Digital Equity as a Pathway to Academic and Health Success – Lessons from Higher Education and Telehealth Initiatives

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Abstract

For many students and families, the digital divide is more than an inconvenience, it is a barrier to learning, health, and opportunity. In today's classrooms, lack of laptops or reliable broadband access can mean falling behind in coursework. In many communities, the same lack of access can mean missing a doctor's appointment or vital health information. This study examines how digital equity initiatives can simultaneously enhance academic success and health outcomes through integrated education and telehealth interventions. Guided by the Social Determinants of Health (SDH) framework and Rogers' Diffusion of Innovation (DOI) theory, the research analyzes a cross-sector digital inclusion initiative that provided laptops, broadband connectivity, and digital literacy training to underserved students and community residents. While part of a broader mixed methods initiative, this paper focuses on the quantitative analysis of the digital equity outcomes. Data were derived from student academic records (N=580), telehealth usage logs (N=50), and structured questionnaires (N=50). This research employs statistical modeling to explore the effects of multi-pillar digital interventions, encompassing hardware, connectivity, and training on longitudinal academic engagement and telehealth utilization.

Observations indicate that improved access to digital resources increases student engagement, participation in telehealth services, and overall satisfaction with learning and health support programs. Findings reveal that broadband access was a statistically significant indicator of educational engagement with a P-value of 0.029 while access to laptop devices fell into a marginal range of 0.072. This indicates an obvious distinction between the necessity of a connection and the presence of a device. Further findings also show that students with broadband connections are significantly more likely to engage in telehealth services compared to those without such access. Students equipped with broadband internet are 5.23 times more likely to employ telehealth services than other students who lack such access, confirming that the presence of broadband multiplies telehealth use chances.

Keywords: *digital equity, telehealth, higher education, broadband connectivity, social determinants of health.*

Introduction

It is undeniable that the rapid growth in digital technology has positively influenced numerous sectors such as education and health. This growth has provided previously absent opportunities and reshaped access to information, learning modalities, and service delivery modes [1]. Digital technologies not only serve as essential infrastructure for accessing course materials, completing assignments, participating in online discussions but also navigating and accessing healthcare services. Despite the numerous advantages and widespread usage, its benefit is not fairly distributed among various populations. A large proportion of students do not have equal access to digital resources or equivalent levels of digital competency. These disparities, collectively

termed the "digital divide" have significant implications for educational and telehealth equity [2]. Digital divide as defined by the National Digital Inclusion Alliance refers to inconsistency in accessing and efficiently engaging digital technologies within individuals and communities, due to the disparity in digital infrastructure, skills, and support [3]. Financial limitations and insufficient digital infrastructure also constitute part of this multidimensional inequality known as the "digital divide" [3].

Within the educational context, students from low-income backgrounds, first-generation college attendees, those who come from rural regions, encounter increased vulnerabilities to digital exclusion. These students are less likely to possess personal computers, more inclined to depend on smartphones as their principal internet-enabled device, and more prone to encounter unreliable or insufficient internet connectivity. [4, 5]. The impacts of digital disparity in education are critical. Students experiencing digital divide face various challenges from accessing education resources to engaging with their faculty and peers. As a result, these students are equally digitally excluded and often have poor academic performance and learning outcomes [6, 7]. Additionally, digital inequities compound to other forms of disadvantage that go beyond education. The profound implication of digital divide is observed in health care access and equity. The use of technology in healthcare delivery is increasingly influenced by digital connectivity [8]. Telehealth refers to the delivery of healthcare services through adoption of any form of technology and telecommunication [9]. This includes accessing online health information, scheduling a video call with a doctor or healthcare provider, and receiving messages via online portals [9]. Individuals are hence willing to frequently employ telehealth due to its various advantages such as reduced travel time and cost and the flexibility to both provider and patient convenience [10, 11, 12]. Nonetheless, the advantages of telehealth are not evenly distributed. Inadequate internet connectivity, insufficient digital literacy, and restricted access to digital devices disproportionately impact underprivileged groups [8]. These barriers hinder individuals' access to telehealth, consequently deepening existing disparities in health. Bridging this divide requires focused intervention in digital infrastructure, skills training, and enhanced internet access to foster digital equity.

In the light of the digital inequities influencing both educational and health outcomes, this study observes an already implemented multi-sector digital equity project conducted by a non-profit organization. This initiative was funded by a non-profit organization to expand broadband access and digital literacy in the northeastern region of the USA. Anchored at a HBCU. This study was designed with the intention to facilitate digital inclusion among university students as well as community members. This study underscores evidence that universities catering for marginalized populations are well equipped to address digitally divide [13, 14]. This intervention incorporates provision of digital devices, broadband and telehealth education. The project supported the distribution of 580 laptops to university students, with subsequent telehealth education. Additionally, 50 laptops were distributed to eligible residents for telehealth services, and 200 laptops were distributed to eligible community members as well as targeted digital and connectivity support with the aim of improving the participants' capacity with digital platforms and telehealth services. This project utilized community trust, institutional strength and equity centered mission to solve the interconnected differences by using the university and urban community as location for sites. The study examined how interventions towards digital equity affect education and health sectors and provides a model for how HBCUs act as anchor institutions for mitigating digital divide in underserved communities.

Research Questions

This study seeks to answer the following research questions:

1. What is the effect of Broadband and Laptop Access on Students' Education Engagement?

2. Is the relationship between Students' Broadband Internet Access, Household Health Condition and Telehealth Services?

Theoretical and Conceptual Framework

This study integrates Social Determinant of health (SDH) frameworks and Rogers' Diffusion of Innovation theory (DOI) to provide a more robust structural conditions impacting technology adoption.

Social Determinant of Health (SDH)

This study is underpinned by the Social Determinant of Health (SDH) framework shown in figure 1.

Figure 1: Social Determinants of Health [15]

This framework underscores that non-medical factors largely shape health and educational outcomes. These factors include social, economic and environmental conditions as well as distribution of power, wealth and resources at global, national and local level [16]. The World Health Organization defines SDH as "the conditions in which people are born, grow, live, work and age" which are themselves influenced by broader political, social and economic forces [17]. This implies that health and educational outcomes are strongly determined by structural

disadvantages and the level of deprivation within individuals' living environment. Studies have identified digital divide as a structural determinant of health as it hinders people's ability to access healthcare services and health information. [18] asserts that the benefit of digital health tools is disproportionate and an individual's ability to engage these tools amounts to their social and economic background making it difficult for the marginalized population to access healthcare. As such, access to broadband and devices as well as digital literacy are all SDH related factors that influence individual's access to digital health systems. Similarly, [19] viewed digital health equity from the perspective of political economy. He reports that digital exclusion is not restricted to mere gaps in technology but a reflection of a wider social and economic imbalance within the healthcare system. This aligns with World Health Organization [20] assertions that economic policies and systems are wider forces contributing to SDH.

Additionally, digital literacy has also been identified as a critical mechanism linking social determinants to health and educational outcomes. [21] found that the socioeconomic status of rural residents influenced their engagement in digital health behavior with educational level as well as their income level impacting their ease to embrace digital health services. These findings imply that intervention towards alleviating inequity in education and health sectors must address both access to digital infrastructure and skills needed to utilize the technologies effectively.

This study views educational engagement and telehealth usage as interrelated outcomes of digital inclusion. Access to broadband connectivity and digital literacy are fundamental structure determinants within SDH framework which influences learning opportunities and health care access. Digital literacy gained via educational participation can influence ability to navigate health systems digitally while improved connectivity enabling telehealth access may likewise facilitate participation in digital learning environments. This implies that interventions directed towards digital equity can generate a ripple effect across domains by simultaneously imparting academic behavior as well as health seeking behaviors.

Rogers' Diffusion of Innovation (DOI) theory

Roger's Diffusion of innovation explains how new ideas or technologies spread within a social system over time through communication channels and social influence [22]. The emphasis of this theory is that adoption is not totally dependent on access alone, rather on individuals' perceived opinion of an innovation's advantage, compatibility, observability and trialability. The theory further classifies adopters into five categories based on readiness to adopt a new technology. These categories as shown in Fig 2 include innovators, early adopters, early majority, late majority, and laggards, where the underserved populations fall in the late adopters and laggards' categories. Thus, reflecting the influence of social and structural factors on pace and pattern of adoption.

Within the context of digital divide, DOI demonstrates why marginalized populations often remain as late adopters of digital technology despite the availability of infrastructure. Digital literacy, low trust and inadequate institutional support are common barriers that limit this part of the broader population. Thus, DOI serves as an important framework for understanding how access to devices, broadband connectivity and digital skills training jointly impact and the adoption and sustenance of digital health and educational technologies.

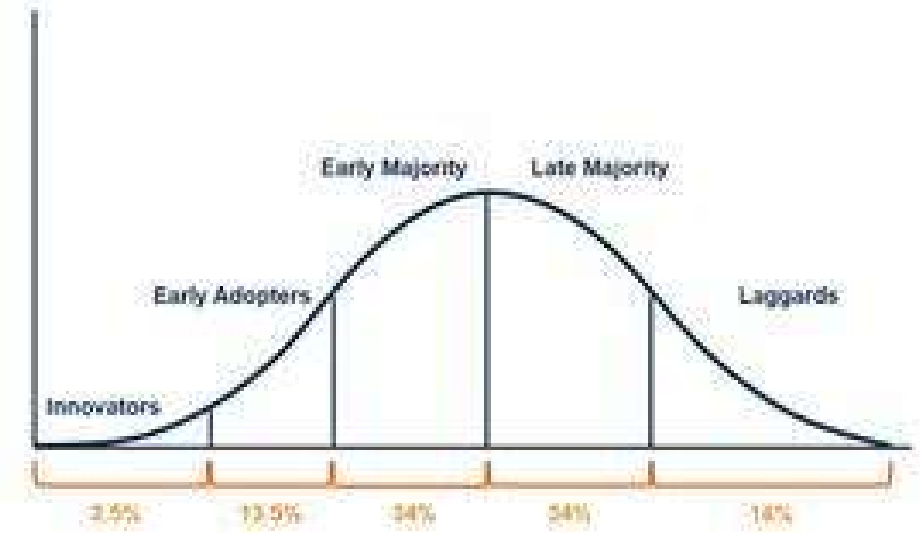

Figure 2: Distribution of Adopters [23]

While earlier studies indicate that device ownership, access to connectivity and other relevant infrastructures are pivotal in enhancing digital and educational equity [4], [24] however argued that providing digital infrastructure alone is not sufficient to alleviate digital exclusion. Rather, digital literacy, belief in technological impact and culturally relevant supports are equally needed in adoption and sustained use. This is corroborated by [25] whose research discovered a higher adoption of telehealth among the black population in comparison to the white population due to perceived health threat. This finding reinforces Roger's idea that the perceived advantage of technology accelerates its adoption within a community. These findings reinforce the importance of DOI in persistent digital inequities beyond mere access.

Conceptualizing the Triad: Devices, Broadband, and Literacy Training

Digital equity is increasingly understood as a multidimensional construct that requires the concurrent availability of appropriate digital devices, reliable high-speed internet access, and skills necessary to use digital technologies effectively. Recent studies commonly assert that intervening on any one component alone is insufficient, as meaningful participation in education and healthcare ecosystems depends on interaction with each of the three elements [26, 27]. In the learning environment, the use of devices and internet access is the foundation for students to achieve success. [26] noted that students who lacked internet access or devices for learning lacked engagement and recorded poor results while carrying out online education. Likewise, UNESCO [28] found that more than 60% of elementary schools around the world were without access to the internet. Additionally, research indicates that the distribution of devices and connectivity to support improved academic results also requires the distribution of digital skills to the end-user.

Digital literacy skills training has been found as one of the essential mediators of outcomes. [29] argued that there is a positive influence of digital literacy skills on academic outcomes, and both digital self-efficacy and unplanned learning of digital skills emerged as essential mediators.

Students who had better skills were more capable of exploiting internet services effectively. This points towards the coming together of the triad of accessibility, as technology is used as an enabler of accessibility, and skill levels of technology determine its effective use. This relationship also holds for telehealth. Regarding this, a study conducted by [27] revealed a significant association between those who use only smartphones and mobile internet and missed telehealth appointments when compared to the use of broadband internet and computers. According to [30], just 26% of seniors in a middle-income nation possessed sufficient e-Health literacy. In both higher education and the field of telehealth offerings, consensus has been reached within literature concerning the following research finding that the combination of devices, access, and literacy creates digital equity. However, some knowledge gaps remain. The number of longitudinal studies on the lasting efficacy of triad-related intervention is small, and there is a lack of quality research on models for digital literacy on a scalable level for at-risk populations. Future research endeavors must avoid the mindset of solely focusing on the area of access.

Methodology

This research was conducted among undergraduates in a Historically Black College and University (HBCU) in the USA and the residents of northeastern region of the USA from Fall 2023 to Spring 2024. The participants were 580 HBCU undergraduates (predominantly aged 18-24, with student status verified through institutional records) and 250 community residents (aged 18 and older, including vulnerable populations identified by socioeconomic eligibility criteria such as limited broadband access). The study strictly follows a quantitative research design, and the concepts used in the study were deduced using the theories of digital equity and inclusion as Social Determinants of Health (SDH) and Rogers' Diffusion of Innovation (DOI) theory. This approach gives unbiased information about the role of digital equity in educational success and health care access outcomes. Validity was maintained by data source triangulation, use of anonymized data, and statistical verification. The research was approved by the Institutional Review Board of the HBCU (IRB Protocol #XXX, 2023, 045) and all activities were carried out in compliance with participant privacy and consent standards.

Implementation Framework

The triadic model of implementation is used to examine the function of digital equity to an end in terms of academia and health. The model covers device access, infrastructure, and capacity as constituent and reinforcing parts of digital equity. The basis of the model and its selection emanate from the realization that digital equity, to an end, basically involves a series of unrelated tasks [31].

Digital Inclusion and Telehealth Training Program Evaluation

The Digital Inclusion and Telehealth Training Program were evaluated through a mixed-methods data collection methods. The NGO Health and Broadband Connectivity Needs Survey (a 37- item questionnaire covering aspects of access, skills, and health status) was carried out with 50 people, both in-person and electronically from March to November 2024, for the initial needs assessment as well as for the post-training follow-up. The resulting data was quantitatively analyzed in SPSS. After device distribution, 14 students who took part in the training were

divided into four focus groups in November 2024, following semi-structured protocols. The discussions that were audio-recorded were thematically analyzed in NVivo through inductive coding (e.g., recognizing gratitude themes) and deductive alignment with frameworks such as Diffusion of Innovations (DOI) and Social Determinants of Health (SDH), which was complemented by content analysis to convert qualitative insights into numeric data. Notably, the focus group discussion was carried out to inform a broader project, but they are not part of the current findings.

Besides that, telehealth training participation logs for 35 out of 50 trainees were used for quantitative engagement tracking (e.g. attendance and completion rates) which has been ongoing since April 2024 via Salesforce and spreadsheets. This is further presented in Table 1.

Table 1: Overview for the Digital Inclusion and Telehealth Training Program Evaluation

Element	Instruments	Timing/Sequencing	Number of Respondents / Observations	Generation/Analysis Method
Surveys	NTIA Health and Broadband Connectivity Needs Survey (37 items on access, skills, health status)	March-November 2024 (initial needs assessment, followed by post-training follow-up)	50 respondents	Distributed physically in-person/electronically; analyzed via SPSS.
Focus Groups	Semi-structured protocols (e.g., questions on reactions, usage, barriers) with audio transcripts which are later converted to numerics through content analysis	November 2024 (post-device distribution)	14 students (across 4 groups)	Recorded discussions generated observational data; analyzed thematically using NVivo for inductive coding (e.g., gratitude themes) and deductive alignment with DOI/SDH.
Telehealth Logs	Training participation records (e.g., attendance, simulated use during sessions)	Ongoing from April 2024 (post-laptop distribution)	35 logs (from 50 trainees)	Generated via Salesforce/spreadsheets by program staff; analyzed quantitatively for engagement metrics (e.g., completion rates).

Infrastructure Upgrades

The second pillar focuses on the structural issues related to connectivity, which was enabled via the installation of Wi-Fi 6E in areas of heavy student traffic such as libraries, residence halls, student centers, and health service facilities. The choice of Wi-Fi 6E technology came due to its ability to offer higher bandwidth, lower latency, and the ability to support numerous users at the same time, which is important for hybrid learning environments, telehealth visits, or data-intensive scholarship. The installation was done using usage analytics in a manner that was optimized for spatial demand.

Capacity Building

The third pillar focused on the development of human capacity for telehealth literacy and technical certification. The students underwent training sessions aimed at equipping them with skills for telehealth platform use, digital privacy and security, and telehealth communication. On the other hand, technical certification opportunities were available with the intent of improving digital skills and employability. The combination of the two covered the basis for ensuring that the students had access not only to technology but also the skills to leverage access for the sake of academic and health achievements.

Through these three elements, there exists an integral framework for implementing digital equity as an educational intervention as well as an intervention for public health. The integrative approach where device access, high-quality infrastructural support, and building capacity come together shows how digital equity can be collectively harnessed for academic achievement, telehealth utilization, and enhancing higher education inclusive systems.

Quantitative Data Sources

Data sources consisted of academic performance metrics that include course completion rates from institutional records, telehealth usage logs (anonymized records of actual engagement, such as session frequency, service types, and continuity for 50 residents post, training), and structured surveys such as the Health and Broadband Connectivity Needs Survey. A 37-item instrument assessing internet access-device ownership, and telehealth interest, was administered to 50 residents via the Polco vendor. No observational or qualitative data were considered.

Data Collection and Analysis

Three data collection instruments were used: (1) the survey to establish a baseline for connectivity and health needs; (2) academic records for performance metrics; and (3) telehealth records for patterns of usage. Planning followed a phased sequence with baseline surveys scheduled for March-April 2024 (before the distribution), device distribution and infrastructure upgrades April-August 2024, and post-intervention logs/academic metrics collected till Spring 2025. Number of respondents/observations: 50 survey participants, 580 student records, and 50 telehealth logs. Regression analysis and chi-square analysis were used for the analysis through SPSS. This data analysis is in line with each objective of the study. To establish “The Effect of Broadband and Laptop Access on Students’ Education Engagement” the study used simple linear regression analysis with broadband and laptop access as independent variables and students’ education engagement as dependent variables. To establish the “Relationship between Internet

Access and Household Health Condition," the study used Chi-square test. Lastly, to establish "The Effect of Students Broadband Internet Access on Telehealth Service," the study used binary logistic regression analysis.

Results and Preliminary Findings

The regression results from Table 2 and Figure 3 reveal that broadband and laptop access have different impacts on students' educational engagement. Broadband access positively and significantly affects educational engagement (B = 0.071, = 0.153, p = 0.029), students who have broadband at home are more likely to be engaged in their educational activities. Access to laptops was not significant when measured at the 5% significant level (p = 0.072) despite it being positively correlated with educational engagement (B = 0.456, Beta = 0.126).

Table 2: The Effect of Broadband and Laptop Access on Students' Education Engagement

Model	Unstandardized Coefficients (B)	Beta	Sig.
(Constant)	0.819		0.001
Broadband access	0.071	0.153	0.029
Access to laptop	0.456	0.126	0.072

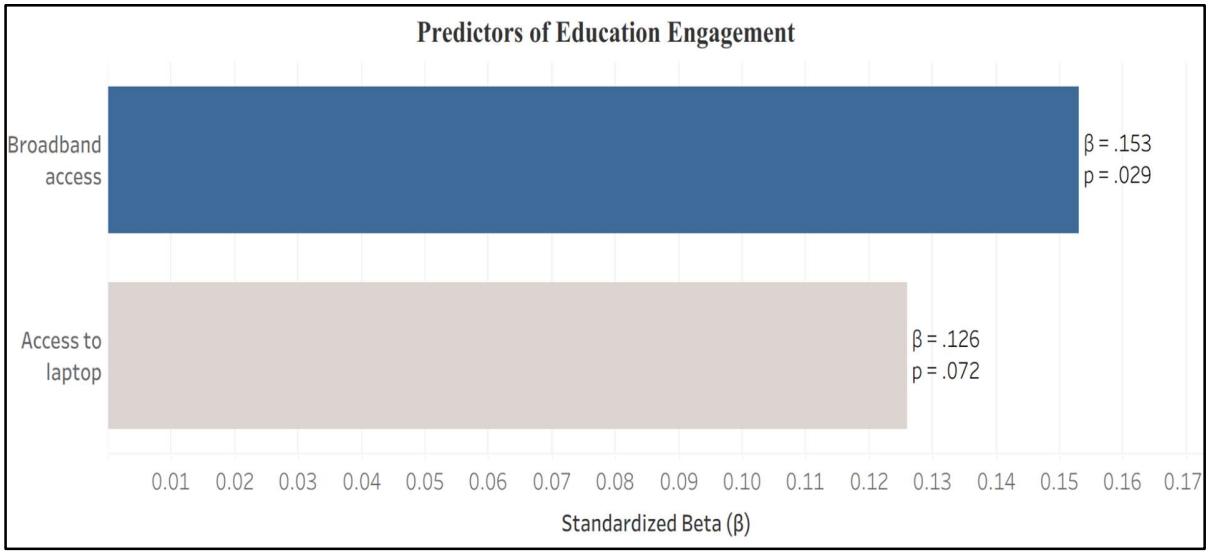

Figure 3. Standardized beta (β) coefficients for broadband access and laptop access as predictors of students' education engagement. Broadband access was positively and significantly associated with educational engagement (β = .153, p = .029), while laptop access was also positive but did not reach conventional statistical significance (β = .126, p = .072).

This means that the impact of the laptop variable on educational engagement is considerably less than the impact of broadband when both variables are considered simultaneously. It also implies that students have other internet devices such as phones which enhance their academic engagement aside from access to laptops. Furthermore, having a significant constant (B = 0.819, p = 0.001) means a positive level of educational engagement exists even without having these access variables. Holistically, the results point toward the fact that students' educational engagement is a lot more influenced by having dependable broadband access than by owning a device. It also highlights the fact that a wider availability of connectivity and technology, learning time or time invested in learning improves significantly, further reinforcing the positive impact of internet connectivity highlighted within this analysis.

The chi-square and correlation analyses result from Table 3 reveal a statistically significant relationship between internet access and household health condition.

Table 3: Chi-Square and Correlation Tests showing the Relationship between Internet Access and Household Health Condition

	Value	Asymp. Sig. (2-tailed)
Pearson Chi-Square	88.388[a]	0.000
Likelihood Ratio	88.668	0.000
Linear-by-Linear Association	5.677	0.017
Pearson Correlation	Internet Access	
Household Health Condition	0.164	
Sig. Value	0.017	

The Pearson chi-square test identifies a highly significant relationship ($\chi^2 = 88.388$, $p < .001$) suggesting that variations in access to the Internet are systematically associated with differences in reported health conditions within households. This is also confirmed by the likelihood ratio statistic ($\chi^2 = 88.668$, $p < .001$) that shows that changes in Internet access levels correspond to the variations in health status. The significant linear-by-linear association ($\chi^2 = 5.677$, $p = .017$) points to a systematic trend in the relationship, that is, greater internet access is associated with slightly better household health condition.

Furthermore, the Pearson correlation coefficient ($r = .164$, $p = .017$) expresses a positive but weak relationship between internet access and household health conditions, that is, the higher the access to internet connectivity, the better the health condition to some extent. Although the correlation is low in size, its statistical significance explains the importance of internet access as a factor linked to household health status that means other determinants, however, are likely to have a greater impact.

The binary logistic regression in Table 4 below shows the effect of students' broadband internet access on telehealth service.

Table 4: Binary Logistic Regression Analysis showing the Effect of Students Broadband Internet Access on Telehealth Service

	B	S.E.	Wald	Sig.	Exp(B)
Constant	-3.636	0.446	66.570	0.000	0.026
Broadband Internet Access	1.655	0.212	60.996	0.000	5.233

Telehealth usage and access to broadband internet connection are positively correlated ($B = 1.655$, $SE = 0.212$, $Wald = 60.996$, $p < 0.001$). This means that students with broadband connections are significantly more likely to engage in telehealth services compared to those without such access. Students equipped with broadband internet are 5.23 times more likely to employ telehealth services than other students who lack such access. Furthermore, the negative and statistically significant constant ($B = - 3.636$, $p < 0.001$) shows that without broadband access, the initial or starting point probability of a student using telehealth services is very low. In summary, the model illustrates that for student telehealth service use, having a broadband internet connection is the main crucial enabler.

The indicated trend appears to reflect the evidence found in literature among cautionary perspectives that the digital divide must be remedied with more than bandwidth. Specifically, there is a need for necessary investment within digital literacy, support, or adoption. In assessing the manner within which the various indicated points of convergence and divergence might apply to the study at issue, the indicated statistical relationships of small positive yet significant gains within the area of healthcare outcomes tied to internet access, with the significant telehealth utilization increases tied to the presence of broadband access, do not merely add their own observations regarding digital divide equity; they suggest that digital access represents a key impetus within the enhancement of access to the realm of healthcare generally due to the positive enhancement of telehealth access among the possessors of broadband already [15, 25, 26].

Conclusion & Future Work

This research makes an original contribution to the literature on digital equity by empirically illustrating that broadband access is a sector-catalyzing factor that facilitates engagement with education and healthcare. The findings are based on a quantitative study that explores an HBCU-led and non-profit organization-funded intervention for digital equity. It makes a novel argument connecting education and telehealth outcome trajectories using a shared infrastructure and building capacities. The current findings indicate that broadband access is a statistically significant predictor of students' engagement with education, while device access has little impact. This supports the claim that the need for internet connectivity is greater than access to digital devices. From the healthcare perspective, the findings show a weak but significant relationship between the presence of internet connectivity in the household and their level of health conditions. In addition, stronger relationships exist between the presence of broadband in the house and the use of telehealth, where students who have broadband are more than five times likely to use telehealth services. Theoretically, the study combines the Social Determinants of Health Theory and the Diffusion of Innovations Theory to clarify the reasons behind the disparities in the outcome of interventions with only the presence of the internet in the house being the solution to the problem of digital equity in the study by defining digital equity as the triumvirate of devices, broadband, and digital literacy in the study.

Future studies can be extended by conducting full-scale validation of findings and a longitudinal study design. The next phase of research will include a larger sampling base over different cohorts and school semesters, where various institutional-level variables such as academic achievement and telehealth usage records will be considered. Additionally, the long-term improvements or deterioration of engagement and telehealth can be examined. Future research should investigate the extent to which improved telehealth access and digital inclusion programs serve as catalysts for community members to pursue higher education.

Qualitative follow-up interviews and focus groups with students, community members, and telehealth professionals will allow for the assessment of perceptions and outcomes. Although the next phase of focus group work aims to provide deeper insights, some preliminary trends coming from the previous focus group sessions held earlier during the research process have been used as a guide for the current focus group phase. Even though such trends have not been formally analyzed within the present paper, they serve as a basis for developing the research process and maintaining its coherence across all phases of research.

Lagged analyses will also be possible with a longitudinal design and include longer-term academic progress. In conclusion, a comparison of similar institutions and urban areas will allow for the evaluation of the HBCU anchored digital equity model for its transferability. This can provide policy-relevant guidance for broadband, device, and digital literacy investments.

Limitation of the Study

Several limitations were experienced during the conduct of this study and were taken into consideration during the analysis of the results. The study took place at a Community Center among undergraduates in a Historically Black College and University (HBCU) in the USA and the residents of Northeastern region of the USA and this may not be generalizable to other

locations. The research employed a quantitative methodology utilizing surveys, academic records, and telehealth usage logs, which ensured objectivity, dependability, and statistical validity of the findings. While this provided a measurable baseline for advancements in digital literacy, future versions could benefit from mixed-methods validation by pairing these quantitative transformations with standardized, objective technical performance assessments. The paper used surveys to measure changes at different points in time, and the development of digital and telehealth skills was evaluated based on engagement patterns and metrics. Furthermore, the issue of the digital divide in the community is still a process that needs to be addressed, as the differences in digital literacy and access to technology are still influencing the dynamics of participation. The process of coordinating the distribution of the surveys, training, laptop distribution, and continuous outreach efforts posed some practical challenges in terms of maintaining momentum throughout the process. Lastly, since the results are more indicative of the short to mid-term outcomes of implementation, a longitudinal study in the future would be beneficial in investigating academic participation, telehealth utilization, health and educational outcomes. Also, addressing the digital gap is a continuous process, rather than a singular event.

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