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AHRQ Final Progress Report

Title of Project: Leveraging Health System Telehealth and Informatics Infrastructure to Create a Continuum of Services for COVID-19 Screening, Testing, and Treatment: A Learning Health System Approach

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Structured Abstract

Purpose: The goal for this project was to illuminate, from the perspective of a single health system connected to a state-wide telehealth network, the impact of COVID-19 (C-19) challenges on new and existing healthcare services.

Scope: This study employed a rapid cycle mixed-methods approach to describe, evaluate, and distill evidence of "what worked" in a health system's telehealth response to C-19. The objective was to describe what new services were put in place, how responses were implemented, what worked, how we discovered and corrected mistakes, and what benefits and unintended consequence were observed.

Methods: Multiple methods were used across aims to generate study findings. These include a combination of retrospective longitudinal data analysis on the MUSC Health System and SC state-level cohorts to examine quantitative questions and document analysis, administrative systems records extraction, and prospective interviewing to examine system responses, patient and provider insights, and unintended consequences.

Results: Our three Aims resulted in more than 40 publications, webinars, and toolsets that helped our system optimize its responses to the pandemic. We learned that real-time data sources, well integrated practice and research teams, and a commitment to a "Learning Health System Approach" are essential for responding in a crisis. We found communicating our findings using non-traditional approaches helped us learn from our audience and collaborators. The impact of this work led to greater responsiveness, better access, improved quality of care during the C-19 pandemic than would have been possible without the disciplined learning health system approach.

Key Words: telehealth, telemedicine, COVID-19

PURPOSE

The C-19 pandemic reached the US with little warning, and thus caught both public health and medical care delivery systems inadequately prepared to cope with the pandemic. Effectively screening, testing and treating the population for this dangerous virus became an unprecedented challenge for healthcare systems which were in parallel suffering enormous economic challenges in maintaining normal patient care. Most health systems have disaster plans, but the plans are focused on short-term events, such as mass casualties or hurricanes. The Medical University of South Carolina (MUSC) had a well-developed and tested disaster plan normally implemented to respond to disruptions due to hurricanes. An important facet of the plan was free Virtual Urgent Care (VUC) visits hosted by the MUSC Center for Telehealth. Through collaboration across multidisciplinary teams and strategic planning, four telehealth programs with corresponding informatics systems were deployed in the initial weeks of the pandemic: VUC screening, remote patient monitoring for C-19 positive patients, continuous virtual monitoring to reduce workforce risk and utilization of personal protective equipment, and the transition of outpatient care to telehealth. However, the speed, diverse needs, and high volume of services were unprecedented and thus these changes required extensive evaluation to better prepare for future challenges. This proposal aimed to inform these choices through examining the effects of these four telehealth programs and corresponding informatics innovations as initial responses to the C-19 pandemic. Special attention was paid to the ability of these innovations to address patient and healthcare worker safety and the provision of high-quality care. Additionally, continued surveillance of the consequences of these programs, including any unintentional exacerbation of healthcare disparities, was examined along with the steps taken to mitigate these effects and close gaps in care for socially vulnerable populations.

Specific Aims:

AIM 1: Describe characteristics of how the urgent C-19 requirements modified the standard telehealth or health systems processes.

AIM 2: Measure and compare the health systems C-19 adjustments with regards to: overall patient volume, service uptake, delivery learning curves, and safety/quality indicators as they changed over time, with special emphasis on differences observed for underserved and high-risk populations.

AIM 3: Assess population health outcomes, value, and cost from the perspectives of patients and providers with special attention to changes in access to acute care, emerging gaps in preventive care, unintended consequences of C-19 responses, differential effect on underserved and high-risk populations, and specific issues emerging in rural locations and in broadband “digital deserts”.

SCOPE

Background

The world has experienced both unprecedented crisis and unparalleled adaptation in response to the C-19 global pandemic.[1] Health care systems were forced to rapidly adjust standard care processes and deploy new healthcare delivery approaches in order to screen and care for C-19 positive patients and maintain routine care in way that ensured both patient and staff safety.[2] When regulatory changes in the US opened the door for expanded telehealth usage during the public health emergency[3], organizations with an established infrastructure for telehealth—like the Medical University of South Carolina (MUSC)—were best positioned to respond. MUSC is the state's only integrated, academic health sciences center with a unique charge to serve the state through education, research and patient care. The state's leader in obtaining biomedical research funds, in fiscal year 2019, MUSC set a new high, bringing in more than $284 million. The MUSC Health system is headquartered in Charleston with the larger system comprised of four rural health centers, more than 100 outreach sites, nearly 275 telehealth locations across the state. In 2019, for the fifth consecutive year, U.S. News & World Report named MUSC Health the No. 1 hospital in South Carolina (SC). MUSC'S Center for Telehealth (Center) was recently awarded one of two National Telehealth Centers of Excellence by HRSA due to the comprehensive catalogue of services developed by the center and the strength of its evaluation program.[4] Additionally, the Center serves as the administrative home for the South Carolina Telehealth Alliance (SCTA), a collaboration between all of the state's major healthcare systems, as well as payers, state agencies, and community stakeholders committed to advancing telehealth access and services for all South Carolinians.

Context

SC has pervasive incidences of chronic disease, high poverty and a large percentage of medically underserved areas making residents particularly vulnerable to C-19. The Federal Medical Assistance Percentage for SC during fiscal year (FY) 2017 was 71.30%.[8] SC's poverty rate is the ninth highest in the country with 16.6% of residents living below the federal poverty level.[9] Economic barriers to care include a high uninsured rate of 12.9% for residents under 65 years of age.[10] Of the state's 46 counties, HRSA designates 43, or 93.5%, as completely or partially medically underserved.[11] Workforce distribution and access issues are evident in that 44 counties, or 95.6%, of SC's counties are designated as full or partial Primary Care Health Professional Shortage Areas (HPSAs).[8] Geographic barriers to healthcare access are demonstrated by the fact that, in 61% of SC counties, over 50% of residents who require hospitalization are hospitalized outside their county of residence. Over half of pediatric patients are hospitalized outside their county of residence in 36 of 46 counties (78%). South Carolina also has a prevalence of chronic medical conditions,

TABLE A. SC Health Indicators and Rankings

Indicator	Ranking
SC Carolina Life Expectancy Compared to Other States[5]	42nd
Top 10 US States for High Prevalence for Diabetes[6]	7th
Human and Economic Costs Related to Diabetes for 2015[6]	$3 Billion
Top 10 US States for Stroke Mortality, CDC[7]	6th
% of Diabetes-Diagnosed Individuals with Co-Morbidities	
Hypertension (70%)	High Cholesterol (66%)

such as diabetes, stroke, and hypertension. Table A provides snapshot of the state's health indicators and rankings.

Settings

Due to MUSC Health system's statewide reach and service mission, the system's status as SC's only tertiary/quaternary care referral center, and the administrative home for state's telehealth delivery system, the South Carolina Governor's Office designated MUSC to serve as the lead medical entity to coordinate the state's response to C-19. This application seeks to illuminate, from the perspective of a single health system connected to a statewide telehealth network, the impact of C-19 challenges on new and existing healthcare services – including the impact of C-19 on care delivery for chronic medical conditions such as stroke and diabetes. Patient care delivery settings include inpatient and outpatient facilities as well as the patient's home.

Participants

Services deployed across the continuum of care have implications for almost every patient population. The impacts on the following populations, organized by intervention, were examined in detail: (1) VUC screening: self-referring patients across the state with special attention to racial minorities and those residing in "broadband deserts"; (2) C-19 testing: patients across the state referred via VUC to drive through testing locations or self-referred to walk up testing sites, including those deployed in underserved "hotspots"; (3) RPM for C-19 positive patients: adult C-19 positive patients across the state who do not require hospitalization and elect to enroll in the program with particular emphasis on high risk patients, those with chronic diseases, racial and ethnic minorities, and those residing in "broadband deserts"; (4) HCW exposure reduction: C-19 positive patients who are hospitalized at an MUSC location, including emergency departments, individual inpatient rooms at both floor and intensive care settings and on cohorted C-19 units as well as HCWs to include physicians, advanced practice providers, nurses, medical assistants, physical therapists, and respiratory therapists; (5) Ambulatory video visit conversion: adult and pediatric patients across the state with particular attention paid those with chronic conditions, racial and ethnic minorities, to rural, underserved areas and "broadband deserts" and providers to include physicians, advanced practice providers, phycologists, social workers, nurses, medical assistants, respiratory therapists, and nutritionists.

Background on C-19 Incidence and Prevalence in SC

On June 13, 2020, SC had 17,710 confirmed C-19 cases and approximately 155,000 estimated cases. On this date, 770 individuals tested positive, the highest number ever, a huge spike with a steadily increasing testing rate and an increasing percent of positive tests (14.8%) among those tested. At that time we had 593 deaths for C-19 in the state. While these numbers were low at the time compared to those in some other states, they were rapidly increasing. However, the SC Governor lifted restrictions. This was a concern because the SC population carries a great burden of health disparities both by geographic location and in vulnerable subgroups. Thus, we made a point of ensuring that rural and high-risk populations were well represented in all our evaluations.

Our data showed very large differences among counties in C-19 cases, and an excess amount of cases and deaths for minority populations. Rural counties with high proportions of African American residents, high poverty rates, and medically underserved citizens were the hardest hit. C-19 deaths occurred disproportionally in African American patients. Forty percent of recorded C-19 deaths were patients of black race, while only 28% of the population in SC is black. The population cumulative C-19 rate per million residents (M) varied greatly in SC. Charleston county's rate in the summer of 2020 was 1,610/M; Richland is 3,611/M; Florence is 4,439; while the poorer more rural counties of Lee, Clarendon and Williams have 10,961/M, 8,495, and 6,631, respectively.

METHODS

Study Design

Multiple methods were used across aims to generate study findings. These include a combination of retrospective longitudinal data analysis on the MUSC Health System and SC state-level cohorts to examine quantitative questions and document analysis, administrative systems records extraction, and prospective interviewing to examine system responses, patient and provider insights regarding process changes and unintended consequences.

AIM 1: Describe characteristics of programmatic interventions in screening, testing, and treatment and how the urgent COVID-19 requirements modified the standard telehealth or health systems processes.

- A multi-methods approach using program tracking data, workflows, provider and patient experience survey data, program and technical documents, and observations were used to develop thick descriptions of how the health system's processes were transformed to meet the needs of the C-19 pandemic.
- Additionally, key informant interviews were conducted with providers, telehealth leadership, and program managers. Respondents were purposefully selected based on involvement with the C-19-R. Interview questions focused on program implementation, processes, "roadblocks" and successes. The 60-minute semi-structured interviews were audio recorded and professionally transcribed.
- Finally, cross-referencing our Epic EHR research permissions, we conducted telephone interviews with 14 MUSC patients about their experience receiving video visits versus audio only visits during C-19 in the ambulatory care context. Respondents were purposefully selected to ensure a mix of demographics including race and sex. The semi-structured 30-minute telephone interview focused on questions related to patient experience with each modality, perceptions of the care they received, and any unintended consequences.

AIM 2: Measure and compare the health systems C-19 adjustments with regards to: overall patient volume, service uptake, delivery learning curves, and safety/quality indicators as they changed over time, with special emphasis on differences observed for underserved and high-risk populations.

- Aim 2 deployed a learning health system, quantitative approach to examine how the telehealth C-19 response improved effectiveness and efficiency of care. This included evaluation of the program's ability to reach a large population, the usability of the activities, and sustainability at scale. Specifically, program tracking data, registry and EHR data, and provider satisfaction surveys were used to assess the ability of the C-19 response to impact quality and efficiency with specific focus on observed differences among underserved and high-risk populations.
- Further description of methods, particularly approaches to geographic mapping of utilization data, are documented in the results.

AIM 3: Assess population health outcomes, value, and cost from the perspectives of patients and providers with special attention to changes in access to acute care, emerging gaps in preventive care, unintended consequences of the C-19 response(C-19-R), differential effect on underserved and high-risk populations, and specific issues emerging in rural locations and in broadband "digital deserts."

- Various quantitative hypotheses were tested using claims, EHR, and registry data across multiple disease states and patient groups. Analyses varied based on sub-aims and included generalized linear mixed modeling, differences-and-differences approaches, and interrupted time series analyses.
- Further description of methods, particularly approaches to geographic mapping of utilization data, are documented in the results.

Data Sources/Collection

- ***Telestroke Registry.*** MUSC maintains a registry of all patients evaluated within the Telestroke consultation network. The registry includes information on patient characteristics (age, race, sex) and process measures such as "time from stroke to ED" or "door to needle" times. In 2013, MUSC began collecting patient stroke severity measured by the NIHSS on admission and on discharge, as well as symptomatic intracerebral hemorrhage rate, and patient mRS at multiple intervals.
- ***Press Ganey Patient Satisfaction.*** Press Ganey began administering patient experience surveys to telehealth patients discharge dates of 4/1/2020 onward. There is a 4-7-day lag between the discharge date and the date the survey is sent. Telemedicine patients are identified using these three designators – MYCHART VIDEO VISIT COVID-19, TELEMEDICINE NEW, and TELEMEDICINE RETURN for the adult ambulatory providers/physicians and pediatric clinics that we are already surveying. Surveys were emailed to patients with a valid email address in Epic.
- ***Epic Records / Data Warehouse.*** Epic is MUSC's Electronic Health Record (EHR) system that captures real-time data from inpatient and ambulatory patients. Epic went live for MUSC ambulatory practices in May 2012 and went live for MUSC hospitals in July 2014. Epic was used to identify patients for this project, and as the platform for the patient and provider decision support tools. In addition. EPIC data from calendar year 2019 and the available months from 2020, 2021 and 2022 from all MUSC hospitals and practices were used to assess access and outcomes. MUSC's protocol-based process for EHR data extraction from the clinical research data warehouse (RDW), which is

directly fed from Epic was used for the extraction process. Variables not available in the structured data were extracted from clinical notes.

- ***Zipnosis.*** Zipnosis data (Zipnosis, Inc. Minneapolis, Minnesota), contains records from each of the free virtual care consultation and screening contacts for symptomatic individuals which was captured in the telehealth system. The informatics research team developed a NLP approach to identify key symptoms that supplemented structured data used for the electronic triage used to prioritize and inform scheduling for the drive-through testing facility.
- ***SC All-Payer Hospital and ED Discharge Data.*** The SC All-Payer Discharge data sets contain all facility records from hospital admission, emergency department visits and outpatient surgery visits for the population of SC (SC Revenue and Fiscal Affairs Office). The variables included are similar to data available for SC in the AHRQ HCUP SID data. However, with appropriate IRB, the MUSC Comparative Effectiveness Data Analytics (CEDAR) core can request linkages to our EHR or other files and receive data that is useful for the evaluation of specific interventions, or assessments for selected populations.
- ***Area Health Resource File and Health Professions Shortage Area Files.*** The Area Health Resources Files (AHRF) (Health Resources & Services Administration) data for SC were used to construct social indicator variables (income, education, poverty, age and race distribution measures for the geographic areas.

Interventions

As previously noted, the following interventions were deployed as part of C-19 response and considered part of our evaluation:

1. VUC screening: self-referring patients across the state with special attention to racial minorities and those residing in “broadband deserts”
2. C-19 testing: patients across the state referred via VUC to drive through testing locations or self-referred to walk up testing sites, including those deployed in underserved “hotspots”
3. RPM for C-19+ patients: adult C-19+ patients across the state who do not require hospitalization and elect to enroll in the program with particular emphasis on high risk patients, those with chronic diseases, racial and ethnic minorities, and those residing in “broadband deserts”
4. HCW exposure reduction: C-19+ patients who are hospitalized at an MUSC location, including emergency departments, individual inpatient rooms at both floor and intensive care settings and on cohorted C-19 units as well as HCWs to include physicians, advanced practice providers, nurses, medical assistants, physical therapists, and respiratory therapists
5. Ambulatory video visit conversion: adult and pediatric patients across the state with particular attention paid those with chronic conditions, racial and ethnic minorities, to rural, underserved areas and “broadband deserts” and providers to include physicians, advanced practice providers, phycologists, social workers, nurses, medical assistants, respiratory therapists, and nutritionists.

Limitations

- The generalizability of our findings is limited because findings from SC may not reflect issues in complex, adaptive health care delivery systems in other states. We have made a point of discussing our findings in view of conditions in SC to improve relevance nationally.

Results

Principal Findings & Outcomes

Aim 1

Describe characteristics of programmatic interventions in screening, testing, and treatment and how the urgent COVID-19 requirements modified the standard telehealth or health systems processes.

Below are the major findings from Aim 1:

- **Rapid Response: Leveraging Statewide Telehealth Infrastructure to Respond to the COVID19 Pandemic.**[12] This study led to a poster describing our virtual care mobilization amidst COVID-19, with particular focus on process improvement and how "roadblocks" were managed. Key outcomes include that in 2020, there was a 1094% increase in virtual urgent care compared to the previous year. Additionally, through the transition to telehealth video visits, compared to the national average, MUSC saw an even more substantial use of telehealth visits in mid-April with the MUSC rate of 68% conducted via telehealth vs the national rate of 14%.
- **Contribution of Continuous Virtual Monitoring to Hospital Safety, Quality, and Value of Care for COVID-19 Patients.**[13] Findings from this study include a description of the use of continuous virtual monitoring (CVM) equipment for COVID-positive or suspected positive patients during the first 52 days of the pandemic. This initiative helped providers attend to patients' needs virtually while averting 19,086 unnecessary in-person interactions. The estimated cost savings for the CVM program for COVID-19 patients in 2020 were $419,319, not including potential savings from avoided COVID-19 transmissions to health care workers. A total of 19,086 PPE changes were avoided, with savings of $186,661. After accounting for the cost of the CVM system, the net savings provided an outstanding return on investment of 20.6 for the CVM program for COVID-19 patient care.
- **Not Home Alone: Leveraging Telehealth and Informatics to Create a Lean Model for COVID-19 Patient Home Care.**[14] The team published a descriptive paper outlining MUSC's COVID-19 remote patient monitoring (RPM) program. The state-wide RPM program followed 1,234 SARS-CoV-2-positive patients, many of whom were older, from underserved populations, or at high risk of serious complications. Care was escalated based on pre-specified criteria to a primary care provider or emergency department visit, with 89% of moderate- to high-risk patients treated solely at home. The RPM nurses facilitated the

continuity of care during escalation or de-escalation of care, provided much-needed emotional support to patients quarantining at home and helped find medical homes for patients with tenuous ties to health care.

- **Provider and health system leadership perspectives on telehealth ambulatory expansion during COVID-19.**[15] This study included qualitative interviews with MUSC leaders from telehealth, ambulatory operations, compliance, and finance to understand the wins and challenges of ambulatory telehealth approaches during the pandemic. Themes indicated diverging views from operational leaders and financial staff. Within the first 3 weeks of the pandemic, the percentage of ambulatory telehealth visits increased from 1% of all visits to 66% of visits, which all respondents described as a huge win for patient care and access. All respondents credited the temporary reimbursement changes, urgency, and ability to build off the existing telehealth
- **Early Insights: Patient and Provider Telehealth Experiences During COVID-19.**[16] This study included an analysis of MUSC's Press Ganey satisfaction qualitative data, comparing 2019 in-person clinic visits to 2020 virtual visits. In analysis of pediatric patient satisfaction during COVID-19, we found different factors driving telehealth patient experience compared to in-person visits. Specifically, we found that telehealth patients placed more emphasis on both the positive and negative factors associated with efficiency. Additionally, telehealth patients expressed concerns related to audio and video quality and the inefficiencies of dropped calls. However, patients were supportive of the efficiencies associated with reduced drive times, and easy access to appointments with ambulatory telehealth visits. The large sample size and broad representation of patient responses assures the scientific rigor of the study and increases the robustness of our results. The written narrative responses informed by quantitative data is innovative and likely to serve as an exemplar for future work in this field.
- **Patient perspectives on audio-only versus video telehealth.**[17] We interviewed 12 patients to understand their experience with telehealth, with a specific focus on patient perspectives of the role of audio-only telehealth in their health care. Patients and providers shared that they find value, efficiencies, and conveniences of both options. Patients cited that waiting for an audio-only call (a telephone call) was much less stressful than navigating a telehealth platform while also citing that there is a greater connection between patient and provider for video visits. Our recommendation is that policy, practice, and payment must align to support innovation and the most cost-effective way to provide access to services.

Aim 2

2. **Measure and compare the health systems C-19 adjustments with regards to: overall patient volume, service uptake, delivery learning curves, and safety/quality indicators as they changed over time, with special emphasis on differences observed for underserved and high-risk populations.**

Aim 2 key findings are described below:

- **Telehealth Utilization Heat Mapping to Drive Telehealth Strategy and Equity.**[18] This project included the completion of the development and validation of zip code and county level indicators of social determinants of health (SDOH) and a new zip code estimation of

the CDC Social Vulnerability Index (SVI),[19] which were used for selecting geographic areas for examination of telehealth penetration in both Aim 2 & 3. Further, we included the Department of Agriculture Food Desert[20] indicators in our SDOH measures. The construction of this comprehensive SDOH data set aggregated at the zip code level constitutes a major innovative contribution to the field of health services research.

- **Utilization of MUSC's COVID Virtual Urgent Care Screening to Testing Triage.[14]** The focus of this study was on MUSC's use of virtual urgent care for COVID-19 screening and triage to testing. Preliminary findings from this analysis included that the program provided widespread, efficient access to COVID screening, education, and streamlined triage & testing. However, this free, public service was disproportionally underutilized by at-risk populations. As these findings were time sensitive, we used quicker methods for dissemination (i.e. presentations) and decided to not write these results up in a publication.
- **Trends in primary care visits and diabetes control for type 2 diabetes patients over 24 months around the COVID-19 pandemic.[21]** This study assessed the effects of the COVID-19 pandemic on management of diabetes for patients with type 2 diabetes at MUSC. Preliminary analyses showed that the composition of the patient cohort changed over the two time periods included in the study. During COVID-19, we observed a higher proportion of Black or African American patients. Similarly, there was a shift in the type of insurance coverage, with higher proportion of Medicaid or privately insured patients seeking care after COVID.

Aim 3

3. **Assess population health outcomes, value, and cost from the perspectives of patients and providers with special attention to changes in access to acute care, emerging gaps in preventive care, unintended consequences of C-19-R, differential effect on underserved and high-risk populations, and specific issues emerging in rural locations and in broadband "digital deserts."**

The team examined multiple hypotheses for Aim 3. Key findings are included below:

- **US Employer-Sponsored Insurance Coverage through the COVID-19 Pandemic.[22]** This study found that the increase in unemployment during the COVID-19 pandemic was not associated with a significant change in employer-sponsored insurance (ESI), at least in the short term. However, younger individuals were more likely to lose ESI coverage during the COVID-19 pandemic compared to the pre-pandemic period.
- **An Examination of Nursing Home Admissions to South Carolina Hospitals in Pre-COVID-19 Years Compared to the COVID-19 Period of 2020.[23]** This study found that there was a large decrease in inpatient and outpatient health care utilization of services for individuals with Alzheimer's Disease and Related Dementias (ADRD) during the first year of the COVID-19 pandemic in 2020, indicating a decrease in access to care. The difference in declines in utilization between individuals with and without ADRD was significant. While individuals without ADRD have returned to pre-pandemic health care utilization levels, individuals with ADRD continue to have a significantly lower level of health care utilization.
- **Characteristics of Patients with Sickle Cell Disease: Patterns of Utilization and**

Cost by Quarter (2017-2020).[24] This study found that individuals suffering from sickle cell disease continued to face higher costs even with less utilization.

- **Changes in Stroke Hospitalization Rates and Outcomes in South Carolina in the 10 Months after COVID-19.**[14] This study found that trends in acute ischemic stroke (AIS) hospitalizations in SC changed considerably from 2019 to 2020 with a substantial decrease in the number of strokes and hospital length of stay but increases in payments and odds of death or discharge to hospice.
- **A Modification of Time-Driven Activity-Based Costing for Comparing Cost of Telehealth and In-Person Visits.**[25] This objective of this study was to demonstrate a modified time-driven activity-based costing (TDABC) approach to compare weighted labor cost of an in-person pediatric clinic sick visit before COVID-19 to the same virtual and in-person sick-visit during COVID-19. Workflow charts were created for the clinic before COVID-19 and during COVID-19. Using TDABC and simulations for varying time, the weighted cost of clinic labor for sick visits before COVID-19 was $54.47 versus $51.55 during COVID-19. The estimated mean labor cost for care during the pandemic did no change from the pre-COVID period; however, this lack of a difference is largely because of the increased use of telehealth.
- **Impact of the Covid-19 Pandemic Measures on Psychotropic Medication Prescribing for Privately Insured Children.**[26] This study found that for children between 0-18 during the pandemic, there were temporary decreases in the prevalence of antidepressants, Anxiolytic/sedative-hypnotic, and antipsychotics, which later returned to pre-pandemic levels. However, decreases in the prevalence of stimulants and antimanic did not return to the pre-pandemic levels.

Discussion

The COVID-19 pandemic stressed the health systems in our state beyond what we imagined when we wrote our proposal. However, the most important lesson that we learned from this research was the essential contribution that strong research designs, real-time data sources, well integrated practice and research teams, and a commitment to a “Learning Health System Approach” can help overcome challenges. We found the structure of waves of communicating our findings using non-traditional approaches, such as webinars, tool kits and seminars, helped us respond and learn from our audience and collaborators. Our three Aims were based on a solid foundation of health services methods and data, which contributed much to our success. One essential finding was the high importance of our well-developed telehealth system, and the critical roles of a management group committed to innovation, and of having embedded researchers in place as a trusted part of the learning system was crucial. Our Aims were ambitious but were for the most part accomplished as planned. We ended up using more mixed methods than we expected. We used data analysis results to help focus our questions for qualitative data collection, and we used results from key informants and other interviews to select data sources and help frame hypotheses to be examined quantitatively. Several of our published papers are exemplars of this approach (see pending publications 1, 4 and 5 below). The study has spawned a great number of additional work and has been essential for providing data to ease the role and financial characteristics of telehealth in SC and beyond.

Conclusion

The disciplined application of descriptive approaches to programmatic interventions in screening, testing, and treatment (Aim 1), combined with real-time adjustments of patient volume, service uptake, delivery learning curves, and safety/quality indicators as they changed over the pandemic (Aim 2) were essential for the successful response of the health system. The quantitative measures of population health outcomes, value, and cost (Aim 3) enabled us to identify underserved areas and populations and make timely changes to improve access to acute care, and to identify differential effect on the pandemic on underserved and high-risk populations, and specific issues emerging in rural locations. As a result, this work may have saved many lives. It also was instrumental in teaching a large group of clinicians and students the value of data-based approaches for improving systems of care.

List of Publications and Products

Publications:

1. Ford D, Warr E, Hamill C, He W, Pekar E, Harvey J, DuBose-Morris R, McGhee K, King K, Lenert L. *Not Home Alone: Leveraging Telehealth and Informatics to Create a Lean Model for COVID-19 Patient Home Care.* Telemed Rep. 2021 Oct 28;2(1):239-246. doi: 10.1089/tmr.2021.0020. PMID: 34841422; PMCID: PMC8621622.

2. Dooley MJ, Simpson KN, Simpson AN, Nietert PJ, Williams JD, King K, McElligott JT. *A Modification of Time-Driven Activity-Based Costing for Comparing Cost of Telehealth and In-Person Visits.* Telemed J E Health. 2022 Oct;28(10):1525-1533. doi: 10.1089/tmj.2021.0338. Epub 2022 Mar 8. PMID: 35263178; PMCID: PMC9587787.

3. Morrow C, Wheeler D, Dooley M, Warr E, Kruis R, King K, Harvey J, Simpson KN. Contribution of Continuous Virtual Monitoring to Hospital Safety, Quality, and Value of Care for COVID-19 Patients. Telemed J E Health. 2023 Feb;29(2):293-297. doi: 10.1089/tmj.2022.0061. Epub 2022 Jun 16. PMID: 35708582; PMCID: PMC9940802.

4. Berini C. Trends in primary care visits and diabetes control for type 2 diabetics before and during the COVID-19 pandemic. PhD Dissertation submitted to the Medical University of South Carolina by Carole Berini, August 2023.

5. Kruis R, Brown EA, Johnson J, Simpson KN, McElligott J, Harvey J. Patient Perceptions of Audio-Only Versus Video Telehealth Visits: A Qualitative Study Among Patients in an Academic Medical Center Setting. Telemed Rep. 2024 Apr 3;5(1):89-98. doi: 10.1089/tmr.2023.0065. PMID: 38595727; PMCID: PMC11002560.

Pending Publications:

1. James A, Jurdi Z, Kruis, R, McElligott J, Simpson K, & Harvey J. Pediatric Patient Telehealth Experiences: A Comparison to In-Person in 2020 and 2022. Submitted to Telemedicine and E-Health.

2. Brown, E, Kruis, R, Jones, J, McElligott, J, King, K., Harvey, J. Scaling the Lessons Learned from Ambulatory Telehealth Approaches during COVID-19: Small Wins, Big Wins, and Some Challenges. Submitted to Telemedicine Reports.

3. Harvey J, McElligott J, Kruis, R, King K. Rapid Response: Leveraging Statewide Telehealth Infrastructure to Respond to the COVID19 Pandemic. Submitted to Telemedicine and e-Health.

4. Simpson A, Ward, R, Simpson K. Impact of the COVID-19 pandemic on heart attack and acute ischemic stroke outcomes in South Carolina among medically-underserved and minority populations. In preparation for submission to the Journal Circulation.

Posters and Presentations:

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