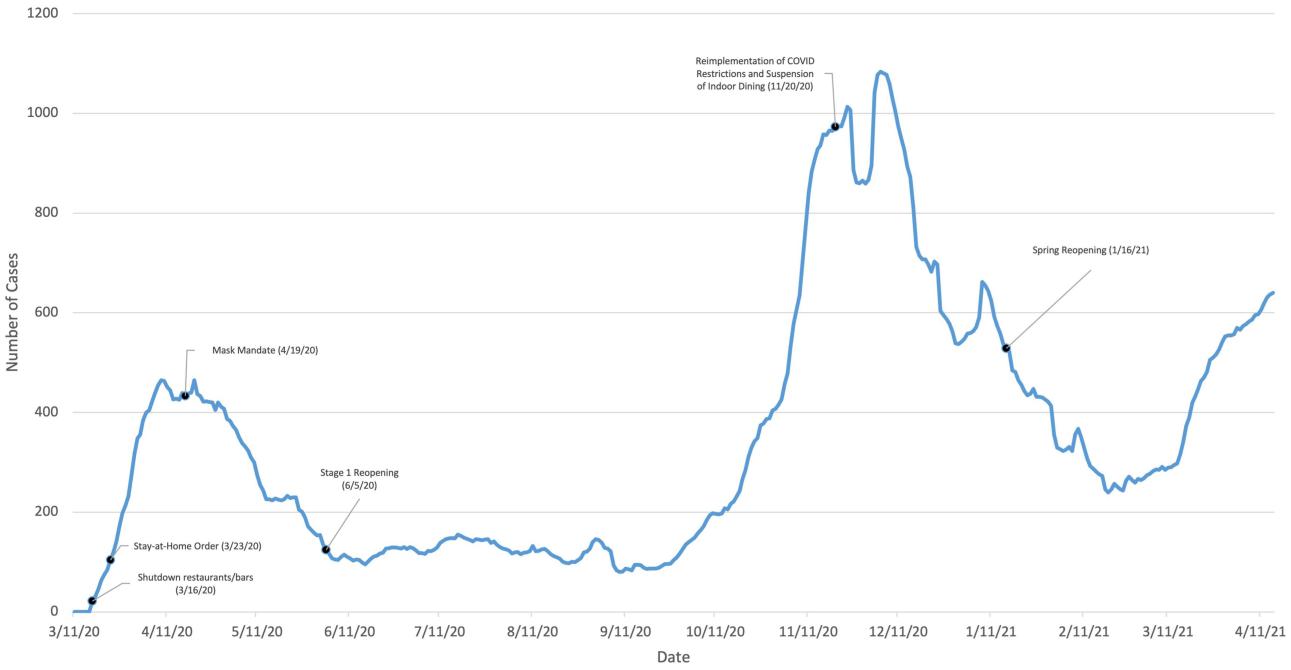

Figure 4 Philadelphia new COVID-19 cases 7 day average.

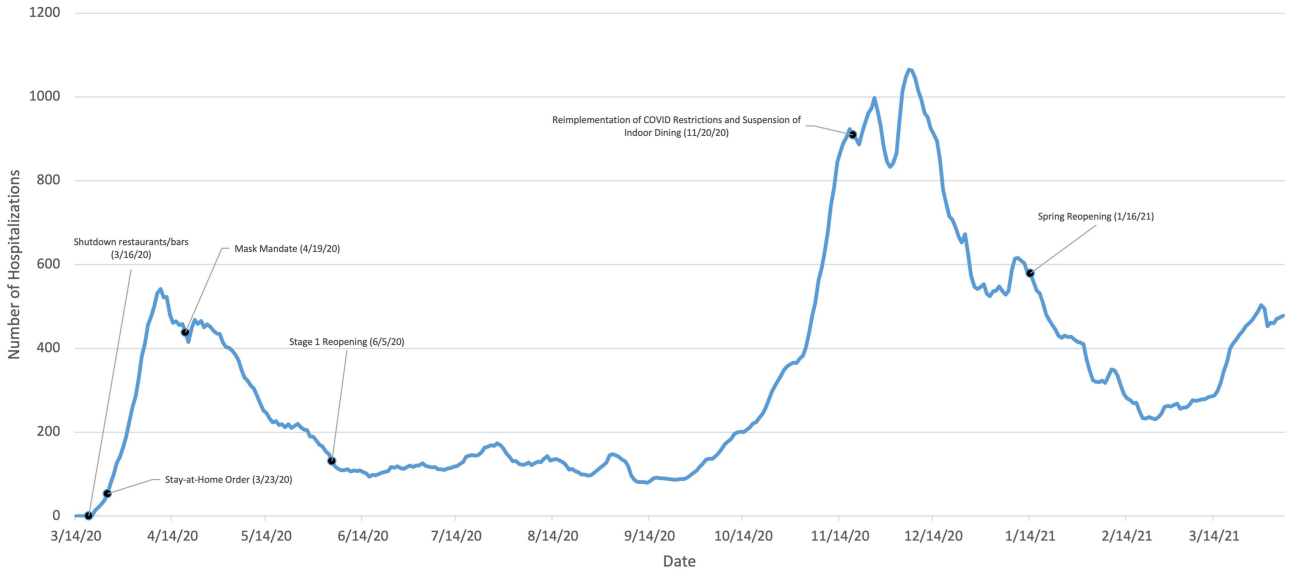

Figure 5 Philadelphia COVID-19 hospitalizations 7 day average.

Mask Mandates

The implementation of the mask mandate on April 19, 2020, led to an immediate and substantial reduction of the spread of COVID-19 in Philadelphia. Two weeks after the mask mandate began, the city saw a 37% decline in cases, a 35% decline in hospitalizations, and a 17% reduction in deaths. This downward trend continued across all 3 metrics, and by 60 days, Philadelphia saw a 34% drop in cases, a 61% reduction in hospitalizations, and a 100% decline in deaths from the time of policy implementation (see Figures 4–6 and Tables 6–8).

Following implementation of the mask mandate in New York City on 4/17/20, there was also an immediate and sustained reduction in cases, hospitalizations, and deaths. At the two-week interval, there was a 47% decline in cases,

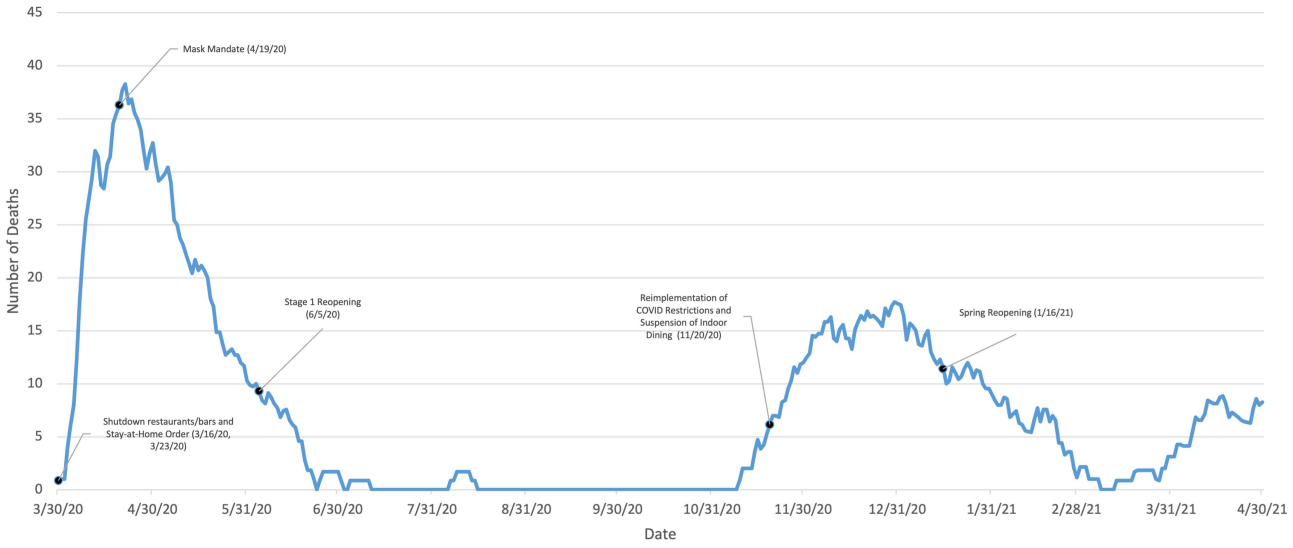

Figure 6 Philadelphia COVID-19 deaths 7 day average.

a 67% decline in hospitalizations and a 45% decline in deaths. At the 60-day interval, there were reductions in all three health metrics, with an 88% decline in cases, a 92% decline in hospitalizations, and a 96% decline in deaths. It is important to note, however, that cases, hospitalizations, and deaths were all decreasing prior to implementation of the mask mandate. The decline in cases, hospitalizations, and deaths was likely due to a combination of the delayed impact of prior policies as well as the newly introduced mask mandate (see Figures 7–9 and Tables 9–11).

Baltimore had a different experience. After implementing its mask mandate on April 15, 2020, Baltimore saw an immediate decrease in COVID-19 cases and deaths, but hospitalizations initially soared. After two weeks, there was a 62% decrease in cases and a 375% decrease in deaths. However, hospitalizations increased by 37%. At the 60-day mark, reductions were seen in all 3 metrics: there was a 43% decline in cases, a 30% decline in hospitalizations, and a 175% decline in deaths. The results illustrate the immediate and prolonged impact that mask mandates can have on reducing the spread of COVID-19 (see Figures 10–12 and Tables 12–14).

Chicago also benefited from the implementation of its mask mandate on April 30, 2020, although there was a delayed reduction in deaths. At the two-week interval, there was a 39% decline in cases, a 22% decline in hospitalizations and a 13% increase in deaths. Sixty days following the rollout of the policy, there were reductions in all three health metrics,

Table 6 Philadelphia COVID-19 Cases % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/16/20	1206%	1437%	683%
Stay-at-Home order	3/23/20	245%	202%	44%
Mask mandate	4/19/20	−37%	24%	−34%
Stage 1 Reopening	6/5/20	−2%	−48%	−35%
Green phase of reopening	7/3/20	80%	−29%	66%
Reimplementation of COVID-19 Restrictions	11/20/20	7%	−66%	−46%
Suspension of Indoor Dining	11/20/20	7%	−66%	−46%
Spring Reopening	1/16/21	−25%	−4%	55%
Retail and dining can expand maximum	3/1/21	38%	85%	9%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 7 Philadelphia COVID-19 Hospitalizations % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/16/20	N/A	N/A	N/A
Stay-at-Home Order	3/23/20	674%	647%	185%
Mask Mandate	4/19/20	−35%	−1%	−61%
Stage 1 Reopening	6/5/20	2%	−30%	−2%
Green phase of reopening	7/3/20	58%	−23%	74%
Reimplementation of COVID-19 Restrictions	11/20/20	25%	−45%	−50%
Suspension of Indoor Dining	11/20/20	25%	−45%	−50%
Spring Reopening	1/16/21	−27%	−44%	4%
Retail and dining can expand maximum	3/1/21	27%	1%	N/A

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 8 Philadelphia COVID-19 Deaths % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/16/20	N/A	N/A	N/A
Stay-at-Home Order	3/23/20	N/A	N/A	N/A
Mask Mandate	4/19/20	−17%	−59%	−100%
Stage 1 Reopening	6/5/20	−100%	−100%	−100%
Green phase of reopening	7/3/20	N/A	N/A	N/A
Reimplementation of COVID-19 Restrictions	11/20/20	133%	117%	0%
Suspension of Indoor Dining	11/20/20	133%	117%	0%
Spring Reopening	1/16/21	50%	114%	−100%
Retail and dining can expand maximum	3/1/21	−100%	−100%	N/A

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

with a 78% decline in cases, an 82% decline in hospitalizations, and an 83% decline in (see Figures 13–15 and Tables 15–17).

Overall, the impact of the mask mandate reveals a significant trend of both immediate and sustained reductions of cases, hospitalizations, and deaths across cities in the US. The results support the current literature on the beneficial impacts of masks on reducing the transmission of COVID-19. All four cities saw a decline in COVID-19 cases in the two weeks following the implementation of the policy. Philadelphia, New York City, and Chicago saw declines in hospitalizations at both 14 days and 60 days following implementation of the policy. All cities had a reduction in deaths in the 60 days following implementation of the mask mandate. While some of the cities examined saw marginal changes at specific time periods, the overwhelming trend across the health metrics studied here and across cities reveals a reduction in COVID-19 cases, hospitalizations, and deaths following implementation of a mask mandate.

Reimplementation of COVID-19 Restrictions

The reimplementation of COVID-19 restrictions in November 2020 produced mixed results in the 4 cities. The one element that seemed to separate Philadelphia and Chicago (which saw generally positive results) from New York and Baltimore is that the former cities' restrictions included reigning in indoor dining, while the latter did not.

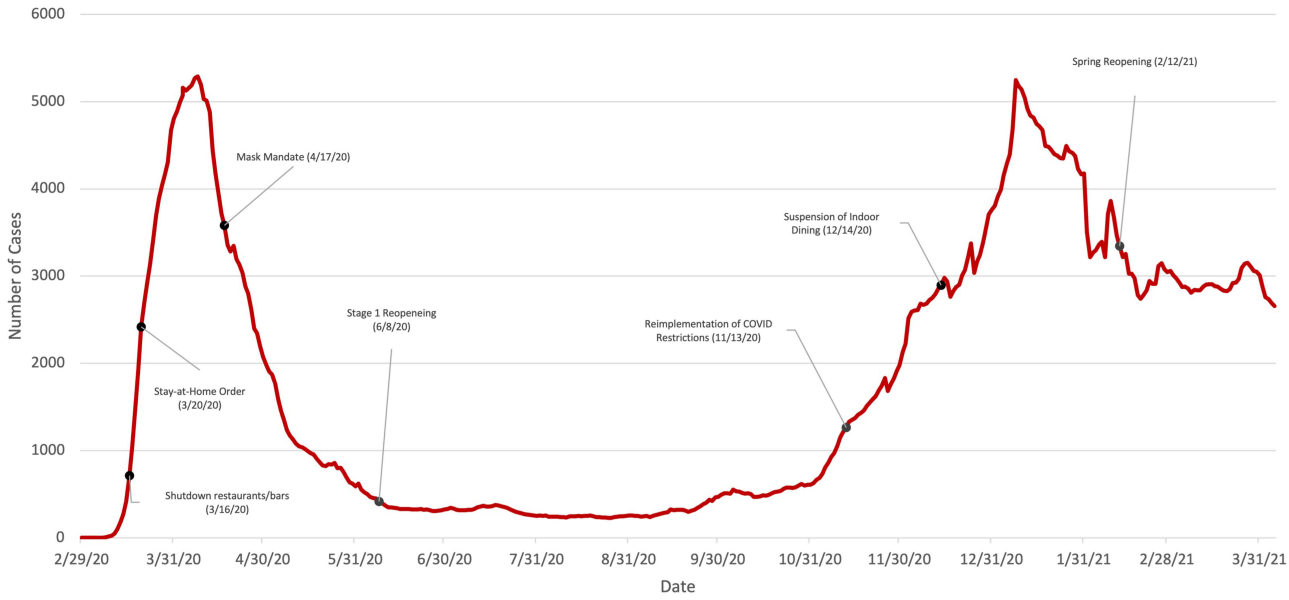

Figure 7 New York City new COVID-19 cases 7 day average.

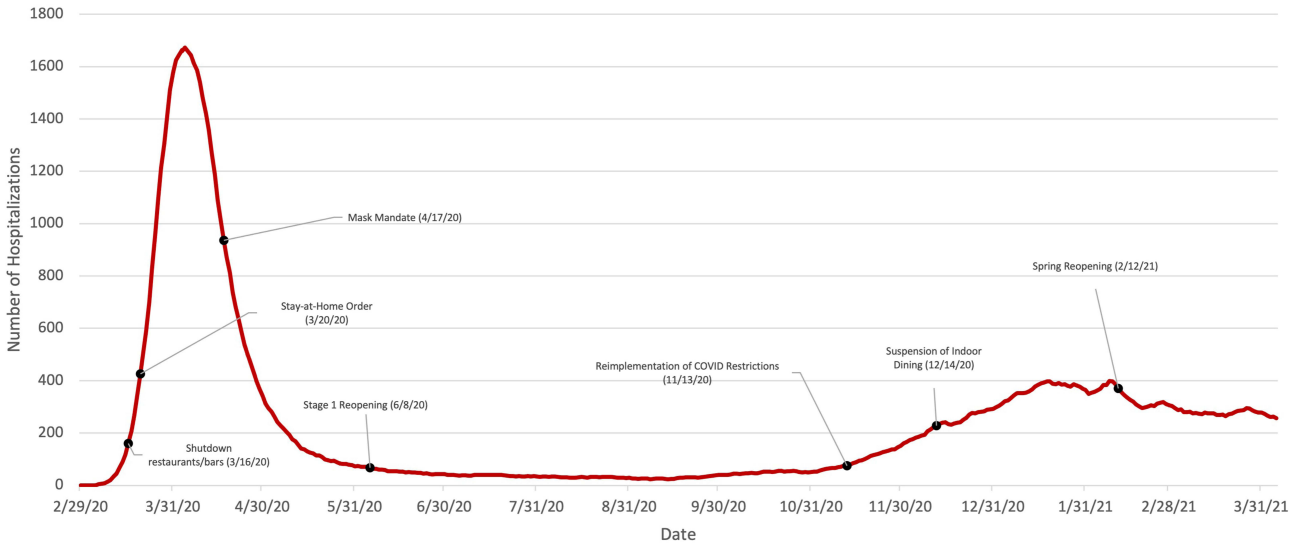

Figure 8 New York City COVID-19 hospitalizations 7 day average.

After reimplementing COVID-19 restrictions on November 20, 2020, Philadelphia saw a sustained reduction in cases and hospitalizations after a brief delay; deaths increased, but they too declined in time. After 30 days, the city saw a 66% decline in cases and a 45% decline in hospitalizations. Unfortunately, deaths at that point had increased by 117%, as the virus swept across the country. At the 60-day mark, however, there was a 0% change in deaths, as cases and hospitalizations declined by 46% and 50%, respectively. The results suggest that the reimplementation of COVID restrictions had a delayed and sustained impact on reducing cases and hospitalizations as well as were able led to a slowdown in the rate of increase in deaths (see Figures 4–6 and Tables 6–8).

The reimplementation of COVID-19 restrictions on 11/13/20 in New York led to an overall increase in cases, hospitalizations, and deaths. By 60 days, cases increased by 249%, hospitalizations increased by 336%, and deaths increased by 1360%. Based on the results, it appears that the initial reimplementation of COVID-19 restrictions in New York City had little impact on reducing the spread of COVID-19. This trend could possibly be explained by a lack

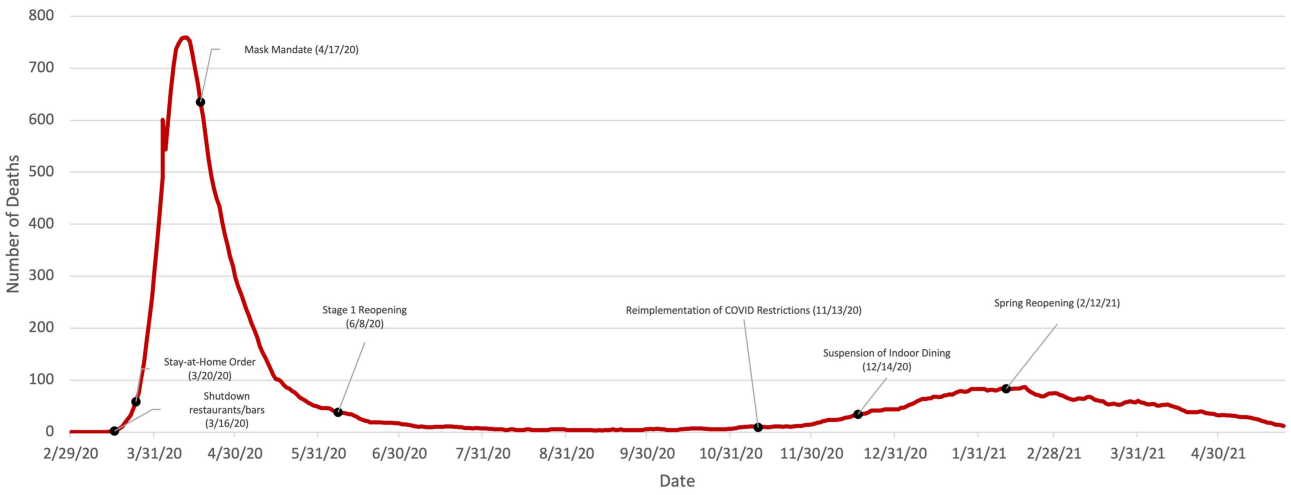

Figure 9 New York City COVID-19 deaths 7 day average.

of suspension of indoor dining included in these restrictions, which will be discussed further in the next section (see Figures 7–9 and Tables 9–11).

The findings in Baltimore were also mixed after that city reimplemented COVID-19 restrictions on November 12, 2020. At the 14-day interval, cases had increased by 35%, hospitalizations had increased by 51%, and deaths had

Table 9 NYC COVID-19 Cases % Change

Policies	Date	14 Day	30 Day	60 Day
Ban nonessential foreign travel	3/8/20	12,186%	28,671%	5800%
NYC declares State of Emergency	3/12/20	1321%	951%	247%
NYC cancels events larger than 500 people	3/13/20	727%	366%	108%
NYC closes all schools	3/16/20	189%	83%	−59%
Shutdown restaurants/bars	3/16/20	189%	83%	−59%
Stay-at-Home Order	3/20/20	41%	−41%	−75%
Mask Mandate	4/17/20	−47%	−90%	−88%
NYC allows gatherings of up to 10 people	5/24/20	−58%	−18%	−34%
Stage 1 Reopening	6/8/20	−11%	−3%	−43%
NYC enters Phase 2 of reopening allowing for office work	6/22/20	8%	−18%	−37%
NYC enters Phase 3 of reopening allowing for spas, parlors, and salons to reopen	7/7/20	−26%	−37%	−66%
NYC enters Phase 4 of reopening allowing higher education and outdoor entertainment	7/22/20	−10%	−24%	−52%
Reimplementation of COVID-19 Restrictions	11/13/20	54%	45%	249%
NYC schools go virtual	11/19/20	56%	38%	150%
Suspension of Indoor Dining	12/14/20	50%	44%	−7%
Spring Reopening	2/12/21	−2%	−43%	−29%
Outdoor gatherings of 25 people allowed	3/22/21	−12%	−62%	−91%
State opens arts and entertainment venues at 33% capacity	4/2/21	−30%	−79%	−89%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 10 NYC COVID-19 Hospitalizations % Change

Policies	Date	14 Day	30 Day	60 Day
Ban nonessential foreign travel	3/8/20	4167%	8689%	861%
NYC declares State of Emergency	3/12/20	1327%	866%	68%
NYC cancels events larger than 500 people	3/13/20	930%	524%	−25%
NYC closes all schools	3/16/20	443%	154%	−64%
Shutdown restaurants/bars	3/16/20	443%	154%	−64%
Stay-at-Home Order	3/20/20	130%	−28%	−84%
Mask Mandate	4/17/20	−67%	−90%	−92%
NYC allows gatherings of up to 10 people	5/24/20	−39%	−50%	−64%
Stage 1 Reopening	6/8/20	−19%	−45%	−61%
NYC enters phase 2 of reopening allowing for office work	6/22/20	10%	−20%	−38%
NYC enters phase 3 of reopening allowing for spas, parlors, and salons to reopen	7/7/20	−49%	−28%	−53%
NYC enters phase 4 of reopening allowing higher education and outdoor entertainment	7/22/20	−3%	−23%	−48%
Reimplementation of COVID-19 Restrictions	11/13/20	75%	154%	336%
NYC schools go virtual	11/19/20	59%	80%	238%
Suspension of Indoor Dining	12/14/20	34%	68%	32%
Spring Reopening	2/12/21	−4%	−26%	−42%
Outdoor gatherings of 25 people allowed	3/22/21	−20%	−65%	−88%
State opens arts and entertainment venues at 33% capacity	4/2/21	−26%	−73%	−100%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 11 NYC COVID-19 Deaths % Change

Policies	Date	14 Day	30 Day	60 Day
Ban nonessential foreign travel	3/8/20	N/A	N/A	N/A
NYC declares State of Emergency	3/12/20	N/A	N/A	N/A
NYC cancels events larger than 500 people	3/13/20	N/A	N/A	N/A
NYC closes all schools	3/16/20	3963%	5563%	975%
Shutdown restaurants/bars	3/16/20	3963%	5563%	975%
Stay-at-Home Order	3/20/20	960%	749%	17%
Mask Mandate	4/17/20	−45%	−80%	−96%
NYC allows gatherings of up to 10 people	5/24/20	−48%	−60%	−83%
Stage 1 Reopening	6/8/20	−56%	−64%	−95%
NYC enters phase 2 of reopening allowing for office work	6/22/20	−65%	−59%	−82%
NYC enters phase 3 of reopening allowing for spas, parlors, and salons to reopen	7/7/20	0%	−17%	−50%
NYC enters phase 4 of reopening allowing higher education and outdoor entertainment	7/22/20	−14%	−57%	−29%

(*Continued*)

Table 11 (Continued).

Policies	Date	14 Day	30 Day	60 Day
Reimplementation of COVID-19 Restrictions	11/13/20	200%	400%	1360%
NYC schools go virtual	11/19/20	100%	244%	722%
Suspension of Indoor Dining	12/14/20	47%	123%	170%
State reopens indoor dining 25% capacity	2/12/21	−12%	−48%	−54%
Outdoor gatherings of 25 people allowed	3/22/21	0%	−32%	−83%
State opens arts and entertainment venues at 33% capacity	4/2/21	−44%	−49%	−100%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

increased by 500%. At the 60-day interval, cases increased by 17%, hospitalizations increased by 92%, and deaths increased by 100%. The results show that while reimplementation of restrictions may have slowed the rate of increase of cases and deaths, hospitalizations continued to climb after the policy was implemented. Here too, this trend could possibly be explained by the fact that suspension of indoor dining was not included in these restrictions (see Figures 10–12 and Tables 12–14).

Following the reimplementation of COVID-19 restrictions on November 16, 2020, in Chicago, there was an immediate and sustained reduction in cases, hospitalizations, and deaths. At the 14-day interval, cases had declined by 6%, hospitalizations had declined by 15% and deaths had declined by 15%. At 60 days, cases declined by 60%, hospitalizations declined by 63%, and deaths declined by 58%. The results suggest that the reimplementation of COVID-19 restrictions in Chicago played an important role in reducing the spread of COVID-19 (see Figures 13–15 and Tables 15–17).

In summary, there was a sustained reduction in cases and hospitalizations in Philadelphia and Chicago and an increase in all health metrics in New York City and Baltimore following the reimplementation of COVID-19 restrictions. While deaths immediately declined in Chicago, deaths in Philadelphia initially increased and then gradually became a - neutral percent change. It is important to note that both Philadelphia and Chicago had suspended indoor dining as part

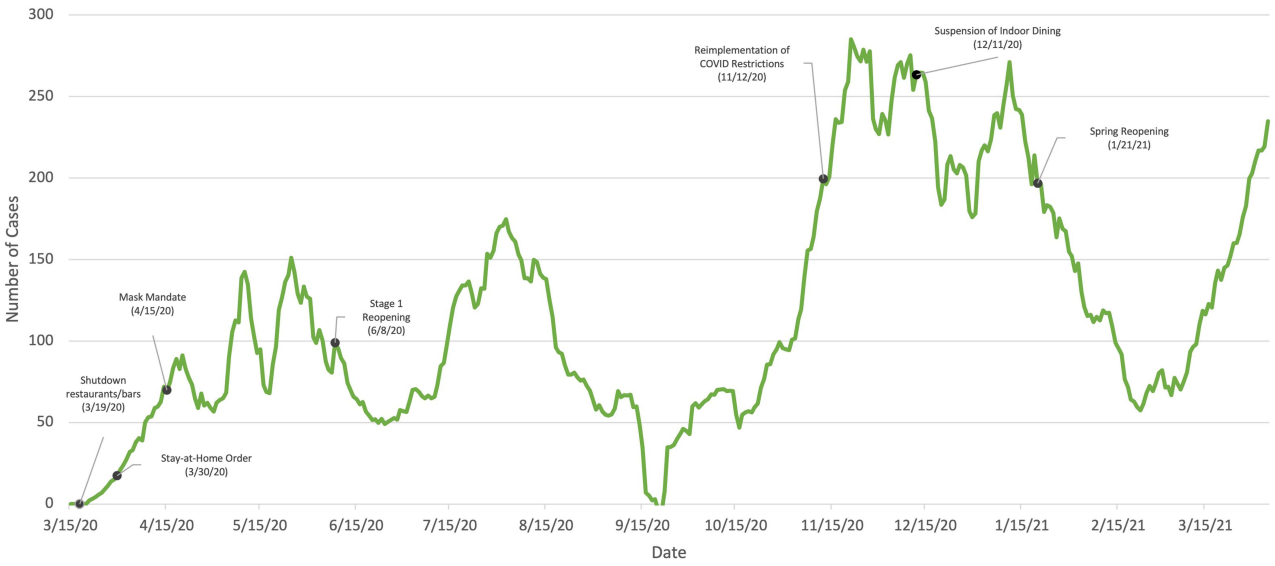

Figure 10 Baltimore new COVID-19 cases 7 day average.

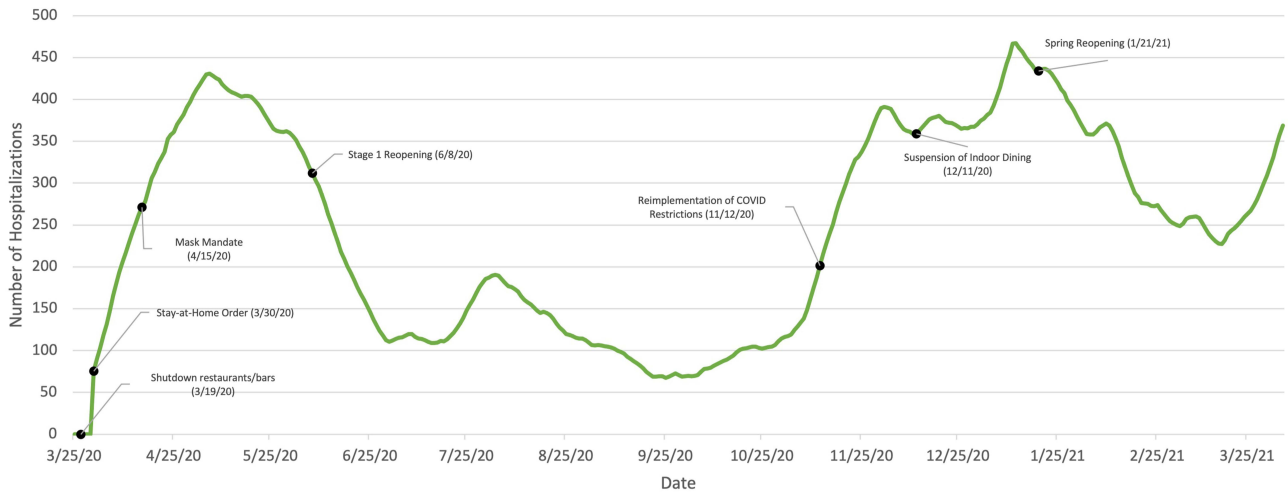

Figure 11 Baltimore COVID-19 hospitalizations 7 day average.

Figure 12 Baltimore COVID-19 deaths 7 day average.

of the restrictions, while New York City and Baltimore did not. This might explain stark difference in impacts of the policy across the cities.

Suspension of Indoor Dining

The suspension of indoor dining resulted in a decline in COVID-19 cases across all 4 cities following 60 days of implementation. Philadelphia and Chicago also saw steep decreases in hospitalizations following the enactment of this

Table 12 Baltimore COVID-19 Cases % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/19/20	1000%	2525%	700%
Stay-at-Home Order	3/30/20	165%	61%	870%
Mask Mandate	4/15/20	−62%	3%	−43%
Cancellation of all events larger than 250 people	5/20/20	−25%	−79%	−4%

(*Continued*)

Table 12 (Continued).

Policies	Date	14 Day	30 Day	60 Day
Continuation of governor stay-at-home order	5/29/20	−78%	−76%	−45%
City allows outdoor dining	5/29/20	−78%	−76%	−45%
Stage 1 Reopening	6/8/20	−37%	6%	145%
Retail open 50% capacity	6/12/20	−18%	144%	278%
Phase 2 reopening allows non-essential businesses to open and expands capacity	6/22/20	50%	124%	129%
Private indoor gatherings 50% allowed	6/26/20	129%	249%	−7%
Rescind stay-at-home order	6/29/20	−6%	51%	−16%
City bans indoor bars and restaurants	7/24/20	3%	−47%	−79%
City reopens indoor dining	8/7/20	−41%	−59%	−80%
Reimplementation of COVID-19 Restrictions	11/12/20	35%	39%	17%
Suspension of Indoor Dining	12/11/20	−44%	2%	−70%
Spring Reopening	1/21/21	−49%	−63%	−55%
City eases covid restrictions	2/22/21	80%	210%	N/A

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 13 Baltimore COVID-19 Hospitalizations % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/19/20	N/A	N/A	N/A
Stay-at-Home Order	3/30/20	233%	388%	317%
Mask Mandate	4/15/20	37%	30%	−30%
Cancellation of all events larger than 250 people	5/20/20	−18%	−56%	−68%
Continuation of governor stay-at-home order	5/29/20	−38%	−69%	−46%
City allows outdoor dining	5/29/20	−38%	−69%	−46%
Stage 1 Reopening	6/8/20	−48%	−60%	−41%
Retail open 50% capacity	6/12/20	−52%	−52%	−35%
Phase 2 reopening allows non-essential businesses to open and expands capacity	6/22/20	−18%	1%	−20%
Private indoor gatherings 50% allowed	6/26/20	0%	59%	15%
Rescind stay-at-home order	6/29/20	−1%	83%	−3%
City bans indoor bars and restaurants	7/24/20	1%	−33%	−53%
City reopens indoor dining	8/7/20	−29%	−37%	−45%
Reimplementation of COVID-19 Restrictions	11/12/20	51%	43%	92%
Suspension of Indoor Dining	12/11/20	−3%	33%	4%
Spring Reopening	1/21/21	−15%	−40%	−41%
City eases covid restrictions	2/22/21	−8%	−4%	N/A

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 14 Baltimore COVID-19 Deaths % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/19/20	N/A	N/A	N/A
Stay-at-Home Order	3/30/20	N/A	N/A	N/A
Mask Mandate	4/15/20	−375%	−100%	−175%
Cancellation of all events larger than 250 people	5/20/20	−50%	−100%	−33%
Continuation of governor stay-at-home order	5/29/20	−75%	−75%	−75%
City allows outdoor dining	5/29/20	−75%	−75%	−75%
Stage 1 Reopening	6/8/20	200%	200%	0%
Retail open 50% capacity	6/12/20	50%	−50%	−50%
Phase 2 reopening allows non-essential businesses to open and expands capacity	6/22/20	67%	−67%	0%
Private indoor gatherings 50% allowed	6/26/20	33%	0%	−100%
Rescind stay-at-home order	6/29/20	N/A	N/A	N/A
City bans indoor bars and restaurants	7/24/20	−67%	−100%	−133%
City reopens indoor dining	8/7/20	200%	0%	−100%
Reimplementation of COVID-19 Restrictions	11/12/20	500%	0%	100%
Suspension of Indoor Dining	12/11/20	−111%	−111%	−33%
Spring Reopening	1/21/21	−100%	−100%	−100%
City eases covid restrictions	2/22/21	N/A	N/A	N/A

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

policy. In New York City and Baltimore, there was an increase in hospitalizations at 60 days after implementation. All cities except Baltimore saw an increase in deaths in subsequent weeks. The timing of the suspension of indoor dining may provide insight into why the reimplementation of COVID-19 restrictions in New York and Baltimore were initially

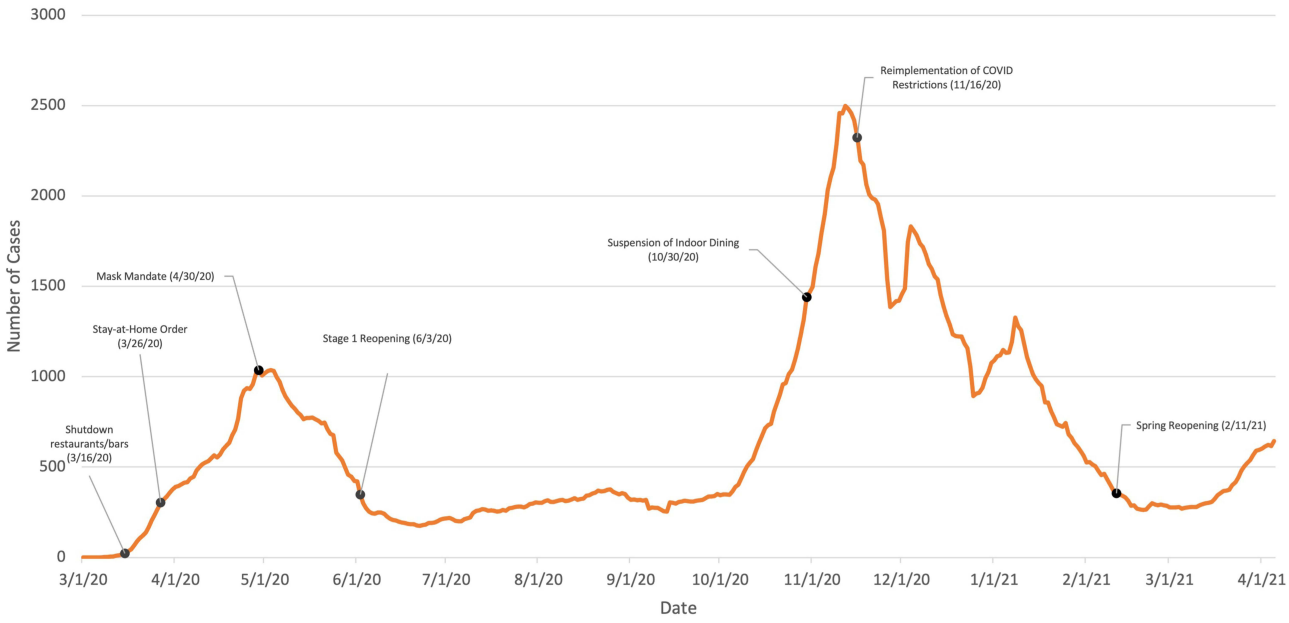

Figure 13 Chicago new COVID-19 cases 7 day average.

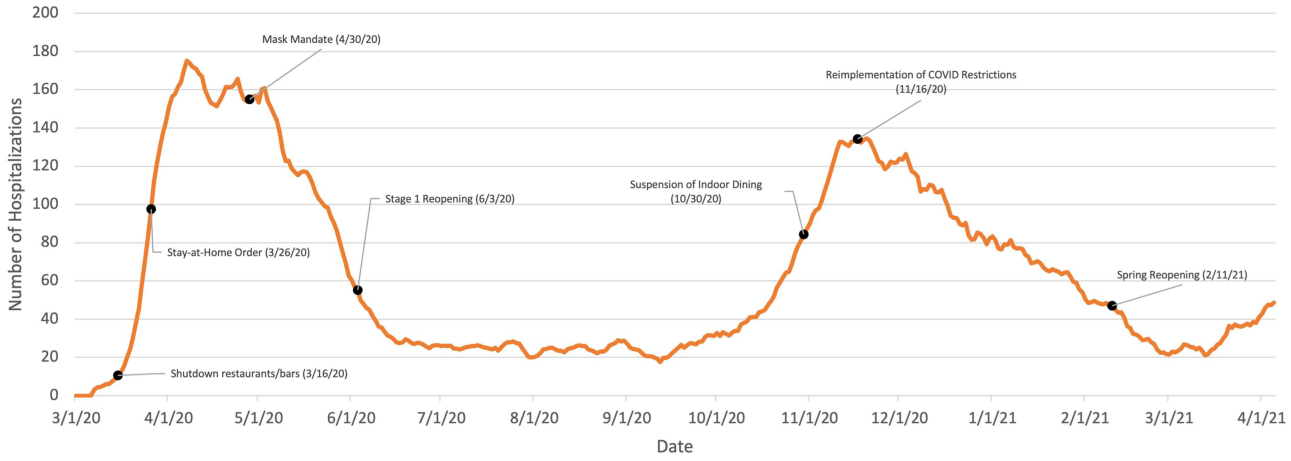

Figure 14 Chicago COVID-19 hospitalizations 7 day average.

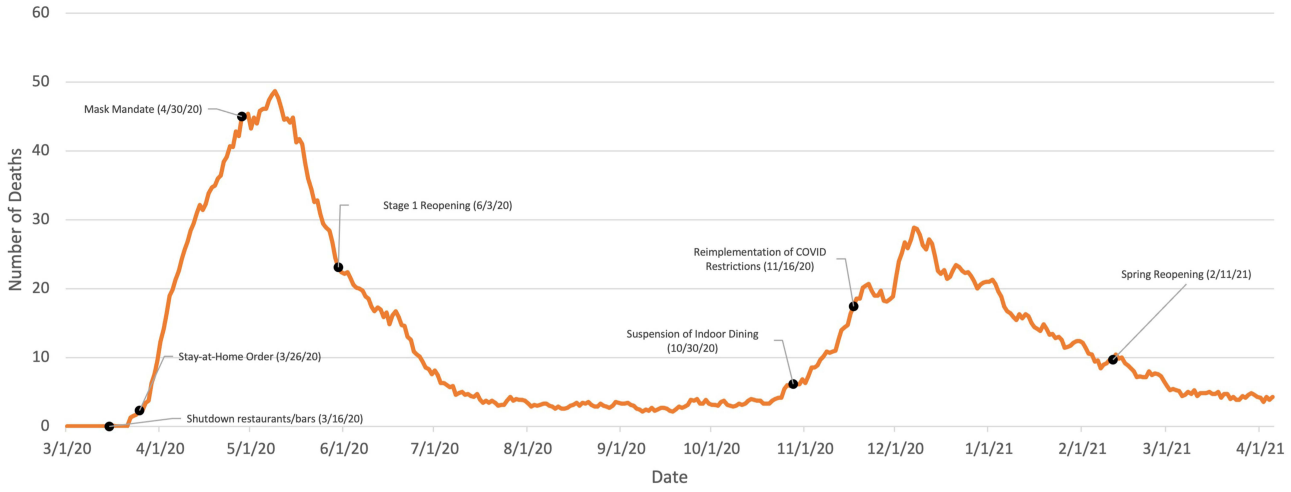

Figure 15 Chicago COVID-19 deaths 7 day average.

ineffective. Both cities did not suspend indoor dining until after the reimplementation of other COVID restrictions; only after the suspension of indoor dining was there a decline in cases.

Following the suspension of indoor dining on 11/20/20 in Philadelphia there was a delayed and sustained reduction in cases and hospitalizations, while there was an increase in deaths that gradually declined. At the 30-day interval, there was

Table 15 Chicago COVID-19 Cases % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/16/20	463%	710%	1144%
Closure of schools	3/17/20	410%	607%	435%
Stay-at-Home Order	3/26/20	39%	53%	−39%
Mask Mandate	4/30/20	−39%	−81%	−78%
City extends stay-at-home order	5/29/20	−46%	−76%	−28%
Stage 1 Reopening	6/3/20	−22%	−37%	−66%

(*Continued*)

Table 15 (Continued).

Policies	Date	14 Day	30 Day	60 Day
City allows religious gatherings at 50 people	6/6/20	−26%	66%	122%
City reopens bars	6/17/20	21%	49%	−45%
City reopens indoor dining at 25% capacity	6/26/20	57%	−56%	88%
Phase 4 reopening allows museums, zoos and theaters	6/26/20	57%	−56%	88%
Reinstate ban on indoor dining and gathering size 10 people	7/20/20	9%	23%	−9%
Suspension of Indoor Dining	10/30/20	44%	−52%	−9%
Reimplementation of COVID-19 Restrictions	11/16/20	−6%	−46%	−60%
City repeals non-essential business curfew	1/31/21	−11%	104%	346%
Spring Reopening	2/11/21	−36%	−42%	97%
City eases COVID restrictions	4/29/21	−41%	−83%	−91%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

a 66% decline in cases, 45% decline in hospitalizations and 117% increase in deaths. At the 60-day interval, there was a 46% decline in cases, 50% decline in hospitalizations and 0% change in deaths. These results reveal the slowly declining increase in deaths. The results show that the suspension of indoor dining had a delayed and sustained impact on reducing cases and hospitalizations and ultimately led to a slowdown in the increase of deaths (see Figures 4–6 and Tables 6–8).

Table 16 Chicago COVID-19 Hospitalizations % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/16/20	841%	782%	541%
Closure of schools	3/17/20	459%	431%	255%
Stay-at-Home Order	3/26/20	16%	−13%	−42%
Mask Mandate	4/30/20	−22%	−68%	−82%
City extends stay-at-home order	5/29/20	−50%	−50%	−65%
Stage 1 Reopening	6/3/20	−44%	−46%	−59%
City allows religious gatherings at 50 people	6/6/20	−47%	−18%	−47%
City reopens bars	6/17/20	−17%	−13%	−33%
City reopens indoor dining at 25% capacity	6/26/20	−3%	−45%	3%
Phase 4 reopening allows museums, zoos and theaters	6/26/20	−3%	−45%	3%
Reinstate ban on indoor dining and gathering size 10 people	7/20/20	35%	−9%	30%
Suspension of Indoor Dining	10/30/20	30%	7%	−24%
Reimplementation of COVID-19 restrictions	11/16/20	−15%	−44%	−63%
City repeals non-essential business curfew	1/31/21	−50%	−34%	9%
Spring Reopening	2/11/21	−57%	−61%	45%
City eases COVID restrictions	4/29/21	−2%	−48%	−100%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Table 17 Chicago COVID-19 Deaths % Change

Policies	Date	14 Day	30 Day	60 Day
Shutdown restaurants/bars	3/16/20	1100%	3000%	4800%
Closure of schools	3/17/20	1500%	3000%	2700%
Stay-at-Home Order	3/26/20	1150%	1800%	1050%
Mask Mandate	4/30/20	13%	−48%	−83%
Stay-at-Home Order	5/29/20	5%	−75%	−85%
Stage 1 Reopening	6/3/20	5%	−75%	−85%
City allows religious gatherings at 50 people	6/6/20	−50%	−75%	−80%
City reopens bars	6/17/20	−38%	−86%	−86%
City reopens indoor dining at 25% capacity	6/26/20	−54%	−54%	−69%
Phase 4 reopening allows museums, zoos and theaters	6/26/20	−54%	−54%	−69%
Reinstate ban on indoor dining and gathering size 10 people	7/20/20	−40%	0%	−20%
Suspension of Indoor Dining	10/30/20	400%	325%	425%
Reimplementation of COVID-19 restrictions	11/16/20	−15%	−4%	−58%
City repeals non-essential business curfew	1/31/21	−44%	−56%	−88%
Spring Reopening	2/11/21	−11%	−78%	−44%
City eases COVID restrictions	4/29/21	0%	−14%	−100%

Notes: Red overlay represents an increase % change. Green overlay represents a decrease % change. Gray overlay represents no % change.

Following the suspension of indoor dining on December 14, 2020, in New York City, there was a delayed reduction in cases, a gradually slowed increase in hospitalizations and a persistent increase in deaths, although they eventually decreased. At the two-week interval, cases had increased by 50%, hospitalizations had increased by 34% and deaths had increased by 47%. At the 60-day interval, cases declined by 7%, hospitalizations increased by 32% and deaths increased by 170%. The results suggest that the suspension of indoor dining had a delayed impact on reducing cases, but limited impact on hospitalizations and deaths (see Figures 7–9 and Tables 9–11).

The suspension of indoor dining in Baltimore on December 11, 2020 resulted in an immediate and sustained decrease in cases and deaths with a delayed slight increase in hospitalizations. At the two-week interval, cases had declined by 44%, hospitalizations had declined by 3%, and deaths had declined by 111%. Sixty days following implementation of the policy, cases declined by 70%, hospitalizations increased by 4%, and deaths declined by 33%. When viewing these results in conjunction with those for the reimplementation of COVID-19 restrictions, it becomes clear that the suspension of indoor dining had a demonstrable impact on the incidence of COVID-19 cases, hospitalizations, and deaths (see Figures 10–12 and Tables 12–14).

The suspension of indoor dining in Chicago on October 30, 2020 resulted in a delayed and sustained reduction in cases and hospitalizations and an increase in deaths. At the 30-day interval, cases had declined by 52%, hospitalizations had increased by 7%, and deaths had increased by 325%. By 60 days following implementation of the policy, cases declined by 9%, hospitalizations decreased by 24%, and deaths increased by 425%. These health metrics indicate that the suspension of indoor dining resulted in a delayed decrease in COVID-19 cases and hospitalizations but not deaths (see Figures 13–15 and Tables 15–17).

Shutdown of Restaurants and Bars

The shutdown of restaurants and bars was the first of the COVID-19 restrictions implemented by each of the cities. These data are useful in understanding the development of the timeline of COVID-19 policy implementation. However, because

the shutdowns occurred before all the other mitigation strategies were in place, there are insufficient data and deceptive statistics on changes in the metrics studied. As most cities did not start collecting data on cases, hospitalizations, and deaths until a few days prior to the shutdowns, there was a sharp increase in cases across the cities at this time. This increase should not be interpreted as a failure of the policy but rather as a reflection of the initial spike in COVID-19 cases, hospitalizations, and deaths during the early stages of the pandemic.

Limitations

Inherent in all population research studies there are limitations to studying policy impacts on community health, and this study is no exception. The limitations to this study include confounding policy impacts on health metrics, varying policies across cities, differing implementation strategies across cities, various hospital systems within cities, under-reporting and misreporting of public statistics, and inability to measure adherence to policies. It should also be noted that different COVID-19 variants can result in fluctuations in transmissibility. Future studies should investigate the long-term impacts of these public health policies in their respective communities.

Conclusion

U.S. cities acted quickly and proactively in response to the COVID-19 pandemic. These quick actions allowed for the implementation of effective policies early in the pandemic. The results from the stay-at-home orders illustrate the delayed impact it has in reducing COVID-19 cases and hospitalizations. The mask mandate led to the immediate and sustained reduction in cases across all four cities. During the spike of COVID-19 in the Fall of 2020, restrictions on indoor dining contributed significantly to reducing COVID-19 cases. By better understanding which policies had the greatest impact on reducing cases, hospitalizations, and deaths, cities across the US can better prepare for future disease outbreaks and pandemics.

Ethics Statement

This study has been exempted from IRB approval by the Office of Human Research at Thomas Jefferson University. The study did not require IRB approval based on the following guidelines: The private information or specimens were not collected specifically for the currently proposed research through an interaction or intervention with living individuals. The investigator cannot readily ascertain the identity of the individuals to whom the private information or specimens pertain, because the private information or specimens are completely anonymized and there is no code that can be used to re-identify them.

Disclosure

The authors report no conflicts of interest in this work.

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