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Economic Payoff of Broadband Infrastructure on Telehealth Adoption and Healthcare Cost Savings: A Strategic Literature Review

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Abstract

Broadband infrastructure is a capital intensive investment that requires decision makers to justify costs with credible, quantifiable benefits. Telehealth is frequently cited as one of the main payoff pathways, but the evidence linking broadband conditions to telehealth adoption and then to monetizable healthcare cost outcomes is fragmented and often not presented in a form that supports disciplined investment appraisal. This strategic literature review synthesizes 89 included studies full text coded records that examine broadband availability, telehealth adoption, and healthcare cost related outcomes in underserved and low access settings. Using a PRISMA guided search protocol and a structured coding template, the review maps how often broadband is measured, characterizes dominant telehealth modalities, summarizes cost related outcomes, and classifies both the strength of the broadband telehealth linkage and the direction of impact on underserved communities. The evidence shows that adequate broadband is associated with higher telehealth utilization, reduced patient travel and time costs, and, in many contexts, lower use of high cost acute care. At the same time, broadband is rarely modeled explicitly, formal cost effectiveness and cost benefit analyses remain uncommon, and equity impacts are mixed.

The novelty of this work lies in combining economic and equity focused synthesis with an explicit framing of broadband enabled telehealth as a socio technical infrastructure problem for engineers and computing professionals. The paper translates the evidence base into design, policy, and curricular implications that can be embedded in engineering and computing programs, including case-based learning, project work, and capstone experiences around broadband constrained telehealth systems. In doing so, it offers the engineering education community a data informed context for teaching systems design, economic analysis, and equity centered innovation.

Keywords: broadband infrastructure, telehealth adoption, healthcare costs savings, ROI, digital divide, health economics, cost benefit analysis, underserved communities.

1. Introduction

Telehealth has moved from a niche innovation to a core component of health service delivery. Virtual visits, remote monitoring, asynchronous communication, and patient portals are now embedded in many health systems and scaled rapidly during the COVID 19 pandemic [1]. These modalities are used to maintain continuity of care, extend specialist access, and reduce barriers related to distance and time [2]. The expansion of telehealth has highlighted its dependence on affordable and reliable broadband connectivity for patients, clinicians, and organizations [3].

Broadband access remains highly uneven. Rural communities, low-income households, racial and ethnic minorities, immigrants, older adults, and people with chronic conditions often face a combination of infrastructure gaps, high subscription prices, limited device availability, and low digital literacy [4,5]. This creates a second digital divide in health, where populations that could benefit most from telehealth are least able to use it [4,11]. In such contexts, telehealth programs deployed on top of unequal broadband can either narrow disparities or widen them, depending on local connectivity and program design [6,15].

Broadband infrastructure is capital intensive, so governments and private investors increasingly ask whether these investments deliver measurable economic value for the health sector [2,12]. Telehealth is one of the main channels through which broadband may generate economic returns, and a growing body of work evaluates telehealth costs and benefits in diverse settings [3,7]. Yet the literature that explicitly connects broadband, telehealth adoption, and healthcare cost outcomes is scattered. Many evaluations focus on telehealth programs without quantifying the incremental economic payoff of broadband itself, while others acknowledge connectivity as a barrier but do not measure broadband in a way that can be incorporated into economic models [1,7].

At the same time, broadband and telehealth are socio technical systems that engineers, and computing professionals help design and maintain. Decisions about coverage, bandwidth, reliability, security, user experience, and integration with clinical workflows are shaped by engineering knowledge as well as by policy and economics [1,13]. For the engineering and technology education community, broadband enabled telehealth therefore provides a rich context in which students can learn to integrate technical, economic, and social considerations.

1.1 Research objectives and questions

The review has three objectives. The first is to synthesize and classify empirical and conceptual evidence on how broadband infrastructure is conceptualized, measured, and linked to telehealth adoption and healthcare cost outcomes in underserved and low access settings. The second is to interpret these findings through an economic and equity lens in order to identify the main channels through which broadband enabled telehealth generates value or reinforces disparities. The third is to translate these insights into implications for engineering and computing education, with a focus on curriculum design, project based learning, and institutional policy.

These objectives lead to three research questions.

RQ1: How do existing studies define and measure broadband infrastructure, and what patterns emerge in its relationship to telehealth adoption and healthcare cost outcomes?

RQ2: Through which economic and equity channels, do broadband enabled telehealth appear to generate savings or costs for patients and health systems in underserved contexts?

RQ3: How can this evidence base inform curriculum, pedagogy, and policy in engineering and computing programs so that students learn to design broadband and telehealth systems that are efficient, equitable, and context aware?

1.2 Contribution and novelty for engineering education

In line with the focus of the American Society for Engineering Education, this paper makes three contributions. First, it provides a structured map of the broadband telehealth economics evidence that can serve as a teaching case for systems and infrastructure courses. Second, it reframes broadband enabled telehealth as a socio technical design problem that requires integration of technical, economic, and equity considerations. Third, it proposes concrete curriculum and policy applications, showing how engineering and computing programs can incorporate broadband telehealth scenarios into courses, laboratories, and capstone projects to prepare students for work on digital infrastructure for health.

2. Conceptual and theoretical framework

The analysis rests on four pillars: health economics and cost benefit analysis, digital divide and digital equity, technology diffusion, and the strategic literature review perspective.

The study is anchored on a multi theory framework that integrates Cost Benefit Analysis, Health Economics Theory, Digital Divide Theory, and Technology Diffusion Theory to explain how broadband infrastructure investments translate into telehealth adoption and healthcare cost savings, as illustrated in Figure 1.

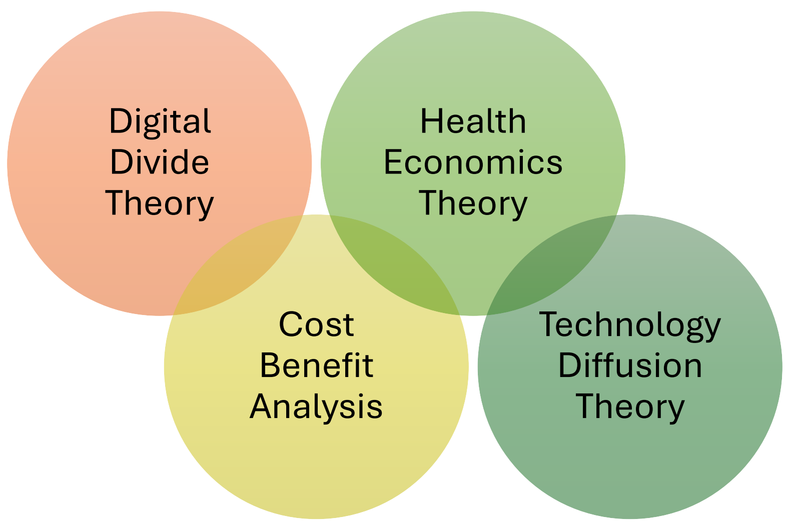

Figure 1. Conceptual framework for the Economic Payoff of Broadband Infrastructure on Telehealth Adoption and Healthcare Cost Savings

Health economics treats broadband infrastructure as an upstream capital investment that enables downstream changes in how care is produced and consumed [1,3]. Cost benefit analysis compares the stream of benefits from broadband enabled telehealth with the capital and operating costs of broadband deployment and maintenance. Across telehealth evaluations, recurring benefits include reduced patient travel time and transport costs, fewer emergency visits and hospitalizations, improved disease control through more frequent monitoring, provider time savings, and productivity gains when patients and caregivers miss less work [3,7]. Only a small subset of studies embeds telehealth within formal economic frameworks, and even fewer incorporate broadband costs directly [7].

Digital divide theory highlights how differences in infrastructure, access, skills, and support shape technology use [4,11]. In this review, broadband coverage, speed, reliability, affordability, device access, and digital literacy all influence who can use telehealth and in what ways. Coding within the dataset shows that many included studies focus on underserved communities such as rural residents, safety net patients, racial and ethnic minority groups, low-income households, immigrants, older adults, and people with complex chronic conditions [4,6]. Direction of impact codes capture whether telehealth, in the context of existing broadband, narrows or widens gaps, which is central to RQ2 and RQ3 [11].

Technology diffusion theory offers a lens on how broadband and telehealth spread together [3,9]. Broadband expansion and telehealth uptake are coupled processes that move through populations and organizations over time. Early adopters in well-resourced settings are often first to benefit from high quality video visits and advanced monitoring, while low resource settings adopt more slowly [3]. Several studies describe "video gaps" in which better connected populations use video visits more, while others rely on audio only telehealth or have limited telehealth adoption [5,15]. This theory connects directly to RQ1 and RQ3 by underscoring the importance of modelling infrastructure and behavior jointly.

A strategic literature review aims to support decisions by identifying where evidence is strong, where it is thin, and what research would most improve practice and policy [7,13]. Here, the strategic goal is to provide insight for health and telecommunications decision makers and for engineering educators who must decide how to integrate broadband telehealth topics into curricula and institutional planning.

3. Methods

This section explains how the review was designed, screened, coded, and synthesized to assess whether the existing literature can support engineering economy reasoning about broadband enabled telehealth. Rather than estimating a pooled return on investment, the method maps what the literature actually measures about broadband, telehealth adoption, economic outcomes, and equity effects, and then interprets the strength and limits of that evidence for investment appraisal and educational use.

3.1 Design and protocol

The study uses a systematic literature review design that follows the logic of PRISMA 2020, adapted for a focused set of questions on broadband, telehealth, and economic outcomes [7,8]. The protocol is implemented in a Strategic Literature Review coding sheet and a descriptive analysis sheet. It defines population, exposure, outcomes, study types, and time frame, and sets explicit inclusion and exclusion rules aligned with the three research questions.

3.2 Eligibility criteria

From the study, the population of interest includes individuals and communities whose access to care is shaped by broadband and who are plausible users of telehealth [3,13]. Studies were eligible if they focused on rural residents, low-income households, racial and ethnic minority communities, immigrants and refugees, older adults, people with chronic diseases, or safety net users, or if they offered disaggregated results for these groups [4,6]. General population studies were included when they covered areas with known connectivity challenges [5,11].

The exposure is broadband infrastructure or high-speed internet access [1,12]. Eligible studies include those that directly examine broadband deployment, coverage, or speed; those that measured household or community broadband access; analyses that treated broadband as a contextual factor in telehealth programs; and policy evaluations of broadband related regulations or subsidies [1,12]. Studies that discussed telehealth without substantive treatment of connectivity were excluded.

Outcomes were defined along two axes. The first covers telehealth adoption and utilization: any telehealth use, number or share of visits conducted via telehealth, program enrolment, readiness, feasibility, acceptability, and satisfaction [3,9]. The second covers economic or cost related outcomes: patient travel and time costs, provider or system costs, utilization-based cost avoidance, reimbursement and revenue, productivity effects, and explicit cost effectiveness or cost benefit metrics [1,7]. Studies were included if they reported telehealth adoption with a clear link to broadband; economic outcomes were coded where they appeared.

3.3 Search strategy and data sources

Searches were conducted in Scopus, PubMed, and EconLit databases, reflecting a balance of health, technology, social science, and economics coverage [7,8]. Additional targeted searches in telecommunications and rural health information sources were used to capture policy and practice oriented work [12,14]. The target period was 2015 to 2024, aligned with the current broadband era and the pandemic accelerated expansion of telehealth [3,9]. Titles and abstracts were imported into the Strategic Literature Review workbook, duplicates were removed, and potentially relevant studies were taken to full text review. A total of 101 full text records were coded in detail. After final eligibility assessment, 89 studies were retained for synthesis, as summarized in Table 1 and Figure 2.

Table 1. Search strategy and study selection summary for SCOPUS, PubMed, and EconLit, showing search queries used, date of search, filters applied, and numbers of records identified, screened, excluded, and finally included in the review.

Database	**Search Query Used**	**Date Search**	**Initial Records Identified**	**Filters**	**Records Identified after Filters**	**Duplicates Removed**	**Records Not retrieved**	**Records Screened**	**Records Included**
SCOPUS	(broadband OR "high speed internet" OR "fixed broadband" OR "mobile broadband") AND (telehealth OR telemedicine OR "remote patient monitoring" OR "virtual care") AND ("cost effectiveness" OR "cost-effectiveness" OR "cost benefit" OR "cost-benefit" OR "economic evaluation" OR "cost savings" OR "healthcare costs" OR "health care costs" OR "return on investment") AND (rural OR underserved OR "medically underserved" OR "low income" OR "resource limited" OR "digital divide")	29th November 2025	633	DATE FILTER: 2020 AND 2025, SUBJECT AREA , "MEDICINE" , "COMPUTER SCIENCE", "BUSINESS, MANAGEMENT AND ACCOUNTING" , "HEALTH PROFESSIONS, "ENGINEERING" "ECONOMICS, ECONOMETRICS AND FINANCE, DOCUMENT TYPE "ARTICLE, BOOK, CONFERENCE PAPER" AFFILIATED COUNTRIES, "United States" AND LANGUAGE , "English" AND ACCESS "ALL OPEN ACCESS"	97	2	3	92	80
PUBMED	(("Telemedicine/economics"[Mesh] OR "Telemedicine"[Mesh] OR telehealth[tiab] OR telemedicine[tiab] OR "remote patient monitoring"[tiab] OR "virtual care"[tiab])) AND (broadband[tiab] OR "high speed internet"[tiab] OR "internet access"[tiab] OR "internet connectivity"[tiab]) AND ("Cost-Benefit Analysis"[Mesh] OR "Economics, Medical"[Mesh] OR "Health Care Costs"[Mesh] OR "cost effectiveness"[tiab] OR "cost-effectiveness"[tiab] OR "cost benefit"[tiab] OR "economic evaluation"[tiab] OR "cost savings"[tiab]) AND (rural[tiab] OR underserved[tiab] OR "medically underserved"[tiab] OR "low income"[tiab] OR "resource limited"[tiab] OR "digital divide"[tiab])	29th November 2025	9	NO FILTERS	9	0	5	4	4
ECONLITT	("telehealth broadband" OR "broadband telehealth" OR "telemedicine broadband" OR "broadband telemedicine" OR "telehealth and broadband" OR "telemedicine and broadband") AND ("cost effectiveness" OR "cost-effectiveness" OR "cost benefit analysis" OR "cost-benefit analysis" OR "economic evaluation" OR "return on investment") AND (rural OR underserved OR "digital divide" OR "medically underserved")	29th November 2025	40	DATE FILTER: 2020 AND 2025,	31	2	24	5	5
			682		137	4	32	101	**89**

3.4 Study selection and PRISMA flow

Study selection followed a staged PRISMA style process [7]. In the first stage, titles and abstracts were screened against eligibility criteria and assigned a relevance percentage. Only papers at or above a 60 percent relevance threshold were taken to full text review. In the second stage, full texts were assessed for eligibility, and reasons for exclusion were documented where applicable. The review workbook contains 101 fully coded records. Of these, 89 met the final eligibility criteria and were included in the synthesis, while 12 were excluded after full text assessment.

Figure 2 shows the overall selection process is summarized in a PRISMA 2020 flow diagram. The diagram reports the number of records identified in each database, the number removed as duplicates, the number excluded at title and abstract level, and the number of full text papers excluded with reasons. The final box shows the 89 studies that met all eligibility criteria and were included in the synthesis.

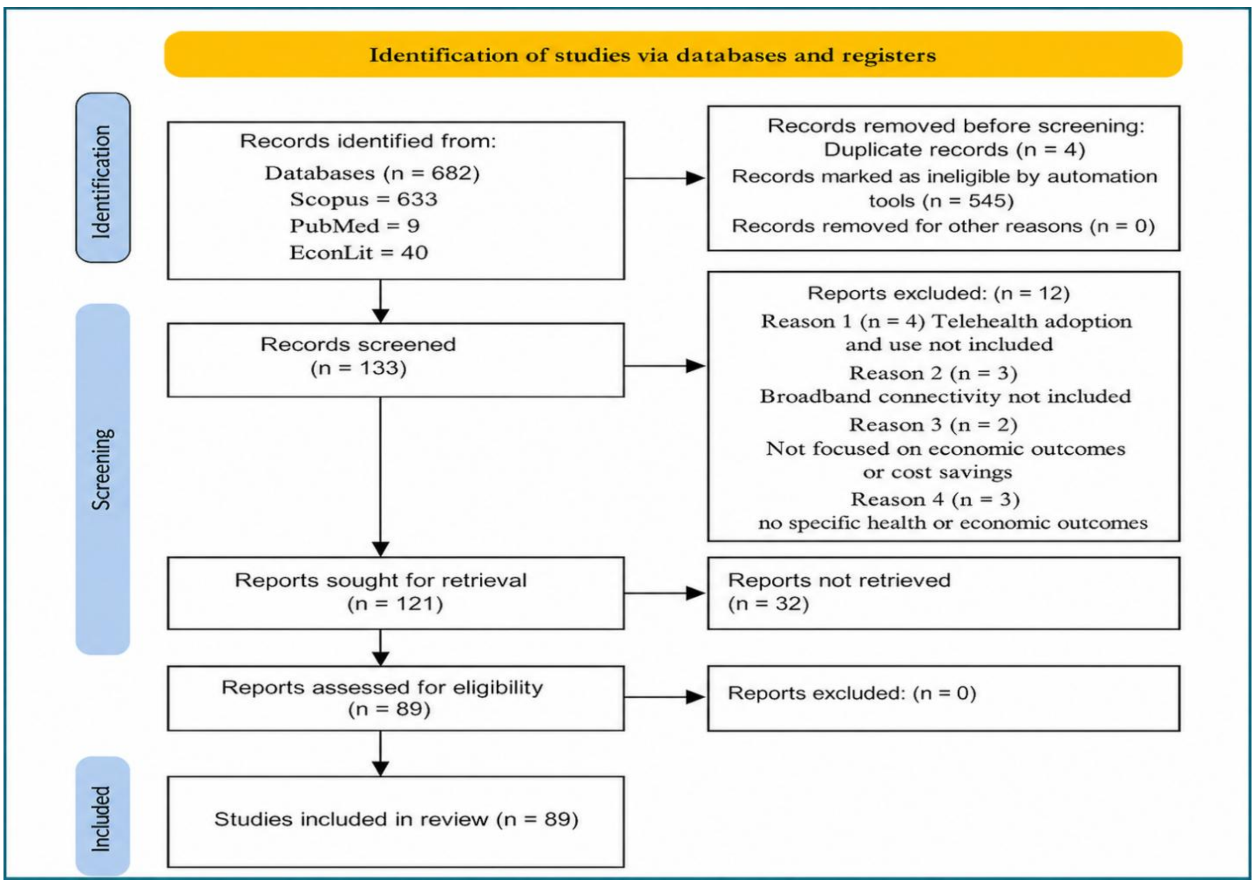

Figure 2. PRISMA 2020 flow diagram of study identification, screening, eligibility assessment, and inclusion for the systematic review of the economic payoff of broadband infrastructure on telehealth adoption and healthcare cost savings.

3.5 Data extraction and coding

Data extraction used a detailed framework like those in earlier telehealth economics and digital equity reviews [4,7]. For each paper, the Strategic Literature Review coding sheet records country, whether the study is solely United States based, subnational setting, continent, community setting, paper type, study design, grouped design category, method, sample size, unit of analysis, broadband measurement, broadband upgrade evaluation, broadband metric type, and whether upgraded and non-upgraded areas are compared [1,12].

Telehealth variables capture modality, service type, setting, and adoption or utilization of metrics [3,9]. Equity variables capture whether underserved communities are in focus and the direction of impact for those communities (increase, decrease or gap persists, mixed, no clear change, or not stated) [4,11]. The economic coding sheet records telehealth modality, service type, setting, adoption metrics, economic outcome type, whether healthcare cost or patient cost outcomes are reported, direction of system cost impact, any return on investment or cost benefit figures, and narrative economic conclusions [3,7].

The descriptive analysis sheet aggregates these variables into counts and percentages and underlies the charts and tables that summarize study types, geographic distribution, organization types, broadband measurement, economic outcome types, strength of broadband adoption linkage, and equity impacts.

3.6 Quality appraisal

Quality appraisal used narrative judgments aligned with the Mixed Methods Appraisal Tool [7]. For each study, design appropriateness, sampling strategy, measurement quality, and outcome reporting were assessed. Evidence strength for adoption and cost outcomes was classified as strong, moderate, weak, or none. These appraisals inform interpretation in the discussion.

3.7 Analytic approach

Analysis combines descriptive statistics from the descriptive sheet with narrative synthesis based on coded conclusions. Descriptive summaries focus on study types, geographies, organization types, telehealth modalities, broadband measurement and upgrades, economic outcome types, strength of broadband adoption linkage, and direction of impact for underserved communities. Figures and tables provide visual summaries of these patterns, and the discussion interprets them considering the conceptual framework and the three research questions.

4. Results

4.1 Overview of included studies

The final evidence base contains 89 included studies. Empirical papers account for 64 studies, theoretical and conceptual work contributes 17 studies, systematic studies contribute 7 studies, and one additional review type paper is included. This composition indicates that the field has a substantial observational and applied base, but remains relatively thin in formal modeling and fully economic evaluation work.

Grouped study designs show further detail. Cross sectional studies are most common (18), followed by cohort studies (15), qualitative designs (12), and quasi experimental designs (12). Systematic reviews make up 10 papers, conceptual analyses 9, policy reviews 8, ecological or geospatial designs 6, randomized controlled trials 5, mixed methods 3, protocols 2, and modelling studies 1. This distribution indicates a strong descriptive and observational base with relatively few experimental and modelling studies that would directly support stronger causal and economic inference.

Figure 3 presents the distribution of study types.

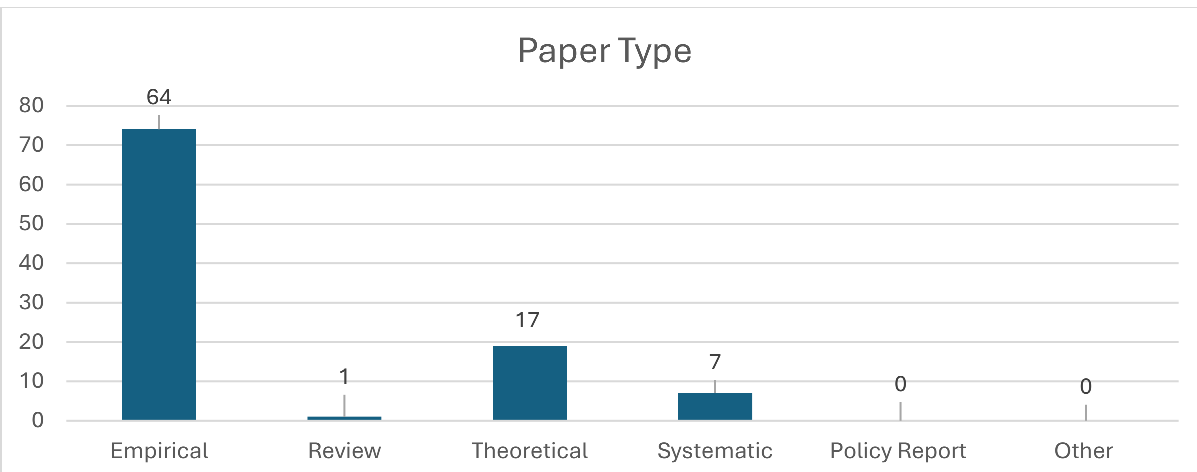

Figure 3. Distribution of study types (empirical, theoretical, systematic, other).

4.2 Geographic and organizational patterns

The geographic distribution of the included studies is highly concentrated. Seventy studies are coded to North America, and 69 of the 89 included studies are solely United States based. Thirteen studies are global in scope, while the remaining studies are distributed across Africa, Europe, Asia, and Australia and New Zealand in small numbers. This pattern confirms that the evidence base remains strongly skewed toward United States contexts.

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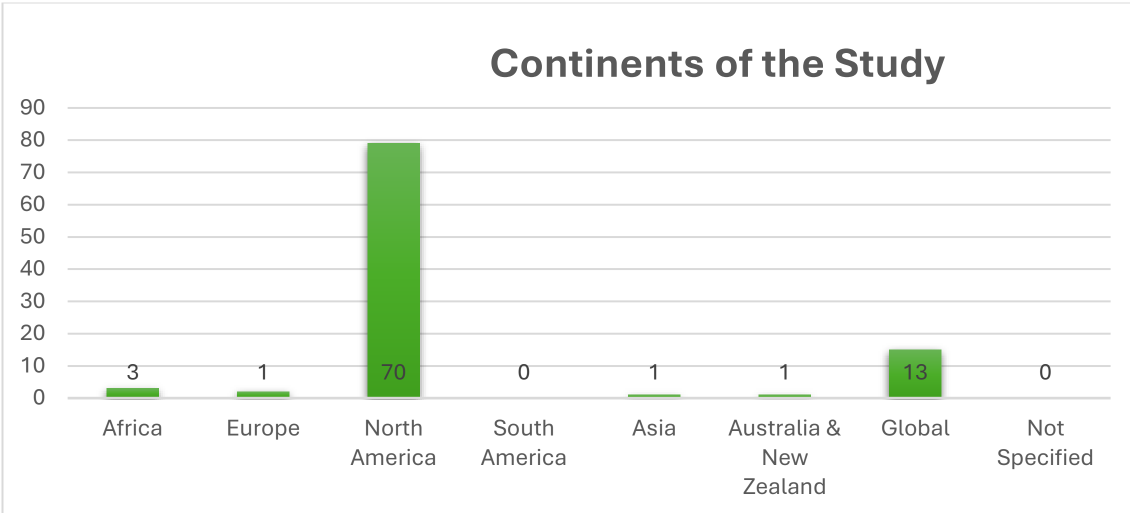

Figure 4. Geographic distribution by continent and United States versus non-United States settings.

Organizationally, universities are the primary contributors. Universities produce 59 of the 89 included studies. Government organizations account for 11 studies, research firms for 4, and other organizations such as nonprofits, health systems, and consortia for 14. One paper has unspecified organizational origin. This pattern is consistent with telehealth and rural health literature in which academic and governmental actors are central evaluators and knowledge producers.

Figure 5 provides the distribution of the type of organization

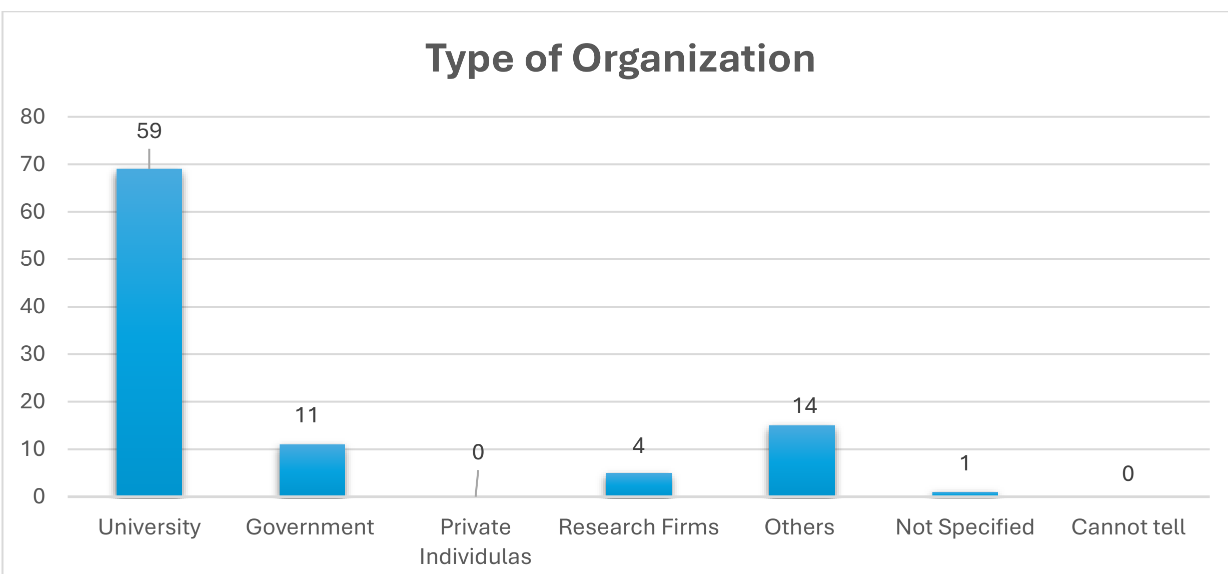

Figure 5. Type of organizations producing the paper (university, government, research firms, others, not specified).

This pattern mirrors other rural health and telehealth evidence bases where academic, governmental, and intermediary organizations partner to evaluate telehealth and broadband.

4.3 Telehealth adoption and utilization outcomes

Telehealth adoption and utilization outcomes are central to the included evidence base and are part of the study scope across all 89 included studies. Common metrics include any telehealth use, the number or share of visits conducted via telehealth, enrollment in telehealth programs, and measures of readiness, feasibility, acceptability, and satisfaction. Studies cover a range of modalities including general telehealth, video visits, audio visits, remote patient monitoring, mobile health applications, and patient portals. Service types include primary care, chronic disease management, behavioral health, specialist consultations, emergency triage, and post acute care. Settings span home based care, clinic to home, clinic to clinic, hospital based services, and community access points.

Although this review does not pool effect sizes, the coding and existing literature indicate that broadband access and quality are central determinants of who uses telehealth, for what services, and how consistently.

4.4 Broadband measurement and upgrade evaluation

Broadband is measured less consistently than telehealth adoption. Only 28 of the 89 included studies explicitly measure broadband or internet access using quantitative indicators such as subscription rates, coverage maps, or speed tests. Thirteen additional studies provide qualitative evidence about connectivity through interviews, focus groups, or narrative reporting. The remaining 48 studies mention broadband as an important contextual factor but do not operationalize it with explicit metrics, which limits the precision of any economic interpretation.

Broadband upgrades are rarely analyzed as interventions. Only 6 of the 89 included studies explicitly evaluate broadband upgrades or expansions, for example by comparing telehealth outcomes before and after upgrades or across upgraded and non upgraded areas. The remaining 83 studies do not treat upgrades as distinct exposures, even when they describe evolving connectivity conditions.

Figure 6 shows the extent of broadband measurement.

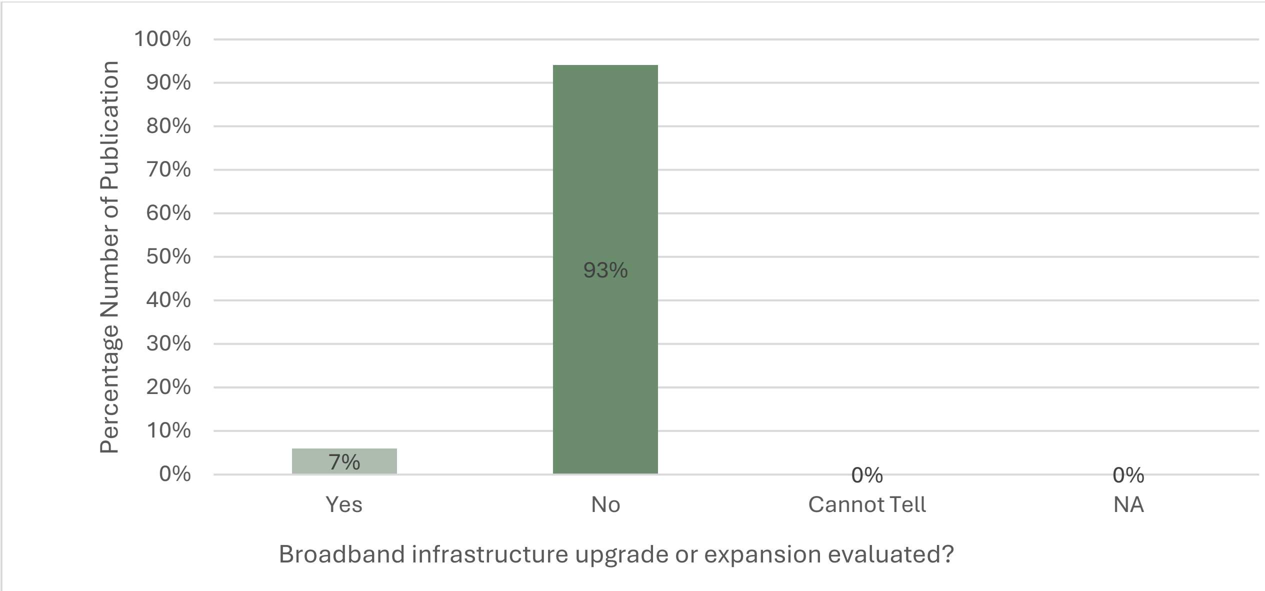

Figure 6. Extent of broadband measurement and evaluation of broadband upgrades.

The descriptive analysis also codes the strength of the broadband telehealth linkage. Twenty one studies are coded as strong, with direct analytic connections between broadband conditions and telehealth outcomes. Forty two are coded as moderate, with broadband playing a clear but not fully quantified role. Twenty two are coded as weak, and four show no discernible linkage. Taken together, these patterns show that broadband is widely recognized as important but is not yet treated consistently as a first class explanatory variable in the literature.

Figure 7 summarizes the pattern of broadband measurement and upgrade evaluation.

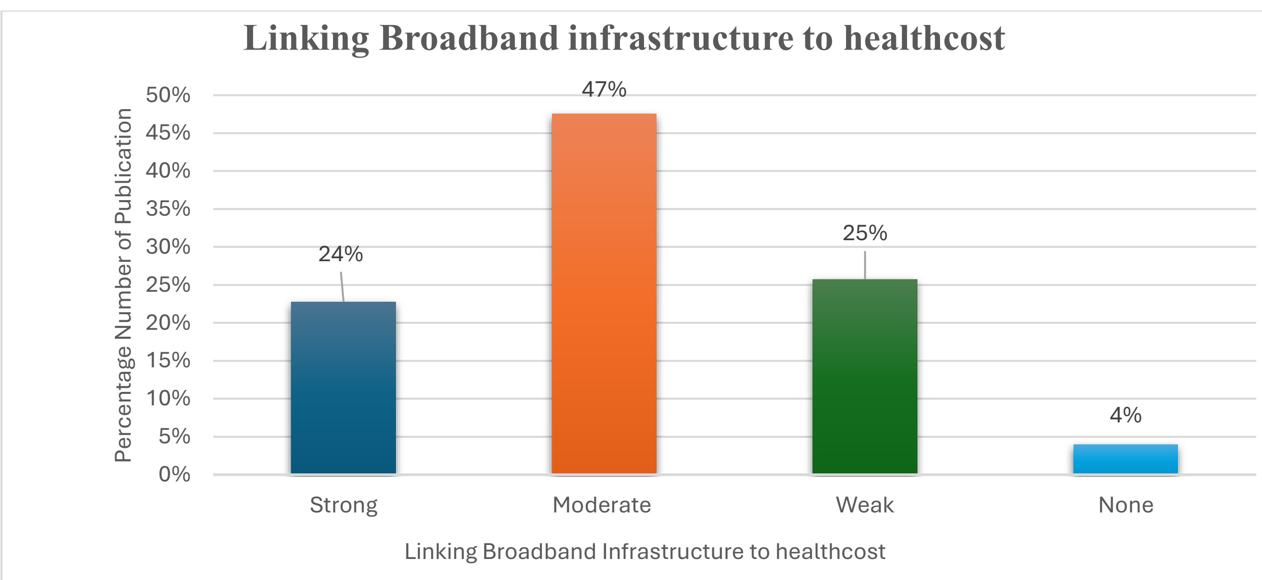

Figure 7. Strength of linkage between broadband infrastructure and telehealth adoption (strong, moderate, weak, none).

These patterns show that broadband is widely recognized as important but is not consistently operationalized as a core explanatory variable.

4.5 Economic outcome types and cost impacts

Economic outcomes are less consistently reported than adoption outcomes. Forty seven of the 89 included studies have no explicit economic metric. Among the studies that do report economic outcomes, 14 focus on patient time and travel outcomes, such as transport costs, travel time, caregiver time, or productivity losses. Another 14 report provider or health system cost outcomes, including program costs, direct medical costs, intensive care costs, and efficiency measures. Six report return on investment or cost benefit style figures. Three rely primarily on utilization measures as proxy economic outcomes. One addresses reimbursement related effects, and four report other economic outcomes that do not fit the preceding categories.

Figure 8 summarizes the distribution of economic outcome types.

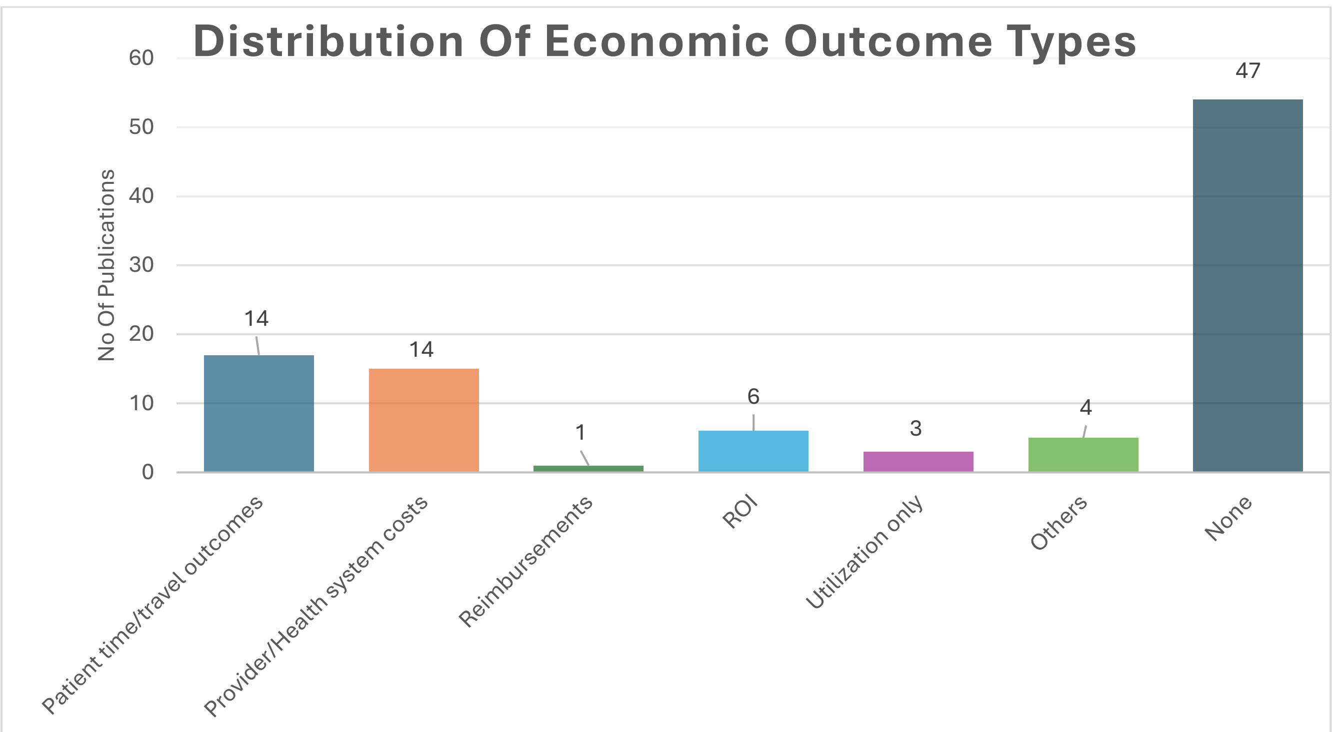

Figure 8 providing the distribution of economic outcome types.

Direction of health system cost impact is also coded. Among the included studies, 26 indicate cost savings, 3 indicate net cost increases, 4 indicate mixed effects, and 3 are neutral, while 53 do not assess system cost direction. In parallel, 17 studies report direct healthcare cost outcomes and 19 report patient cost or time saving outcomes. These results suggest recurring economic payoff channels, but they also show that the evidence base is still incomplete for full investment appraisal.

4.6 Equity impacts for underserved communities

Equity impacts are summarized by the direction of impact for underserved communities. Thirty seven studies report increased access or adoption for underserved groups. Twenty seven report lower adoption or persistent disadvantage. Ten report mixed effects, five report no clear change, and ten do not clearly assess the direction of impact. These mixed patterns align with digital health equity work, which finds that telehealth can either reduce or exacerbate disparities depending on how it is implemented in the context of local broadband and social conditions.

Figure 9 presents the distribution of equity impacts for underserved communities.

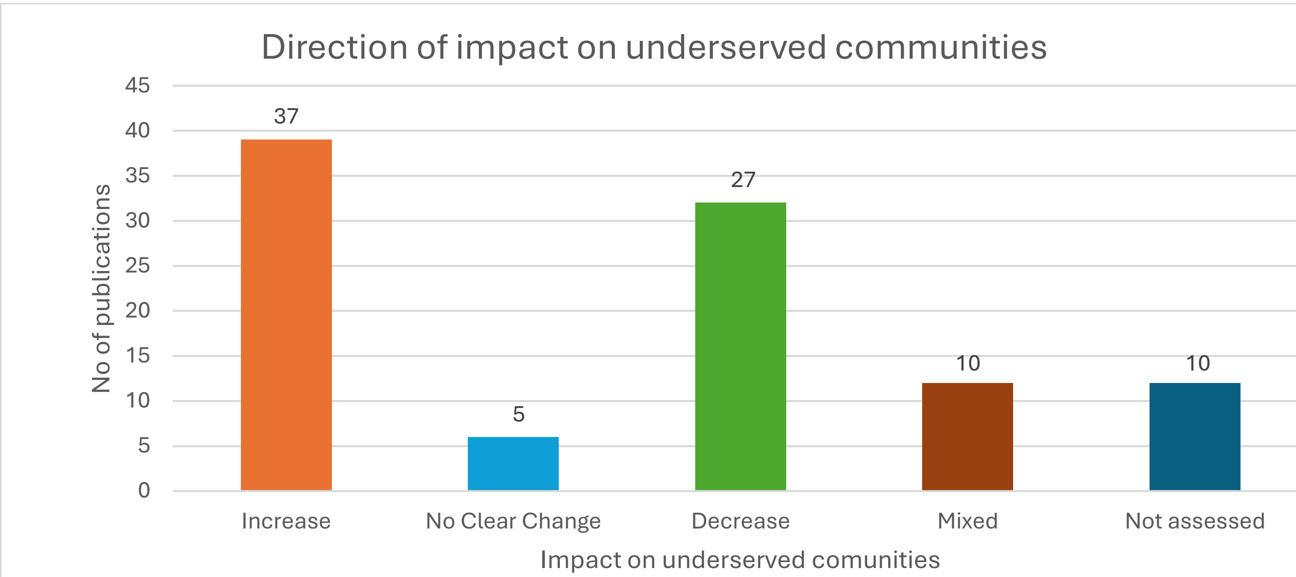

Figure 9. Aggregated direction of impact on underserved communities.

These mixed patterns align with digital health equity work, which finds that telehealth can either reduce or exacerbate disparities depending on how it is implemented in the context of local broadband and social conditions.

5. Discussion

5.1 Interpretation of main findings

The review shows that the evidence base at the intersection of broadband, telehealth adoption, and economic outcomes is rich but uneven [3,7]. Empirical studies form the backbone, but experimental and modelling work are scarce. Geographically, the literature is heavily concentrated in the United States, with relatively little work from other regions. Telehealth adoption outcomes are widely reported, while economic outcomes are less frequently quantified and often partial. Broadband is widely acknowledged but not consistently measured, and only a minority of studies treat broadband upgrades as interventions. Equity impacts are mixed, with some studies showing improved access for underserved communities and others showing persistent or widening gaps [4,6].

5.2 Broadband as an enabling infrastructure

Broadband functions as enabling infrastructure for telehealth [1,3]. Strong or moderate linkage codes in many studies indicate that connectivity is often a necessary condition for high quality telehealth, particularly for video visits and data intensive remote monitoring [3]. However, the limited use of explicit broadband metrics means that investments in broadband are rarely evaluated in terms of marginal health and economic returns [1,12]. Without precise broadband measurement, it is difficult to estimate how moving a community from low speed to high speed or from unserved to served status changes telehealth use and costs.

5.3 Economic payoff channels

Even without many full cost benefit analyses, the literature points to several consistent economic payoff channels [3,7]. One channel is reduced patient travel and time cost. In rural and remote areas with long travel distances, telehealth often eliminates or reduces trips for routine care, yielding direct savings for patients and productivity gains through reduced time away from work [1,13].

The second channel is utilization shift. Several cohort and quasi experimental studies document reductions in emergency visits and hospitalizations after telehealth programs are introduced, along with improved disease control indicators [7,8]. These changes suggest potential system level savings when telehealth is integrated into care pathways.

A third channel is provider and system efficiency. Telehealth can reduce no show rates, allow more flexible scheduling, and enable clinicians to cover more patients or locations without travel [3,9]. Where quantified, these gains reduce per visit costs or increase capacity [7].

Financial and reimbursement effects are also present. In some settings, telehealth helps maintain revenue by preserving visit volumes during disruptions and by opening new service lines [9,10]. Stable payment policies are important for long term viability [7,14]. At the same time, some programs increase costs, especially where new platforms, devices, and support staff are added without offsetting savings [7].

5.4 Equity and design of broadband telehealth systems

The equity patterns show that broadband enabled telehealth can narrow or widen disparities [4,6]. When broadband coverage and affordability are adequate, and when programs provide device support, digital literacy assistance, and culturally adapted design, underserved groups can gain access they did not previously have [4]. This is especially evident in rural areas and safety net settings with historically poor access [13].

Where broadband coverage is poor, prices are high, or digital skills are low, better connected and more affluent groups are more likely to use telehealth and to use higher value modalities such as video [5,15]. In those settings, broadband status mediates access to higher quality telehealth, creating a broadband mediated gap layered on existing social inequalities. From an engineering perspective, this underscores the need to design telehealth systems that are robust to bandwidth constraints, accessible from a range of devices, and complemented by non-technical support strategies.

5.5 Evidence gaps and limitations of the literature

Several gaps limit the current economic case for broadband as health enabling infrastructure [7,13]. Few studies treat broadband upgrades as explicit interventions, which makes it difficult to estimate the rate of return on specific investment types [12]. Formal economic evaluations are rare, so most studies provide partial rather than comprehensive views of costs and benefits [7]. Geographic coverage is limited, with sparse evidence from low and middle income countries that may see large marginal gains from broadband and telehealth [14].

Measurement is another constraint. Self-reported access and generic internet use proxies can misclassify households and obscure variation in speed, reliability, and affordability [5,11]. More frequent use of objective coverage and speed data, merged with health system and claims datasets, would support stronger analyses. Finally, many studies were conducted during COVID 19, when policies and behaviors were unusual [9]. It is not yet clear which telehealth, and broadband patterns will persist under more stable conditions.

6. Implications for engineering and technology education

The findings have implications not only for health system and telecommunications decision makers but also for the engineering and computing education community. At a high level, the evidence base confirms that broadband and telehealth function as coupled infrastructure systems whose performance depends on technical, economic, and social design choices. This framing aligns with program outcomes that call for systems thinking, data informed decision making, and understanding the broader impacts of engineering solutions.

For policymakers and funders, the review reinforces calls to plan broadband and telehealth together rather than as separate policy streams [2,12]. Regions with heavy chronic disease burdens and weakness in person access are often broadband constrained as well. Aligning telehealth priority maps with broadband deployment plans can increase both access and economic payoff [13].

For engineering and computing programs, broadband enabled telehealth provides a powerful context for curriculum design. Courses in communications, networking, health systems engineering, operations research, and socio technical systems can use the mapped evidence as a case study to illustrate how infrastructure decisions influence downstream service delivery and cost [1,3]. Students can replicate or extend elements of the descriptive analysis, model simple cost benefit scenarios for broadband upgrades that support telehealth, or design architectures that are resilient to bandwidth constraints in underserved communities.

The review also suggests opportunities for capstone and project based learning. Multidisciplinary teams of students can design and evaluate prototypes of telehealth systems for rural or low income urban communities, explicitly incorporating realistic broadband constraints, reimbursement rules, and user support needs [13]. Other teams can work with anonymized data based on the coding template used in this review to build dashboards that visualize where broadband telehealth investments are likely to yield the greatest returns.

Broadband enabled telehealth is well suited for engineering economy instruction because it connects infrastructure investment to measurable operational outcomes while requiring explicit perspective, time horizon, discounting, and uncertainty analysis. Students can learn to define appraisal boundaries, avoid double counting across stakeholders, quantify benefits and costs, and test uncertainty through scenario and sensitivity analysis.

At the institutional level, engineering schools can engage with health system partners, state broadband offices, and community organizations to shape policy conversations about digital infrastructure for health [11]. Joint courses or minors on digital infrastructure for health can be developed in partnership with public health, nursing, or medical programs, using broadband and telehealth as anchor topics. Telehealth case studies can also inform institutional strategies for community engagement and regional economic development.

7. Limitations of this review

This review is constrained by both the underlying evidence base and the coding approach [7]. The synthesis is based on 89 included studies. Relevant work in gray literature, engineering domains, or non English languages may still be missing. Quality appraisal relied on narrative judgments aligned with the Mixed Methods Appraisal Tool rather than a single summary score [7].

Economic reporting is incomplete in many primary studies. Cost implications are often described qualitatively or not at all [3,7]. The economic synthesis therefore rests on a subset that may not fully represent the wider telehealth landscape. The strong United States focus limits generalizability to other regulatory and health system contexts [13]. Finally, all descriptive statistics in the figures reflect what is reported in the coded papers and should be interpreted as patterns in the evidence base rather than as global population parameters.

8. Conclusion

Broadband and telehealth together form a coupled infrastructure system that is reshaping how care is delivered, particularly in underserved communities [3,13]. This strategic literature review, based on 89 included studies, shows that adequate broadband is consistently associated with higher telehealth utilization, reduced patient travel and time costs, and, in many contexts, reductions in high cost acute care use [1,7]. At the same time, broadband is often treated as background context rather than a measured variable, formal economic evaluations are uncommon, and equity impacts are mixed [4,6].

For the engineering and computing education community, these findings define a rich problem space for teaching systems thinking, socio technical design, and economic reasoning. Broadband enabled telehealth sits at the intersection of communications engineering, computer networks, health systems, operations, and human centered design. Using the patterns mapped in this review, instructors can build case studies, design projects, and laboratory exercises that require students to reason about bandwidth constraints, reliability, cost structures, and user experience under real world limitations.

The synthesis also points to opportunities for capstone and project based learning. Teams of students can model the economic impact of broadband upgrades on telehealth access in rural counties, design architectures for resilient telehealth delivery in low bandwidth environments, or prototype tools that help health systems visualize where broadband investments would yield the largest access and equity gains [12,13].

Finally, the work highlights the role of engineering schools as institutional actors in digital health policy conversations. By engaging with health system partners, broadband providers, and community organizations, engineering programs can help shape policies and projects that align broadband deployment, telehealth design, and equity goals [11]. Embedding broadband telehealth scenarios into curricula, research experiences, and community engagement strategies can prepare graduates who are not only technically competent but also able to design and evaluate infrastructures that advance both efficiency and justice.

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