RESEARCH & POLICY

INSIGHTS

The Uneven Web:

Internet Speeds and the Complex Digital Divide

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ABSTRACT

The digital divide has been primarily operationalized as yes/no access to broadband. Recently available speed test data sheds new light on this issue. This study utilizes 2023 average speeds to better understand the relationships between average download and upload speeds and specific socioeconomic groups. Results show that roughly one-third of U.S. tracts analyzed had download speeds at least five times faster than upload speeds. In addition, an urban-rural divide persists. Specific groups experienced faster download speeds in urban tracts (percentage of Hispanics) compared to rural tracts. Likewise, other groups experienced faster download speeds in rural tracts compared to urban tracts (more educated). Future research should focus on obtaining additional qualitative information from specific groups, their access to broadband technology, and how it is being used.

INTRODUCTION

Broadband studies have traditionally focused on binary, yes/no variables to understand where broadband is available, who has access to it, and its overall impacts. However, as more broadband data becomes available, different analyses are possible, shedding new light on the digital divide. For this research and policy insights study, we looked at average download and upload speed tests from Speedtest® by Ookla Global Fixed Network Performance Maps and specific socioeconomic and demographic variables from the 5-Year American Community Survey (ACS).

While speed test results are not the perfect metric to understand the digital divide, they do provide a different lens to understand this issue. Speed tests are typically conducted by users, and this dataset only includes speed tests conducted using home connections, or what is also known as fixed broadband – through browsers and apps, not cellular data mobile networks. Granted, slower speed test results may not be related to poor access, but rather to homes subscribing to slower plans despite faster plans being available due to affordability or devices/system issues such as the type and location of Wi-Fi router, device memory, and configuration, etc.[1] Also, users in rural areas may have a higher propensity for speed testing when experiencing network issues.[2]

However, speed tests capture what the user experiences. Likewise, our intent here is not to determine broadband quality or access based on speed tests. Rather, we want to better understand which groups have faster or slower average download and upload speeds. This information can better inform community members, policymakers, internet service providers, and pundits on how broadband is experienced by community groups, which in turn may help explain differences in adoption and outcomes.

[1] https://dl.acm.org/doi/abs/10.1145/3517745.3561441

[2] https://www.sciencedirect.com/science/article/pii/S0143622814000782?via%3Dihub

Specific socioeconomic and demographic variables were selected that are known to affect technology adoption or are directly related to economic development outcomes[3]. The variables analyzed included: the percentage of rural population, the percentage of the population ages 18 to 34, the percentage of the population age 65 or older, the percentage of White non-Hispanic, the percentage of Hispanic, the percentage of the population age 25 or older with a Bachelor's degree or higher, the percentage of individuals in poverty, and the percentage of workers age 16 and older working from home.

DATA & METHODS

Data for this study were obtained from the U.S. Census 2020 Decennial Survey, the 5-Year American Community Survey (ACS), and the Speedtest® by Ookla Global Fixed Network Performance Maps. The decennial Census gathers multiple variables at the Census block level every ten years. One of these variables is the population living in rural Census blocks. The ACS contains hundreds of demographic and socioeconomic variables for all counties in the U.S.

Ookla publishes quarterly data, including average download and upload speeds as well as average latency and number of tests completed. A weighted average by number of speed tests and quarterly data was calculated to obtain 2023 values. Census tracts with fewer than 50 speed tests were removed to minimize the impact of outliers.

All data were downloaded or aggregated to the Census tract level for the year 2023 (2020 for the decennial census). A total of 83,252 Census tracts, or more than 98 percent, were included in the analysis[4]. These, in turn, were divided into five groups with an equal number of tracts (quintiles with roughly 16,630 tracts each) based on specific socioeconomic and demographic variables[5]. Quintiles were used to control the number of tracts per group and avoid different numbers of tracts, as well as provide readers with an easier way to identify patterns or relationships. Weighted average download and upload speeds were then calculated for each quintile.

Lastly, Pearson correlations were calculated to showcase the magnitude and direction of the relationships between variables. Pearson coefficients range from -1 to +1, where a value closer to 0 indicates a weak or no correlation at all. A value closer to -1 or +1 indicates a very strong correlation. A negative coefficient indicates that as one variable increases, the other decreases. A positive coefficient indicates that as one variable increases or decreases, so does the other one.

In addition to analyzing all tracts with Ookla data and 50 or more speed tests, urban and rural tracts were also analyzed separately. Tracts were considered rural if their 2020 decennial rural population in Census blocks was 50 percent or higher. Conversely, urban tracts had less than 50 percent of their population in rural Census blocks. Distinguishing urban and rural tracts sheds additional light on understanding which groups are using faster or slower internet. Pearson correlations were also completed for urban and rural tracts.

[3] Americans' Use of Mobile Technology, Home Broadband | Pew Research Center

[4] There were 84,400 tracts in the 2019-2023 5-Year ACS dataset

[5] Separate quintiles were calculated for each socioeconomic and demographic variable

RESULTS

Before looking at socioeconomic and demographic variable quintiles and average download and upload speeds, **Table 1** breaks down the number of tracts with less than the average 100 megabits per second (Mbps) average download and 20 Mbps average upload (the current broadband definition), as well as by the download-to-upload ratio. This ratio is important to understand because upload speeds are becoming more and more important, particularly as society and the economy continue to digitize, and sending data to the network (upload) is critical for remote work, videoconferencing, etc.

A ratio of one means average download and upload speeds are identical, while a ratio less than one means upload speeds are faster than download speeds. A ratio greater than one means download speeds are higher than upload speeds. For example, a ratio of 3 says that average download speeds for that tract were three times higher than average upload speeds.

TABLE 1. 100/20 Mbps and Speed Ratios

Characteristic	Number of Tracts	Percent Total (83,252)
Less than average 100/20 Mbps	10,388	12.5
Download to Upload Ratio		
Less than 1 (upload is faster than download)	328	0.4
Between 1 and 2.9	37,736	45.3
Between 3 and 4.9	17,479	21.0
Between 5 and 9.9	17,248	20.7
10 or higher	10,461	12.6

Source: Ookla; Author's Calculations

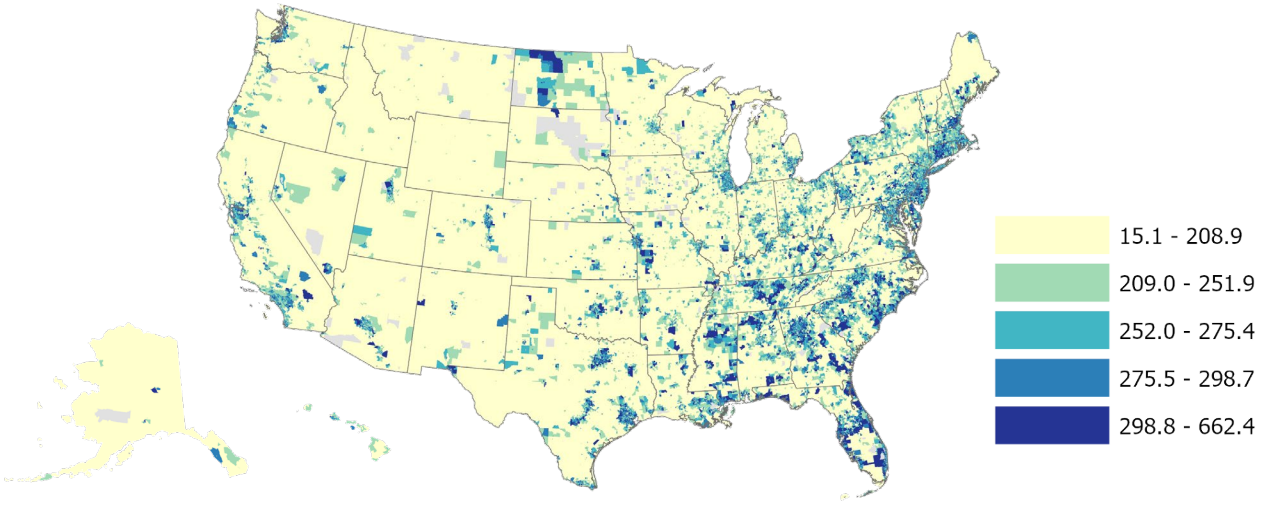
A little more than 12 percent of Census tracts analyzed had an average download and upload speed lower than 100/20 Mbps. This does not mean broadband is not available. However, most folks who completed speed tests were experiencing average download and upload speeds below the current threshold for broadband.

About two-thirds of the Census tracts analyzed experienced average download speeds slightly faster than average upload speeds and up to 4.9 times faster. Less than one percent of Census tracts analyzed had average upload speeds faster than average download speeds. On the other hand, a little more than 12 percent had average download speeds at least ten times faster than average upload speeds. When all is said and done, more than 99 percent of Census tracts analyzed had slower average upload speeds compared to average download speeds.

Figures 1 & 2 show the Census tracts used in this analysis by average download speed and average upload speed quintiles. Notice how the quintile thresholds are faster when looking at download speeds. Second, there is not much of a spatial spread when it comes to average download speeds. Faster tracts are on the east and west coasts as well as urban areas. The rest of the country is in the slower quintile. Regarding upload speeds, however, there is a more noticeable geographic variance. Faster tracts are not only on the east/west coasts or urban areas, but rather suburban and rural areas as well.

FIGURE 1. Average Download Speeds (Mbps) by Quintiles

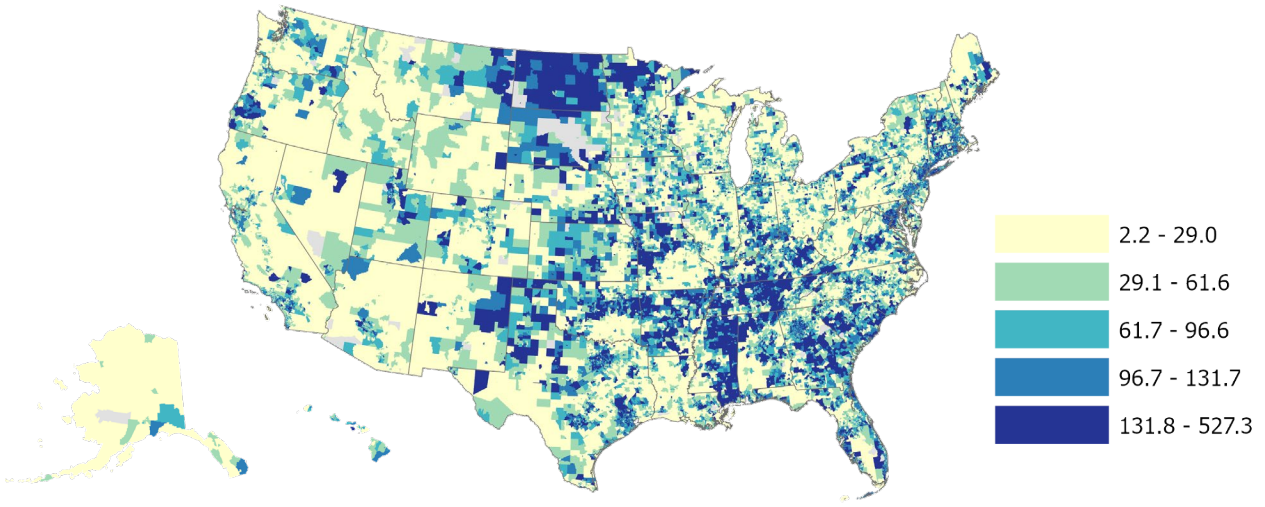
No. of tracts used: 83,252



Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

FIGURE 2. Average Upload Speeds (Mbps) by Quintiles

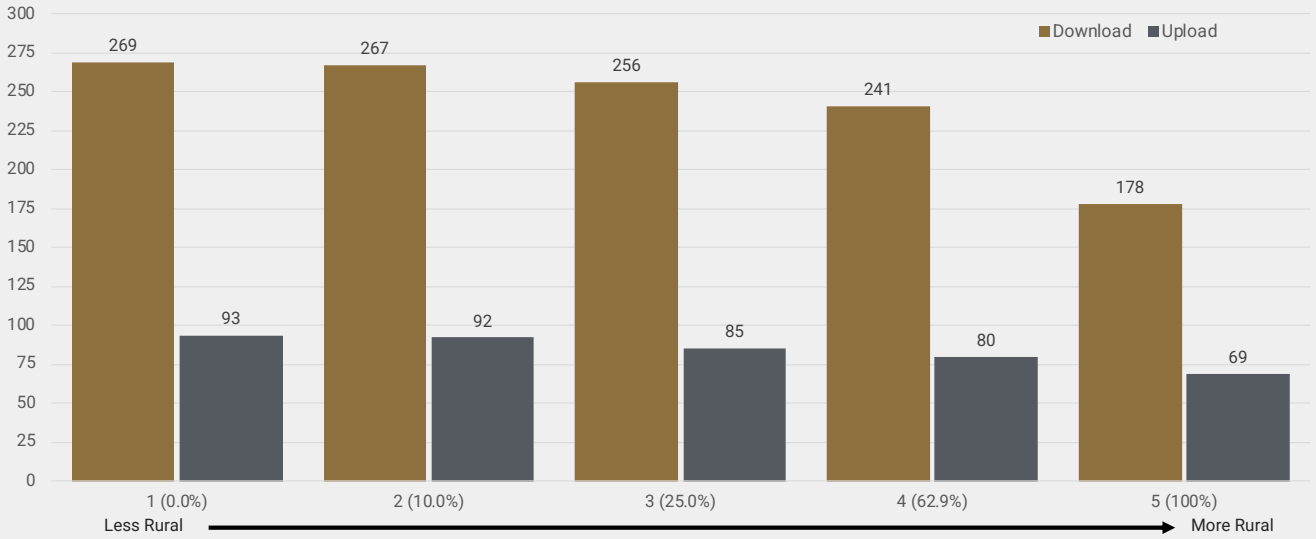
No. of tracts used: 83,252



Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

Figure 3 looks at the percentage of the rural population and average download and upload speeds divided into groups[6]. A trend is noticeable, whereas the percentage of the rural population increases, average download and upload speeds decrease. Notice that the average download speeds in Census tracts where the percentage of rural population was zero were almost 100 Mbps faster compared to Census tracts where the percentage of rural population was 100 percent. The Pearson correlation is much stronger between rural and download (-0.62) versus rural and upload (-0.18).

FIGURE 3. Percent Rural Vs. Download & Upload Speeds (Mbps)



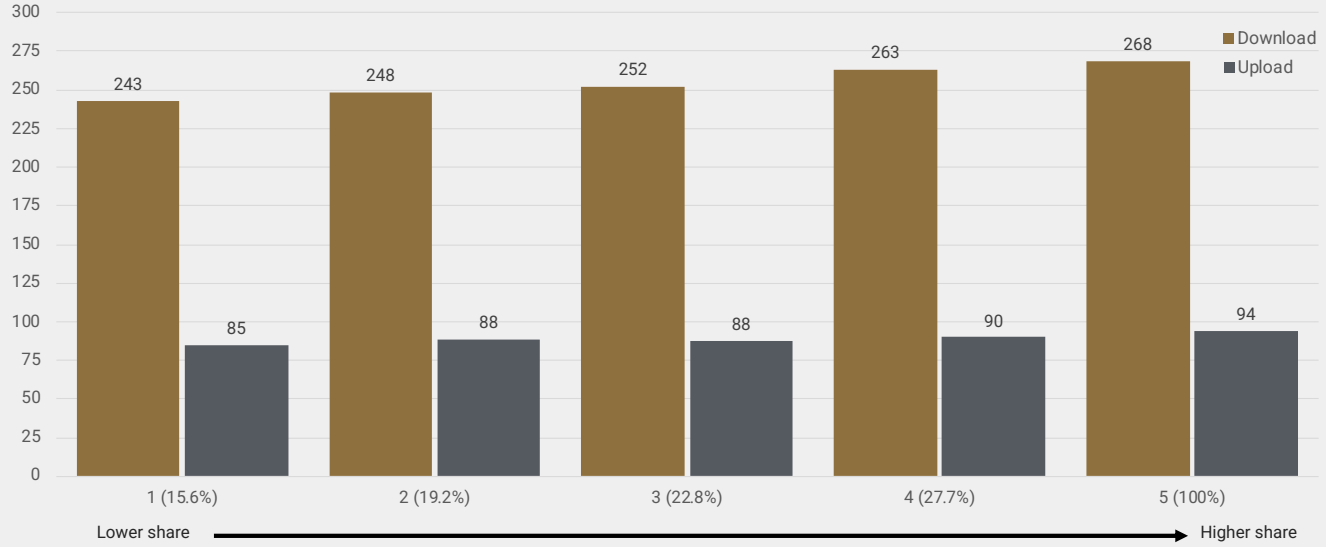
Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 83,190; Pearson correlation coefficients for percent rural & download (-0.62) & upload (-0.18) statistically significant at the p<0.01 level

Figures 4 & 5 show the percentage of the population ages 18 to 34 and age 65 or older, and average download and upload speeds divided into quintiles. Regarding the younger age group, there is a visible pattern where the share of those ages 18 to 34 increases, and both average download and upload speeds increase. However, this trend is inverted when looking at Figure 3, whereas the share of those ages 65 or older increases, the average download and upload speed decreases. All Pearson correlation coefficients are statistically significant at the p<0.01 level and confirm that the relationship with the younger age group is positive, albeit weak, while being negative and slightly stronger with the older age group.

[6] Quintiles were not used for this variable given its variance. Groups 1, 4, and 5 did follow percentile breakdowns.

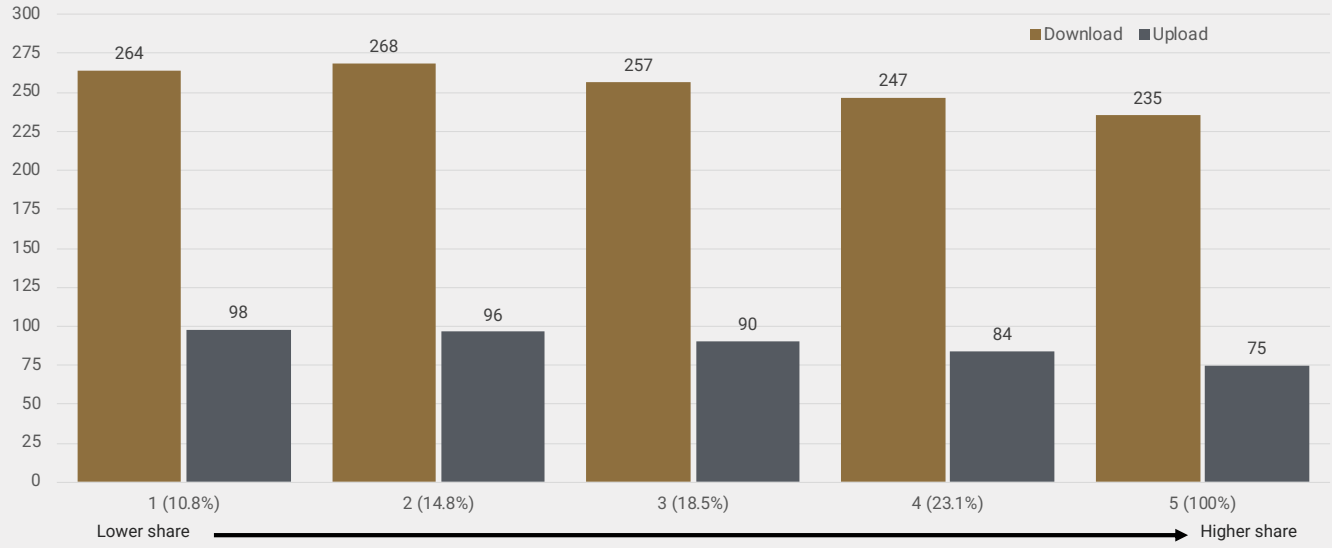
FIGURE 4. Percent Ages 18-34 Vs. Download & Upload Speeds (Mbps)



Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 83,252; Pearson correlation coefficients for percent age 18 to 34 & download (+0.15) & upload (+0.06) statistically significant at the p<0.01 level

FIGURE 5. Percent Age 65+ Vs. Download & Upload Speeds (Mbps)

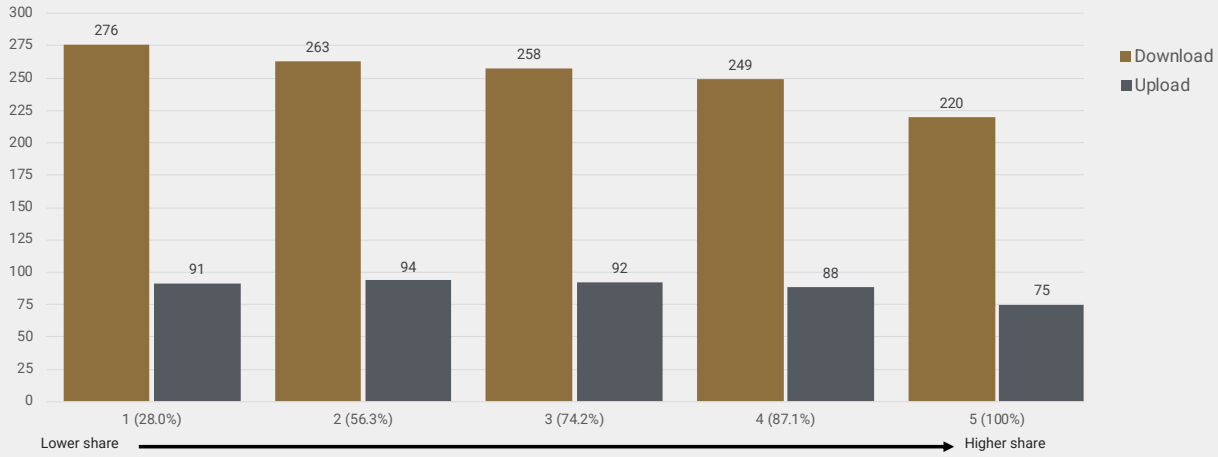


Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 83,252; Pearson correlation coefficients for percent age 65+ & download (-0.23) & upload (-0.14) statistically significant at the p<0.01 level

Next, we look at race/ethnicity. **Figures 6 & 7** show the percentage of the population that is White non-Hispanic and the percentage of the population that is Hispanic[7] divided into quintiles. Figure 4 shows that as the share of White non-Hispanics increased, average download and upload speeds decreased. The Pearson correlation coefficients were both negative and statistically significant. When it comes to the share of Hispanics, this relationship is positive and has a slightly weaker Pearson coefficient. This is consistent with recent peer-reviewed research findings.[8].

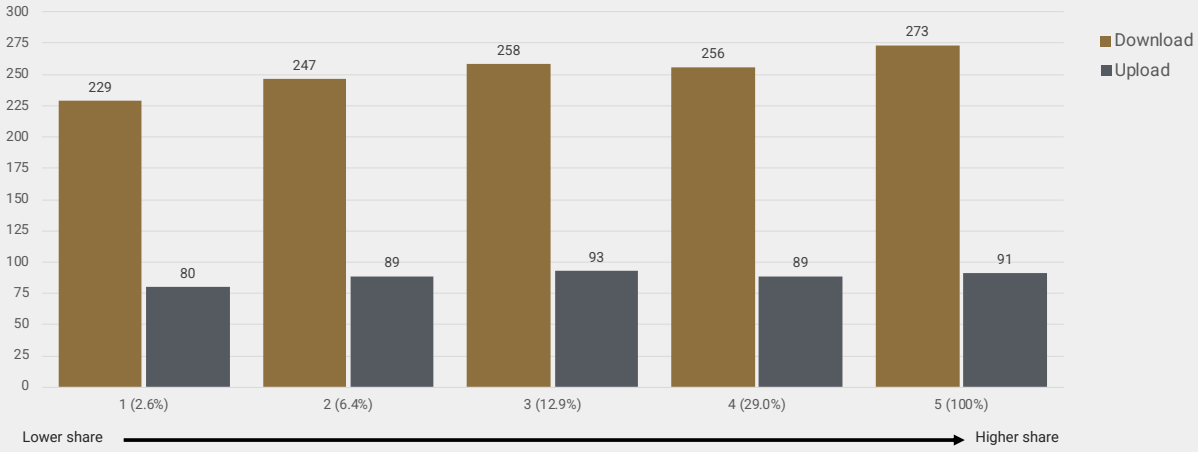
FIGURE 6. Percent White non-Hispanic Vs. Download & Upload Speeds (Mbps)



Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 83,252; Pearson correlation coefficients for percent age 65+ & download (-0.28) & upload (-0.08) statistically significant at the p<0.01 level

FIGURE 7. Percent Hispanic Vs. Download & Upload Speeds (Mbps)



Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

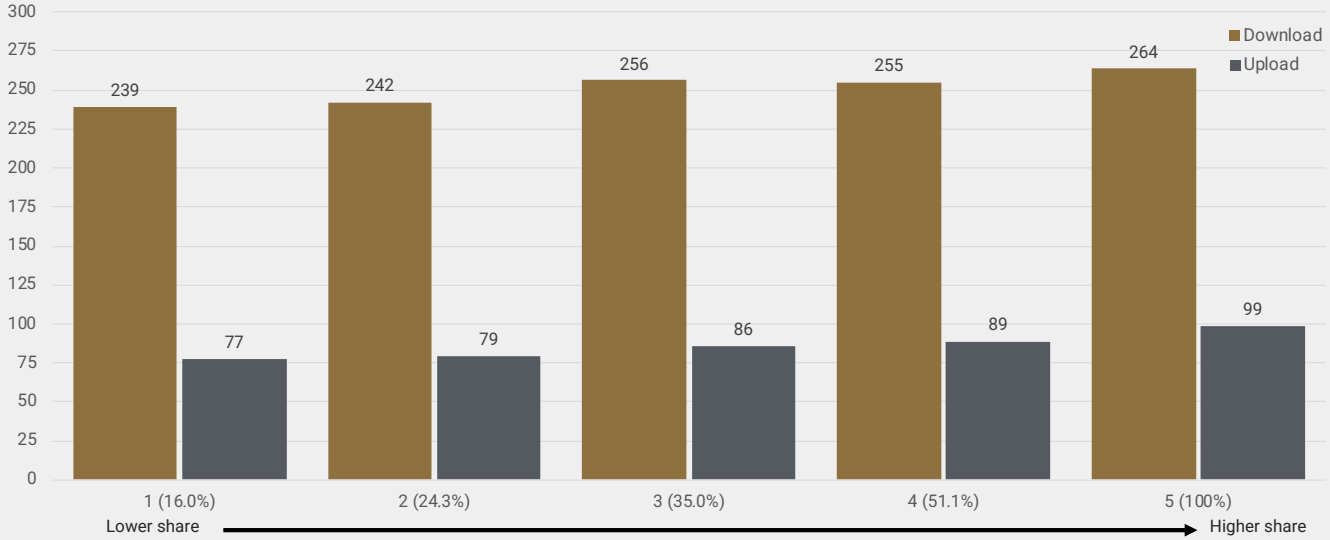
No. of tracts used: 83,252; Pearson correlation coefficients for percent age 65+ & download (+0.20) & upload (+0.03) statistically significant at the p<0.01 level

[7] Hispanics were selected because they are the largest minority group in the country. The Census Bureau identifies 8, mutually exclusive race/ethnicity categories.

[8] https://www.sciencedirect.com/science/article/pii/S0308596124000740

Figure 8 divides the share of those age 25 or older with a bachelor's degree or higher into quintiles. There is a weak, positive relationship between the more educated and faster average download and upload speeds. Tracts with the lowest share of those with a bachelor's degree or higher (<16%) had average download speeds almost 30 Mbps slower compared to tracts where the share of the most educated was higher. The Pearson coefficients were statistically significant, and both were positive and weak (0.17).

FIGURE 8. Percent Age 25 or Older with a Bachelor's Degree or Higher Vs. Download & Upload Speeds (Mbps)

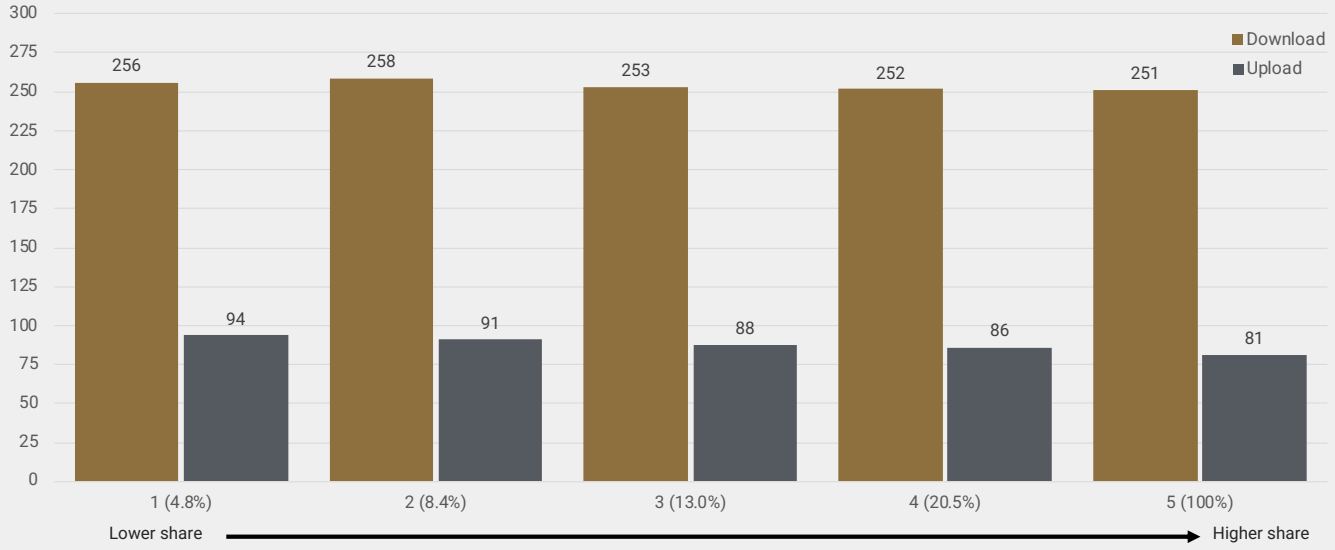


Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 83,242; Pearson correlation coefficients for percent age 25+ with a bachelor's or higher & download (+0.17) & upload (+0.17) statistically significant at the p<0.01 level

Five groups based on the individual poverty rate and average download and upload speeds are shown in **Figure 9**. There is a negative, though weak, relationship. Pearson coefficients were negative and statistically significant, but weak (less than -0.1).

FIGURE 9. Individual Poverty Rate Vs. Download & Upload Speeds (Mbps)

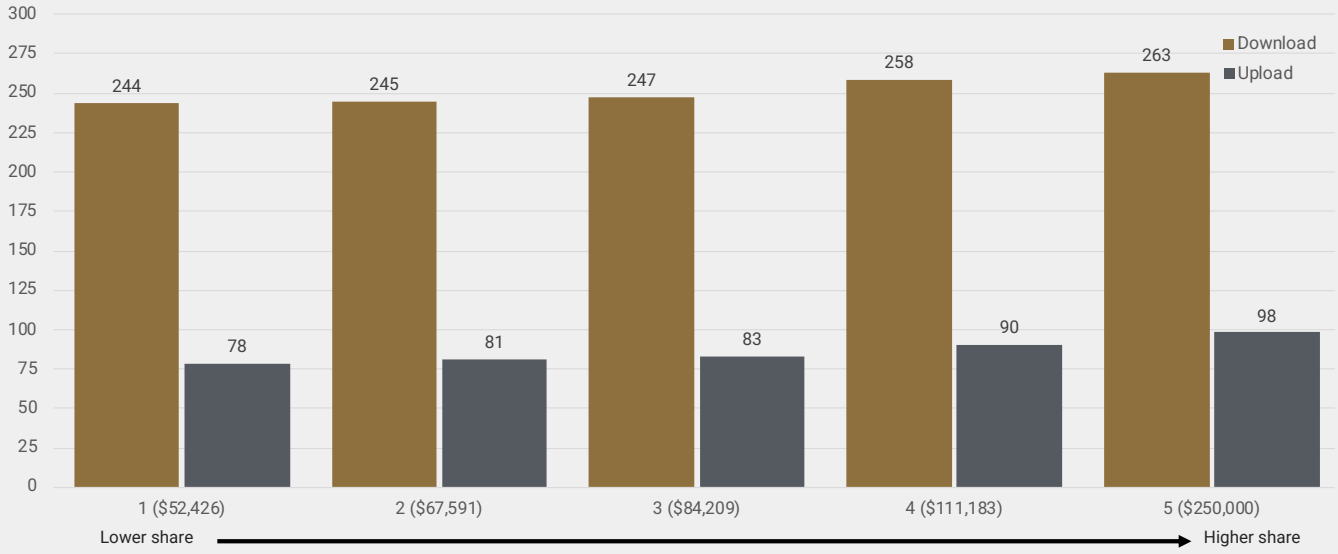


Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 83,134; Pearson correlation coefficients for individual poverty rate & download (-0.05) & upload (-0.09) statistically significant at the p<0.01 level

Median household income quintiles and average download and upload speeds are shown in **Figure 10**. As expected, as the average median household income increases, so do the average download and upload speeds. Notice also that the Pearson coefficients are the same for download and upload. In other words, the strength and magnitude of the relationship with median household income is the same for download and upload speeds.

FIGURE 10. Average Median Household Income Vs. Download & Upload Speeds (Mbps)

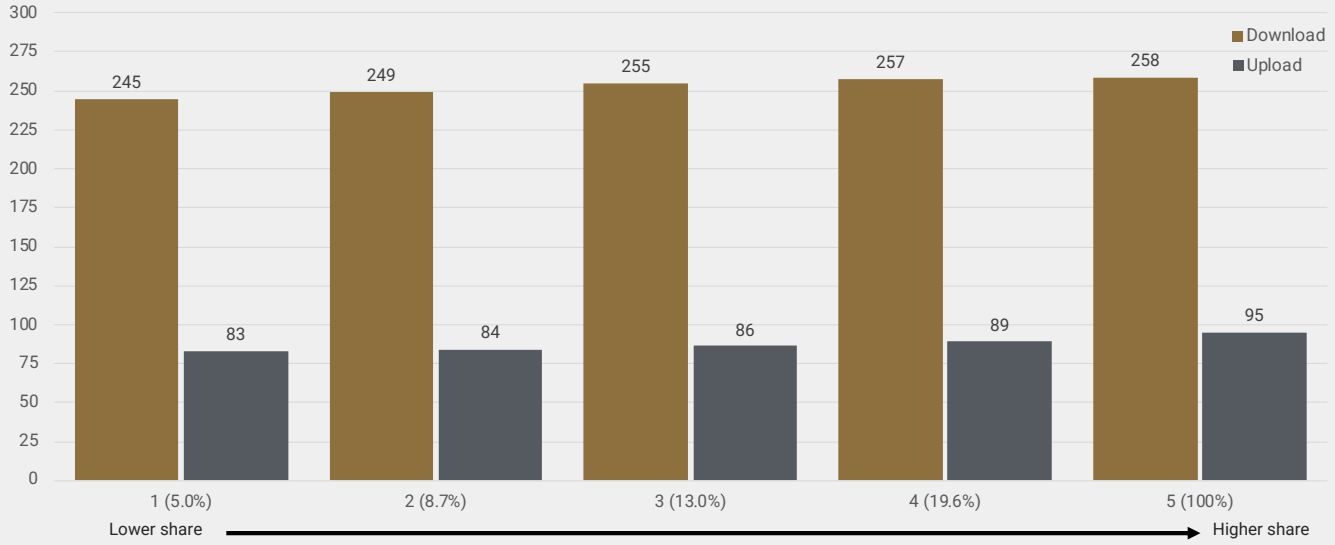


Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 82,672; Pearson correlation coefficients for median household income & download (+0.14) & upload (+0.14) statistically significant at the p<0.01 level

Lastly, **Figure 11** divides the share of workers aged 16 or older working from home and average download and upload speeds. Here, too, a weak relationship is visible. The Pearson coefficients were positive and statistically significant, but weak (+0.11).

FIGURE 11. Percent Working from Home Vs. Download & Upload Speeds (Mbps)



Source: 2023 Speedtest® by Ookla Global Fixed Network Performance Maps; Census 2019-2023 ACS

No. of tracts used: 83,180; Pearson correlation coefficients for individual poverty rate & download (+0.12) & upload (+0.11) statistically significant at the p<0.01 level

In other words, faster average download and upload speeds existed in tracts with a lower rural population, a younger population, a higher share of Hispanics, more educated, and a higher share of those working from home. On the other hand, slower average download and upload speeds existed in tracts with a higher share of rural population, older, White non-Hispanic, and individual poverty rate.

Table 2 shows the Pearson coefficients between selected characteristics and average download and upload speeds by types of Census tracts (overall, urban, or rural). All results are statistically significant at the p<0.01 level unless specified. The number of tracts analyzed is shown in parentheses, and the strongest correlation coefficients are bold.

Several results are worth discussing. First, the strongest correlations were between average download and upload speeds and the percentage of the rural population. This confirms that an urban-rural digital divide remains, even when utilizing average internet speeds. Note as well that the negative relationship is weaker with upload speeds. This alludes to the fact that tracts with higher rural populations also have faster upload speeds, compared to download speeds. On the other hand, educational attainment, income, and percentage of workers working from home had almost identical download and upload correlation coefficients[9].

[9] These three variables are highly correlated, with an average Pearson coefficient of +0.70.

Second, among urban tracts, the strongest correlation with download speeds was with the percentage population age 65 or older, while the strongest relationship with average upload speeds was with the share of the population age 25 or older with at least a bachelor's degree. In urban tracts, the older population experienced slower download speeds while the more educated experienced faster upload speeds. Likewise, note how average upload speeds were more strongly correlated with median household income in urban tracts compared to average download speeds. Also note that the correlation between download and being more educated was negative, though very weak. More research is needed to further untangle this relationship.

Among rural tracts, older and more educated groups experienced faster download speeds, while older folks also experienced slower upload speeds. And while the correlation with more educated and upload speeds was negative (the opposite of what was observed in urban tracts), it was not statistically significant. An interesting fact that future research can help explain is why more educated individuals were correlated with faster upload speeds in urban tracts, while being correlated with download speeds in rural tracts. Perhaps it has to do with the type of work being conducted by more educated individuals in urban versus rural areas.

TABLE 2. Pearson Coefficients for Speed Tests and Specific Socioeconomic Characteristics

Variable	Overall		Urban		Rural	
	Avg. Download	Avg. Upload	Avg. Download	Avg. Upload	Avg. Download	Avg. Upload
Percent Rural	**-0.62** (83,190)	**-0.18** (83,190)	-----	-----	-----	-----
Percent Ages 18 to 34	+0.15 (83,252)	+0.06 (83,252)	-0.00[N] (65,378)	+0.02 (65,378)	+0.09 (17,812)	+0.05 (17,812)
Percentage 65 or Older	-0.23 (83,252)	-0.14 (83,252)	**-0.15** (65,378)	-0.12 (65,378)	**-0.16** (17,812)	**-0.11** (17,812)
Percent White non-Hispanic	-0.28 (83,252)	-0.08 (83,252)	-0.14 (65,378)	-0.02 (65,378)	+0.04 (17,812)	-0.00[N] (17,812)
Percent Hispanic	+0.20 (83,252)	+0.03 (83,252)	+0.13 (65,378)	+0.00[N] (65,378)	-0.06 (17,812)	-0.06 (17,812)
Percentage 25 or Older with a Bachelor's Degree or Higher	+0.17 (83,242)	+0.17 (83,242)	-0.03 (65,372)	**+0.16** (65,372)	**+0.16** (17,810)	-0.01[N] (17,810)
Individual Poverty Rate	-0.05 (83,134)	-0.09 (83,134)	-0.11 (65,282)	-0.13 (65,282)	-0.11 (17,795)	+0.2 (17,795)
Median Household Income	+0.14 (82,672)	+0.14 (86,672)	+0.05 (64,900)	+0.16 (64,900)	+0.19 (17,716)	-0.01[N] (17,716)
Percent Working from Home	+0.12 (83,180)	+0.11 (83,180)	+0.00[N] (65,319)	+0.12 (65,319)	+0.02 (17,802)	-0.06 (17,802)

Notes: [n] not statistically significant

Older residents experienced slower download speeds in urban and rural tracts. Remote workers were associated with faster upload speeds in urban tracts and slower upload speeds in rural tracts. White non-Hispanic individuals were associated with slower download and upload speeds overall and in urban tracts, but not in rural tracts. Lastly, individuals in poverty experienced faster upload speeds in rural tracts, but slower download and upload speeds in urban tracts.

CONCLUSIONS

As more broadband data becomes available, additional research is being conducted that broadens our understanding of the digital divide. In the past, binary yes/no analyses were conducted. Today, thanks in part to internet speed and data availability, additional research is being done that sheds additional light on the digital divide.

This study utilized average download and upload speeds and specific socioeconomic variables to uncover which groups use faster or slower broadband. A simple Pearson correlation analysis was conducted to gauge the type (direction) and strength (magnitude) of these relationships.

Results present a mixed bag of insights. While the urban-rural divide continues, different groups experience faster/slower download and upload speeds. Future research can focus on a particular group and include qualitative data to better understand the level of access to technology that exists and how it is being used. One thing is clear: as more data becomes available, the digital divide becomes more complex.

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