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Determinants of broadband access and affordability: An analysis of a community survey on the digital divide

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ABSTRACT

Broadband access in the home is a necessity, especially since the COVID-19 pandemic. Increasingly, connectivity is of vital importance for school, work, family, and friends. Existing international research on the implementation of broadband has studied its adoption patterns with a focus on the rural/urban digital divide. This paper explores the digital divide in a case study of the seventh largest city, by population, in the United States; San Antonio is a majority-minority city where over half of the people are Hispanic. This paper focuses on the five key affordability factors that drive broadband adoption. Researchers test social exclusion theory, the structural facets of poverty and social marginality to ascertain its potential impact on broadband access. The authors conducted a survey in both English and Spanish to learn more about the affordability factors that influence the broadband digital divide. Through our analysis, we found evidence that four of the factors (geographical disparities, profit-based discrimination, technology deployment cost, and socio-economic factors) played a role in the digital divide in this case study. The results of this study demonstrate that the digital divide is not exclusively a rural/urban digital divide, but can also occur in an intra-city context. This is especially evident in low-income areas within the city because they have substantially lower broadband adoption rates. The results of this study demonstrate the importance of looking closely at issues of social exclusion of marginalized groups and the affordability of broadband access intra-city.

There has been a dramatic rise in the use of broadband across the United States and other countries globally. Digital inclusion is a cross-cutting theme across several Sustainable Development Goals (SDGs), and the United Nations’ “declaration of Digital Interdependence” associates digital inclusion as human rights (UN Secretary General’s High-Level Panel on Digital Cooperation, 2019). However, many countries lack broadband access within their regions and the digital divide has become especially apparent since the global pandemic COVID-19 impacting countries (OECD, 2020) including the United States.

Because of the COVID-19 pandemic, cities across the globe are struggling to close the digital divide quickly to help mitigate the effects on the health, education and economies of their communities. City planners would be wise to identify ahead of time the local challenges of moving toward digital inclusion to make certain that the implemented solution is afforded every opportunity for success. Every community is different because each faces unique historical, political, financial, and logistical challenges. This article sets forth a rubric with five factors; 1) geographical disparities; 2) competition; 3) profit based discrimination; 4) technology deployment cost; and 5) socio-economic factors by which any community can analyze the local challenges of moving toward digital inclusion. We provide a case study of a large ethnically diverse U.S. city to illustrate how this analysis can be applied in the real world. Cities that engage in this kind of planning will enhance the opportunity to bridge the digital divide in an effective manner.

1. Case study on broadband access and affordability in San Antonio

Americans have a hearty appetite for using the internet at home to do schoolwork, work from home, and engage with family and friends which has tremendously increased during COVID-19 pandemic. The internet holds great potential for society, but there are digital divide barriers that block access to broadband in homes. Today, nearly a quarter of the U.S. population does not have access to broadband at home (Pew Research Center, 2019).

This paper studies access to broadband in the home and examines broadband affordability for residents of a major metropolitan city in the United States. We present a case study conducted through a community survey focused on digital access and inclusion in Bexar County, Texas. Bexar county contains San Antonio, the seventh largest city in the U.S.

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by population. San Antonio is a majority-minority city where over half of the people are Hispanic. It is also strategically located near southern United States border to Mexico with key ties to commerce, immigration, and tourism between the two countries and regions. Along with the global transformations in creating Smart Cities, San Antonio also set its ambition in 2018 that digital inclusion as one of its major goals (Flahive, 2018).

The National Digital Inclusion Alliance (NDIA) finds San Antonio among those U.S. cities with the highest percentages of households lacking broadband access at home (Royall, 2018). NDIA ranked all 623 of these communities by the percentage of households without “wire-line” broadband subscriptions (“Broadband such as cable, fiber optic or DSL”), as well as the percentage of each community’s households that lacked broadband internet subscriptions of any type, including mobile data plans. San Antonio Texas ranks 129th and has a total of 93,237 households without Broadband of any type (National Digital Inclusion Alliance, 2018). Unlike other studies, the researchers were not only interested in learning about the availability of home broadband service, but rather the extent to which households are actually connected to broadband. Researchers discovered that basic needs such as shelter and food are of paramount concern and having access to the internet is not a priority unless those needs are met (Royall, 2018).

San Antonio lags behind its neighbor to the North, Austin when measuring the percentage of households with a broadband subscription. According to an Austin digital inclusion report, 95% of survey respondents have a home broadband internet connection, which is slightly higher than in 2014, which was 92% (Straubhaar et al., 2018). They also indicated that among 5% of respondents that did not have a home internet connection, 72% use the internet at another location, like public libraries or using a mobile hotspot connection. According to the United States Census Bureau (2018), San Antonio ranks very low when compared to similar cities (such as Austin with 14.2%) in Texas when it comes to broadband internet subscriptions with 23.4% of households are without a broadband connection. However, there does appear to be some potential solutions to help bridge the digital divide in San Antonio. In 2014, Assistant City Attorney Gabriel Garcia described the history of broadband usage in San Antonio at a panel discussion on the future of broadband in San Antonio. He stated that Austin has the Greater Austin Area Telecommunication Network (GAATN), which has helped Austin over the last 20 years, to usher the city into significant telecommunication developments. His argument was that San Antonio could capitalize on an extensive network of fiber optic cable running throughout the city, but it is mostly “dark” or unused (Sitz, 2014). A strategy that involves leveraging existing resources can help mitigate the digital divide especially if the strategy helps to lower or eliminate costs to the user.

Paradoxically, while Texas pays among the least amount for internet service in the country, broadband adoption in San Antonio still remains low (Pettaway, 2020). According to McCann (2020), Texas has the lowest internet cost compared to other comparable states. Overall, the costs of internet access is relatively inexpensive in San Antonio when compared to other cities in the U.S., so this suggests that cost may not play an important role in broadband adoption rates.

The research question of this paper is, what are the factors that explain the relationship between broadband access and affordability? The extant research has focused on broadband adoption in relationship to the urban and rural digital divide (Oyana, 2011; Pereira, 2016; Rendon Schneir & Xiong, 2016). Our research is different in that we examine the digital divide within a city and identify significant differences in access intra city related to issues of affordability, while still utilizing the five-factor framework. We identified five factors, which emerged from an extensive literature review, to scrutinize what drives broadband access and affordability. The five factors; geographical disparities, competition, profit-based discrimination, technology deployment cost, and socio-economic factors are all well documented and help to illuminate the depth and breadth of the digital divide across the globe.

2. DISA survey

In the U.S., much of the existing research relies on the American Community Survey (ACS) from the United States Census Bureau, which provides valuable information on types of computers and internet subscriptions. The most recent ACS available is from 2018. However, there are limitations to using the ACS. For example, the sample size is not sufficient to provide estimates for small intra city analysis because the Census Bureau is geared toward providing aggregated data from multiple years large metropolitan areas. Another limitation is that there is a sizable delay between collections and release of the data. The most recent release is for years from 2014 to 2018.

Collectively, the ACS provides excellent reference information on computer and internet access for Bexar County. However, there is limited geographic detail and no information on actual usage patterns. To fill this gap, the authors deployed the 2020 Digital Inclusion Survey and Assessment (DISA). DISA, which is analyzed in this paper, was designed to provide local area information on access and usage on a much more granular level, with the ability to disaggregate along political boundaries of San Antonio City Council Districts and Bexar County Precincts. The authors operationalized DISA by conducting their own survey of households and measured their access to broadband in the home. The researchers targeted respondents within a large metropolitan city and the surrounding county in the United States. The goal of the project was to determine the driving factors that indicate affordability of broadband for communities within a city (Rhinesmith et al., 2019). We believe that our findings from this case study are applicable to other large cities globally facing an intra-city digital divide with broadband access.

This paper is divided into five sections. The first section discusses our theoretical explanation of the broadband digital divide in homes. The second section provides our literature review and identifies five key factors for understanding broadband access and affordability. Our third section discusses the research methods utilized to study the phenomena. After this we provide descriptive statistics from our survey sample. We then test a logistical regression model on broadband access and affordability. Our final sections provide a discussion of the most important results and our conclusions from this case study.

3. Social exclusion theory

We use social exclusion theory, a multidimensional concept, that goes beyond material poverty and associates social exclusion with exclusion from social participation, cultural and structural processes, opportunities to build human capital, access to services and power structures, as the underlying conceptual framework for the intra city digital divide in this study. Social exclusion has previously been associated with unemployment, poor job skills, low income, poor housing and neighborhoods that lack security and poor family structures (Social Exclusion Unit, 1998). Levitas (1998) defined it within the broader dialogue of redistribution, moral, and social integration discourses that is concerned with inequality and poverty, structural oppression as opposed to moral condemnation of disadvantage groups, and paid work. Miliband (2006) expanded this to social inequality as concentrated and deep exclusion. Concentrated exclusion can occur due to geographic concentration of disadvantages, while deep exclusion results due to disadvantages on multiple and overlapping levels of structural oppression that intersect along various factors. In effect, those who are socially excluded have the inability to participate effectively in economic, social, political and cultural life due to some characteristic alienation from mainstream society (Duffy, 1995), and are deprived in opportunities and resources due to structural oppression associated with being part of certain race, socio-economic status, and/or their geographical location.

In this study, we look at digital divide as a gap between those who have access to the broadband and those who do not. With this
4. Broadband access and affordability literature review

The following five factors on broadband access and affordability emerged from the literature review, as shown in Table 1. Each factor is discussed in relation to the literature.

4.1. Geographical disparities

When it comes to broadband access, research shows there are large disparities. Moreover, inequalities exist between different populations depending upon their geographical locations. In most urban areas, quality internet service is readily available and embraced, unlike rural areas where large investments and diminishing profits make building broadband infrastructure an unattractive investment. In rural areas, distance has a chilling effect on potential service providers and exacerbates a large disparity in broadband performance (Riddlesden & Singleton, 2014). The inverse relationship between infrastructure costs and broadband access is most evident when we take into account factors like population density, availability of similar services, and the level of broadband speed and performance. In a more recent study from England, Riddlesden and Singleton (2014) compiled 4.7 million internet speed tests from between 2010 and 2013 in an effort to pinpoint disparities in broadband speeds. Their methodology included calculating a speed ratio by dividing the number of speed test performed by the population for each district. Their findings indicated that a geographic bias did persist over the entire period of their study (Riddlesden & Singleton, 2014).

Further research has provided insights into the costs associated with the deployment of high capacity broadband and the cost implications in rural areas (Rendon Schneir & Xiong, 2016). Rendon Schneir and Xiong (2016) deployed a cost model to determine the price of a home connected with fiber and copper-based network in rural areas versus a town or village. The cost model utilizes a variety of elements. Ultimately, the researchers concluded, that the cost for deploying a network infrastructure is 80% higher in rural areas as compared to deployment in a town or village (Rendon Schneir & Xiong, 2016). The pressure to offer the same services for the same price in communities where the cost to deploy the technology is high will undoubtedly

| Factors                              | Characteristics                                                                 | Major references                                      |
|--------------------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------|
| Geographical disparities             | Low population density and high deployment costs discourage private investments, creating little or no commitment to connecting areas that include smaller towns and rural areas. Even in remote locations where the broadband is available, the monthly cost can be higher because building telecommunications networks in rural areas is costly. | (Riddlesden & Singleton, 2014), (Rendon Schneir & Xiong, 2016), (Pereira, 2016), (Oyana, 2011), (Mingliu & Wolff, 2004), (Grubesic, 2004). |
| Competition                          | Competition in the telecommunications sector helps make broadband more affordable to its citizens. However, there is low competition in rural areas, therefore, increasing service costs (deployment, operation, and maintenance of wireless broadband access networks are taken into consideration) that leads to the issue of affordability. | (Krizanovic et al., 2014), (Yates et al., 2010), (Prieger & Hu, 2008), (Prieger, 2013). |
| Profit based discrimination          | Minority households may have lower demand for broadband service. In this case, carriers do not enter because they expect profit to be too low to support entry. To foster further broadband implementation in rural areas, the cost-benefit is a key factor affecting rural broadband affordability that needs to be addressed. | (Prieger, 2003), (Oyana, 2011), (Krizanovic et al., 2014), (Liu et al., 2018). |
| Technology deployment cost           | Deployment of broadband technology can be expensive. Offering broadband services in a local area requires investment; local areas are only enabled for broadband when the expected stream of future profits. However, this expectation results in unaffordable service. | (Liu et al., 2018), (Rhinesmith et al., 2019), (Lyons, 2014). |
| Socio-economic factors: income, education, race, and age | The poor, the less educated, and non-whites are on the disconnected side of the divide. High monthly costs are a limiting factor to broadband subscriptions, followed by the cost of a digital device. Age is another factor, consumers below 24 years are either studying or just beginning employment and may not be able to afford the current price plan. Low-income Americans participate in a cycle of “un-adoption,” in which they adopt broadband connectivity at home, and then drop it for financial or other reasons, only to re-subscribe again when conditions warrant. | (Townsend et al., 2013), (Flamm & Chaudhuri, 2007), (Glass & Stefanova, 2010), (Choudrie & Dwivedi, 2006), (Powell et al., 2010), (West, 2015). |
discourage private investments, creating little or no commitment to connecting areas that include smaller towns and rural areas due to a low return on investment.

In another study, Pereira (2016) posited that even if broadband access were readily available in rural areas, the cost for service would be so high that residents would not subscribe. This author attributes that finding due to the unique economic and cultural situation in many rural and remote areas. It is believed that low economic development and cultural interchange are obstacles for telecommunication and information technologies (Pereira, 2016). These obstacles have amplified the digital divide and hastened the reduced use of broadband technology. The lack of telecommunication infrastructure in rural areas is primarily due to the high costs of building “last-mile” networks in those communities (Pereira, 2016). Further exacerbating the problem is that research indicates that wireline may be difficult to set up in rural and remote areas. While Digital Subscriber Lines (DSL) can be utilized in areas with scattered populations, they are most effective in areas with high to medium density housing. As a result, the first 5–10 km of wireline access may be too cost prohibitive to install. While wireless networks could provide an alternative solution, researchers question the cost-benefits rationale of extending internet access to these high-cost, low income areas (Pereira, 2016). Furthermore, markets for broadband are low in rural and remote areas and the few broadband access providers provide their service at higher costs due to the high deployment costs. According to Oyana (2011), limited broadband access is common in rural communities due to geographic remoteness and low population density. Moreover, due to the lower-economic status of residents in rural areas, residents are less likely to adopt broadband due to affordability (Grubesic, 2004; Minglu & Wolf, 2004).

The vast majority of studies on geographic disparities and access to broadband confirm the existence of a rural/urban digital divide. However, the existing research in the geographic factor does not explore the digital divide through a community survey, with most of the research focusing on technical issues with urban/rural access. By contrast, our focus is on the broadband digital divide intra-city. The argument is that within a city there can be different population densities, income, and cost factors. Our hypothesis is as follows:

**H1.** Income disparities within the city decrease the use of broadband access at home.

### 4.2. Competition

Research from around the globe has examined the relationship between competitiveness in the telecommunications sector to determine if increased competition lowers the costs of broadband. In a study of the Croatian broadband market, researchers analyzed the economic aspect of a decision to deploy broadband by using financial analyses to show the effects of service penetrations on the overall costs of network deployments (Krizanovic et al., 2014). For this analysis, which covered a ten-year period, a municipality was selected because it contained three distinct area types – urban, suburban, and rural. Thus, in this case, the most important costs associated with broadband deployment were operation and the maintenance of wireless broadband access networks. Considering the financial investment in broadband technology, competition in the telecommunications sector within a country helped to make broadband more affordable to its citizens.

To test the hypotheses that policy initiatives contribute to broadband diffusion and affordability, Yates et al. (2010) reviewed a number of case studies of nations that have been successful at utilizing information and communication technology. It was determined that greater technological development was found in those nations where competition for providing telecommunication services was strongest (Yates et al., 2010). In other words, when there is greater broadband diffusion in areas that encourages competition, it helps make broadband more affordable to its citizens.

Where there are fewer providers in low-income or rural areas this can affect the issue of affordability. Some researchers have suggested that one of the benefits of broadband technology availability is an increase in economic development but for this to occur, an increase in competition is important because rural areas have significantly fewer providers. A case study in South Carolina demonstrated that rural areas in the United States are generally lagging behind their urban counterparts in broadband availability. There are also far fewer wireline and mobile options in the 10 poorest (rural) counties in South Carolina compared to the 10 with the highest incomes (which are more urbanized) (Prieger, 2013). Prieger and Hu (2008) examined the gap in broadband access between minority groups and white households along with the quality of service and competition as components of the digital divide. Unquestionably, service quality is an important determinant of demand, therefore, competition can increase demand by lowering prices and increasing quality. If competition increases, providers would necessarily need to take into account the price sensitivity of those communities, then, it can contribute to the closing of the digital divide and offer affordability to the citizens of these communities (Prieger, 2013; Prieger & Hu, 2008).

Existing research shows that broadband access and affordability are related to the degree of competition within the city (Prieger & Hu, 2008; Yates et al., 2010). Most of the existing research examines competition from the perspective of rural areas where firms having little incentive to enter these markets. Our research is different since we examine intra city competition. The greater the competition among internet service providers the greater the pressure to lower broadband costs and create more affordability. Our hypothesis is the following:

**H2.** Increases in competition by internet service providers within the city, will decrease costs of broadband at home and increase access.

### 4.3. Profit-based discrimination

Broadband availability and affordability in areas with high concentrations of poor, minorities, or rural households provides the starkest examples of the digital divide. In many cases, providers will not enter the market in these areas because the prospect for high profit margins is too low to merit entry (Prieger, 2003). Prieger (2003) conducted a study, where ZIP codes were the unit of observation that analyzed the services offered through nearly all of the more than 22,000 DSL wire service centers. This study monitored cable modem access in 3133 counties with 29,769 observations. The results of the study concluded that costs were lower in areas where subscriber’s density was higher. In areas with low subscriber density, the DSL customer was typically too far from DSL wire service centers and required stronger, therefore, more expensive carrier signal.

In the broadband market, lower-income households are typically the most price sensitive (Liu et al., 2018). Rural users also pay more on average for broadband than urban users because of a lack of providers leaves them with fewer options than their urban counterparts. Moreover, rural residents are more likely to live in areas without broadband coverage or with lower quality broadband service. Thus, where population density is high, as in urban areas, they are not as price sensitive. Providers will remain in areas where density is high and the income of the area has less impact than in sparsely settled rural areas. In other words, low-density areas will have the fewest predicted number of broadband providers because of the likelihood of lower profits. In addition to the income factor, less dense areas that are isolated, and have high populations of low-income minorities, are also lacking broadband internet service providers when compared to large metropolitan areas.

Recent studies indicate that profit-based discrimination, where a provider fails to offer services in communities that offer little potential for profits, occurs in isolated and remote regions with a high percentage of low-income minorities in comparison to large metropolitan areas Oyana (2011). That same study also controlled for, income, number of
individuals in a household, education, and age. Age was deemed important because researchers assumed that younger generations were more technologically savvy than older generations. The demand side of the equation exhibited several factors influenced wireless deployment and implementation. Those factors included the percentage of the population with at least some college education, percentage of the population between the age of 5 and 54 years, and the presence of high median household income. Widespread wireless adoption is a key strategy to bridging the digital divide. However, two groups; 1) senior citizens; and 2) individuals who are less educated are the most likely to not adopt wireless broadband technology (Oyana, 2011).

Furthermore, Krizanovic et al. (2014) postulated that having the ability to overcome the technical challenges of deployment did not guarantee market success for new broadband access technologies in rural area markets. Further, market success requires overcoming both the cost-benefit issues and the technical challenges when deploying broadband technology. The solution proposed by Liu et al. (2018) includes deploying cost-effective satellites to provide broadband services in rural or isolated areas, where the deployment of other technologies can be cost prohibitive. Hence, satellite technology can be an economical solution to provide access to broadband internet. However, satellite comes with its own limitations. For example, customers report issues with high latency, which is the amount of delay that occurs in a round-trip data transmission to a satellite.

Profit-based discrimination occurs when there is an unwillingness on the part of internet service providers to enter a low-profit market especially with minority and low-income households, where the internet service provider believes it cannot maximize profit. Most of the existing research examines profit-based discrimination from the perspective of rural areas, however, this study focuses on intra-city profit-based discrimination. Therefore, our next hypothesis states that:

**H3.** Minority and low-income households will have less access to broadband at home.

### 4.4. Technology deployment cost

Deployment costs are another reason why rural communities are unable to access broadband technology. Most private telecommunication companies want to earn a good return on their investment soon after deployment. Thus, they might offer broadband services but at a higher price due to recoup deployment costs. Based on a study by Rhinesmith et al. (2019), which focuses more on the ability to pay rather than the willingness to pay, researchers combined findings from various studies to understand consumer behavior with respect to broadband decision-making. This qualitative study used surveys and focus groups of community-based organizations, individuals, and families and found that the internet is important to low-income communities. Most participants in the study could easily identify that the benefits of broadband outweigh the costs but the participants in low-income communities faced cost-related challenges that made a home broadband subscription impractical (Rhinesmith et al., 2019). In other words, low-income individuals and families understand the value of broadband but due to limited resources having broadband access is out of reach even for those who are capable of using the technology.

According to Lyons (2014), supply and demand drive the residential broadband market. Demand factors include price, reliability, and quality of service. On the supply side, the most important factors are; population density; degree of competition; and current deployment in the market. Offering broadband services in a local area requires sizeable investments because the deployment of broadband service is expensive. For example, a typical determination to invest would take into account, the cost of supplying broadband and population density. More densely populated areas could give rise to an assumption that demand will rise over time in more densely populated areas faster and, therefore, should be enabled first (Lyons, 2014). Liu et al. (2018) explained that cost-effective solutions, like satellites, that provide broadband service could result in high latency or poor service quality. On the supply side of the equation, when a provider decides to offer broadband services they can select from an urban or rural locale. Since offering broadband requires substantial investments like installation of modems in local exchanges or wireless base stations (Lyons, 2014) there is little incentive to deploy broadband services in areas where the expected stream of future profits is low.

If the costs to deploy broadband are higher in minority and low-income communities, it is presumed that internet service providers will not prioritize deployment. Most of the research looks at case studies where technology deployment costs are high, while in this study we examine this factor through a community survey. Essentially, it becomes too expensive to for internet service providers to serve these marginalized communities. Our hypothesis is as follows:

**H4.** An increase in technology deployment costs will decrease the use at home of broadband in marginalized communities.

### 4.5. Socio-economic factors: income, education, race, and age

Those caught on the wrong side of the digital divide include the poor, the less educated, and non-whites. These digital inequalities exist in large measure because of socio-economic factors that keep these populations from accessing broadband technology. Barriers to access include demographic factors such as income level, race, age and level of education. In remote populations, the high cost of connectivity necessitates using wireless technology like the satellite but at significantly slower speeds (Townsend et al., 2013). Lack of income is a major factor that affects broadband access even where the technology is readily available. Besides, there is strong evidence according to Flamm and Chaudhuri (2007) that broadband price is indeed a statistically significant driver of low broadband adoption.

A study by Glass and Stefanova (2010) found that high monthly subscription costs and the perceived lack of need were the two key hurdles from acquiring broadband subscriptions, followed by the cost of a new device. That study was conducted by using previous literature that dealt with demand for advanced telecommunication services. It included price elasticities of demand and evaluation of the digital divide based on geographical, economic or demographic consumer characteristics. Glass and Stefanova (2010) argued that studies on the digital divide generally find the correlation between adoption and socioeconomic factors such as age, race, income and education are the most significant. However, there is an underlying economic principle of both supply and demand for providers. Providers will only invest if the investment will yield higher profits than other comparable opportunities. Similarly, households connect if they can afford and desire the technology (Glass & Stefanova, 2010). Furthermore, studies indicate that broadband providers operating in rural areas avoid operating in low-density markets with fewer customers to avoid attempting to recover sizable investments for network infrastructure. Another challenge to families is the lack of disposable income, which makes it difficult to purchase devices or gain access to broadband (West, 2015). Some of the solutions proposed to achieve higher broadband adoption rates in rural areas include government sponsored universal broadband. Should governments opt to put in place policies that provide financial support for broadband access this could go far to bridge the digital divide. (Glass & Stefanova, 2010).

The relationship between age and income is important because different age groups calculate the affordability of broadband differently. Research by Choudrie and Dwivedi (2006) suggests that consumers younger than 24 years-old are slow to adopt broadband. Future researcher should strive to understand the reasons for slow adoption among ages 24 and below. This may be because the majority of consumers under 24 years-old are either in school or just entering the workforce and may not be able to afford a broadband plan. One
potential solution could be to consider alternative price plans to create a mass-market demand. Powell et al. (2010) posited that low-income Americans participate in a cycle of “un-adoption,” in which they adopt broadband connectivity at home, and then drop it for financial reasons, only to re-subscribe again when financial conditions improve.

Our last hypothesis examines the impact of socioeconomic factors such as income, age, race, and gender on broadband access at home. Most prior research studied this factor through a general social economic lens, while this research focuses more on the issues of affordability in terms of marginalized groups. Our hypothesis is as follows:

\textbf{H5.} The greater the disparities in socioeconomic status with marginalized groups (based on income, age, race, and gender) the greater the decreases in broadband access at home.

5. Research methods

As stated, this project was designed to investigate San Antonio’s level of digital inclusion and/or divide, with greater granularity and focus that that provided by the American Community Survey and other sources. In particular, the project design allows comparisons of digital access and experiences across the ten City Council Districts and four Bexar County Precincts encompassing the City of San Antonio.

Drawing from model reports developed for other major urban areas (e.g., Austin and Seattle), we identified levels and sources of digital inequity in our communities, considering linkages between geographic, socioeconomic and demographic factors in describing and accounting for differential access.

5.1. Data collection

As illustrated in the Fig. 1, a broad-based sampling strategy was used to ensure representation of participants by race, ethnic, socioeconomic, age, gender and educational statuses were included in order to reflect the diverse experiences and viewpoints throughout the City of San Antonio.

The goal was to access a cross-section of residents from 10 City Council districts as well as Bexar County areas outside the city limits of San Antonio. Data were collected through respondents completing the DISA 2020 survey online (e.g., at libraries, community centers with computer facilities or contacted from the email list), by interviewers with tablets collecting the data onsite (e.g., at community events, utility payment centers), SMS Message Service (SMS), web-based announcements, QR Codes, agency outreach with interviewers and paper based surveys. The outreach was designed to generate a representative sample (non-probability) of the population with or without the broadband (see Fig. 1). The survey was distributed in English and Spanish and produced well over eight thousand (8393) initial starts of the survey. Selecting only respondents indicating that they live in Bexar County and that spent at least 45 s on the survey completion produced a final analytic sample of \( n = 6048 \) respondents.

5.2. Sample

The demographic and socioeconomic composition of the final sample is compared to profiles from the American Community Survey (Table 2). Women are somewhat over-represented in the Digital Inclusion Survey. Young (18–24) respondents and those with less than a high school degree are somewhat under-represented. Overall, however, the distributions by race and ethnicity, age, education and income compare very well, providing a basis for confidence in the results. Further, the distributions by Bexar County Precincts and City Council Districts show very good geographic representation.

6. Results

Summary statistics for each variable are displayed in Table 3. Overall, 81% reported having Broadband internet access at home, with 19% having no access. About 54% of respondents are women, 49% are Hispanic, 27% are White (non-Hispanic), 18% selected “other” race and 5% identified as Black or African American. Respondents are well distributed by County Precincts. As noted earlier, young adults are somewhat under-represented. Only 3% declined to provide an age category. About 42% report having

![Fig. 1. Sampling plan for survey respondents.](image-url)
Table 2
Digital Inclusion Survey (DIS) and American Community Survey (ACS), demographic comparisons.

| ACS 2014–2018 | DISA Sample |
|---------------|-------------|
| **Frequency** | **Percent** | **Frequency** | **Percent** |
| Sex           | Credit       | Credit       |
| Male          | 695,704      | 48.8         | 1979        | 37.9         |
| Female        | 730,926      | 51.2         | 3245        | 62.1         |
| Total         | 1,426,630    | 100.0        | 5224        | 100.0        |
| Race with separate Hispanic code | Credit       | Credit       |
| White alone   | 440,431      | 30.9         | 1664        | 31.7         |
| Black or African | 105,191  | 7.4         | 290         | 5.6         |
| American alone | 2432        | 0.1         | 31          | 0.6         |
| American Indian/ Alaska Native | 42,313   | 3.0         | 74          | 1.4         |
| Asian alone   | 840          | 0.1         | 15          | 0.3         |
| Native Hawaiian/ other Pacific Islander alone | 1990 | 0.1 | 52 | 1.0 |
| Some other race alone | Credit       | Credit       |
| Two or more races | 19,227       | 1.3         | 102         | 2.0         |
| Hispanic      | 814,206      | 57.1         | 2983        | 57.5         |
| Total         | 1,426,630    | 100.0        | 5191        | 100.0        |

Table 3
Descriptive statistics.

| **Frequency** | **Percent** | **Frequency** | **Percent** |
|---------------|-------------|---------------|-------------|
| **Age categories** | Credit       | Credit       |
| 18–24         | 202,774      | 14.2         | 298         | 5.7         |
| 25–34         | 304,556      | 21.3         | 902         | 17.3        |
| 35–44         | 258,672      | 18.1         | 1042        | 20.0        |
| 45–54         | 234,540      | 16.4         | 940         | 18.1        |
| 55–64         | 202,357      | 14.2         | 1020        | 19.6        |
| 65–74         | 132,617      | 9.3          | 730         | 14.9        |
| 75 plus       | 91,114       | 6.4          | 269         | 5.2         |
| Total         | 1,426,630    | 100.0        | 5201        | 100.0        |

| **Education categories** | Credit       |
| Less than high school | 227,452      | 15.9         | 306         | 5.8         |
| High school diploma or GED | 383,573     | 26.9         | 773         | 14.6        |
| Some college          | 357,970      | 25.1         | 1162        | 21.9        |
| 2 year degree         | 107,594      | 7.5          | 476         | 9.0         |
| 4 year degree         | 227,479      | 15.9         | 1537        | 29.0        |
| Professional degree (e.g., MA, J.D., M.D.) | 109,699      | 7.7          | 921         | 17.4        |
| Doctorate             | 12,863       | 0.9          | 124         | 2.3         |
| Total                 | 1,426,630    | 100.0        | 5299        | 100.0        |
| **Household income groups** | Credit       |
| Under 20,000          | 104,440      | 16.5         | 931         | 18.1        |
| 20,000–39,999         | 126,893      | 20.1         | 971         | 18.9        |
| 40,000–59,999         | 107,702      | 17.0         | 908         | 17.7        |
| 60,000–79,999         | 83,423       | 13.2         | 693         | 13.5        |
| 80,000–99,999         | 61,780       | 9.8          | 507         | 9.9         |
| 100,000–119,999       | 42,706       | 6.8          | 414         | 8.1         |
| 120,000 or more       | 105,628      | 16.7         | 711         | 13.8        |
| Total                 | 632,572      | 100.0        | 5135        | 100.0        |

San Antonio council districts: census and sample comparisons.

| Census, 2010 | DISA, 2020 |
|---------------|------------|
| Council district | Population | Percent | Frequency | Valid Percent | Overall Percent |
| District 1     | 112,446    | 8.5      | 519       | 10.4          | 10.2           |
| District 2     | 123,574    | 9.3      | 532       | 10.6          | 10.5           |
| District 3     | 118,855    | 9.0      | 632       | 12.6          | 12.4           |
| District 4     | 123,163    | 9.3      | 496       | 9.9           | 9.8            |

Notes: All variables are dichotomies. The mean is the proportion with the attribute. Correlations are with broadband access. * p ≤ .05. ** p ≤ .01. *** p ≤ .001.
children under age 18 in the household and 55% report that they are employed. Higher household incomes and higher educational levels are strongly associated with broadband access. Based on reasons for using free wireless, ability to afford home internet is substantially related (correlation of \(-0.257\)) home access, followed to “only way” and “runs out.” Interestingly, free access at schools or at the housing authority plays little role in understanding home access (correlation of 0.02). Finally, three variables are included that illustrate reports about internet usage. About 63% indicated they search for health, nutrition or exercise and this is substantially related to having home access (correlation = 0.257). About one-third indicated they had found or applied for a job and about 26% indicated doing schoolwork online. These two usage patterns are less correlated with home access.

Fig. 2 shows our dependent variable in more detail corresponding to the various ZIP codes in San Antonio. What we notice is that there is much lower broadband access at homes in the southern part of the city and higher broadband access across the northern part. If we look at broadband connections at an even more granular level, we can see that the digital divide is more pronounced in areas that experience disparities in education, homeownership, health insurance, employment, and life expectancy. Current racial residential patterns do not differ greatly from the 1930s when discriminatory racial housing policies were standard practice. Whites more heavily populate the northern areas of Bexar County, the eastern areas are more populated by African Americans, and the inner city (southern and western areas) are where the majority of the city’s Latinos live.
Income is an important factor in assessing the San Antonio-Bexar County digital divide especially when counting low to very low-income households. In very low income households, where incomes fall below $20,000, forty-eight percent (48%) report that they do not have internet connection in their home; and those with low household incomes, those with incomes between $20,000 and $39,000, report that twenty-seven percent (27%) of them do not have an internet connection in their home (see Fig. 3).

Fig. 4 illustrates the market share of major broadband carriers in San Antonio. Currently, the market is dominated by two providers (AT&T and Spectrum) where they control nearly 3/4ths of the home broadband market. As discussed earlier, despite the presence of two dominant broadband providers, Texas and San Antonio still have lower broadband subscription rates when compared to other parts of the country (McCann, 2020).

Table 4 presents a series of logistic regression results designed to predict access to broadband internet connectivity. The odds ratios [Exp (B)] identify the influences of the variables. A value of 1.00 would depict no difference, values less than 1.00 indicate lower likelihood of having broadband and values greater than 1.00 show increased likelihood. In the first panel, we enter demographic and geographic variables to test for differential access. Then we add age, presence of children and employment status, both to identify their independent influences and to determine the extent to which they alter findings from the first panel. The third panel adds household income and respondent’s education. Finally, we enter a set of variables focused on reasons for using free wireless access.

The odds ratio for Women is 0.81, indicating they are 19% (1.00-0.81) less likely to report having broadband than men. Strikingly, the odds ratio for Black respondents is 0.48, indicating less than half as likely to have broadband compared to Whites. Hispanics and those of “other” races also are much less likely to have broadband. The differences by geography intra-city are equally pronounced, with districts 1, 2 and 4 reporting dramatically lower access.

In the next panel, controlling for age, children and employment status has little impact on the coefficients for the first set of variables. However, age groups 35–44 and 65–74 both show an increased likelihood. Presence of children has almost no influence, while being employed increases the likelihood substantially (odds ratio = 2.64).

The third panel introduces income and education. As expected, there are strong influences of the variables. Those in the highest income category have more than eight times the likelihood of having broadband and higher education more than doubles the access, independently of all of the other variables in the analysis. It is noteworthy that influences for gender of respondent, other races and Hispanic are substantially reduced (coefficients closer to 1.0). This reduction is less prominent for the Black respondents and by geography.

Not surprisingly, reasons for using free wireless services are substantially related to having broadband access at home. The only unexpected finding is that “running out” of data is not important. Further, controlling for these variables has little impact on the coefficients for the variables introduced in the earlier panels. Cumulatively, these variables produce a Nagelkerke R-Square of 0.31. The most influential variables are income and education, but it is important to note the influences of Black and Precincts that remain even after control of the other variables.

7. Discussion of results

This paper examined broadband access and affordability using five key characteristics taken from the literature and tested them through a case study of San Antonio using the social exclusion theoretical understanding. We assessed digital divide as associated with geographical location, economic factors such as low income, education, and employment status, socio-cultural barriers such as race, age and number of children, and structural factors such as poor infrastructure and market place competition.

Our Hypothesis 1 examined broadband access and affordability based on geographic disparities. Controlling for all other factors, the statistical results showed the digital divide in broadband access depended upon where you lived in San Antonio. The statistical analysis showed that certain districts within the city, especially those from lower income areas, had much less broadband access at home. We also mapped broadband access by ZIP codes (Fig. 2) showing these marginalized communities, typically those in lower socioeconomic status in the southern part of the city.
Table 4
Logistic regression: dependent variable – broadband access at home (yes/no).

|                | Panel (1) | Panel (2) | Panel (3) | Panel (4) |
|----------------|-----------|-----------|-----------|-----------|
|                | Exp(B)    | Exp(B)    | Exp(B)    | Exp(B)    |
| **Female**     | 0.81**    | 0.81**    | 0.89      | 0.88      |
| **Race**       |           |           |           |           |
| Black          | 0.48**    | 0.46**    | 0.64**    | 0.63**    |
| Hispanic       | 0.57**    | 0.54**    | 0.86      | 0.84      |
| Other race     | 0.58**    | 0.58**    | 0.73      | 0.72      |
| White          | Reference  | Reference  | Reference  | Reference  |
| **Precinct**   |           |           |           |           |
| Precinct 1 (South West) | 0.32***   | 0.23***   | 0.46***   | 0.47***   |
| Precinct 2 (North West)  | 0.38***   | 0.40***   | 0.54***   | 0.55***   |
| Precinct 3 (North)      | Reference  | Reference  | Reference  | Reference  |
| Precinct 4 (South East) | 0.37***   | 0.38***   | 0.55***   | 0.56***   |
| **Age**         |           |           |           |           |
| Age 18–24       | 0.93      | 1.56      | 1.37      |           |
| Age 25–34       | 1.07      | 1.34      | 1.24      |           |
| Age 35–44       | 1.34      | 1.24      | 1.28      |           |
| Age 45–54       | Reference  | Reference  | Reference  | Reference  |
| Age 55–64       | 1.03      | 1.02      | 1.03      |           |
| Age 65–74       | 1.47      | 1.33      | 1.33      |           |
| Age 75+         | 0.97      | 0.92      | 0.83      |           |
| Presence of children under 18 | 0.96      | 1.16      | 1.12      |           |
| **Employed**    | 2.64**    | 1.39**    | 1.41**    |           |
| **Income**      |           |           |           |           |
| Income under 20K | Reference  | Reference  | Reference  | Reference  |
| Income 20K–39K  | 1.80**    | 1.72**    |           |           |
| Income 40K–59K  | 2.53**    | 2.15**    |           |           |
| Income 60K–79K  | 5.00      | 3.68**    |           |           |
| Income 80K-plus | 8.26      | 6.07**    |           |           |
| **Education**   |           |           |           |           |
| Little high school | 0.88      | 0.72      |           |           |
| High school     | Reference  | Reference  | Reference  | Reference  |
| Some college    | 1.40      | 1.38      |           |           |
| Certificate     | 1.47      | 1.47      |           |           |
| Bachelor        | 2.37      | 2.25      |           |           |
| Profession designation | 2.74      | 2.59      |           |           |
| Broadband runs out | 1.04      |           |           |           |
| Free house authority | 2.00      |           |           |           |
| Only way to access | 0.65      |           |           |           |
| **Cannot afford broadband** | 0.30      |           |           |           |
| – 2 Log Likelihood | 4482.66   | 4316.92   | 3853.40   | 3629.41   |
| Cox & Snell R Square | 0.04      | 0.07      | 0.16      | 0.19      |
| Nagelkerke R Square | 0.06      | 0.12      | 0.25      | 0.31      |

* p ≤ .05.
** p ≤ .01.
*** p ≤ .001.

The Hypothesis 2 examined marketplace competition and broadband access and affordability. Currently, there is limited competition within the broadband service market in San Antonio with two providers controlling nearly 3/4ths of its market share (i.e., Spectrum and AT&T), but there was limited evidence that this impacted overall costs and affordability compared to other cities in the country as discussed in the background section. Paradoxically, our research indicates that San Antonio has little competition but still has relatively low rates compared to other major cities in the U.S.

Hypothesis 3 examined the existence of profit-based discrimination influencing broadband access and affordability. Profit-based discrimination occurs where broadband service providers chose not to enter a market because they expect to generate suboptimal profits. We can say that Hypothesis 3 was supported in our logistic regression analysis, with minority households having significantly less access than other groups to broadband at home.

Hypothesis 4 examined the cost of deploying technology. We overlaid our broadband access data by district and showed that most of the broadband access at home can be found in the northern part of San Antonio. Moreover, subscribers to Hughesnet, a satellite provider were concentrated in the southern end of the city where there are fewer internet services confirming Hypothesis 4.

Our final Hypothesis 5 examined the socioeconomic factors and broadband access at home. We found evidence that those residents with less education had decreased broadband access at home, confirming Hypothesis 5. Income, race, and ethnicity also had an impact on broadband access at home.

Our findings are consistent with social exclusion theory: digital divide exists between different racial and ethnic groups and in various geographical clusters within the city. Furthermore, overlaps of inequalities in age, income, employment and level of education intersected with geographical clustering in digital divides shows the depth of social exclusion likely driving the city’s digital divide and in effect depriving residents of opportunities and resources including better access to broadband. The geographical clusters where the disparities were evident were the southeastern areas of the city and those that are more populated by Blacks. Black respondents in our study, in general, are less likely to have broadband compared to White respondents who reside in the northern part of the city. These same communities experienced racially discriminatory housing policies in the 1930s (Coates Library, 2020) and now find themselves deep inside the digital divide. Although discriminatory “redlining” lending policies were banned 50 years ago, the effects of those policies continue to disadvantage low income and racially segregated communities. This is manifested in pockets of southeast San Antonio, populated mainly with Blacks and Hispanics in deep poverty, through lack of opportunities, reduced access to better education and employment, and diminished opportunities for cultivation of social networks. Moreover, considering race within the context of income and employment, the odds of having broadband strongly decreased for Blacks while these factors did not predict broadband access with Latinos, Whites and others. In addition, a majority of the studies have associated access in rural communities and digital divide, which is conceptually similar to our findings of more limited access for inner-city clusters in southern and western areas with lower income and less education, residing in County precincts 1 and 2 that have high concentrations of Latinos and Blacks. This is consistent with our hypothesis and major contributions of this investigation of an intra-city digital divide.

Gender predicted the likelihood of broadband access: the odds of women likely to report having broadband is less compared to men. This is consistent with the global context of women lagging behind in access to broadband (Sharma, 2016; Web Foundation, 2020). Men and women have equal access to technology; however, men more than women use internet to improve their income, health or education despite the same ownership. Women continue to be excluded in digital access, and they are also less likely to hold employment, have higher education and income, which can have broader impact on policies and programs (Sharma, 2016), in San Antonio (Sáenz & Casura, 2017).

Age groups 35–44 and 65–74 both show an increased likelihood of broadband at home; however, within the context of income and education, the likelihood of broadband at home increased for those within the age groups of 18–24 and 25–34. This is in line with the researchers’ assumptions that younger generations are more technologically savvy, college educated, and have higher income than the older generations and would rely on and use the internet. Presence or absence of children did not predict having broadband at home.

Income is a major factor that is likely to influence broadband adoption especially where technology is available. Higher household incomes and higher educational levels are strongly associated with broadband access while very low-income households do not have broadband connections in their homes. Despite the availability of broadband, lacking in higher education and income creates systematic disadvantage and socially excludes low income San Antonians from accessing job opportunities online, completing school work for children, and limiting them from accessing important health and other information keeping them at a disadvantage. Provisions for free access to internet at public spaces, such as schools or in government managed housing did not guarantee usage since selected few have the resources.
knowledge and skills to utilize them for better quality of life.

In terms of affordability, unlike Flamm and Chaudhuri (2007) study, our study did not support the hypothesis that broadband price, data, and market competition are significant drivers of low broadband adoption. However, we did find that the existence of relatively few major providers of broadband dwarf smaller broadband providers in the city, and the behemoths are less likely to provide services in low-population density and low-income areas. The pronounced failure of the broadband market in areas that already experience disparities in education, homeownership, health insurance, employment, and life expectancy, highlight the inherent flaws in neoliberal market reliance on self-regulation to achieve digital inclusion.

Not only does our study show that there is a digital divide in San Antonio, but the results demonstrate that geography, race, gender, education, and income drive the digital divide in San Antonio. The outcomes in our study imply that the disparity of broadband in San Antonio is consistent with our theoretical assumptions that digital exclusion is driven by complex and systematic deprivations and can further propagate poverty and lack of opportunities for those who are digitally excluded. Hence, addressing the digital divide through inclusive public policies that address the drivers of digital divide along with providing broadband access to those who are lacking, especially during the COVID-19 pandemic, is imperative.

8. Conclusion and limitations

This paper examined broadband access and affordability using a community survey of residents in our case study of San Antonio. Our original research question asked about factors that explain access and affordability of broadband in the home. We applied the social exclusion theory as a way of understanding how broadband access impacts marginalized groups within a city. Evidence was found to support four out of five tested hypotheses. There was a digital divide especially in terms of geography and socioeconomic status. This confirmed the social exclusion theory as it relates to marginalized groups and broadband access. In that, certain disadvantaged groups within the city are just not able to afford this important technology to improve their quality of life. This is especially evident with stay at home orders in San Antonio, and other parts of the U.S as a result of the COVID-19 pandemic, with nearly a quarter of the residents with no broadband at home to complete schoolwork, work from home, and complete other critical tasks. Ensuring widespread wireless adoption is a key strategy to bridging the digital divide. Addressing poverty through education and job-skills trainings to improve income and socio-economic factors, as well as policy initiatives that address the technical challenges of deployment can contribute to diffusion and affordability of broadband. These results may help guide the development of more inclusive policies in San Antonio and may be useful for other communities. Further, the five factors from the literature may provide a useful framework for studies in other communities and nations.

8.1. Limitations

There are some limitations to this research that should be noted. First, we are limited in that we just provide a case study of one city in the U.S.; therefore, our results may not be generalizable to other cities across the U.S or internationally. Second, we are limited in that although we tried to get access to all socioeconomic groups in the community, particularly underserved low income and minority residents, our results are still slightly skewed to those in higher income categories compared to the American Community Survey. Finally, the study design is cross-sectional, which severely constrains any cause and effect conclusions. However, we controlled for key variables identified in the literature so the patterns identified might generalize to other urban communities.

From these limitations, future research might include extending this study to other cities in the U.S. or internationally. For example, assuming parallel questions, one could compare responses to those from the neighboring city of Austin, which has over 95% broadband access. Another possibility is to do follow up interviews with those respondents that did not have broadband access to explore more fully reasons for lack of access and consequences of the lack of access for life choices and opportunities. Further, it would be valuable to follow up with respondents to determine how things may have changed in the new COVID-19 era.

Authors’ statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Choudrie, J., & Dwivedi, Y. K. (2006). Examining the socio-economic determinants of broadband adopters and non-adopters in the United Kingdom. IEEE. https://doi.org/10.1109/HICSS.2006.169 (85a-85a).
Coates Library (2020). Redlining: The racist policy that shaped San Antonio’s urban core. Retrieved from https://coateslibrary.omeka.net/exhibits/show/clauseblack/community/involvement/redlining.
Duffy, K. (1995). Social exclusion and human dignity in Europe. Council of Europe.
Flahive, P. (2018). What ‘smart city’ means: San Antonio launches committee on innovation, technology. Retrieved from Texas Public Radio https://www.tpr.org/post/what-smart-city-means-san-antonio-launches-committee-innovation-technology.
Flamm, K., & Chaudhuri, A. (2007). An analysis of the determinants of broadband access. Telecommunications Policy, 31(6–7), 312–326. https://doi.org/10.1016/j.telepol.2007.05.006.
Foley, P. D., Allison, X., Brown, K., & Fisher, J. (2003). Connecting people: Tackling exclusion? London: Greater London Authority.
Glass, V., & Stefanova, S. (2010). An empirical study of broadband diffusion in rural America. Journal of Regulatory Economics, 38(1), 70–85. https://doi.org/10.1007/s10930-010-9119-y.
Gnibrec, T. H. (2004). The geodemographic correlates of broadband access and availability in the United States. Telecommunications and Informatics, 21(4), 335–358. https://doi.org/10.1016/j.teli.2004.02.003.
Krzanovic, V., Zagor, D., Ramic-Drlje, S., & Svedek, T. (2014). Business models and cost optimization of wireless rural broadband access implementation. IEEE (pp. 170–174).
University of Split. https://doi.org/10.1109/SOFISTIC.2014.7039079.
Levitas, R. (1998). Delivering social inclusion. The inclusive society? Social exclusion and new labour (pp. 159–177). London: Palgrave Macmillan UK. https://doi.org/10.1057/97802303511552.
Liu, Y.-H., Prince, J., & Wallsten, S. (2018). Distinguishing bandwidth and latency in households’ willingness-to-pay for broadband internet speed. Information Economics and Policy, 45, 1–15. https://doi.org/10.1016/j.infeconpol.2018.07.001.
Lyons, S. (2014). Timing and determinants of local residential broadband adoption: Evidence from Ireland. Empirical Economics, 47(4), 1341–1363. https://doi.org/10.1007/s00181-013-0790-6.
McCann, A. (2020). Best state for working from home. WalletHub https://www.walshub.com.edu/best-states-for-working-from-home/72801/.
Miliband, D. (2006). Social exclusion: The next steps forward. London: ODPM.
Minguzzi, L., & Wolf, R. S. (2004). Crossing the digital divide: Cost-effective broadband wireless access for rural and remote areas. IEEE Communications Magazine, 42(2), 99–105. https://doi.org/10.1109/MCOM.2003.1267107.
National Digital Inclusion Alliance (2018). Worst connected cities. Retrieved from https://www.digitalinclusion.org/worst-connected-2018/.
OECD (2020). Science, technology and innovation: How co-ordination at home can help the global fight against COVID-19. Retrieved from http://www.oecd.org/coronavirus/policy-responses/science-technology-and-innovation-how-co-ordination-at-home-can-help-the-global-fight-against-covid-19-as0477c1/.
Oyana, T. J. (2011). Exploring geographic disparities in broadband access and use in rural southern Illinois: Who’s being left behind? Government Information Quarterly, 28(2), 252–261. https://doi.org/10.1016/j.giq.2010.09.003.
Pereira, J. P. R. (2016). Broadband access and digital divide. Paper presented at the new advances in information systems and technologies, Cham.
Pettaway, T. (2020). As residents work from home, study shows Texas pay among the least for internet service. mySA.
Pew Research Center (2019). Internet/broadband fact sheet. https://www.pewresearch.
