Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ _____

Rachel Neenan Date

4/18/2022

Implications of broadband internet access for telehealth provision at outpatient mental health facilities

By

Rachel Neenan

Master of Science in Public Health

Health Policy and Management

Ilana Graetz, PhD
Committee Chair

Janet Cummings, PhD
Committee Member

Peter Joski, MSPH
Committee Member

4/18/2022

Implications of broadband internet access for telehealth provision at outpatient mental health facilities

By

Rachel Neenan

Bachelor of Science in Nutrition

Pepperdine University

2017

Thesis Committee Chair: Ilana Graetz, PhD

An abstract of

A thesis submitted to the faculty of

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Science in Public Health

in Health Policy and Management

2022

4/18/2022

Abstract

Implications of broadband internet access for telehealth provision at outpatient mental health facilities

By Rachel Neenan

Background: Telehealth increases access to mental health services, particularly for rural populations. Poor internet access is common in rural areas and can be a barrier to telehealth services, such as videoconferencing. Currently, little is known about how internet access impacts the provision of telehealth services at mental health facilities.

Objective: Measure the association between county-level broadband access and telehealth provision at mental health facilities and determine if this association changes based on rurality.

Methods: Outpatient mental health facility data were merged with broadband access data, along with area and facility-level confounders. Rurality and internet access were interacted in an adjusted multivariate logistic regression model to predict the probability of telehealth.

Results: The study included 8,845 U.S. outpatient mental health facilities, about two thirds of which (68.8%) offered telehealth. Among facilities in non-urban counties, better internet access was associated with a 1.61 percentage point increase in the likelihood of telehealth provision compared to facilities in urban counties (p=0.005).

Conclusion: Better county-level internet access in non-urban counties was associated with a higher likelihood of a mental health facility offering telehealth compared to urban counties. Ongoing efforts to expand internet access in rural regions are critical to ensuring access to telehealth for underserved populations.

4/18/2022

Implications of broadband internet access for telehealth provision at outpatient mental health facilities

By

Rachel Neenan

Bachelor of Science in Nutrition

Pepperdine University

2017

Thesis Committee Chair: Ilana Graetz, PhD

A thesis submitted to the faculty of

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of

Master of Science in Public Health

in Health Policy and Management

2022

4/18/2022

Chapter I. Introduction

Recent estimates suggest that about a fifth of the U.S. adult population has a mental illness.[1] Despite this great burden of illness, a large proportion of those with mental illness struggle to receive mental healthcare; more than one third of adults with serious mental illness reported not receiving treatment in 2019.[2] One reason for this is poor geographic access to mental health facilities.[3] In rural areas especially, facilities tend to be located further from patients' homes, requiring long commutes and lost income due to travel time.

Telehealth has been championed as a means to bypass the barrier of poor geographic access and provide needed mental health services.[4–8] Additionally, facility closures due to the recent Covid-19 pandemic exacerbated existing challenges with mental healthcare access and further necessitated the ramping up of telehealth for mental health services.[9,10] Research suggests that telehealth is an effective means of delivering mental health services and is comparable to in-person care.[11] Particularly, rural mental healthcare facilities implementing telehealth services is desirable as it leverages the local knowledge and cultural awareness of rural providers.[12–14]

Broadband internet is ideal for telehealth interactions because it is continuous and provides high speed data transmission, both of which are essential for videoconference calls – a common modality for telehealth delivery of mental health services. However, rural and tribal areas typically have poor internet availability with 22.3% and 27.7% of these populations lacking access to high-speed broadband services, respectively.[15] This raises an important question of whether facilities in rural areas are less likely to offer telehealth due to poor local internet connectivity.

Existing research on telehealth implementation for mental health and other health services has yielded mixed results, with some studies reporting broadband access as a barrier, especially for rural areas.[5,16–18] Other researchers have found no associations between internet access and telehealth provision, but measures are typically broad geographically (e.g., at the state level), or only take into account one facet of internet access –such as the number of internet providers in an area.[7,19] Because telehealth has potential to help reduce rural mental health disparities, understanding barriers to telehealth provision at mental health facilities is important. Because of the drastic increase in telehealth use and role it will likely continue to play in mental health treatment, this research is also timely. Thus, the aims of this project are to examine the relationship between broadband internet availability and the provision of telemedicine at U.S. outpatient mental health facilities, and to explore differences in this relationship between facilities located in rural compared to urban areas. My hypothesis as follows:

There will be a stronger positive association between telehealth provision and broadband internet access for facilities in rural areas compared to those in urban areas, after controlling for facility and area-level characteristics.

I have drawn on the Consolidated Framework for Implementation Research (CFIR)[20] to develop a conceptual model, and I have selected the confounders most relevant to my focal relationship based on existing literature describing the implementation of telehealth.[19,21,22] Multivariate logistic regression will be used to estimate the association between broadband access and telehealth provision for U.S. outpatient mental health facilities as a whole and for facilities subset by urban/rural location. While many more commonly used internet access data categorize an area as simply having or not having access to any internet provider or a predetermined level of internet speed, this study will include continuous data on the proportion of the county population having access to various internet speeds and various numbers of internet

providers. The richness of this data will allow me to explore multiple facets of internet access and its relationship to telehealth service provision – a novel approach that will provide insight into mental healthcare access in context of digital divide.

Chapter II. Review of the Literature

Overview

Exploration of internet access in relation to telehealth at mental health facilities is warranted because telehealth has potential to improve mental healthcare access for underserved, rural communities. First, I will discuss the current state of unmet mental health needs in the U.S. and background information surrounding telehealth as a means of mental health service delivery. Next, I will explain how this research project has been grounded in the Consolidated Framework for Implementation Research (CFIR), including the hypothesized mechanisms and moderators. Lastly, I will explore current literature surrounding internet access and telehealth use for mental and other health services.

The Issue

There are significant unmet mental health needs in the U.S. Over one third of adults with serious mental illness reported not receiving treatment in the past year in 2019, and over one quarter of adults reporting symptoms of anxiety or depression reported needing but not receiving treatment in 2021.[2] There are a myriad of reasons for this, including vast mental health provider shortages, poor geographic access to mental health providers and facilities, cost barriers, and enduring social stigma surrounding mental illness.[3,23,24] Currently, 6,078 mental healthcare shortage provider areas (HPSAs) exist in the U.S. with over 136 million people residing in these areas.[25] Two thirds of these mental HPSAs are in rural areas where geographic access is a key barrier.[23] Lengthy commutes and lost income due to travel pose barriers for patients who live a long distance from the nearest facility. While there are unmet needs in both urban and rural parts of the U.S., the greater proportion of rural mental HPSAs demonstrate a clear need for improving access to mental health treatment for rural populations.[5]

Background

The use of remotely delivered mental health services, or 'telemedicine' has grown significantly in recent years,[26,27] with the percent of all mental health facilities offering remote services more than doubling from 15.2% in 2010 to 38.0% in 2019.[28] Although definitions can vary according to insurers, providers, and regulatory bodies, telemedicine is generally defined as the provision of remote clinical services using telecommunications technologies including videoconferencing, the internet, streaming media, and wireless communications.[29] Telehealth for the delivery of mental health services has generally been reported to be comparable to in-person care; a 2013 review found evidence that it was an effective means of service delivery for many populations and for many different healthcare settings.[11] Telemedicine has also been purported to help overcome the barrier of poor geographic access and healthcare provider shortages to provide mental health services to underserved minority, homeless, and rural populations in particular.[4–8] Several studies support the integration of rural mental health psychologists with remotely located psychiatrists, leveraging both the cultural awareness of local providers and the specialized knowledge of psychiatrists to provide effective care to rural patients.[12–14]

The Covid-19 pandemic has impacted the mental health of the US population, with more adults reporting symptoms of anxiety and depression[1] and more adults reporting an unmet need for therapy since 2020.[30] Telemedicine use for mental health services increased dramatically out of necessity to continue serving patients as facilities temporarily closed or reduced their capacities. Although it may not be representative of all mental health practitioners nationally, one survey of psychologists in outpatient facilities reported a 26-fold increase in the use of telemedicine compared to use prior to the pandemic.[31] Although some of these changes were temporary, it is likely that telehealth will play an increased role in mental health service delivery in the future.

As its use has expanded, the body of research surrounding the barriers and facilitators of implementing telemedicine has grown. Key and commonly cited barriers include financial issues (e.g., costs, reimbursement), legal issues (e.g., licensing regulations), and technical issues (e.g., effective equipment, adequate internet connection).[8,21,32–35] An adequate internet connection is especially important if the remote visit will take the form of a videoconference call, per the Centers for Medicare and Medicaid's guidelines on telemedicine.[36] Whether delivered through cable modem, fiber, Digital Subscriber Line (DSL), or wireless networks, high-speed broadband internet is ideal for these interactions. This is because broadband provides continuous access (no need to reconnect to the internet) and high-speed data transmission, both of which are essential for facilitating videoconference calls. The Federal Communications Commission (FCC) recently reported that around 19 million Americans do not have access to high-speed broadband internet,[15] a figure that is considered by some to be a significant underestimate.[37] Rural and tribal groups are disproportionately affected with 22.3% and 27.7% of these populations lacking access, respectively.[15] This raises an important question of whether facilities seeking to provide telehealth services will be limited due to poor internet connections and slow speeds.

Mental health facilities play an essential role in the delivery of mental health services, especially for underserved populations. The Substance Abuse and Mental Health Services Administration (SAMHSA) solicits data annually from all U.S. mental health facilities, which consist of outpatient facilities, community mental health centers, general hospitals, and psychiatric hospitals.[28] Notably, individual and small group practices do not qualify as mental health facilities.[28] Research suggests that it is primarily high-income patients that seek treatment at these smaller practices, while mental health facilities are more likely to be located in low-

income areas and more likely to serve those with serious mental illnesses.[38] Since these facilities are key to providing needed services to underserved groups, including remote and rural populations,[38] it is important to understand if poor broadband access prevents the use of telemedicine for their patients.

Relevant Theory

I have drawn on the Consolidated Framework for Implementation Research (CFIR) to develop a conceptual model exploring the relationship between broadband access and the provision of telehealth services at mental health facilities.[20] CFIR is based on a comprehensive review of implementation theory literature. It was created by combining existing constructs, defining those constructs, and dividing them into five key domains*:* Intervention Characteristics, Outer Setting, Inner Setting, Characteristics of the Individuals Involved, and the Process of Implementation.[20] The intervention characteristics refer to the intervention and its essential components along with any components that are adaptable and can be tailored to the organization. The outer setting includes the broader context of structures, politics, economics, and culture within which an organization exists, while the inner setting domain captures specific features of these contexts at the organization level. The domain assessing characteristics of individuals reflects the key role individuals play in affecting implementation with their beliefs, norms, and cultural affiliations. Lastly, the implementation process includes the actual planning, execution, and evaluation of the intervention itself.[20]

Other frameworks related to telehealth or health information technology were considered.[39–43] Some seemed better suited for healthcare entities with a focus on organization-level factors for which large scale data is unavailable (e.g., hardware and software, human-computer interface, communication).[40,43] Another modified the Donabedian model for telehealth

specifically, which might be preferrable if one was examining the frequency of telehealth use (as an organizational outcome) rather than simply whether it is offered.[41] My research question, however, at its core is about an outer setting factor (internet access) affecting implementation of a new technology (telehealth). Thus, CFIR is suitable for the purposes of framing this study. To select the constructs most relevant to my focal relationship, I have drawn on previous research describing the implementation of telehealth for mental health services.[19,21,22] My conceptual model is represented in Figure 1, with any unmeasured constructs denoted by italics.

Mechanisms

One means through which broadband access could increase the use of telehealth is by increasing the number of potential modalities for telehealth. Within the CFIR domain of intervention characteristics, there are both core elements of the intervention that cannot change and adaptable components that can be altered or tailored to suit an organization.[20] From this perspective, we can consider the remote provision of services to be essential to the definition of telehealth, whereas the modality of telehealth delivery (telephone call, smartphone app, website portal, zoom call) can be varied. If either the facility or the patient or both do not have broadband internet access, the potential modalities for telehealth are decreased. There are alternate means of accessing the internet, such as cellular service. However, communications software and apps built for computers that meet CMS criteria of being both audio and visual typically run best with stable high-speed internet. Thus, this conceptual model posits that broadband internet would make telehealth more feasible due to the increase in potential modalities with which an organization could choose to implement telehealth.

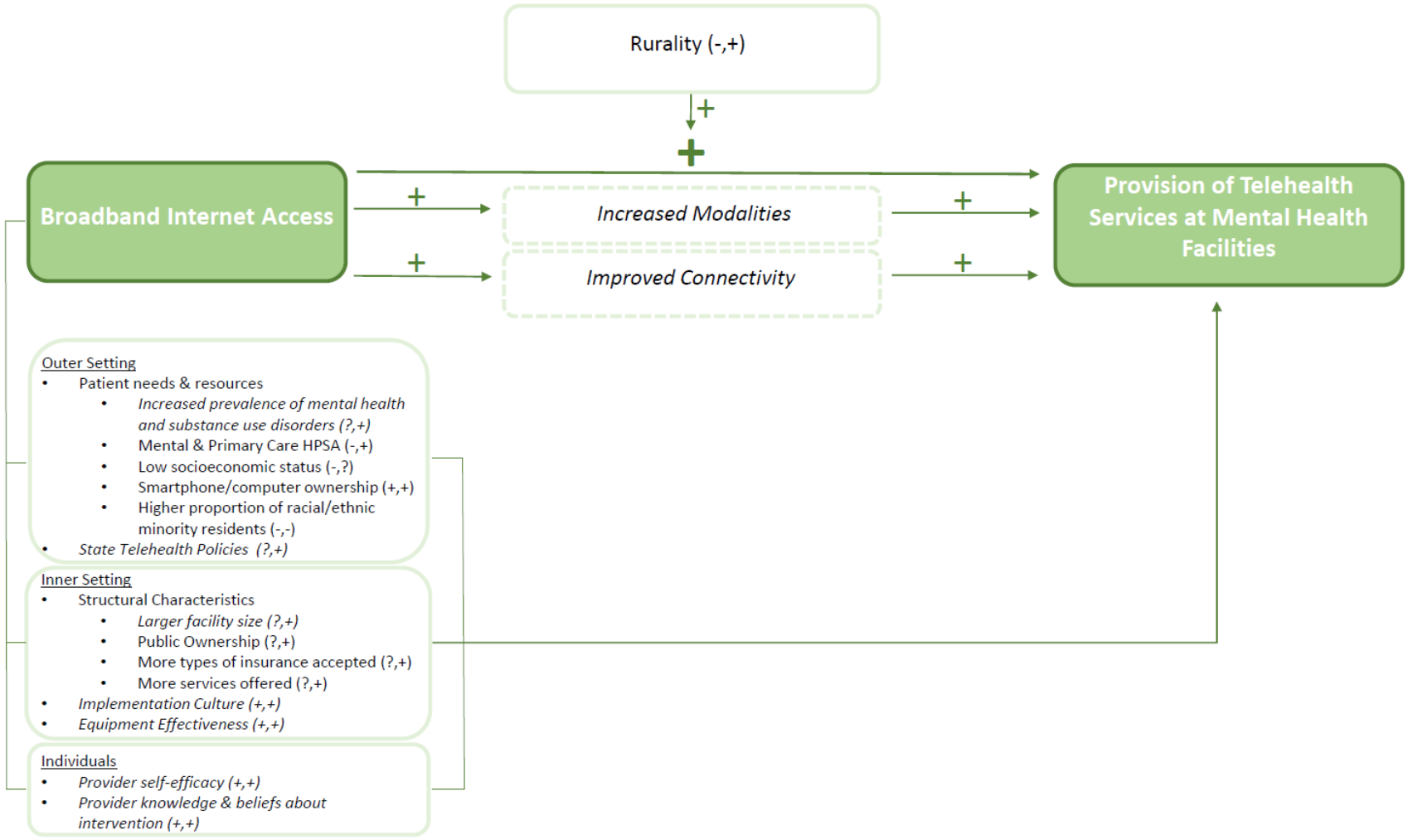
Another related mechanism through which broadband can affect telehealth services falls within the implementation process domain.[20] Providers and patients alike can be concerned that

telehealth visits will not be as effective as in-person visits, because patient-provider communication will suffer due to technology issues.[4,18] In other words, lag time during videocalls as well as disruptions where the connection is lost entirely can lead to poorer satisfaction with telehealth.[44] Presuming that broadband internet access is the best source of a strong, stable internet connection, the execution of telehealth with broadband internet will be more successful and the evaluation more positive, making mental health facilities more likely to include telehealth as an offered service.

Moderators

Even though internet speeds and the number of available internet providers vary in both rural and urban areas, remote and rural areas experience wider variation in internet access.[15] Particularly, the range of access in rural areas includes slower speeds than urban areas. Twenty-five megabits per second (mbps) is the minimum speed that the FCC considers high-speed internet access.[45] While there is reason to suspect higher speeds in urban areas (1000 versus 250mbps) would still offer improvements in connectivity, this relationship would likely be more pronounced for rural areas when comparing speeds of 100 versus 25mbps, for example. Thus, there is reason to suspect that the rurality of a facility would modify the relationship between broadband and telehealth provision, resulting in a stronger positive association.

Figure 1. Conceptual Model for Broadband Access and Telehealth Provision at Mental Health Facilities



Empirical Literature

Internet Access and Telehealth for Mental Health

Research on broadband access and telehealth provision for mental health services specifically is limited. The only known quantitative study is a cross-sectional study by Zhao and colleagues examining various facility and state-level factors in relation to telehealth provision at mental health facilities.[19] Broadband access was included as one of many state-level characteristics; it was measured as the percentage of counties with access (defined as 25mbps) within a state; states were then sorted into one of three categories representing low, medium, and high access. They did not find a significant relationship between internet and facility telehealth provision; however, this seems unsurprising given the non-specificity of the measure.[19] Aggregation to the state level fails to capture smaller scale geographic variations. It also does not consider variations in speed or the number of internet providers serving an area.

Research surrounding the use of telehealth for mental health services in rural locations is mixed. Rural facilities are more likely to utilize telemedicine likely due to the long travel times for patients living far from facilities,[7,46,47] yet these facilities are often located in the areas least likely to have adequate technological capabilities. Qualitative studies describing the use of telehealth for mental health services in rural areas often include broadband access as a cited barrier.[21,32,35,48] Recently, an online survey study where psychologists reported on their telehealth use prior to and during the pandemic documented smaller increases in telehealth use in rural areas compared to urban and suburban areas.[31]

Internet Access and Telehealth for Other Health Services

There are more studies that examine broadband access in relation to patients choosing telehealth for other non-mental health services. Wilcock and colleagues found that internet

access was significantly related to the number of Medicare telehealth visits for fully rural counties, with rural beneficiaries with poor broadband access having 34% fewer visits compared with those in counties with high broadband availability.[17] Reed and colleagues found that better neighborhood internet access was associated with patients choosing a video visit with their primary care clinicians compared to an office visit.[49] Although these studies focus on patient-level telehealth use rather than telehealth provision at facilities, they still serve to motivate this study in that providers might consider their patients' internet access or their patients' demand for telehealth when determining whether or not to invest in telehealth service provision. One study of rural community health center clinician attitudes toward telehealth reported that 'internet speed,' and 'fear of technical failures' were barriers to telehealth provision, both of which can occur on either the patient or the provider end.[18]

Variations of Telehealth

For this study, I am assuming that rural facilities generally serve rural clientele residing within their county and that large proportions of rural residents are not receiving remote treatment solely from mental health providers located far away (e.g., in a distant urban county). Although it is possible for rural residents to receive mental health services entirely remotely, several studies support telehealth implementation programs that integrate local providers and support. For example, a pediatric telepsychiatry program in rural Canada found that experiences with videoconferencing technology as a means of providing psychiatric services were positive, yet families desired local services to help support and implement treatment recommendations.[13] In another study, a rural women's shelter in Texas used telepsychiatry for evaluation and treatment after a physical examination and initial psychological interview were conducted onsite. This helped improve acute access to psychiatric assessment and treatment, and after the patient

had stabilized, care was transferred to the local community mental health center.[14] Rural providers have cultural awareness and knowledge about issues that are unique to rural communities,[12] which is why telehealth provision at rural facilities is important to examine.

While high-speed broadband internet is ideal for certain interactions, internet-use trends suggest that smartphones and cellular networks are increasingly popular ways of accessing the internet.[50] Some mental health practitioners have taken advantage of this shift and sought to reach remote populations via smartphone applications, text-message based interventions, or videocalling via smartphone (often referred to as mobile health or mhealth).[51–53] Alternatively, some telemedicine programs involve patients driving to a location with internet access (e.g., school, physician's office) to receive services there, as a work-around for poor internet access at the patient's home.[4,54,55]

Using videoconferencing to provide psychological or psychiatric treatment has been reported to be effective and comparable to receiving in-person care.[11] However, there is less available evidence for the effectiveness of mobile health interventions, such as applications.[56,57] It is unclear at present whether these alternatives are being frequently utilized by mental health facilities in remote and rural locations, or if poor broadband access still poses a significant barrier to the implementation of telehealth.

Conclusion

In short, exploration of the relationship between broadband internet access and telehealth use at mental health facilities is warranted; it can help elucidate if poor internet access remains a barrier for telehealth provision. A previous study related to this topic did not find any significant associations, but broad categorizations of internet access at the state level were used, limiting the ability to detect more incremental effects. Broadband access has been cited in the literature

qualitatively as a barrier to using telehealth for mental health services in rural areas. In addition, associations between patients' rurality and internet access as a predictor for telehealth use have been documented for other kinds of health services. Thus, this research project will use granular measures of broadband deployment and national mental health facility data to explore the relationship between internet access and telehealth provision at mental health facilities and how this relationship changes based on rurality.

Chapter III. Method

Databases

Broadband Internet Access

The FCC collects data biannually from internet service providers for each census block they provide service to, including the type of internet they provide and the highest speed they advertise in these areas. This data is collected via an FCC form called "Form 477," which every service provider that offers internet at speeds of 0.2 Mbps in at least one direction is legally required to file twice a year.[58] From this data, the FCC compiles area summary tables at various geographic levels (e.g., state, county, congressional district) with a unique area code for each row.[59] These areas can be referenced by their code in a separate FCC Geography Lookup Table.[60] The data contain the number of residents having access at each speed level (0.2, 4, 10, 25, 100, 250, & 1000 megabits per second (mbps)), the number of providers serving the area (0, 1, 2 or 3+ providers) at each level of internet speed, and the types of internet offered (ADSL, cable, fiber, other, satellite, and wireless).[61] These granular, continuous measures of internet access in terms of both internet speeds and providers make this database ideal for the purposes of this study.

Mental Health Facility Characteristics

National data on mental health and substance treatment facilities were obtained from the Substance Abuse and Mental Health Services Administration (SAMHSA) Behavioral Health Treatment Services Locator.[62] Substance abuse facility data in the locator come from the National Substance Abuse Treatment Survey (N-SSATS) and mental health facility data in the Treatment Service Locator come from the National Mental Health Services Survey (N-MHSS).[28,63] The N-MHSS is a national population-based survey for which data is solicited

annually from all known mental health and substance abuse facilities.[64] Surveys are collected via web, phone, or mail during the months of March through December, with a response rate of 89% in 2020.[65] The data available for download from the locator include the facility's address, types of services offered, and various other facility characteristics. Of note, the N-MHSS does not include individual or small group practices, Department of Defense facilities, or facilities in jails or prisons.[66] This database is suitable for my research question as mental health facilities serve vulnerable, low-income and remote/rural populations. In addition, it provides up-to-date information on services and location which are necessary for my research aims.

Additional Covariates

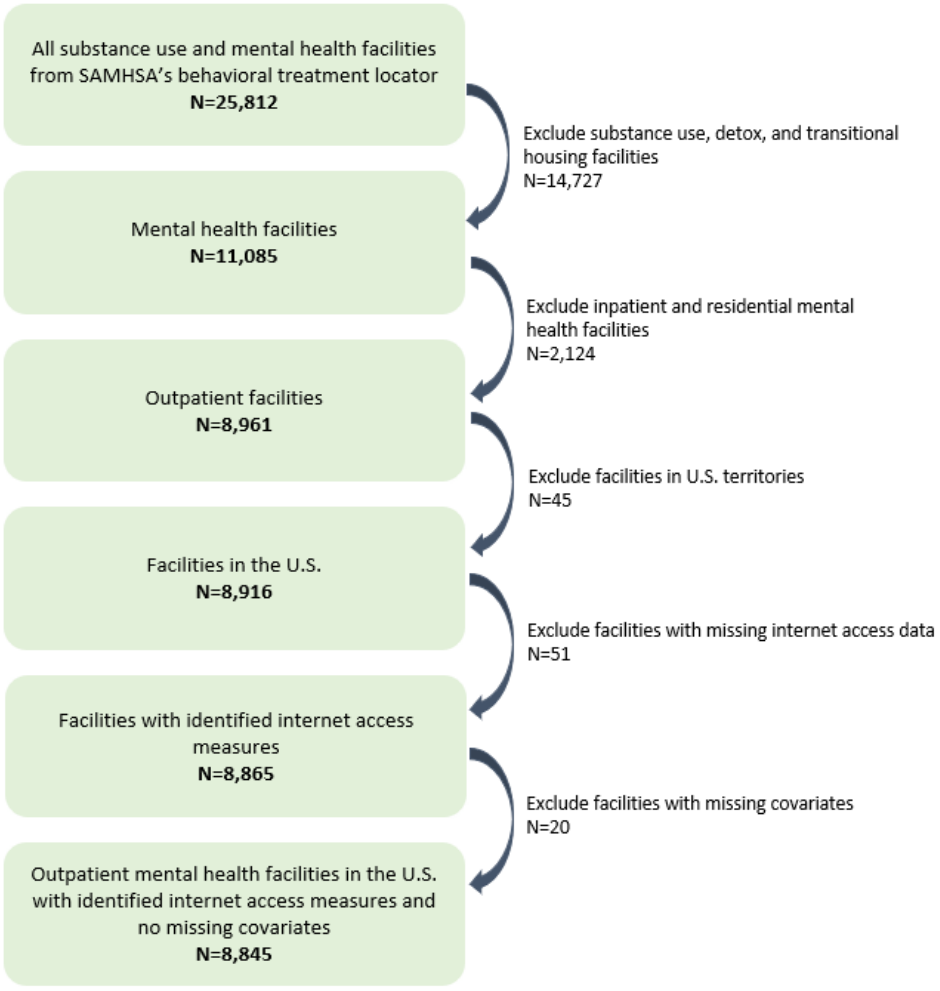
The Area Health Resource File is a national dataset containing data on healthcare provider access, health insurance rates, and a variety of other demographics at the county level.[67] Lastly, the American Community Survey from the census contains county-level estimates of technology ownership from the computer and internet use module.[68]

Sample

This study was approved as exempted by the IRB. I extracted all facility data from the Treatment Service Locator[62] in March 2021. The mental health facility data in the locator at that time represented all completed N-MHSS surveys from the year 2020, for which data collection started in March 2020 and ended in November 2020 with an average two-month processing time to update in the Treatment Services locator.[1] Notably, the timing of this data collection coincides with the onset of the Covid-19 pandemic. The initial download included 25,812 facilities total. I excluded all substance abuse facilities, yielding a sample of 11,085 mental health facilities (*Figure 2*). I further excluded all facilities that did not provide outpatient services due to the study focus on telehealth provision, retaining residential and inpatient facilities as long as they

provided outpatient services in addition to their residential and inpatient services. and those in U.S. territories (N=47), yielding 8,916 outpatient facilities in the United States.

Figure 2. Derivation of Analytic Sample



The Area Table representative of broadband deployment in December 2019[59] and the Geography Lookup Table[60] were downloaded from the FCC open data website. I limited the observations to those at the county level and merged the data with the Geography Lookup Table to obtain county names and state abbreviations. I summed the population for each county to obtain a percentage of the population served at each speed/provider combination. I further

collapsed these percentages to make mutually exclusive categories for each speed/provider combination (e.g., 0 or 1 providers offering 100mbps / 2 or more internet providers offering 100mbps). After merging internet access data with mental health facility data based on county and state name, 51 facilities were not matched with internet access data and were excluded.

Lastly, the facility data were merged with county-level demographic information from the 2019 5-year American Community Survey [69] and the 2018-2019 County-Level Area Health Resource File[70] using county and state name. I further excluded 20 facilities with missing values in any of the model covariates, yielding a final analytic sample of 8,845 outpatient mental health treatment facilities.

Research Design

Description of Research Design & Threats to Validity

The design of this study is to determine if county-level internet access is associated with the probability of a mental health facility offering telehealth services. The main threat to internal validity is potential confounding. There are likely area level factors that are correlated with both internet access and the landscape of health services within a region. I will address this by controlling for area level demographic factors as well as other measures of healthcare access. This study is also cross-sectional, capturing a snapshot of the association between broadband access and telehealth provision during 2020, a year when telehealth was rapidly scaled up due to the Covid-19 pandemic. Broadband access is expanding and regulations surrounding telehealth are rapidly evolving, so any associations documented in this study cannot be assumed to apply to previous or future years, limiting generalizability.

Independent and Dependent Variables

The independent variable will be broadband internet access, which falls within the outer setting domain within CFIR. Broadband internet access is typically defined as stable, high-speed internet access that is always available and is faster that dial-up internet. I consider all technology types of broadband in this analysis – ADSL, cable, fiber, other, satellite, and wireless.

Telemedicine is typically defined as the remote provision of health services;[29] this can take various forms including calls, videoconferences, and/or asynchronous monitoring and messaging. Certain entities such as the Center for Medicare and Medicaid Services (CMS) define telehealth more narrowly for reimbursement eligibility, with 'telehealth' being a synchronous remote patient-provider encounter that includes an audio and visual component and occurs onsite at an eligible facility.[71] For the purposes of this study, the definition of telemedicine will not be limited to CMS guidelines, but rather will include the broad definition of any remote health services provided via telecommunications technologies.

Measures

A summary of constructs and associated measures can be viewed in Table 1.

Broadband Internet Access

Measures of speed and number of providers will be collapsed from the FCC dataset as described above into one continuous variable to capture internet access: percentage of the county population having access to two or more providers offering 100mbps. This speed was chosen because broadband at 25mbps is available to most of the population and is considered the baseline definition of high-speed access by the FCC. Though 25mbps may be adequate for basic streaming, it is plausible that more generous speeds allow for better videoconferencing

connections and leave room for multiple members of the household to be using the bandwidth simultaneously. One hundred megabits per second is the next highest speed category which can capture more generous and less widely diffuse access. Notably, there have been calls from the FCC commissioner and senators to change the minimum definition of high-speed internet to be 100mbps.[72,73] The category of two or more providers was chosen to represent competition between providers that might result in better service or pricing.

Telehealth at Mental Health Facilities

Telehealth provision at mental health facilities will be represented by an indicator variable for the presence or absence of telehealth services. This information is drawn from an N-MHSS survey question in which respondents are asked to indicate if their facility offers any telemedicine services.[64] Included in this survey question is a parenthetical definition of 'telemedicine' which reads "(Internet, Web, mobile and desktop programs)."[64] Because of this, my measure for telehealth will be broad and cannot claim to capture only certain kinds of telehealth like videoconferencing.

Rurality

To measure the construct of rurality, I will use the rural-urban commuting area (RUCA) codes defined by the USDA.[74] Values range from 1-9 with core metropolitan areas having a value of 1 and the most rural areas having a value of 9. I condensed these codes into two categories based on the code documentation to increase interpretability for reporting results. Codes 1-5 indicate counties with those with urban populations of 20,000 or more, which will be referred to as 'Urban' counties for readability, moving forward. Codes 6-9 represent counties with urban populations of less than 20,000 and will be referred to as 'Non-Urban' counties.

Covariates

Outer Setting

A variety of selected outer setting measures will be assessed using area-level estimates taken from nationally representative data. Healthcare provider access will be measured using an indicator variable for whether the area is designated as a Mental Healthcare Provider Shortage Area (HPSA) and a Primary Care Provider HPSA. Healthcare provider shortage areas are based on population-to-provider ratios, with shortage areas having a low number of healthcare providers relative the size of the population.[23] Area-level socioeconomic status will be captured by several measures. Median-level income in thousands is a continuous variable which will come from the American Community Survey. County-level unemployment rate and the uninsured rate for adults aged 18-64 will also be included from the Area Health Resource File (AHRF). Technology ownership will be captured by the percent of residents who own a smartphone as their only means of internet access; this comes from the ACS. Lastly, the percentage of Black county residents and the percentage of Hispanic county residents will be included as demographic variables from the AHRF. State-level factors will be captured using fixed effects.

Inner Setting

Facility, or inner-setting characteristics will be assessed using key questions from the N-MHSS survey. Facility ownership will be divided into three categorial options: Private For-Proft, Private Non-Profit, or Public Agency/Department. In addition, each facility will have a binary variable indicating whether payment assistance or sliding scale fees are offered. Because telehealth is used for outpatient services, a variable indicating if the facility offers any inpatient or residential services will be included to control for potential facility specialization. Lastly, the types of insurance accepted will be included as covariates in the form of four non-mutually

exclusive variables for each type – Private insurance, Medicare, Medicaid, and Military Insurance.

Unmeasured

The two hypothesized mediators of increasing potential modalities and improving connectivity will remain unmeasured, as will facility culture and equipment effectiveness within the inner setting domain. The inner setting construct of facility size will be unmeasured; although this variable is collected by SAMHSA, it is not included in the treatment locator data download. Individual-level characteristics including self-efficacy and personal knowledge and beliefs surrounding the intervention also will not be measured for this analysis.

Table 1. Constructs and Associated Measures

Construct	Measure	Hypothesized Relationship to Telehealth Use
Dependent Variable		
Telehealth Provision at Mental Health Facilities	**Facility Provision of Telehealth** • Facility indicated that "Telemedicine/telehealth therapy (including Internet, Web, mobile, and desktop programs)" are offered as a modality at their location *Dichotomous*	
Independent Variable		
Broadband Internet Access	**Broadband Deployment** • Percent of county population served by 2 or more internet providers offering 100 mbps *Continuous*	As broadband internet access increases, facilities will be more likely to offer telehealth.
Outer Setting		
MH Provider Access	**Mental HPSA Indicator** • County designated as a Mental Healthcare Professional Shortage Area (Full, Partial or None) *Ordinal*	As MH provider access decreases, facilities will be more likely to offer telehealth.

Healthcare Provider Access	**PCP HPSA Indicator** • County designated as a Primary Care Healthcare Professional Shortage Area (Full, Partial or None) *Ordinal*	As PCP provider access decreases, facilities will be more likely to offer telehealth.
Area Level Socioeconomic Status	**Median household income** • County median household income in thousands of dollars *Continuous* **Uninsured Rate** • County level uninsured rate for those aged 18 to 64 *Continuous* **Unemployment Rate** • County level unemployment rate for those aged 16 and older *Continuous*	As median income decreases, facilities will be more likely to offer telehealth. As the uninsured rate increases, facilities will be more likely to offer telehealth. As the unemployment rate increases, facilities will be more likely to offer telehealth.
Smartphone Ownership	**County Level Percent of Households with Smartphones** • Percent of households with a smartphone as their only means of accessing the internet *Continuous*	As the percent of households with smartphones only increases, facilities will be less likely to offer telehealth.
Racial Demographics	**Black Population** • County level percent of Black residents *Continuous* **Hispanic Population** • County level percent of Hispanic residents *Continuous*	As the percent of Black and Hispanic populations increase, facilities will be less likely to offer telehealth.
Inner Setting		
Facility Ownership	**Facility Operation Status** • Private for-profit, Private non-profit, Public agency or Department *Categorical*	Publicly owned facilities will be more likely to offer telehealth.
Insurance Accepted	**Insurance Accepted** • Four separate indicators for the following categories: Medicaid, Medicare, Military Insurance, Private Insurance *Dichotomous*	Facilities accepting military insurance will be more likely to offer telehealth and those accepting Medicaid will be less likely to offer telehealth.

Facility Services	**Facility Offers Inpatient Services** • Facility indicated offering any inpatient services (in addition to outpatient services) *Dichotomous*	Facilities offering inpatient services will be less likely to offer telehealth.
Payment Assistance	**Payment Assistance/Sliding Scale Fees** • Facility indicated offering payment assistance or sliding scale fees *Dichotomous*	Facilities offering payment assistance will be more likely to offer telehealth.
Moderator/Outer Setting		
Rurality	**2010 Rural-Urban Commuter Area Codes** • Counties with > 20k urban residents (1-5) *referred to as Urban* • Counties with < 20k urban residents (6-9) *referred to as Non-Urban* *Dichotomous*	Non-urban facilities will be more likely to offer telehealth. Increasing rurality will strengthen the positive association between broadband and telehealth provision.
Unmeasured		
Increased Modalities - Mediator *Improved Connectivity - Mediator* *Prevalence of Mental health disorders – Outer Setting* *State Policy Environment – Outer Setting* *Facility Culture - Inner Setting* *Equipment Effectiveness - Inner Setting* *Facility Size – Inner Setting* *Self-Efficacy - Individuals* *Knowledge and Beliefs about Intervention - Individuals*		

Data Analysis

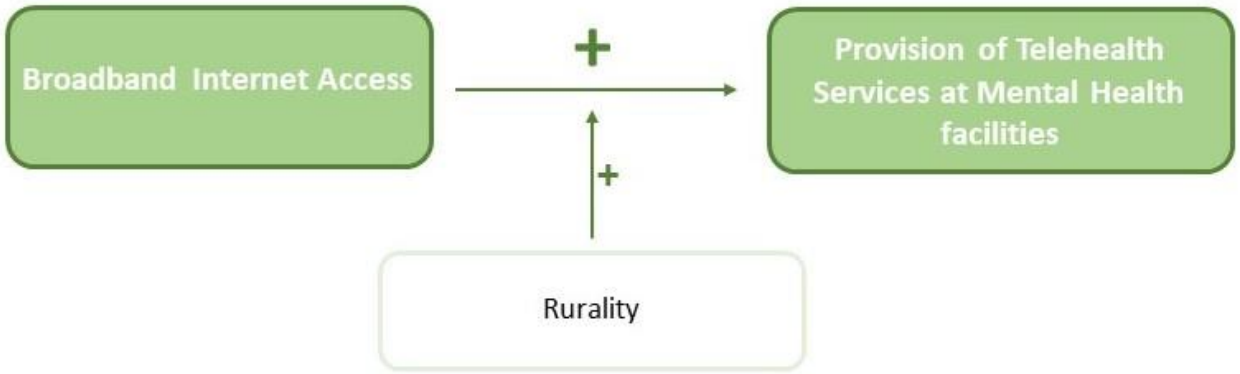
Research Questions

What is the relationship between internet access and telehealth provision at mental health facilities?

Does this relationship change based on rurality?

Hypothesis

There will be a stronger positive association between telehealth provision and broadband internet access for facilities in rural areas compared to those in urban areas, after controlling for facilities in area-level characteristics.



Analytic Strategy

Multivariate logistic regression will be used to estimate the association between broadband access and telehealth provision using Stata SE 17.[75]

$$\Pr(telehealth \mid internet*rurality, confounders) = F(B_0 + B_1 internet*rurality + B_n confounders)$$

This model is suitable to examine this relationship as telehealth provision is captured as a dichotomous outcome. Various facility and area-level characteristics will be included to control for potential confounding. A term interacting rurality and internet access will be used to assess whether rurality is a moderator of the relationship between internet access and telehealth provision. Results will be reported as the marginal effects of a unit increase in county broadband access on the likelihood of a mental health facility offering telehealth services. Sensitivity analyses will be conducted to explore and compare other available measures of internet access. An alpha level of 0.05 will be used to determine statistical significance. Observations with missing data will be excluded.

Chapter IV. Results

Sample Characteristics

A total of 8,845 outpatient mental health facilities were included in my analysis *(Table 2)*. About two thirds (68.8%) of facilities offered telehealth. The mean percentage of county residents with access to two or more providers offering 100mbps was 47.4 (SD=32.8). When subset by telehealth status, average county internet access was poorer for facilities offering telehealth (44.8%, SD=32.5) compared to facilities not offering telehealth (53.0%, SD=32.7).

Bivariate Results

When examining other county-level characteristics, facilities offering telehealth were more likely to be located in non-urban counties and counties designated as full Mental Healthcare Provider Shortage Areas (HPSA) and full Primary Care Physician HPSAs. Thirty-one percent of facilities offering telehealth were in whole county designated mental HPSAs, as compared to 18.2% of facilities not offering telehealth ($P < 0.0001$). Median household income was slightly lower (58.5k vs 62.3k, $P < 0.0001$) and the uninsured rate was slightly higher (11.7% vs 10.3%, $P < 0.0001$) for counties of facilities that offer telehealth, compared with counties of facilities that did not offer telehealth. County unemployment rates were similar between groups. Facilities offering telehealth had a lower average percent of Black county residents (11.0% vs 13.3%, $P < 0.0001$) compared to those that did not, while the percentage of Hispanic residents was similar between the two groups. Lastly, the percentage of county households with smartphones as the only means of internet access was slightly higher for facilities offering telehealth versus facilities that did not offer telehealth (7.3% vs 6.7%, $P < 0.0001$).

Table 2. Characteristics of U.S. Outpatient Mental Health Facilities in 2020, Stratified by Telehealth Provision

	All Facilities	Facilities Offering Telehealth	Facilities Not Offering Telehealth	
N, %	**8,8845, 100**	**6,089, 68.8**	**2,756, 31.2**	
	Percent / Mean (SD)	**Percent / Mean (SD)**	**Percent / Mean (SD)**	**P-Value***
County-Level Characteristics				
Internet accessibility				
Percentage of county residents with ≥2 providers offering 100 mbps, mean (SD)	47.4 (32.8)	44.8 (32.5)	53.0 (32.7)	P < .0001
County RUCA** Designation, %				
Located in county with >20k urban residents	83.7	80.6	90.5	P < .0001
Located in county with <20k urban residents	16.3	19.4	9.5	
County Mental HPSA Designation, %				
None	6.2	6.0	6.8	P < .0001
Partial	66.6	62.7	75.2	
Full	27.2	31.3	18.0	
County PCP HPSA Designation, %				
None	7.0	7.3	6.3	P < .0001
Partial	86.4	85.0	89.4	
Full	6.6	7.7	4.3	
Median household income in thousands, *mean (SD)*	59.7 (16.2)	58.5 (16.9)	62.3 (16.7)	P < .0001
Unemployment rate, *mean (SD)*	4.1 (1.2)	4.1 (1.3)	4.0 (1.0)	P = .0009
Uninsured rate for adults aged 18-64, *mean (SD)*	11.3 (5.1)	11.7 (5.3)	10.3 (4.5)	P < .0001
Racial Demographics				
Percentage of Black residents, mean (SD)	11.7 (14.0)	11.0 (13.6)	13.3 (14.8)	P < .0001
Percentage of Hispanic residents, mean (SD)	12.7 (14.2)	12.5 (14.6)	12.9 (13.5)	P = .18
Percentage of county households with smartphone as only means of internet access, *mean (SD)*	7.1(3.0)	7.3 (3.1)	6.7 (2.7)	P < .0001
Facility-Level Characteristics				
Offering inpatient services***, %	20.5	19.6	22.5	P = .0015
Ownership type, %				
Private non-Profit	20.2	59.0	64.9	P < .0001
Private for-Profit	60.9	19.5	21.8	
*Government**** or IHS/Tribal*	18.9	21.5	13.2	
Payments accepted, %				
Sliding scale fee or offering payment assistance	48.9	50.3	45.9	P < .0001
Medicaid	90.0	89.7	90.6	P = 0.17
Private Insurance	85.1	86.3	82.5	P < .0001
Medicare	72.6	73.9	69.6	P < .0001
Military Insurance	56.2	60.9	45.8	P < .0001

Notes: Abbreviation: SD – standard deviation. Mbps = megabits per second.

**Based on Chi-square or T-test*

***Rural-Urban Commuting Codes from USDA – 2013*

****In addition to offering outpatient services*

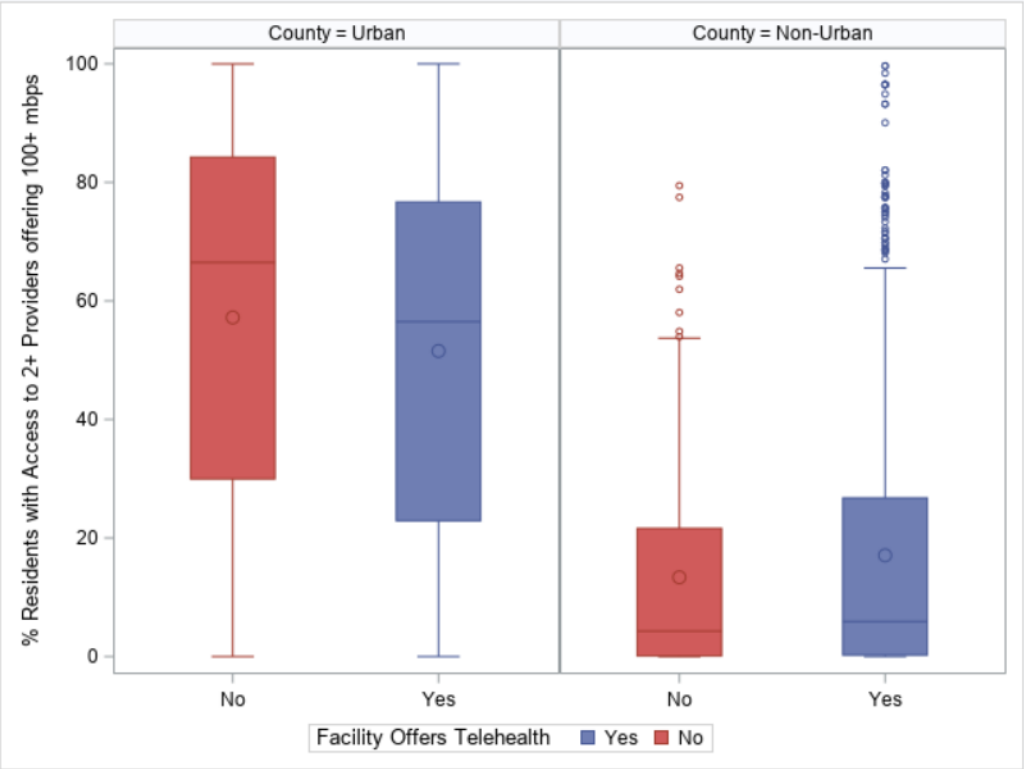
*****Government facilities are operated by state, local, county, or municipal government agencies, or the U.S. Department of Veterans Affairs*

When examining facility-level characteristics, 20.5% of facilities offered inpatient or residential services in addition to outpatient services, and facilities offering telehealth were more likely to provide outpatient services alone than those did not (P = 0.0015). Higher proportions of government or tribal-owned facilities and lower proportions of private facilities were observed among facilities offering telehealth (P < 0.0001). For payment acceptance, facilities that provided telehealth were more likely to offer sliding scale fees/payment assistance (50.3% vs 45.9%, P < 0.0001), and to accept Medicare, Military Insurance (Tri-care), and private insurance, compared to those not offering telehealth (P < 0.0001). The largest difference was for military insurance, with 45.8% of non-telehealth facilities, as compared with 60.9% of telehealth-offering facilities accepting military insurance. Ninety percent of facilities accepted Medicaid; there was no significant difference for Medicaid acceptance rates between facilities offering and those not offering telehealth (P = 0.17).

Rurality and Internet Access

When facilities were stratified by telehealth provision and urban-rural designation, differences in broadband internet access emerged *(Figure 3)*. Facilities in non-urban counties that offer telehealth have better county-level internet access on average. A mean of 17.1% of the population have two or more internet providers that offer 100mbps or greater speeds serving their census block, compared to 13.4% in counties of facilities not offering telehealth. In contrast, this relationship is reversed among facilities locating in urban counties. Broadband access was higher for facilities not offering telehealth compared to facilities that offer telehealth (57.2% vs 51.6%, P < 0.0001).

Figure 3. Internet accessibility in counties where outpatient mental health facilities locate, by telehealth provision and urban/non-urban designation



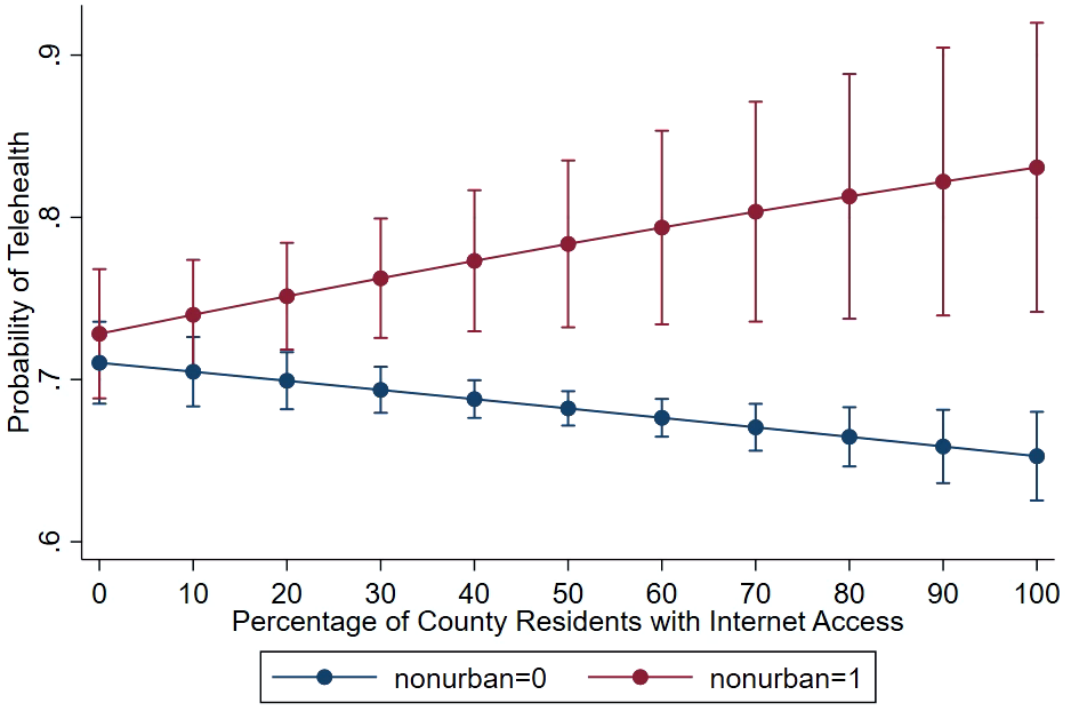
Multivariate Logistic Regression Results

Results from a logistic regression analysis showed that the interaction coefficient was significant at P=0.019. Further descriptive analyses showed that as internet access increases, the difference between the probability of telehealth provision between urban and nonurban facilities also increases (Figure 4; $P < 0.000$ for all points). When 0% of county residents have internet access, the predicted probability of telehealth provision is 71.0% for urban facilities and 72.8% for nonurban facilities (1.8 ppt difference). When 47.4% of county residents have internet access, which is the mean level of internet access for the sample, the predicted probability of telehealth provision is 68.4% for facilities in urban areas and 78.4% for facilities in nonurban areas (10 ppt difference). At 100% county internet access, there is a 17.8 percentage point

difference between the two groups, with the probability of telehealth being 65.3% for urban facilities and 83.1% for nonurban facilities.

Marginal effect estimates for the interaction between internet access and rurality can be viewed in Table 3. Each additional ten percent of county residents with internet access was associated with a 1.03 percentage point increase in the likelihood of telehealth provision for facilities in nonurban counties (P = 0.06). In contrast, better internet access was negatively associated with telehealth for facilities in urban counties (ME = -0.57 ppt, P = 0.02). The difference between these effects for nonurban compared to urban facilities was +1.61 percentage points on average, which was statistically significant (P = 0.006).

Figure 4. Predicted Probability of Varying Levels of Internet Access on Telehealth Provision, Comparison between Urban and Nonurban Facilities



Other Factors Associated with Telehealth Provision

The estimated marginal effects for other covariates included in the model can be viewed in Table 3. The only other county-level factor positively associated with telehealth use was having a higher unemployment rate (ME = +2.02 ppt for each additional percent unemployed, P = 0.007). Government-owned facilities (ME = +8.52 ppt, P <0.001; ref=Private for Profit) and those accepting military insurance (ME = +8.62 ppt, P <0.001) were more likely to offer telehealth. Facilities that provided inpatient services (ME = -3.60 ppt, P =0.004) and those accepting Medicaid insurance (ME = -3.29 ppt, P = 0.05) were less likely to offer telehealth. In addition, facilities in counties with higher proportions of Black residents were less likely to provide telehealth services (ME = -0.21 ppt for each additional percent of Black residents, P <0.001).

Table 3. Multivariate logistic regression analyses examining the association between area and facility characteristics and the provision of telehealth at U.S. outpatient mental health facilities[1]

	ME[2]	SE[3]
Internet Accessibility x Rurality[4]		
Nonurban	-0.57*	0.24
Urban	+1.03	0.55
Contrast (Nonurban vs Urban)	+1.61**	0.58
County Mental HPSA[5] Designation		
None	Ref	
Partial	-8.77	2.51
Full	+4.18	2.62
County Primary Care Provider HPSA Designation		
None	Ref	
Partial	+1.35	2.49
Full	-1.54	3.39
% County Residents owning smartphone as only means of internet access	-0.35	0.35
County median income in thousands	-0.05	0.05
County unemployment rate	+2.02**	0.75
County % Black residents	-0.21***	0.05
County % Hispanic residents	+0.08	0.07
County Uninsured rate for adults 18-64	-0.18	0.28
Facility offers inpatient services	-3.60**	1.23
Facility Ownership		
Private for Profit	Ref	
Private Not for Profit	+5.01	1.37
Government or Tribal	+8.52***	1.64
Facility Payments Accepted		
Offers payment assistance or sliding scale fees	+0.88	1.00
Accepts Medicare	+0.90	1.21
Accepts Medicaid	-3.29*	1.68
Accepts Private Insurance	+2.04	1.54
Accepts Military Insurance	+8.62***	1.13

* Significant at $p < 0.05$ **Significant at $p < 0.01$ ***Significant at $p < 0.001$

1. Multiple Logistic Regression Model, controlling for state fixed effects. Marginal effects represent the predicted percentage point change in the probability of a facility offering telehealth based on a one unit change in the explanatory variable, while holding all other variables at their mean.
2. ME = Marginal Effect
3. SE = Standard Error
4. Estimates the effect of each additional ten percent of residents with internet access for facilities in nonurban counties, with internet access defined as the percentage of county residents having 2 or more internet providers offering speeds of 100mbps or greater serving their census block.
5. HPSA = Healthcare Provider Shortage Area

Sensitivity Analyses

Sensitivity analyses were conducted to assess the relationship between various measures of internet access and telehealth provision at mental health facilities in non-urban counties

(Appendix A). These estimates do not factor in state fixed effects due to several states being excluded due to limited variability in the outcome variable when using this smaller subset of the analytic sample. For continuous variables indicating both speed and number of providers, several measures (e.g., 3+ providers offering 25mbps, 2+ providers offering 1000mbps) were significant in predicting telehealth use (See Figure A.1). There are very few non-urban counties that have less than three providers offering 25mbps or more than two providers offering 1000mbps, resulting in minimal variation in measures above or below these thresholds. No relationship was indicated for broad measures of county-level broadband access from ACS census data (percent households with any type of internet, percent households with any broadband internet) for non-urban mental health facilities (See Figure A.2). Notably, the ACS census measure of "households with cellular internet access only" negatively predicted telehealth provision at non-urban mental health facilities (-5.59 ppt for each additional 10% of county residents with cellular internet only, $P = 0.02$).

Chapter V. Discussion

Summary

In short, the effects of internet access on the provision of telehealth differed between urban and nonurban facilities. Better internet access was positively associated with telehealth provision in nonurban counties and negatively associated with telehealth provision in urban counties. The estimated difference between the two groups also increased as county-level internet access increased. My hypothesis that rurality would moderate this relationship stands.

Conclusions

Broadband Internet & Telehealth Provision at Non-Urban Facilities

Based on these results, it seems that internet access is still a barrier to telehealth provision at some mental health facilities located in non-urban areas. Telehealth was more likely to be offered if the county had more residents with higher internet speeds and more internet providers. Yet, the effect size was quite small – just over a 1 percentage point increase in probability for each additional 10% of residents having access. It is hard to say from these analyses how important this barrier is compared to other barriers or incentives that rural facilities consider in implementing telehealth services. For example, there are various state-level policies, insurance regulations, and other individual factors surrounding telehealth that might impact whether a facility offers telehealth as a service modality. More qualitative research with rural mental health providers could serve to elucidate the relative importance of different barriers and incentives. Alternatively, it also is possible that the effect size is small because internet access matters the most for the most rural areas, and this sample included a more generous definition of rurality for the purposes of statistical power.

Findings in Relation to Previous Literature

Broadband Access and Telehealth

This exploration of internet and telehealth provision builds on previous work by Zhao and colleagues who similarly found no relationship between broadband access and telehealth implementation when considering all mental health facilities.[19] This analysis delves more deeper into specific measures of internet access and variations by rurality, contributing to knowledge surrounding telehealth implementation for mental health facilities.[7,17,48]

Other Factors Associated with Telehealth

Various indicators of community-level need were associated with telehealth provision echoing previous findings, although the measures used have varied. I used healthcare provider shortage area indicators, unemployment, and insurance coverage, while Spivak and colleagues used designated medically underserved areas, and Kaufman and colleagues used the community needs index.[46,76] Government ownership and accepting military insurance were both strongly associated with telehealth for urban and non-urban counties alike. These findings are consistent with previous research.[19,46] The association between a higher proportion of Black residents and lower telehealth use was anticipated based on previous literature. Some recent studies focusing on racial differences in telehealth use have reported Black patients are more likely to complete phone instead of video visits, less likely to activate online patient portals, and have lower internet use generally compared to their white counterparts.[77–79] This disparity warrants further research.

Strengths and Limitations

This study provides a valuable contribution to the growing bodies of knowledge surrounding both mental healthcare access and the digital divide. Less commonly used measures of internet access provide more detail and insight into current broadband coverage and how this is associated with the provision of remotely delivered mental health services at outpatient mental

health treatment facilities. Additionally, this study uses national mental health facility data, leveraging information from a large sample of diverse facilities across the U.S..

Key limitations include the analysis being a cross-sectional study from the year 2020, so causality cannot be determined, and results cannot be claimed to hold for previous or future years. Mental health facility data collection occurred between March and November of 2020, so it is unclear to what extent facilities might have taken into account changing telehealth reimbursement guidelines and policies when reporting their service information. However, this snapshot can still be useful in elucidating whether broadband remains a topic to be explored in the context of barriers to telehealth. Additionally, measures of broadband were at the county level which may not always accurately represent a facility's catchment area. Some urban facilities may serve a smaller geographic area than a county while some rural facilities may serve multiple counties. Another limitation is the broad definition of telehealth use as defined in the mental health facility data set which could include non-broadband internet use such as cellular. I have sought to account for this by including smartphone ownership in my model and by running sensitivity analyses on measures of cellular internet access.

An additional limitation is that there are several unmeasured constructs. Individual-level factors such as mental healthcare providers' self-efficacy along with their knowledge, beliefs, and experiences related to telehealth could all play a role in determining telehealth provision. Rural providers may have lower self-efficacy and fewer experiences with telehealth due to historically poor internet connections in the area. Since these constructs are not included in my analysis, the estimate could be biased away from the null. Other unmeasured factors include state policies related to telehealth regulations or reimbursements. It is possible that states with more favorable telehealth policy environments (e.g., payment parity laws) might also be more likely to invest in

broadband infrastructure, which would confound the focal relationship and also bias the estimate away from the null.

Implications

Mental Healthcare Access

Broadband access remains a barrier to telehealth provision at mental health facilities in non-urban areas, limiting potential to alleviate rural mental health disparities. As telehealth becomes a more common modality following the pandemic, there is potential for an increased disparity in mental health access for rural populations if they remain unconnected and unable to access remote services.

Broadband Internet Access

Since internet was positively associated with telehealth provision in non-urban counties, these findings support initiatives to improve broadband infrastructure for remote populations. These results also lend support to the notion of viewing broadband internet access as a social determinant of health.[80]

For the purposes of further research surrounding internet access, measuring higher speeds such as 100 or 250mbps may be more meaningful compared to the current definition of high-speed broadband access of 25mbps. Sensitivity analyses indicated that measures of the percentage of the population with one or two internet providers offering 25mbps were nonsignificant and poor predictors compared to higher speeds (likely due to minimal variation at this relatively low level). These results also call into question the effectiveness of very broad measures of internet access (e.g., percent with any internet or any broadband) in accurately capturing this construct.

Recommendations for Future Research

Future research should include a qualitative exploration of facilities in rural areas with high mental health needs that do not currently provide telehealth to elucidate remaining barriers to telehealth provision. In addition, further analyses with panel data examining how the relationship between broadband internet and telehealth use changes over time would be useful, particularly as many telehealth policies and reimbursement requirements have shifted as a result of the pandemic. As internet access continues to expand and telehealth becomes a routine means of health service delivery, these studies could help shed light on the relative importance of internet access as a barrier compared to other regulatory or area-level factors.

References

1. Nov 19 P, 2020. Mental Health and Substance Use State Fact Sheets. KFF. Published November 19, 2020. Accessed March 28, 2021. https://www.kff.org/statedata/mental-health-and-substance-use-state-fact-sheets/

2. Dec 13 P, 2021. Mental Health and Substance Use State Fact Sheets. KFF. Published December 13, 2021. Accessed February 12, 2022. https://www.kff.org/statedata/mental-health-and-substance-use-state-fact-sheets/

3. Brenes GA, Danhauer SC, Lyles MF, Hogan PE, Miller ME. Barriers to Mental Health Treatment in Rural Older Adults. *Am J Geriatr Psychiatry*. 2015;23(11):1172-1178. doi:10.1016/j.jagp.2015.06.002

4. Bischoff RJ, Hollist CS, Smith CW, Flack P. Addressing the Mental Health Needs of the Rural Underserved: Findings from a Multiple Case Study of a Behavioral Telehealth Project. *Contemp Fam Ther*. 2004;26(2):179-198. doi:10.1023/B:COFT.0000031242.83259.fa

5. Myers CR. Using Telehealth to Remediate Rural Mental Health and Healthcare Disparities. *Issues Ment Health Nurs*. 2019;40(3):233-239. doi:10.1080/01612840.2018.1499157

6. Schueller SM, Hunter JF, Figueroa C, Aguilera A. Use of Digital Mental Health for Marginalized and Underserved Populations. *Curr Treat Options Psychiatry*. 2019;6(3):243-255. doi:10.1007/s40501-019-00181-z

7. Khairat S, Haithcoat T, Liu S, et al. Advancing health equity and access using telemedicine: a geospatial assessment. *J Am Med Inform Assoc*. 2019;26(8-9):796-805. doi:10.1093/jamia/ocz108

8. Hirko KA, Kerver JM, Ford S, et al. Telehealth in response to the COVID-19 pandemic: Implications for rural health disparities. *J Am Med Inform Assoc*. doi:10.1093/jamia/ocaa156

9. Nagata JM. Rapid Scale-Up of Telehealth During the COVID-19 Pandemic and Implications for Subspecialty Care in Rural Areas. *J Rural Health*. n/a(n/a). doi:10.1111/jrh.12433

10. Ziedan E, Simon K, Wing C. *Effects of State COVID-19 Closure Policy on NON-COVID-19 Health Care Utilization*. National Bureau of Economic Research; 2020:w27621. doi:10.3386/w27621

11. Hilty DM, Ferrer DC, Parish MB, Johnston B, Callahan EJ, Yellowlees PM. The Effectiveness of Telemental Health: A 2013 Review. *Telemed E-Health*. 2013;19(6):444-454. doi:10.1089/tmj.2013.0075

12. Richardson LK, Frueh BC, Grubaugh AL, Egede L, Elhai JD. Current Directions in Videoconferencing Tele-Mental Health Research. *Clin Psychol Publ Div Clin Psychol Am Psychol Assoc*. 2009;16(3):323-338. doi:10.1111/j.1468-2850.2009.01170.x

13. Greenberg N, Boydell KM, Volpe T. Pediatric telepsychiatry in ontario: Caregiver and service provider perspectives. *J Behav Health Serv Res*. 2006;33(1):105-111. doi:10.1007/s11414-005-9001-3

14. Thomas C, Miller G, Hartshorn J, Speck NC, Walker G. Telepsychiatry program for rural victims of domestic violence. *Telemed J E-Health Off J Am Telemed Assoc*. Published online 2005. doi:10.1089/TMJ.2005.11.567

15. Federal Communications Commission. *2020 Broadband Deployment Report*. FCC; 2020. Accessed March 29, 2021. https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2020-broadband-deployment-report

16. Douthit N, Kiv S, Dwolatzky T, Biswas S. Exposing some important barriers to health care access in the rural USA. *Public Health*. 2015;129(6):611-620. doi:10.1016/j.puhe.2015.04.001

17. Wilcock AD, Rose S, Busch AB, et al. Association Between Broadband Internet Availability and Telemedicine Use. *JAMA Intern Med*. 2019;179(11):1580-1582. doi:10.1001/jamainternmed.2019.2234

18. McClellan MJ, Florell D, Palmer J, Kidder C. Clinician telehealth attitudes in a rural community mental health center setting. *J Rural Ment Health*. 2020;44(1):62-73. doi:10.1037/rmh0000127

19. Zhao X, Innes KE, Bhattacharjee S, Dwibedi N, LeMasters TM, Sambamoorthi U. Facility and state-level factors associated with telemental health (TMH) adoption among mental health facilities in the United States. *J Telemed Telecare*. Published online September 2, 2019:1357633X19868902. doi:10.1177/1357633X19868902

20. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci*. 2009;4(1):50. doi:10.1186/1748-5908-4-50

21. Lin CCC, Dievler A, Robbins C, Sripipatana A, Quinn M, Nair S. Telehealth In Health Centers: Key Adoption Factors, Barriers, And Opportunities. *Health Aff (Millwood)*. 2018;37(12):1967-1974. doi:10.1377/hlthaff.2018.05125

22. Uscher-Pines L, Cantor J, Huskamp HA, Mehrotra A, Busch A, Barnett M. Adoption of telemedicine services by substance abuse treatment facilities in the U.S. *J Subst Abuse Treat*. 2020;117:108060. doi:10.1016/j.jsat.2020.108060

23. Mental Health Care Health Professional Shortage Areas (HPSAs). KFF. Published November 21, 2019. Accessed October 11, 2020. https://www.kff.org/other/state-indicator/mental-health-care-health-professional-shortage-areas-hpsas/

24. Arundell LL, Greenwood H, Baldwin H, et al. Advancing mental health equality: a mapping review of interventions, economic evaluations and barriers and facilitators. *Syst Rev*. 2020;9. doi:10.1186/s13643-020-01333-6

25. *Designated Health Professional Shortage Areas Statistics: First Quarter of Fiscal Year 2022; Designated HPSA Quarterly Summary*. Bureau of Health Workforce. HRSA. U.S. Department of Health & Human Services https://data.hrsa.gov/Default/GenerateHPSAQuarterlyReport

26. Barnett ML, Huskamp HA. Telemedicine for Mental Health in the United States: Making Progress, Still a Long Way to Go. *Psychiatr Serv*. 2019;71(2):197-198. doi:10.1176/appi.ps.201900555

27. Mehrotra A, Jena AB, Busch AB, Souza J, Uscher-Pines L, Landon BE. Utilization of Telemedicine Among Rural Medicare Beneficiaries. *JAMA*. 2016;315(18):2015-2016. doi:10.1001/jama.2016.2186

28. National Mental Health Services Survey (N-MHSS): 2019, Data On Mental Health Treatment Facilities | CBHSQ Data. Accessed March 29, 2021. https://www.samhsa.gov/data/report/national-mental-health-services-survey-n-mhss-2019-data-mental-health-treatment-facilities

29. What is telehealth? How is telehealth different from telemedicine? | HealthIT.gov. Accessed December 1, 2020. https://www.healthit.gov/faq/what-telehealth-how-telehealth-different-telemedicine

30. Unmet Need for Counseling or Therapy Among Adults Reporting Symptoms of Anxiety and/or Depressive Disorder During the COVID-19 Pandemic. KFF. Published March 9, 2021. Accessed March 28, 2021. https://www.kff.org/other/state-indicator/unmet-need-for-counseling-or-therapy-among-adults-reporting-symptoms-of-anxiety-and-or-depressive-disorder-during-the-covid-19-pandemic/

31. Pierce BS, Perrin PB, Tyler CM, McKee GB, Watson JD. The COVID-19 telepsychology revolution: A national study of pandemic-based changes in US mental health care delivery. *Am Psychol*. 2021;76(1):14-25. doi:10.1037/amp0000722

32. LeRouge C, Garfield MJ. Crossing the Telemedicine Chasm: Have the U.S. Barriers to Widespread Adoption of Telemedicine Been Significantly Reduced? *Int J Environ Res Public Health*. 2013;10(12):6472-6484. doi:10.3390/ijerph10126472

33. Lee JGL, LePrevost CE, Harwell EL, et al. Coronavirus pandemic highlights critical gaps in rural Internet access for migrant and seasonal farmworkers: a call for partnership with medical libraries. *J Med Libr Assoc JMLA*. 108(4):651-655. doi:10.5195/jmla.2020.1045

34. Woodall T, Ramage M, LaBruyere JT, McLean W, Tak CR. Telemedicine Services During COVID-19: Considerations for Medically Underserved Populations. *J Rural Health*. Published online July 2, 2020. doi:10.1111/jrh.12466

35. Crock Bauerly B, McCord RF, Hulkower R, Pepin D. Broadband Access as a Public Health Issue: *J Law Med Ethics J Am Soc Law Med Ethics*. 2019;47(2 Suppl):39-42. doi:10.1177/1073110519857314

36. Telemedicine | Medicaid. Accessed March 29, 2021. https://www.medicaid.gov/medicaid/benefits/telemedicine/index.html

37. Office USGA. Broadband Internet: FCC's Data Overstate Access on Tribal Lands. 2018;(GAO-18-630). Accessed October 12, 2020. https://www.gao.gov/products/GAO-18-630

38. Cummings JR, Allen L, Clennon J, Ji X, Druss BG. Geographic Access to Specialty Mental Health Care Across High- and Low-Income US Communities. *JAMA Psychiatry*. 2017;74(5):476-484. doi:10.1001/jamapsychiatry.2017.0303

39. Talal AH, Sofikitou EM, Jaanimägi U, Zeremski M, Tobin JN, Markatou M. A framework for patient-centered telemedicine: Application and lessons learned from vulnerable populations. *J Biomed Inform*. 2020;112:103622. doi:10.1016/j.jbi.2020.103622

40. Sittig DF, Singh H. A new sociotechnical model for studying health information technology in complex adaptive healthcare systems. *Qual Saf Health Care*. 2010;19(Suppl 3):i68-i74. doi:10.1136/qshc.2010.042085

41. Hebert M. Telehealth success: evaluation framework development. *Stud Health Technol Inform*. 2001;84(Pt 2):1145-1149.

42. Edmunds M, Tuckson R, Lewis J, et al. An Emergent Research and Policy Framework for Telehealth. *eGEMs*. 2017;5(2). doi:10.13063/2327-9214.1303

43. Chang H. Evaluation Framework for Telemedicine Using the Logical Framework Approach and a Fishbone Diagram. *Healthc Inform Res*. 2015;21(4):230-238. doi:10.4258/hir.2015.21.4.230

44. Perry K, Gold S, Shearer EM. Identifying and addressing mental health providers' perceived barriers to clinical video telehealth utilization. *J Clin Psychol*. 2020;76(6):1125-1134. doi:https://doi.org/10.1002/jclp.22770

45. industry TCTC is the E in C at BH has more than a decade of experience in the telecom, Divide HBWABIS as the D, Neutrality N, cybersecurity, Since 2015 IA. The FCC Definition of Broadband: Analysis and History. BroadbandNow. Accessed February 13, 2022. https://broadbandnow.com/report/fcc-broadband-definition/

46. Spivak S, Spivak A, Cullen B, et al. Telepsychiatry Use in U.S. Mental Health Facilities, 2010-2017. *Psychiatr Serv Wash DC*. 2020;71(2):121-127. doi:10.1176/appi.ps.201900261

47. Talbot JA, Burgess AR, Thayer D, Parenteau L, Paluso N, Coburn AF. Patterns of Telehealth Use Among Rural Medicaid Beneficiaries. *J Rural Health Off J Am Rural Health Assoc Natl Rural Health Care Assoc*. 2019;35(3):298-307. doi:10.1111/jrh.12324

48. Drake C, Zhang Y, Chaiyachati KH, Polsky D. The Limitations of Poor Broadband Internet Access for Telemedicine Use in Rural America: An Observational Study. *Ann Intern Med*. 2019;171(5):382-384. doi:10.7326/M19-0283

49. Reed ME, Huang J, Graetz I, et al. Patient Characteristics Associated With Choosing a Telemedicine Visit vs Office Visit With the Same Primary Care Clinicians. *JAMA Netw Open*. 2020;3(6). doi:10.1001/jamanetworkopen.2020.5873

50. Greenberg-Worisek AJ, Kurani S, Rutten LJF, Blake KD, Moser RP, Hesse BW. Tracking Healthy People 2020 Internet, Broadband, and Mobile Device Access Goals: An Update Using Data From the Health Information National Trends Survey. *J Med Internet Res*. 2019;21(6):e13300. doi:10.2196/13300

51. Greater Oregon Behavioral Health, Inc. - RHIhub Telehealth Toolkit. Accessed March 28, 2021. https://www.ruralhealthinfo.org/toolkits/telehealth/3/oregon-behavioral-health

52. Luxton DD, McCann RA, Bush NE, Mishkind MC, Reger GM. mHealth for mental health: Integrating smartphone technology in behavioral healthcare. *Prof Psychol Res Pract*. 2011;42(6):505-512. doi:10.1037/a0024485

53. Chan SR, Torous J, Hinton L, Yellowlees P. Mobile Tele-Mental Health: Increasing Applications and a Move to Hybrid Models of Care. *Healthcare*. 2014;2(2):220-233. doi:10.3390/healthcare2020220

54. Pradhan T, Six-Workman EA, Law KB. An Innovative Approach to Care: Integrating Mental Health Services Through Telemedicine in Rural School-Based Health Centers. *Psychiatr Serv*. 2018;70(3):239-242. doi:10.1176/appi.ps.201800252

55. Mussulman L, Ellerbeck EF, Cupertino P, et al. Design and Participant Characteristics of a Randomized-Controlled Trial of Telemedicine for Smoking Cessation among Rural Smokers. *Contemp Clin Trials*. 2014;38(2):173-181. doi:10.1016/j.cct.2014.04.008

56. Chan S, Torous J, Hinton L, Yellowlees P. Towards a Framework for Evaluating Mobile Mental Health Apps. *Telemed E-Health*. 2015;21(12):1038-1041. doi:10.1089/tmj.2015.0002

57. Hilty DM, Chan S, Hwang T, Wong A, Bauer AM. Advances in Mobile Mental Health: Opportunities and Implications for the Spectrum of E-Mental Health Services. *FOCUS*. 2018;16(3):314-327. doi:10.1176/appi.focus.16301

58. Fixed Broadband Deployment Data from FCC Form 477. Federal Communications Commission. Published October 16, 2015. Accessed May 10, 2021. https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477

59. Area Table December 2019 V1 | Data | Federal Communications Commission. Accessed January 29, 2022. https://opendata.fcc.gov/Wireline/Area-Table-December-2019-V1/ws2a-amik

60. Geography Lookup Table | Data | Federal Communications Commission. Accessed May 10, 2021. https://opendata.fcc.gov/Wireline/Geography-Lookup-Table/v5vt-e7vw

61. Area Table June 2020 V1 | Data | Federal Communications Commission. Accessed May 10, 2021. https://opendata.fcc.gov/Wireline/Area-Table-June-2020-V1/ktav-pdj7

62. Map - SAMHSA Behavioral Health Treatment Services Locator. Accessed February 8, 2021. https://findtreatment.samhsa.gov/locator

63. National Survey of Substance Abuse Treatment Services (N-SSATS) | SAMHDA. Accessed February 8, 2021. https://www.datafiles.samhsa.gov/study-series/national-survey-substance-abuse-treatment-services-n-ssats-nid13519

64. SAMHSA. National Mental Health Services Survey (nmhss) Questionnaire - 2019. Dasis.SAMHSA.gov. Accessed May 10, 2021. https://wwwdasis.samhsa.gov/dasis2/nmhss.htm

65. *Substance Abuse and Mental Health Services Administration, National Mental Health Services Survey (N-MHSS): 2020. Data on Mental Health Treatment Facilities. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2021.*

66. National Mental Health Services Survey | CBHSQ Data. Accessed March 28, 2021. https://www.samhsa.gov/data/data-we-collect/n-mhss-national-mental-health-services-survey

67. Area Health Resources Files. Accessed December 5, 2021. https://data.hrsa.gov/topics/health-workforce/ahrf

68. Bureau UC. Why We Ask About... Computer and Internet Use. Accessed January 29, 2022. https://www.census.gov/acs/www/about/why-we-ask-each-question/computer/

69. Bureau UC. American Community Survey 5-Year Data (2009-2019). Census.gov. Accessed December 5, 2021. https://www.census.gov/data/developers/data-sets/acs-5year.html

70. Data Downloads. Accessed January 29, 2022. https://data.hrsa.gov/data/download

71. MEDICARE TELEMEDICINE HEALTH CARE PROVIDER FACT SHEET | CMS. Accessed October 12, 2020. https://www.cms.gov/newsroom/fact-sheets/medicare-telemedicine-health-care-provider-fact-sheet

72. Senators ask the FCC to change the definition of high-speed broadband. Engadget. Accessed January 30, 2022. https://www.engadget.com/senators-fcc-change-definition-high-speed-broadband-222150947.html

73. FCC Hangs on to 25/3 Mbps Broadband Definition for 2021 Broadband Deployment Report - Telecompetitor. Accessed January 30, 2022. https://www.telecompetitor.com/fcc-hangs-on-to-25-3-mbps-broadband-definition-for-2021-broadband-deployment-report/

74. USDA ERS - Rural-Urban Commuting Area Codes. Accessed May 10, 2021. https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/

75. *StataCorp*. StataCorp LLC; 2021.

76. Kaufman T, Geraghty EM, Dullet N, King J, Kissee J, Marcin JP. Geospatial Information System Analysis of Healthcare Need and Telemedicine Delivery in California. *Telemed E-Health*. 2016;23(5):430-434. doi:10.1089/tmj.2016.0144

77. Wegermann K, Wilder JM, Parish A, et al. Racial and Socioeconomic Disparities in Utilization of Telehealth in Patients with Liver Disease During COVID-19. *Dig Dis Sci*. Published online January 28, 2021. doi:10.1007/s10620-021-06842-5

78. Jain V, Rifai MA, Lee MT, et al. Racial and Geographic Disparities in Internet Use in the U.S. Among Patients With Hypertension or Diabetes: Implications for Telehealth in the Era of COVID-19. *Diabetes Care*. 2021;44(1):e15-e17. doi:10.2337/dc20-2016

79. Rivera V, Aldridge MD, Ornstein K, Moody KA, Chun A. RESEARCHRacial and Socioeconomic Disparities in Access to Telehealth. *J Am Geriatr Soc*. 2021;69(1):44-45. doi:10.1111/jgs.16904

80. Benda NC, Veinot TC, Sieck CJ, Ancker JS. Broadband Internet Access Is a Social Determinant of Health! *Am J Public Health*. 2020;110(8):1123-1125. doi:10.2105/AJPH.2020.305784

Appendix

A. Sensitivity Analyses

Figure A.1. Marginal Effects and Statistical Significance for Other Measures of Internet Access on Telehealth Provision at Non-Urban Mental Health Facilities

Multivariate Logistic Regression, controlling for county and facility characteristics included in Tables 1 & 2; $P < 0.05$

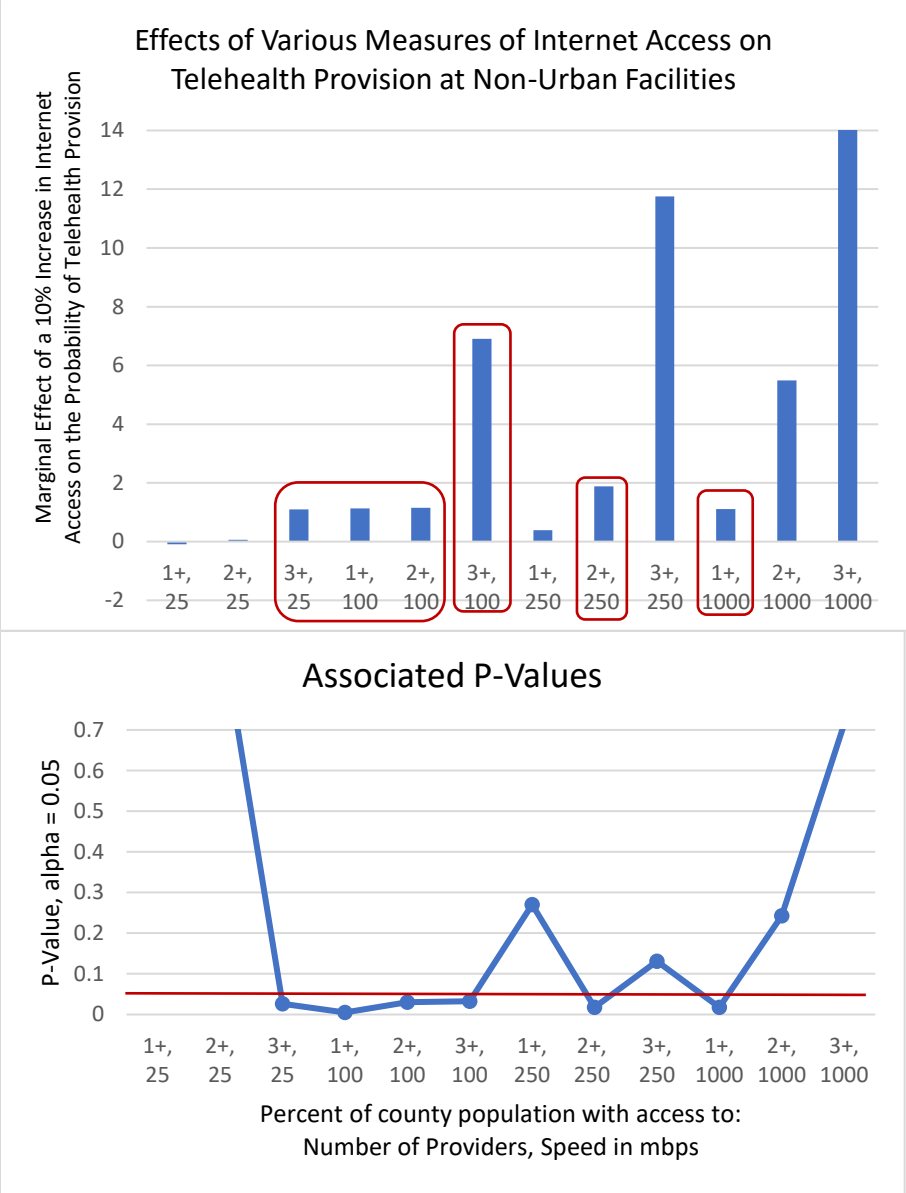


Figure A.2. Marginal Effects and Statistical Significance for ACS Census Measures of Internet Access on Telehealth Provision at Non-Urban Mental Health Facilities

Multivariate Logistic Regression, controlling for county and facility characteristics included in Tables 1 & 2; $P < 0.05$