Provide Medical Care is in Critical Condition: Analysis and Stakeholder Decision Support to Minimize Further Harm

September 2021

CRITICAL INFRASTRUCTURE DECISION SUPPORT

By late September, at least four states have declared Crisis Standards of Care (CSC), and an additional eight have delayed elective surgeries and/or are at risk of enacting CSC. Patient diversions across state lines further punctuate the dynamic we outlined in the Cascading failures model (see page 7).

As the COVID-19 pandemic reaches another phase, with increased and protracted strains on the nation's critical infrastructure and related National Critical Functions such as *Provide Medical Care,* CISA is undertaking a renewed push for cyber preparedness and resilience, as well as decision support for stakeholders within critical infrastructure sectors. Over time, we find these original insights increasingly valuable, and in service of timely decision support, we offer them to you in their original form. As British statistician George E. P. Box noted, "All models are wrong, but some are useful." We hope that these models and insights are useful to you and stimulate additional discussion and exploration for mutual benefit.

This CISA Insight will speak to:

- Analysis and insights into strains on the nation's critical infrastructure, specifically through impacts to the National Critical Function *Provide Medical Care,*
- The compounding risks and harms that apply to all critical infrastructure sectors and the 55 National Critical Functions, through impact to essential critical infrastructure workers, and
- Our intention to share our preliminary analysis, enable decision support, and assist in risk reduction across multiple stakeholders and critical infrastructure sectors.

While many of the issues addressed in this *CISA Insight* could be useful to several audiences, it is primarily addressing critical infrastructure and cybersecurity leadership at the nation's hospitals and healthcare delivery organizations; owners and operators of other critical infrastructure; employers of essential critical infrastructure workers; state, local, tribal, and territorial leadership; and, sector coordinating council members across the 16 critical infrastructure sectors. The Cybersecurity and Infrastructure Security Agency is keenly focused on the functional capability and availability of the Critical Infrastructure facilitating all 55 National Critical Functions, and the impacts to the essential critical infrastructure workers who provide these vital functions.

National Critical Function *Provide Medical Care*

Preliminary CISA COVID-19 Task Force analysis (through July 1, 2021) is included. Titled "Measuring the COVID-19 Pandemic's Effect on the National Critical Function *Provide Medical Care*," this appendix focuses on risks to cyber and physical infrastructure in the Healthcare and Public Health sector. This analysis incorporates public data from the Centers for Disease Control and Prevention (CDC) and the U.S. Department of Health and Human Services (HHS), and has been coordinated with government partners in CDC, the HHS' Office of the Assistant Secretary for Preparedness and Response (ASPR), and the HHS Data Strategy and Execution Workgroup (DSEW), among others. In addition, CDC has reviewed and is publishing a sub-set of this analysis titled *The Impact of Hospital Strain on Excess Deaths During the COVID-19 Pandemic* as a Morbidity and Mortality Weekly Report.

As CISA Director Jen Easterly emphasized in her recent Black Hat Conference keynote, "One particularly pernicious vector are those ransomware attacks against the healthcare sector, already highly stressed because of COVID.... We cannot allow avoidable cyber disruptions to cost human lives." Given the recent increases in case rate and hospitalizations, especially those requiring treatment in the Intensive Care Unit, and associated system stress, we call particular attention to the operational analysis on the effects of ransomware attacks on the healthcare and public health sector's ability to deliver the *Provide Medical Care* NCF (see page 13). The impacts of a ransomware incident on a hospital system's healthcare network illustrates the reduced capacity and external stress that cyberattacks can cause on healthcare infrastructure. This is particularly concerning, since we see a strong positive correlation between increased system stress and patient bed count (see page 15). Our research shows the operational effects of hospitals experiencing two simultaneous shocks. Beyond the obvious consequences of disruptions to diagnostic, testing, and treatment equipment, even minor reductions in efficiency caused by cyber incidents compound to increase staff workload and degrade the system's ability to provide medical care.

The *Provide Medical Care* analysis to date has had a heavy focus on hospitals and ICU utilization subsets, but we acknowledge there are other entities, functions, and stakeholders in the sector which may benefit from future analysis.

Essential Critical Infrastructure Workers

In addition to the direct stress on the Healthcare and Public Health sector, there are also on-going concerns for general critical infrastructure security due to health impacts on essential critical infrastructure workers (see CISA Director August 13, 2021 updated ECIW memo). In addition to deaths caused directly by COVID, the number of deaths from other causes exceeded expectations in 2020. Of greatest concern for critical infrastructure security, the impacts of these "excess deaths" (which CDC defines as the difference between expected and observed number of deaths in specific time periods) have not been distributed randomly or equally. Unlike COVID deaths, overall excess deaths in 2020 were most pronounced in people aged 25-44 years old (see page 9). Specifically, working-age adults, who constitute most of the essential critical infrastructure workers, experienced significant excess deaths from the indirect effects of the COVID-19 pandemic. Understanding this analysis is important because it can help identify potential cascading impacts across critical infrastructure sectors through impacts to available workforces. In the Appendix, we outline the additional effects of cyber disruption; ensuring the preparedness and resilience against ransomware attacks of critical infrastructure workforces can help avoid preventable harm.

Because the impact of COVID cases on all critical infrastructure employees impacts healthcare institutions' ability to provide medical care, CISA recently updated considerations and guidance for employers in COVID-19 Vaccination Hesitancy within the Critical Infrastructure Workforce.

Decision Support and Risk Reduction

In addition to the attached analysis, CISA offers a number of other products and services to assist you in risk reduction efforts, including:

- Bad Practices
- Get Your Stuff Off Search
- StopRansomware.gov
- MS-ISAC Ransomware Guide
- Malicious Domain Blocking (via Center for Internet Security)
- Cyber Hygiene Services

Our critical infrastructure and related NCF analysis is on-going and CISA will engage on future topics in collaboration with your respective Sector Risk Management Agencies.

Together with our federal partners and the critical infrastructure community, CISA is keenly focused on the functional capability and availability of all 55 National Critical Functions, and the impacts to the essential critical infrastructure workers who provide these vital functions. Together we can work towards turning the tide of COVID-19 – especially as the country enters the next phase of the pandemic and grapples with new and more virulent variants.

CISA'S ROLE TO STRENGTHEN NATIONAL RESILIENCE

Through CISA's efforts to understand and advise on cyber and physical risks to the nation's critical infrastructure, we help partners strengthen their own capabilities. We connect our stakeholders in industry and government to each other and to resources, analyses, and tools to help them build their own cyber, communications, and physical security and resilience, in turn strengthening national resilience.

For more information or to seek additional help, please visit the CISA COVID-19 Resource Page or contact us at Central@CISA.DHS.GOV.

Appendix: Measuring the COVID-19 Pandemic's Effect on the National Critical Function *Provide Medical Care*

CISA | CYBERSECURITY AND INFRASTRUCTURE SECURITY AGENCY

Measuring the COVID-19 Pandemic's Effect on the National Critical Function Provide Medical Care

CISA COVID Task Force Analysis
July 1, 2021*

*This supplement of on-going COVID Task Force analysis was summarized as of 7/1/2021; subsequent analysis is on-going and may be shared in future publications

Executive Summary

The COVID-19 pandemic exacerbated existing strains on the *Provide Medical Care* National Critical Function (NCF) initially caused by a flood of patients, all needing acute care, which overwhelmed hospital systems. This caused degradation and disruption to the American healthcare infrastructure, contributing to further loss of life. From the start of the pandemic, signs of strain on the healthcare system were evident across the country; statistics showed commodity shortages, healthcare workforce shortages, and capacity shortages. The surge in hospitalizations put an extraordinary amount of stress on hospital systems at the local level, resulting in some states or organizations implementing Crisis Standards of Care (CSC).

The purpose of this analysis was twofold: first, to understand the functional impact of COVID-19 surges on hospital system operations, and second, the cascading effects on critical infrastructure sectors and National Critical Functions. For example, examining where and when excess deaths occurred provided insight into the impacts of overwhelmed hospital systems and the subsequent effects on critical infrastructure workforces outside the healthcare sector. Excess deaths are defined as the difference between the expected and observed number of deaths in specific time periods according to the Centers for Disease Control and Prevention (CDC).

Finally, the analytic approach also provided insight into the effects that ransomware attacks can have on the healthcare system. By studying hospital systems impacted by ransomware and those not impacted, it revealed differences in how quickly otherwise comparable hospitals and healthcare facilities became stressed under the same pandemic conditions.

This analysis helped key stakeholders at the federal, regional, state, and local levels understand the consequences of severe hospital strain on the *Provide Medical Care* NCF and identify particularly vulnerable populations, including some essential critical infrastructure workers. Key findings included: a cascading effects model of how surges in hospital patient volume lead to broader systemic degradation, regression results demonstrating that current hospital strain leads to significant excess deaths in the future, and regression results showing that ransomware cyberattacks on hospitals lead to significant and sustained hospital strain and related consequences.

PURPOSE

This document aggregates and synthesizes analyses measuring the COVID-19 pandemic's effect on Hospital and healthcare delivery organization infrastructure's ability to deliver the National Critical Function *Provide Medical Care* through the lenses of standards of care and excess deaths. These analytic conclusions are preliminary; we expect they could be strengthened and deepened in collaboration with HHS, CDC, and the private sector.

This document is intended to simplify CISA analysts' review of the body of information reported to date on the effects of the pandemic on the Healthcare and Public Health (HPH) sector and patient outcomes.

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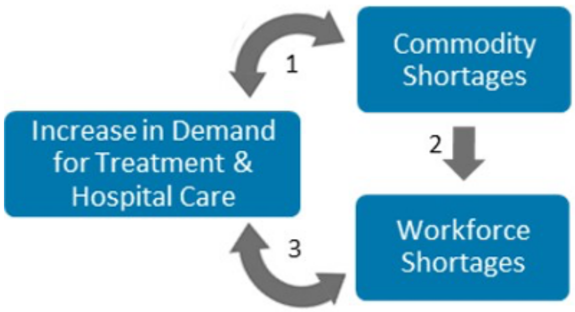
The Pandemic's Local and National Strain on Hospital Capacity

In November 2020, the United States was beginning a third rise in cases of COVID-19. However, unlike the peaks from April and July of that year, the third surge was not geographically constrained. The previous peaks had overwhelmed hospitals at the local level through demand that exceeded capacity. Commodity shortages and workforce shortages had also affected the provision of medical care at the local level in places where cases spiked.

By November, the number of COVID-19 patients hospitalized surpassed the spring and summer peaks. Moreover, the duration of the strain, especially in areas that were sustained CDC hotspots, changed the dynamics among the risk drivers.

Disrupted Functions and Degraded Care: By December 2020, the pandemic had begun to push healthcare facilities into a crisis, causing degradation to the *Provide Medical Care* NCF. Most states had at least some facilities employing contingency operations, including diverting patients and using temporary facilities, to stretch staff, space, and resources.

Constraints to available hospital space, staffing and resources drove consideration and adoption of Crisis Standards of Care (CSC), the most extreme operating condition for hospitals. As of 31 December 2020, nine states had formally authorized and three more states had observed informal implementation of CSC at hospitals in response to surging COVID-19 cases. That implementation varied widely across the country and



Concurrent shortages of commodities, shortages of workers, and spiking demand for health services have strained healthcare networks nationwide. These drivers reinforce each other, and their dynamics magnify the effects, resulting in diminished capacity and resilience.

Arrow 1: Increasing demand for care will likely result in commodity shortages. These shortages may result in delays or degradation of care.

Arrow 2: Analysis by the CISA COVID Task Force indicates personal protective equipment (PPE) shortages may result in greater chance of exposure for healthcare workers. Contraction of the virus by healthcare workers leads to temporary workforce shortages.

Arrow 3: Increase in demand for care may result in prolonged exposure of the healthcare workforce to high numbers of COVID patients, increasing the likelihood of contracting the virus. The absence of sick healthcare workers with relevant experience treating COVID-19 will likely diminish the efficacy of treatment, resulting a long-term increase in demand for care.

Figure 1 – Mutually Reinforcing Dynamics Further Strain Provide Medical Care NCF

The rising demand for medical intervention, commodity shortages, and workforce shortages were not affecting medical care independently, but also aggravating one another, resulting in hospitals' reduced capacity and resilience. The CISA COVID Task Force (CTF) created a conceptual model to help describe these dynamics (see Figure 1) that had begun to pose a threat to the critical infrastructure facilitating the *Provide Medical Care* National Critical Function (NCF) at the regional and national level.

Tracking where these risk drivers were highest provided insight into where the likelihood of degraded or disrupted functionality was highest.

even within regions. For example, in CISA Region 6 at the end of 2020, New Mexico had authorized and implemented CSC; Arkansas had authorized but hospitals had not implemented CSC; Oklahoma had not authorized but hospitals had implemented CSC; and Texas and Louisiana had neither authorized nor implemented CSC.[1]

The consequences of CSC are substantial, as CSC operations require that new patients presenting symptoms below predetermined thresholds of risk to life, or with a low likelihood of survival, may not be able to access critical care. Those determinations can cause increased mortality in affected states or regions and harm long term health outcomes for chronically ill patients requiring consistent access to healthcare.

Implications of CSC: When hospitals enacted CSC, many preventative care and elective procedures were suspended, resulting in progression of serious conditions in some individuals who would have benefitted from early diagnosis and intervention. This exacerbated the fact that many Americans were also “delay[ing] or avoid[ing] medical care during the pandemic…including 12 percent who…avoided urgent or emergency care” for fear of exposure to COVID-19, according to an 11 September 2020 CDC report.[2] Between March and June 2020, emergency department visits declined by 23 percent for heart attacks, 20 percent for strokes, and 10 percent for diabetic emergencies.[3]

Reduced emergency department visits did not mean that fewer Americans were suffering from those ailments; in fact, deaths were up for all three of those ailments in 2020. For example, by the end of 2020, mortality from cardiac arrest had increased nationwide since the start of the pandemic, according to research published 14 November 2020 in the *Journal of the American Medical Association* (JAMA).[4] Extended pre- hospital transportation times, caused by lack of bed space across large regions, also correlated with increased mortality for victims of penetrating wounds and motor vehicle accidents, according to two separate articles from the *American Journal of Surgery*.[5,6]

The conceptual model below considers a worse- case scenario, where cascading effects caused by COVID-19 surges leads to systemic degradation—the failure of healthcare facilities to provide the care demanded by the public due to excessive volume, or staffing and equipment shortages, resulting in rationing of care and negative public health outcomes (see Figure 2). In the model, facility-level decisions to divert incoming patients can diminish the operational capacity of nearby hospitals. During regional COVID surges, the overwhelming of multiple facilities concentrated patient flows to those remaining facilities still accepting patients. When all facilities within a region reached patient capacity, the region’s residents could temporarily lack access to medical care.

With the third rise in cases, and hospital systems continuously over-burdened (staff, space, and/or supplies), the question as to whether the healthcare and public health critical infrastructure sector was likely to be stressed was no longer an issue. News reports made it clear that overwhelmed hospital systems were unable to provide acute care to all those in need, documenting the rising death toll. With the increasing case count of the third wave, and increasing hospitalizations, prior analyses centered around the likelihood of stress on the infrastructure and associated NCF were overtaken instead by identifying and contextualizing the consequences of the manifest strain, in direct and indirect terms.

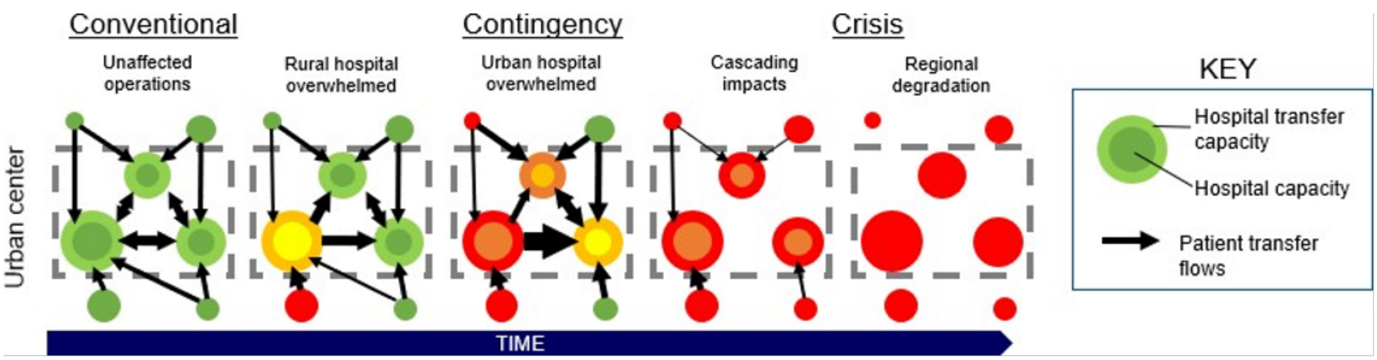


Figure 2 – Conceptual Model of Cascading Impacts of COVID-19 Surge

Consequences of Degraded Functions

The rising death toll in the areas where COVID- 19 cases were high was not limited to solely people who died from COVID-19; more people were also dying from other causes than what would be expected. The technical term for this is *excess deaths*. Excess deaths are defined as the difference between expected and observed number of deaths in specific time periods, according to the Centers for Disease Control and Prevention (CDC). Deaths nationwide were at least 20 percent higher than normal from the previous five years (2015–2019) as compared to 2020. Between February 2020 and June 2021, the CDC reported a predicted excess deaths amount between 580,751 and 713,873 across the United States.[7]

Excess deaths provide insight into the consequence of the overwhelming demand on U.S. hospitals and healthcare facilities. During the COVID-19 pandemic, excess deaths emerged from two main sources: direct causes (those caused by the COVID-19 virus) and indirect causes (e.g. hospital strain, medical avoidance, ransomware attacks).

The Correlation of Cases and Excess Deaths:

Excess death data at the national level provided strategic insight into the consequences of the pandemic on the nation. The CTF's analysis, however, revealed that excess deaths had an even more direct connection to the *Provide Medical Care* NCF. Results from a regression analysis conducted in March 2021 provided strong support for the hypothesis that hospital strain, as measured by intensive care unit (ICU) bed utilization[+], would lead to subsequent increases in excess deaths. This was important because it demonstrated that bed utilization rates can serve as a warning sign to states to prevent localized hospital strain and start diverting resources before it gets too severe, to reduce the pattern of imminent mortality. This analysis indicated that bed utilization was a key indicator for critical infrastructure-related stress to the *Provide Medical Care NCF*, with direct and indirect consequences of excess deaths that emerge in the weeks that follow a surge in COVID-19 hospitalizations.

More specifically, the analysis used a negative binomial regression to model excess deaths (dependent variable) and hospital strain (as the independent variable) across the country at the facility level from March 2020 through January 2021, while controlling for several key variables. The results indicated that as ICU bed utilization increases, the number of excess deaths two, four, and six weeks later also increases. Those results were statistically significant (at the $p<.01$ level) and substantively significant and controlled for state-level differences (e.g. state population, governing party, restrictions). Robustness checks using inpatient bed utilization were consistent and provided similar results.

The marginal effects plot in Figure 5 depicts the significance of ICU bed utilization for excess deaths. It shows predicted values for the number of excess deaths in two weeks as adult ICU bed occupancy increases, based on the regression model described below. (Note that the red line represents the actual predicted values, and the orange shaded bands are the confidence intervals associated with those predicted values.) As shown, the model predicts that if ICU bed capacities nationwide are at 75 percent (as of March 2021), there would be an estimated additional 15,000 excess deaths nationally two weeks later[1].

[+] While pandemic-driven ICU bed utilization is not a direct cause of excess deaths, low ICU capacity is a marker of broader issues that can contribute to excess deaths, such as curtailed services, stressed operations, and public reluctance to seek services.

* This analysis and graphic were developed using data from March 2020-January 2021 and does not account for any vaccinations.

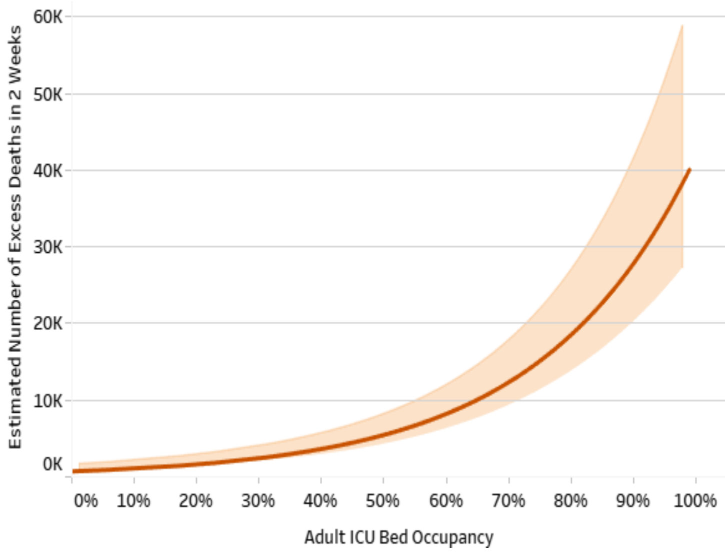


Figure 3 – Estimated Count of National Excess Deaths as ICU Bed Occupancy Increases

Degraded Functionality and Excess Deaths: Excess death data from 2020 captured large increases in deaths from causes other than COVID-19, including Alzheimer disease, diabetes, heart diseases, and cerebrovascular diseases (see figure). Pandemic-driven dynamics—such as strains on medical infrastructure, increased isolation associated with social distancing and stay at home orders, and loss of health insurance amidst the parallel unemployment crisis—all likely contributed to the growth of these indirectly.

Some excess deaths may have resulted from limited access to care where area hospitals enacted contingency standards and CSC. The consequences of that lack of access will likely outlast the pandemic, resulting in increased worsened health outcomes for those who avoided preventative and diagnostic care. Post- pandemic patient influxes, arising from prolonged avoidance of care, may introduce new stressors to the NCF, seen in impacts on hospitals' workforce and cyber infrastructures, even as the direct challenges of the pandemic subside. The inability for major regional hospitals and isolated rural hospitals to absorb surging COVID-19 patients may be the most important factor in regional resilience. Even so, conversion of specialist wings to tertiary care hospitals to extend ICU capacity can diminish access to specialized care.

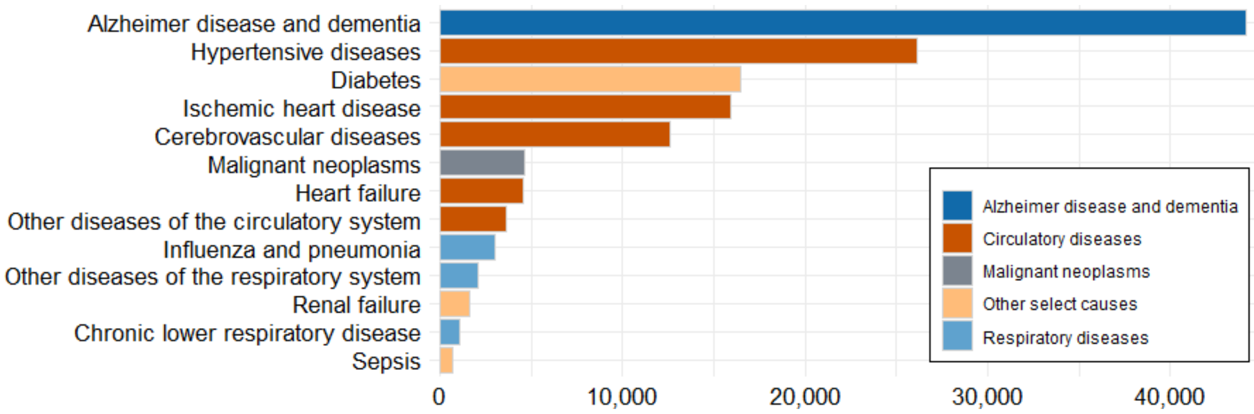


Figure 4 – 2020 U.S. Deaths Above Average, Excluding COVID-19

The excess deaths findings demonstrated the cascading effects of the disruption from the pandemic: direct, acute care demands from surges of COVID-19 patients strained hospitals at the local level. When that strain became severe and required enacting CSC, limited access to care (along with patient hesitancy to seek medical care during the pandemic) led to worse outcomes for many patients suffering from non-COVID-19 issues.

Impacts of Excess Deaths on Critical Infrastructure Workers: These burdens were not distributed randomly or equally: deaths in 2020 as compared to 2019 were most pronounced in people aged 25-44 years old (while direct deaths from COVID-19 disproportionately affected people age 75 and older), as illustrated in the figure below.

Understanding this pattern was important because it helped identify potential cascading effects on other critical infrastructure sectors and related NCFs through the loss of members of their related workforces. Specifically, working-age adults, who constitute most of the essential critical infrastructure workers, experienced significant excess deaths from the indirect effects of the COVID-19 pandemic. Certain demographics that made up large portions of this community were also particularly vulnerable to excess deaths: racial and ethnic subgroups experienced disproportionately higher percent increases in deaths above the expected number, with the most pronounced effect in Hispanic communities, which the Economic Policy Institute estimates made up 21 percent of “essential workers” in 2019 according to their definitions.[8,9]

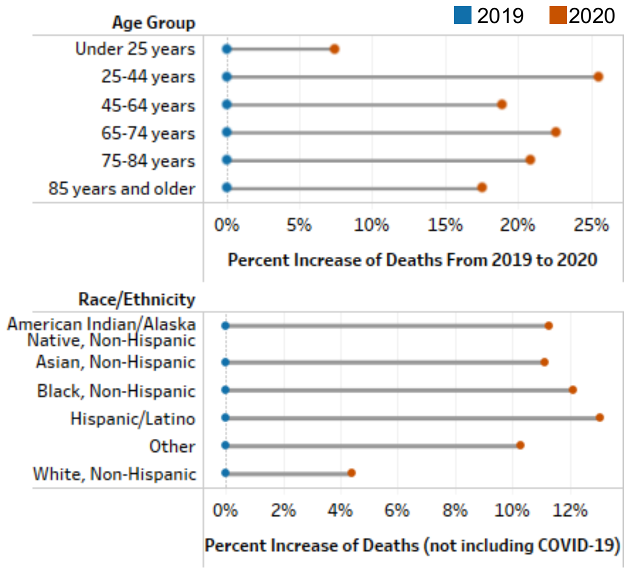


Figure 5 – COVID-19 Deaths 2019 to 2020 Comparison Within Demographics

A Note on Excess Deaths and ECIW

The insights discussed above indicated that increasing the resilience of essential critical infrastructure workers involved managing transmission in the communities in which the workers live. One critical component to doing so became vaccine administration, where prioritization was crucial, especially in the early phases.

Excess deaths analysis provided additional insight into which communities might benefit the most from targeted vaccination because of the indirect effects of the pandemic.

Additional External Stress: Ransomware Attacks

In addition to the pandemic's stress on hospitals across the nation, external pressures, such as ransomware or attacks on healthcare delivery supporting infrastructure, can degrade operations in a time of crisis or urgency.

Insights into the *Provide Medical Care* NCF gained by correlating bed utilization rates and excess deaths led to subsequent analysis on the threat that ransomware poses to U.S. hospital systems. Although there are no deaths directly attributed to hospital cyberattacks, statistical analysis of an affected hospital's relative performance indicates reduced capacity and worsened health outcomes, which can be measured in the time of the COVID-19 pandemic in excess deaths.

The ransomware attack on hospital system's network resulted in inaccessible patient schedules and records, disrupted communication, and delays in processing and communicating test results (Figure 6).

Downstream effects included cancelled or delayed surgeries and cancer treatments, closure of several COVID-19 test collection sites, inability to submit radiology imaging, and loss of communication between hospitals in the network (Figure 7). This forced critical patient diversion, paper-based record-keeping, and suspension of care to high-risk patients. Although there are no deaths directly attributed to the cyberattack, statistical analysis of its relative performance indicates reduced capacity.

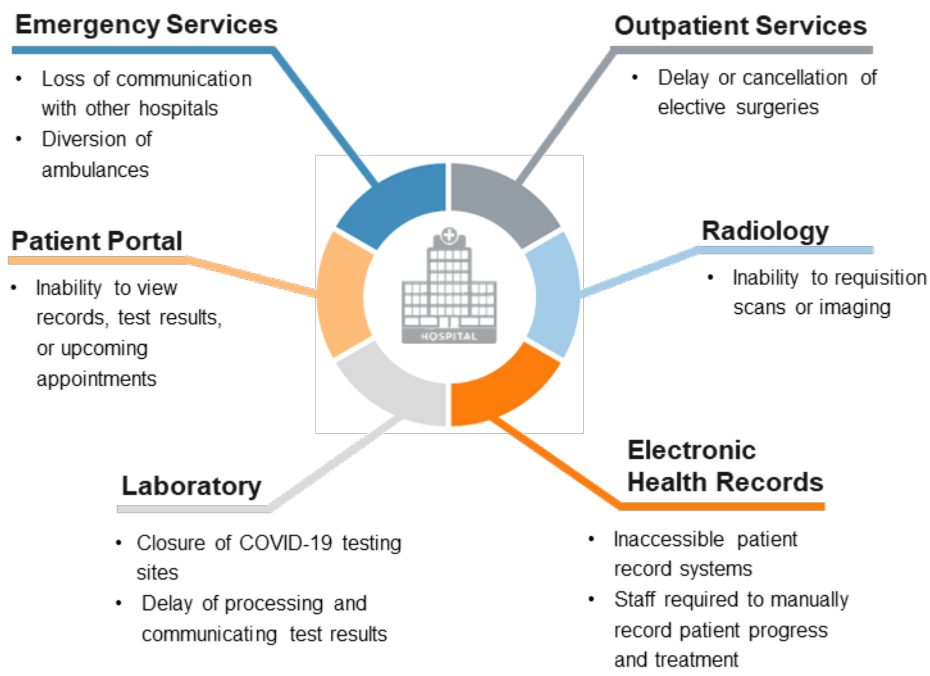
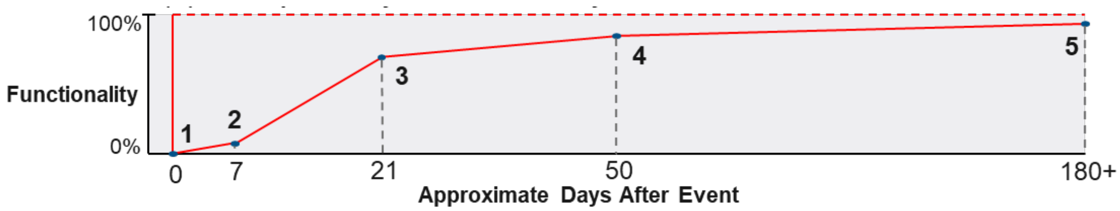


Figure 6 – Hospital System Services and Departments Disrupted by Cyber Attack



1. Immediately after the event, the entire IT network is down, no access to online systems.
2. Available offline back-ups of the system are accessible, restoring access to some.
3. Experts begin returning network functionality to systems after clearing hardware.
4. Majority of hardware has restored access. However, some tools remain offline for cleaning/repair.
5. All hardware has access restored. Some tools may remain out of service or require more cleaning.

Figure 7 – Conceptual IT System Functionality Status After a Ransomware Event

To assess whether experiencing a cyber- attack resulted in increased hospital strain, a regression analysis compared hospitals within the network (facilities that experienced the October 2020 attack) to non-network hospitals. Data for this analysis included 'Reported Hospital Utilization Timeseries' and 'COVID-19 Reported Patient Impact and Hospital Capacity by Facility' data from healthdata.gov[10] and CDC's excess deaths data 'Percent Excess Deaths, Full Data.'[11]

The hospital system's website was used to identify which specific facilities were part of their network. The analysis covered the four months immediately following the attack, from October 2020 to March 2021 to capture the short-term and long-term effects. In the short-term, cyber- attacks may disrupt the ability for healthcare systems to access electronic health records (or EHRs) and network-based services—such as cardiac and oncology technology. This reduces capacity in the short-term, potentially even requiring diversion of critical patients. In critical care, where minutes or hours can determine the survival rate of a patient (such as heart failure), diversions can drastically reduce survivability and recovery. In the long-term, access to EHRs may remain limited, complicating care for long-term patients that have detailed records that determine treatments. Without EHRs, healthcare workers spend more time tracking a patient's health history, reducing the number of beds staff can attend to and potentially leading to worsened outcomes as patients waiting for availability may not get treatment or test results in time to effectively treat their illnesses. In weeks or months after an attack, hospital systems may still have to delay diagnostic and long-term care services due to data losses.

Results indicate that the system's hospitals were more likely to experience hospital strain (measured by ICU bed utilization) in the long term following the attack compared to non- system hospitals. These results were statistically significant and controlled for date, size of the hospital, and type of facility. This supports the assessment of the longer-term implications of cyberattack on degraded hospital capacity, implicating worsened health outcomes as measured in excess deaths. While these conclusions are specific to this incident, it is probable that they apply across the country. The conceptual in Figure 8 is based on descriptions of functionality of parts of the networked medical systems.

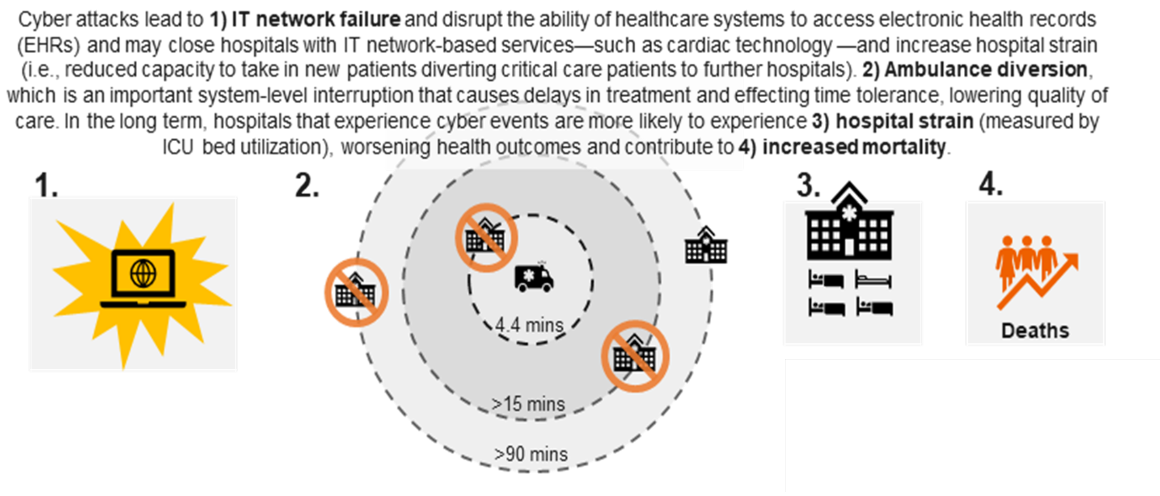


Figure 8 – Conceptual Model of Impact of Cyber Attack on Patient Outcomes

Conclusion

The pandemic posed obvious risks to the nation in 2020, with three waves that each posed severe challenges to multiple critical infrastructure sectors and related NCFs, but primarily the healthcare and public health sector and the *Provide Medical Care* NCF. The CTF's analysis examined healthcare critical infrastructure from a functional perspective to help provide leadership with a strategic-level view of the effects of the pandemic, as well as the cascading effects beyond the sector. The analysis revealed the need for a model to measure the operational impact of stresses to hospitals and other healthcare facilities. The analysis also demonstrated the utility of some metrics in understanding the impacts to critical infrastructure operations, specifically the utilization rate of ICU beds. It also provided an approach to measure the effects that the stress has had in the COVID-19 pandemic, specifically through the lens of excess deaths.

This analytic approach—along with the coincidence of the third wave of cases and a major ransomware attack on a hospital network—allowed additional insights into the effects of ransomware on infrastructure functions. The preliminary findings help establish a more complete picture of the relationship between cyberattacks, hospital strain, and health effects. The examination of attacks on a Hospital System's HealthCare Network helps establish a strong connection between the cyberattacks and increasing hospital strain. When combined with previous results that indicate that hospital strain significantly contributes to degraded functionality, the link from cyberattacks to hospital strain to health outcomes becomes clearer–especially in a time of crisis, such as a pandemic or other disaster.

This team will continue the analysis of critical infrastructure impacts on the Provide Medical Care NCF for the remainder of the Task Force's standing. We believe these evolving insights merit further investigation and modelling with the inter-agency and private sector, as these should inform post-pandemic recovery and resilience investments.

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