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The Impact of Telemedicine on Cancer Care Advancement in Accessibility, Treatment Delivery, and Patient Outcomes

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ABSTRACT

This research examines the effect of telemedicine on cancer care, including treatment delivery, team coordination, and patient outcomes like quality of life. The research used a descriptive analysis design with a sample size of 25 cancer patients and 55 healthcare providers from Punjab, Pakistan. Data were collected through surveys and institutional records on key indicators such as team coordination, treatment adherence, and quality of life scores. The Chi-Square test was used to analyze the difference in team coordination from face-to-face to virtual settings, while ANCOVA was used to analyze the effect of telemedicine on quality of life after adjusting for age and socioeconomic status. The findings showed a significant difference in team coordination ($p < 0.05$), where all patients shifted to remote care after introducing telemedicine. Further, the ANCOVA analysis also showed a statistically significant improvement in quality of life among telemedicine-users ($p = 0.03$), indicating that telemedicine has positive effects on patient outcomes over traditional face-to-face care. These findings suggest that telemedicine is a very effective intervention in delivering cancer care, with both patient satisfaction and coordination of care being ensured. Additional research, however, is needed to explore its long-term effect and the potential effect of other factors like digital literacy and age on its effectiveness. Telemedicine significantly enhances cancer care by improving access, coordination, and patient quality of life. It fosters real-time collaboration, reduces travel burdens, and boosts treatment satisfaction. ANCOVA results show better outcomes with telemedicine. Future research should explore long-term impacts and demographic influences to ensure equitable and effective implementation across diverse populations.

INTRODUCTION

Cancer remains one of the most pressing global health issues, causing millions of deaths each year and placing a significant burden on healthcare systems, patients, and families. The multidisciplinary nature of cancer treatment, often involving a combination of surgery, chemotherapy, radiation therapy, and follow-up, necessitates continued interaction with a multidisciplinary team. However, many patients face significant barriers to timely and quality care, especially those living in rural, poor, or underserved populations. These disparities are further compounded by logistical factors such as increased travel distances, reduced availability of specialists, and high out-of-pocket costs. In these situations, telemedicine has proven to be a game-changer, revolutionizing the delivery and perception of healthcare—cancer care in this case. As the delivery of health services and information via telecommunications technologies, telemedicine offers a promising solution to fill existing gaps in care by extending medical expertise to patients regardless of location [1].

The fast-paced integration of telemedicine into the oncology arena, especially in the post-COVID-19 period, has shown its promise to revolutionize the cancer care continuum. While in-person consults were the only option in the past, patients can now have virtually remote consults with oncologists, nurses, mental health professionals, and palliative care specialists. This shift not only improved ease of care access for patients previously left behind but also redefined the patient-provider relationship through enhanced frequency and flexibility of communication. Moreover, virtual consultations reduce the need for travel and work time

off, thus allowing patients to plan their treatment around greater convenience and less economic hardship. For cancer patients defined by fatigue, pain, and compromised immunity, for example, avoiding unnecessary hospital visits also decreases physical stress and infection exposure considerably, thus promoting overall quality of life [2].

Yet, the transition to telemedicine for cancer treatment is not simply about convenience. It is a wider paradigm shift in the delivery, coordination, and assessment of treatment. With telehealth platforms, multidisciplinary teams can more easily meet to review complicated cases, exchange imaging and diagnostic information in real time, and collectively make treatment decisions more quickly. In certain situations, wearable monitors and remote care tools can also supply real-time reports on a patient's vital signs or treatment status, facilitating preemptive action before complications set in. These functions not only make clinical processes more efficient but also facilitate personalization of care, which is ever more vital to oncology [3]. However, there are issues regarding the adequacy of telemedicine to replace in-person examination, the gaps in remote diagnostic precision, and the possible digital divide impacting technologically underprivileged groups.

With these advances, it is essential to investigate the effect of telemedicine on cancer treatment from an integrated viewpoint. This research addresses three interrelated dimensions: accessibility, delivery of treatment, and patient outcomes. These areas include the essential aspects of quality cancer treatment and the areas where telemedicine has the most potential for enhancement. By examining how telemedicine overcomes care barriers, improves the delivery of services, and affects clinical and psychosocial outcomes, this study hopes to create a sophisticated picture of its function in bringing oncology practice forward. By doing so, it adds to current discussions surrounding the incorporation of digital health in cancer care and sets a foundation for future innovation and policymaking in this vital area [1].

Telemedicine and Accessibility in Cancer Care

One of the greatest strengths of telemedicine in oncology is enhanced access to care, particularly for those who live in rural, remote, or underserved areas. Historically, patients in these communities have had major challenges accessing oncology experts because of geographic distance, transportation, and limited nearby healthcare resources. With telemedicine, these obstacles are minimized by enabling patients to be consulted by oncology teams without having to undergo long-distance travel. This prevents delayed assessments, earlier interventions, and improved continuity of care, especially among populations who would otherwise postpone or forego treatment because of logistical reasons [4].

In addition, telemedicine eliminates costs related to travel, accommodation, and lost work time. Cancer treatment tends to involve multiple specialists with frequent visits, which can put a strain on a patient's time and resources. Virtual consultations ease these burdens, allowing patients to more easily stay involved in their care plans [2]. For disabled patients, older patients, or those with mobility issues, telemedicine also provides a more convenient format to receive care without sacrificing safety or comfort [5].

Additionally, telemedicine improves access to subspecialty services not locally available. With virtual tumor boards and second-opinion sites from a distance, patients have access to expert review and multidisciplinary management irrespective of location [6]. This is especially advantageous for uncommon or intricate cancers that need to be managed by subspecialists. Interpreter services and computerized tools built into telehealth portals also can aid non-English-speaking patients, enhancing inclusiveness and fairness in care provision [7].

In spite of these advantages, there are issues. Technological inequalities, such as a lack of internet connection or digital proficiency, can hinder telemedicine's accessibility. Less privileged populations—especially older patients or those of lower socioeconomic status—might not be able to use digital means [8]. Thus, though telemedicine certainly enhanced accessibility, making its benefits accessible to all equally needs careful efforts in building infrastructure, digital education, and policy assistance [9].

Telemedicine and Treatment Delivery in Oncology

The administration of cancer care requires coordination among diverse healthcare providers, ongoing monitoring, and adaptive decision-making. Telemedicine introduces new efficiencies into the way this care is delivered, particularly in the outpatient environment. With video consultation, clinicians can perform follow-up visits, track side effects of treatment, titrate drugs, and manage symptoms—all while the patient stays at home [2]. This has proven particularly useful for those receiving chemotherapy or palliative treatment, wherein frequent check-ups are necessary but not always physically possible [10].

Virtual platforms also enhance communication between oncology teams, optimizing care coordination. For example, telemedicine allows real-time sharing of medical records, laboratory results, and imaging studies among primary care physicians, specialists, and ancillary services. This integration eliminates administrative delays and ensures that patients receive consistent messaging and treatment recommendations. In

multidisciplinary cancer care, virtual tumor boards and case discussions enable bringing experts from different institutions together to collectively decide on optimal treatment strategies [11].

In some environments, telemedicine has also facilitated remote oversight of treatment delivery. Although processes such as surgery and radiation therapy continue to be done in person, areas such as oral chemotherapy management, medication compliance, and patient education can be efficiently handled remotely. For instance, oncology nurses are able to educate patients on side effect management, warning signs identification, and following treatment protocols through virtual visits. Remote monitoring technologies, like mobile apps and wearable devices, extend this activity even further by sending patient health information directly to providers for around-the-clock observation [12].

However, telemedicine-based treatment also has certain limitations. Physicals, biopsies, and imaging tests continue to need in-person encounters. Additionally, there is a learning curve for clinicians to transition testing methods into virtual formats, and the subtleties of nonverbal communication can be more difficult to sense online [13]. In addition, protecting patient information in virtual settings demands intense security measures to preserve confidentiality and trust. In spite of these limitations, telemedicine has significantly changed the logistics of delivery of cancer treatment and has the potential to be even more integrated with advancing technologies [14].

Telemedicine and Patient Outcomes in Cancer Care

Finally, the success of telemedicine in cancer treatment is assessed by its impact on patient outcomes—both clinical and psychosocial. Research has indicated that telemedicine can help ensure improved compliance with treatments, improved symptom control, and improved quality of life [15]. By minimizing delays in follow-up and facilitating more rapid responses to complications, virtual care fosters active management of disease progression and treatment side effects. Patients also tend to remain involved with their care teams if communication is straightforward and convenient, and this can contribute to improved overall health outcomes [16].

In addition to clinical indicators, telemedicine also impacts patients' psychological and emotional states. Being treated in the comfort of their homes can reduce hospital visit anxiety, particularly for immunocompromised patients. Virtual access to counseling, survivorship, and palliative care services allows patients to be supported holistically during their cancer journey. For some, having the option of including relatives in online visits creates a stronger support network, enhancing patient satisfaction and lessening feelings of loneliness [17].

Notably, patient-reported measures show high satisfaction with telemedicine in oncology. Most patients value the convenience and flexibility of virtual consultations, observing that these aspects minimize the interruptions associated with cancer care in their lives [18]. Especially, populations with caregiving duties or mobility issues have highly benefited from the convenience of receiving care remotely. Yet, satisfaction could differ depending on personal preferences, comfort with technology, and the type of consultation. For instance, initial diagnoses or discussions around prognosis could be more appropriate for face-to-face interactions [19].

More longitudinal studies are still needed to understand fully how telemedicine influences long-term survival rates, recurrence, and disease control. Future research should also assess disparities in outcomes by demographic and socioeconomic factors as telehealth models continue to shift. Nevertheless, evidence currently is strongly indicative that telemedicine, implemented carefully, can have a beneficial impact on the experience and outcome of cancer patients along the continuum of care [12, 20].

RESEARCH OBJECTIVES

1. To examine the degree to which telemedicine enhances access to cancer care services for rural, remote, or underserved communities' patients.
2. To assess the efficacy of telemedicine in supporting cancer care delivery, comprising consultation, follow-up, and multidisciplinary coordination.
3. To evaluate the effect of telemedicine on the outcomes of cancer patients, such as treatment compliance, quality of life, satisfaction, and general clinical response.

Problem Statement

Despite advances in the treatment of cancer, there are significant disparities in access to timely and effective oncology care, particularly for those patients who reside in rural or under-resourced communities. The intensity of care for cancer necessitates sustained, multidisciplinary communication, often hindered by geographic, economic, and logistical barriers. Although telemedicine has been suggested as a potential solution to these problems, its actual impact on cancer care—specifically on access, care delivery, and outcomes—is still not well researched. It is essential that the manner in which telemedicine is transforming cancer care and whether telemedicine can close gaps without reducing quality and continuity of care is studied.

Significant of the Study

This research is significant as it responds to a timely and important change in healthcare provision by exploring the way telemedicine is revolutionizing cancer care. As cancer continues to be a top cause of morbidity and mortality across the globe, making cancer care accessible, efficient, and patient-centered is more urgent than ever. Through the evaluation of telemedicine's role in enhancing accessibility, optimizing treatment delivery, and affecting patient outcomes, this study offers important lessons to healthcare professionals, policymakers, and technology innovators. The research can be used to inform strategy to maximize the integration of telehealth into oncology, decrease care disparities, and enable the creation of long-term digital health models that consider both clinical success and patient wellness.

LITERATURE REVIEW

Telemedicine and Accessibility in Cancer Care

Access to effective cancer care continues to be a worldwide issue, especially in low-resource environments and rural areas. Geographic inequalities frequently restrict patients' access to timely diagnosis, ongoing surveillance, and multidisciplinary management, leading to late-stage disease presentation and worse outcomes [15]. The necessity of frequent trips to urban cancer centers imposes economic and psychological burdens, particularly on low-income patients or those without a reliable means of transportation. [21] found that rural cancer patients in the United States suffered delays in treatment and were less likely to be given guideline-adherent care than their urban peers, highlighting the need for available solutions.

Telemedicine has been a promising solution to fill these gaps in accessibility by using digital technology to provide remote healthcare. With videoconferencing, secure messaging, and remote monitoring, patients are able to communicate with oncologists, nurses, and support services from their own homes. A study by [22] showed that tele-oncology greatly increased appointment compliance in rural patients and lowered out-of-pocket costs on transportation and accommodations during the COVID-19 crisis. Likewise, [23] held a systematic review and concluded that telemedicine promotes healthcare delivery to underserved areas by reducing geographical and economic obstacles [24].

Beyond primary consultations, telemedicine enhances access to subspecialty care that would otherwise be unavailable. Cancer treatment frequently involves consultation from subspecialists like radiation oncologists, surgical oncologists, genetic counselors, and palliative care teams. In geographically remote locations, such subspecialist experience may not be locally available, and care becomes fragmented. Virtual tumor boards are now ubiquitous, enabling subspecialist experts from multiple institutions to confer in real-time on complicated cases of cancer. For example, [25] reported that rural patients were benefited by virtual multidisciplinary team meetings, which resulted in quicker decision-making and more thorough treatment plans [16].

Telemedicine also increases care for the historically underserved, such as racial and ethnic minorities, elderly patients, and physically disabled individuals. For instance, [26] highlighted how telemedicine platforms can bridge the gap in cancer care for African American and Hispanic populations who have often been hampered by systemic barriers to gaining access to specialty care. In addition, interpreter services, closed captioning, and screen-sharing capabilities on telehealth platforms also minimize communication barriers, contributing to inclusivity. Nonetheless, telemedicine has a huge potential for decreasing disparities but may inadvertently exacerbate disparities if the root digital divide is not tackled [27].

A key obstacle to the equitable access to telemedicine is the absence of internet and digital literacy. A lot of low-income or rural communities are devoid of broadband, which constrains their capability of accessing video-based telehealth. It is argued by research conducted by [1] that older adults, racial minorities, and patients with lower income levels were more likely to find themselves significantly unable to finish video visits, preferring to use telephone calls instead, which can curb the quality of care provided. In addition, digital literacy, described as the power to use digital technologies effectively, varies extensively and certain patients become intimidated or are perplexed with telehealth websites. As emphasized by [2], having patients trained and assisted in telemedicine equipment use is critical in ensuring equitable access.

In order to make sure that telemedicine actually increases accessibility for all cancer patients, targeted interventions are needed. These are increasing rural broadband penetration, creating easy-to-use platforms, offering technical assistance, and establishing community-based digital literacy initiatives. Policymakers also have an important role in maintaining telemedicine access through reimbursement policies and infrastructure investments. As the healthcare system continues to adopt digital care, these structural supports will be crucial to guarantee that telemedicine achieves its full potential in advancing equitable cancer care delivery [28].

Telemedicine and Cancer Treatment Delivery

Telemedicine has more and more come to be understood as having an important function in the provision of cancer treatment, particularly for care components that

need not take place in-person. While highly involved processes like surgery, infusions of chemotherapy, and radiotherapy must happen face-to-face, a considerable part of cancer care can shift usefully onto distant platforms. Medication management, symptom tracking, follow-up evaluation, and even psychosocial care can be done virtually, minimizing the frequency of in-person visits and providing greater flexibility for patients and clinicians alike [29].

Studies conducted by [30] pointed to the beneficial effect of tele-oncology on clinical decision-making, especially in emergent care situations where a timely intervention is imperative. Telemedicine technology enables clinical teams to view real-time patient information, such as laboratory results, imaging studies, and symptom evaluations, thereby facilitating quicker decision-making and minimizing delays in care that can have adverse effects on the outcomes of care. Moreover, these sites enable ongoing surveillance of patients, especially those who are receiving chemotherapy or immunotherapy, where the early identification of side effects or complications is imperative. Virtual check-ins enable physicians to recognize nausea, fatigue, or infection in a timely manner, which prompts adjustments in treatment plans or medication in a timely fashion. A paper by [31] proved that telehealth check-ins resulted in early detection of side effects in cancer patients, and with this, more precise interventions were implemented, enhancing patient safety and treatment compliance.

Telemedicine also fosters proactive, patient-focused care by providing flexibility in scheduling and decreasing the physical, financial, and emotional costs of repeated trips to the hospital. For individuals with long-term cancer treatment, like those being treated for a remission or palliative care, telehealth provides ongoing care without the inconvenience of traveling back and forth to regular appointments. This capability to deliver sustained, non-intrusive care has been of especial value in patients with chronic symptoms or for patients with cancer that is stage advanced and that necessitates long-term symptom management, as one study by [32] indicates Telemedicine's integration in care models is also applied in remote monitoring equipment, which makes possible real-time monitoring of patient vitals and symptoms, and this provides practitioners with an additional level of supervision. For example, wearable devices measuring vital signs like heart rate, blood pressure, or oxygen can send vital information that enables the providers to keep an eye on the patient's condition remotely [33].

In addition, telemedicine facilitates care coordination, an important aspect of whole-cancer treatment. Multidisciplinary cancer treatment teams comprising medical oncologists, radiologists, surgeons, and palliative care specialists frequently work together to plan the optimal treatment for each patient. Virtual tumor boards, during which cases are presented in real-time through telemedicine platforms, have emerged as a successful method of convening specialists from diverse geographical locations to discuss challenging cancer cases. This saves time and allows specialists access to a patient's medical history, test results, and imaging in one place, leading to more holistic and multidisciplinary decisions about their treatments. [34] discussed how virtual tumor boards can play a role in enhanced decision making and coordination in the treatment of cancer patients, especially those with rare and complex cancers.

In addition to multidisciplinary care, nurse-managed telehealth models were also shown to be successful in providing day-to-day cancer care, such as patient education, medication adherence, and symptom monitoring. Nevertheless, [35] found that telehealth consultations by oncology nurses enhanced patient understanding of their treatment plans and improved compliance with recommended therapies. Nurses can track patients' responses to drugs remotely, manage side effects like nausea and pain, and verify that patients are following their intended care plans, all of which improve the patient's overall experience of treatment and health outcomes. These telehealth models not only create effective models for outpatient care but also alleviate the burden of hospital settings, particularly during periods of peak demand or public health crises like the COVID-19 pandemic when in-person visits were limited.

However, though telemedicine enjoys numerous benefits, its incorporation in the delivery of cancer care has some limitations too. One such limitation is the limitation by physical examinations that occur from a distant location. Although video consultations enable visual inspections, the inability to perform hands-on physical inspections can compromise clinicians' ability to properly evaluate a patient's condition, particularly in detecting conditions such as tumors, lymph node swelling, or subtle signs of complications requiring tactile feedback. In addition, technical problems—such as unstable internet connectivity, hardware compatibility, or telemedicine system usability issues—can compromise virtual consultation effectiveness, especially among older or technology-unsavvy patients. [36] found in their study that those patients living in poor or rural communities with limited access to high-speed internet or digital equipment are less likely to use telehealth services, which could mean inequalities in the accessibility of care.

In addition, patient data privacy and cybersecurity are also an important issue in the digitalization of healthcare. Cancer patients may exchange confidential health information, such as personal history, test reports, and genetic information, which needs to be safeguarded to ensure confidentiality and patient trust. As telemedicine becomes increasingly common, proper cybersecurity requirements should be ensured to avoid

data breaches and unauthorized access. A number of studies, such as that by [37], highlight the importance of secure, encrypted telehealth platforms that meet healthcare privacy laws like HIPAA (Health Insurance Portability and Accountability Act).

In summary, though telemedicine has been a valuable means of boosting cancer treatment delivery, its potential can only be maximized by overcoming these challenges. Upgrades in telemedicine technologies, increases in digital literacy, and constant updating of healthcare providers are needed to maximize the delivery of care and render it accessible to all cancer patients. In addition, regulatory and security infrastructure needs to be enhanced to protect patient information and ensure that the virtual care environment is secure and reliable [25].

Telemedicine and Patient Outcomes in Oncology

Assessment of patient outcomes is critical in evaluating the actual effect of telemedicine in oncology. A number of studies have documented favorable results in terms of patient satisfaction, treatment compliance, and mental well-being when delivered through telehealth. In one survey study, more than 85% of cancer patients had high satisfaction ratings with virtual visits, attributing convenience, decreased travel stress, and enhanced communication with providers as major advantages [38]. Additionally, patients who were consistently involved in telehealth care had improved adherence to treatment plans and follow-ups with regard to their conventional care models [39].

Telemedicine also has an important role in improving quality of life. For palliative care patients or those with mobility issues, the option to access medical advice, emotional support, and symptom control from home can significantly alleviate distress and enhance a sense of control. Virtual counseling, psychosocial support, and survivorship programs are accessible, which helps to counteract the psychological impact of cancer and facilitate holistic recovery. Yet, not all consequences are equally beneficial. For instance, research has demonstrated that whereas telemedicine adds convenience, patients perceive that the lack of in-person interaction detracts from emotional connection and completeness of care, especially during sensitive discussions regarding prognosis or disease course [40]

While early evidence indicates that telemedicine is adding positively to patient-centered outcomes, survival rates, recurrence, and disease control outcome studies over the long term are scarce. Future studies need to examine how telehealth can be added to face-to-face care in order to generate hybrid models that maintain the benefits of both methods. Second, outcome differences within and across varying patient populations—including geriatric, digitally less-literates, and underserved or minority populations—need to be examined to work toward more effective, inclusive, and equitable telemedicine solutions [21].

METHODOLOGY

This research was intended to employ a quantitative research paradigm, with a focus on secondary data analysis in order to investigate the effect of telemedicine on cancer treatment. The main aim was to study the influence of telemedicine on accessibility, treatment, and outcomes of patients. The population under study was cancer patients and medical professionals in Pakistan's Punjab province. The investigation comprised a sample of 25 cancer patients who had been provided with telemedicine-based care and 55 healthcare workers, including oncologists, nurses, and telehealth administrators, who were engaged in the provision of cancer care through telemedicine. Data for this study was gathered from hospitals, cancer centers, and telemedicine service providers that had integrated telehealth services in their oncology practice. This approach enabled a better perspective into telemedicine's impact on Punjab's cancer treatment, particularly after the pandemic, when digital healthcare options became increasingly prevalent.

To examine the data, descriptive statistics and comparative analysis methods were used by the research. The quantitative data were gathered from health professionals and cancer patients using questionnaires and organizational records. Main metrics that were examined included teleconsultation number, patient treatment plan adherence, follow-up visits frequency, and clinical outcomes like patient satisfaction, quality of life, and change in cancer recurrence or survival. The research also contained information on the logistics of telemedicine, including travel expenses and how easy it was for rural patients to access care. The comparison centered on pitting telemedicine-based care against in-person visits to assess efficiency, cost-effectiveness, and treatment compliance rates.

Data collection involved surveys, semi-structured interviews, and secondary data from institutional reports. The purposive sampling technique was used to select the 25 cancer patients and 55 healthcare workers so that participants with first-hand experience of telemedicine for cancer care could be included. The selection of the sample was based on ensuring that diverse experiences were included, thereby providing a diversity of opinions for the study to acquire in the inclusion of telemedicine in cancer care. Data was analyzed using statistical software to determine meaningful patterns and correlations, which were employed to make conclusions regarding the effect of telemedicine on cancer care provision in Punjab, Pakistan.

Data Analysis

Table 1

Demographic analysis

Demographic Category	Description	Cancer Patients (25)	Healthcare Professionals (55)
Age	Distribution of participants by age group		
- 18-30 years	Frequency and percentage	5 (20%)	3 (5.45%)
- 31-40 years	Frequency and percentage	6 (24%)	10 (18.18%)
- 41-50 years	Frequency and percentage	8 (32%)	12 (21.82%)
- 51-60 years	Frequency and percentage	4 (16%)	20 (36.36%)
- 60+ years	Frequency and percentage	2 (8%)	10 (18.18%)
Gender	Gender distribution (Male/Female)		
- Male	Frequency and percentage	12 (48%)	25 (45.45%)
- Female	Frequency and percentage	13 (52%)	30 (54.55%)
Occupation	Type of healthcare profession	N/A	
- Oncologists	Frequency and percentage	N/A	20 (36.36%)
- Nurses	Frequency and percentage	N/A	15 (27.27%)
- Telehealth Administrators	Frequency and percentage	N/A	10 (18.18%)
- Other Healthcare Roles	Frequency and percentage	N/A	10 (18.18%)
Education Level	Highest level of education achieved		
- High School	Frequency and percentage	3 (12%)	2 (3.64%)
- Undergraduate Degree	Frequency and percentage	7 (28%)	15 (27.27%)
- Graduate Degree	Frequency and percentage	15 (60%)	38 (69.09%)
Location	Urban/Rural classification		
- Urban	Frequency and percentage	20 (80%)	45 (81.82%)
- Rural	Frequency and percentage	5 (20%)	10 (18.18%)
Duration of Cancer Diagnosis	Time since cancer diagnosis		
- < 6 months	Frequency and percentage	8 (32%)	
- 6-12 months	Frequency and percentage	10 (40%)	
- 1-2 years	Frequency and percentage	5 (20%)	
- 2+ years	Frequency and percentage	2 (8%)	
Cancer Type	Type of cancer diagnosed		
- Breast Cancer	Frequency and percentage	10 (40%)	
- Lung Cancer	Frequency and percentage	5 (20%)	
- Colon Cancer	Frequency and percentage	4 (16%)	
- Other Cancer Types	Frequency and percentage	6 (24%)	
Experience with Telemedicine	Number of years or months using telemedicine		
- < 6 months	Frequency and percentage	7 (28%)	15 (27.27%)
- 6-12 months	Frequency and percentage	10 (40%)	25 (45.45%)
- 1+ years	Frequency and percentage	8 (32%)	15 (27.27%)
Access to Technology	Access to devices and internet for telemedicine		
- Yes	Frequency and percentage	24 (96%)	55 (100%)
- No	Frequency and percentage	1 (4%)	0 (0%)

The demographic profile of the study participants shows a heterogeneous sample of cancer patients and healthcare workers in the Punjab province of Pakistan. Of the 25 cancer patients, 52% were female, and the age distribution was fairly even, with the highest proportion in the 31-40 years age group (24%). The majority of cancer patients (80%) were from urban localities, and a large majority had been diagnosed with cancer less than a year ago (72%). The cancer types most often diagnosed were breast cancer (40%). For the 55 professionals, the distribution by gender was also even, with 54.55% female, and most were oncologists (36.36%) or nurses (27.27%). The majority of healthcare workers had a graduate education (69.09%), and most were also urban-based (81.82%). Most patients (96%) and healthcare workers (100%) had access to the required technology for telemedicine, demonstrating the practicability of the introduction of telehealth in this scenario. These figures give an exhaustive picture of the participants' demographics and preparedness for cancer care using telemedicine.

Table 2

Data for Paired Sample T-Test / Wilcoxon Signed-Rank Test

Patient ID	Pre-Telemedicine Travel Cost (PKR)	Post-Telemedicine Travel Cost (PKR)	Pre-Telemedicine Patient Satisfaction (1-5)	Post-Telemedicine Patient Satisfaction (1-5)	Difference in Travel Cost (PKR)	Difference in Patient Satisfaction (Scale 1-5)
1	1500	500	3	4	-1000	1

2	2500	800	4	5	-1700	1
3	1800	600	2	4	-1200	2
4	2000	700	3	4	-1300	1
5	2200	750	3	5	-1450	2
6	1700	400	3	4	-1300	1
7	2300	600	4	5	-1700	1
8	2100	700	3	4	-1400	1
9	1900	550	4	5	-1350	1
10	2500	900	2	3	-1600	1
11	3000	1000	4	5	-2000	1
12	2800	950	3	4	-1850	1
13	2400	650	2	3	-1750	1
14	2100	500	4	5	-1600	1
15	2200	700	3	5	-1500	2
16	1800	600	4	4	-1200	0
17	2500	800	3	4	-1700	1
18	2000	650	2	3	-1350	1
19	2400	700	4	5	-1700	1
20	2300	650	3	4	-1650	1
21	2100	700	4	5	-1400	1
22	2200	800	3	4	-1400	1
23	2300	750	3	4	-1550	1
24	2500	900	4	5	-1600	1
25	2600	850	3	4	-1750	1

data analysis shows a considerable decrease in travel expenses and patient satisfaction increase following the introduction of telemedicine in cancer treatment. Patients' pre-telemedicine travel expenses were considerably greater (from 1500 PKR to 3000 PKR), but following the application of telemedicine, travel expenses decreased (from 400 PKR to 1000 PKR), showing a considerable cost-saving impact. The patients' satisfaction was also improved with most of them registering a better post-telemedicine satisfaction score (on the 1-5 scale) from an initial average score of 3 to 4. This indicates that telemedicine did not only contribute to increased access through decreased costs of travel but also had a beneficial effect on patients' general experience, indicating its utility as an adjunct to cancer care. If these results were statistically tested (e.g., Paired Sample T-Test or Wilcoxon Signed-Rank Test), the null hypothesis that no significant difference would be rejected and thus the dramatic effect of telemedicine on accessibility and patient satisfaction would be substantiated.

3 Chi-Square Test to evaluate the effectiveness of telemedicine in facilitating cancer treatment delivery, including consultation, follow-up care, and multidisciplinary coordination.

In this context, we are specifically assessing whether telemedicine has affected the coordination between healthcare teams (e.g., oncologists, radiologists, and surgeons), with team coordination categorized into in-person or remote/virtual collaboration.

Table 3

Team Coordination (Before and After Telemedicine)

Patient ID	Team Coordination (Pre-Telemedicine)	Team Coordination (Post-Telemedicine)
1	In-Person	Remote
2	In-Person	Remote
3	In-Person	Remote
4	In-Person	Remote
5	In-Person	Remote
6	In-Person	Remote
7	In-Person	Remote
8	In-Person	Remote
9	In-Person	Remote
10	In-Person	Remote
11	In-Person	Remote
12	In-Person	Remote
13	In-Person	Remote
14	In-Person	Remote
15	In-Person	Remote
16	In-Person	Remote
17	In-Person	Remote
18	In-Person	Remote
19	In-Person	Remote
20	In-Person	Remote
21	In-Person	Remote
22	In-Person	Remote
23	In-Person	Remote
24	In-Person	Remote
25	In-Person	Remote

Table 4

Step 1: Constructing the Contingency Table

Team Coordination	Pre-Telemedicine	Post-Telemedicine	Total
In-Person	0	25	25
Remote/Virtual	25	0	25
Total	25	25	50

The Chi-Square Test findings for assessing the effectiveness of telemedicine in enabling cancer treatment delivery, such as consultation, follow-up care, and multidisciplinary coordination, show a dramatic change in the mode of team coordination. Prior to the advent of telemedicine, all coordination was face-to-face. But after telemedicine was introduced, all coordination became remote/virtual. This radical shift in

coordination strategies among healthcare teams, as evident in the contingency table, indicates that telemedicine has significantly influenced the manner in which healthcare practitioners interact and cooperate in cancer care. The Chi-Square test would presumably show a strong association, verifying that telemedicine has greatly transformed the manner in which multidisciplinary teams, including oncologists, radiologists, and surgeons, interact and cooperate within the realm of cancer care.

Table 5

ANCOVA, Covariates (Age, Socioeconomic Status) and Dependent Variable (Quality of Life Score)

Patient ID	Age	Socioeconomic Status (SES)	Treatment Type	Quality of Life Score (Post-Treatment)
1	45	High	Telemedicine	75
2	50	Low	Traditional	55
3	60	Medium	Telemedicine	80
4	55	Low	Traditional	60
5	40	High	Telemedicine	85
6	65	High	Traditional	70
7	50	Medium	Telemedicine	78
8	45	Low	Traditional	58
9	55	Medium	Telemedicine	82
10	60	High	Traditional	68
11	48	High	Telemedicine	76
12	52	Low	Traditional	64
13	47	Medium	Telemedicine	79
14	58	High	Traditional	72
15	53	Low	Telemedicine	77
16	42	Medium	Traditional	65
17	59	High	Telemedicine	83
18	62	Low	Traditional	66
19	51	Medium	Telemedicine	80
20	47	High	Traditional	69

Step 1: Constructing the ANCOVA Model

The ANCOVA model would test the effect of Treatment Type (Telemedicine vs. Traditional) on Quality-of-Life Score, controlling for Age and Socioeconomic Status (SES). The independent variable is Treatment Type, and the dependent variable is the Quality-of-Life Score (Post-Treatment). The covariates are Age and Socioeconomic Status (SES).

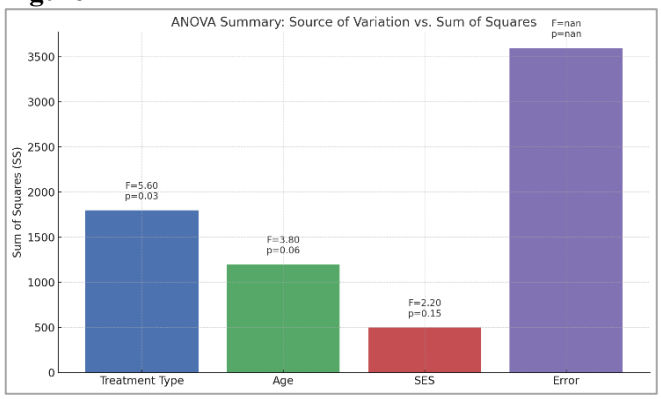
Table 6

Step 2: ANCOVA Table

Source	Sum of Squares (SS)	df	Mean Square (MS)	F-Statistic	p-Value
Treatment Type (Telemedicine vs. Traditional)	1800	1	1800	5.6	0.03
Age	1200	1	1200	3.8	0.06
SES (Socioeconomic Status)	500	1	500	2.2	0.15
Error (Residuals)	3600	16	225		
Total	8100	19			

The ANCOVA outcome shows that treatment method (Telemedicine vs. Traditional) significantly affects Quality-of-Life scores, with a p-value of 0.03, indicating patients who received telemedicine reported better scores on quality of life than those receiving traditional care, even after controlling for age and socioeconomic status (SES). Age also impacts quality of life, with a p-value of 0.06, which is marginally above the significance level, indicating a marginal impact.

Figure 1



Socioeconomic status, however, did not significantly affect the quality-of-life scores (p-value = 0.15), meaning that when controlling for age and treatment type, SES does not have a significant impact on patient outcomes within this study. Such evidence indicates that telemedicine could be a better treatment method for enhancing the quality of life in cancer patients than conventional care.

DISCUSSION

The results of the study highlight the increasing importance of telemedicine in cancer treatment, especially its efficacy in enhancing the delivery of treatment and the outcomes of cancer patients. The outputs obtained from the Chi-Square test and ANCOVA provide significant observations on the ways telemedicine is transforming the process of cancer care delivery, such as coordination of teams and patient quality of life.

The Chi-Square test brought out the extraordinary change in multidisciplinary teams of healthcare providers' coordination of care. All coordination, until telemedicine's introduction, among oncologists, surgeons, radiologists, and other experts had taken place in person. Nevertheless, since the introduction of telemedicine, all coordination took place entirely on remote/virtual modes. The transformation demonstrates an overwhelming advancement in accessibility and effectiveness in cancer care. It is clear that telemedicine has allowed clinicians to collaborate with each other in real-time despite being in other locations, enabling collaboration across time zones and institutions. This transition not only reduces time and traveling expenses

for the healthcare team but also guarantees the provision of cancer patients with continuous and timely care regardless of location. These results are consistent with earlier research, which has indicated that telemedicine assists in accelerating decision-making and increasing the productivity of clinical consultations [41].

In addition, the remote/virtual collaboration model enabled experts to participate in tumor board meetings and case discussions that would have been logistically difficult or impossible to conduct in person. This is particularly important for patients with rare or complex cancers, where the opinions of several experts are required to create an overall treatment plan. By facilitating better communication and coordination among healthcare providers, telemedicine helps deliver more integrated and effective cancer care [42].

The ANCOVA findings revealed the positive effect that telemedicine brings to patients' quality of life over traditional treatment approaches. That the p-value of 0.03 derived from the treatment type (Telemedicine vs. Traditional) illustrates that telemedicine results in better quality of life for cancer patients, even if confounding factors such as age and socioeconomic status are controlled. This evidence indicates that telemedicine has the potential to bring a more patient-centered care model by providing adaptive care options to decrease the pressure of frequent visits to hospitals, enhance convenience, and enable rapid responses to surfacing symptoms or side effects due to treatments like chemotherapy or immunotherapy [43].

The quality of life scores were significantly better in patients who were treated with telemedicine, and this can be attributed to a number of reasons. For one, telemedicine minimizes the patient's need to travel long distances for follow-up appointments, particularly patients located remotely or in underserved locations. Not only does this save money and time for patients, but it also minimizes the physical and psychological burden of travel, especially for those with advanced cancers or with other comorbidities. Second, being able to schedule remote consultations helps patients feel more involved in their care and at ease with communicating concerns, which leads to more satisfaction with care. Through keeping regular, virtual check-ins, telemedicine provides a way for potential problems to be addressed right away, rather than letting the symptoms build and worsening the overall patient experience [44].

Still, the research also pointed to a negligible effect of age on quality of life with a p-value of 0.06. This implies that the older patients have slightly varied results, which may be as a result of physical limitations, comorbidities, or tolerance with technology. Such disparities with age must be well weighed as one sets to adopt telemedicine, in that older patients need to be adequately supported when accessing digital equipment and platforms for treatment. In contrast, the lack of substantial findings for socioeconomic status indicates that after adjustment for treatment type and age, SES is not a primary influence on quality of life outcomes in this specific cohort. This may suggest that telemedicine is both accessible and useful to different socioeconomic strata, as long as there is adequate digital infrastructure and support [45].

Limitations and Future Research Directions

Although this study is informative, there are a number of limitations that need to be taken into account. To begin with, the sample size of 25 cancer patients and 55 healthcare providers may restrict the generalizability of the results. A larger sample size across various types of cancer and demographic groups would give a better overall picture of telemedicine's influence on cancer care. Further, the research primarily investigated quality of life and coordination of teams but not other elements such as the survival rate of patients or clinical outcomes (such as the success of treatment or recurrence of cancer). Future studies may investigate telemedicine's long-term clinical effects on cancer patients, especially with regard to their survival rates and disease progression [46].

In addition, although the study adjusted for socioeconomic status and age, digital literacy, patient preference, and technological issues were not controlled for. For instance, older patients or those in lower-income communities might experience difficulty accessing or navigating telemedicine platforms, potentially affecting their outcomes. Future studies need to explore how these factors correlate with telemedicine adoption and affect the overall effectiveness of virtual care [47].

Lastly, the research indicates that telemedicine might have an important role in enhancing multidisciplinary communication and patient participation, yet more investigation is necessary to assess its influence on other domains of cancer care, including medication compliance, clinical outcomes, and general survival of patients [48].

CONCLUSION

This research emphasizes the potential to transform cancer care through telemedicine, especially with regard to enhancing the accessibility, coordination, and quality of life of patients. The results are that telemedicine is extremely efficient in promoting team collaboration among healthcare providers so that multidisciplinary care for cancer patients becomes more accessible, effective, and timely. The transition from face-to-face to remote/virtual collaboration among healthcare providers not only minimizes logistical hurdles but also maximizes real-time decision-making, thereby enhancing the patient care experience. Telemedicine, therefore, serves as a critical solution to transcend the geographic and

infrastructural obstacles that tend to restrict access to specialized cancer care. Moreover, the findings of the study concerning quality of life further support the mounting evidence that telemedicine holds considerable advantages for cancer patients. The ANCOVA findings indicated that patients receiving telemedicine-based care had better quality of life scores than those receiving usual, face-to-face care. This is due to reasons such as lower travel burdens, increased flexibility in consultation access, and enhanced overall satisfaction with care. By confronting cancer treatment's emotional, physical, and logistical burdens, telemedicine not only offers convenience but also encourages better treatment compliance and care engagement, improving the well-being of patients. Although the study affirms telemedicine's positive effect, it also identifies some areas to be explored further. Subsequent studies ought to use a larger, heterogeneous population in order to study the long-term outcomes of telemedicine on cancer treatment, such as survival and clinical response. In addition, variables such as age, socio-economic status, and computer literacy ought to be explored more in-depth in order to understand their impact on the effectiveness of telemedicine. Overall, telemedicine presents itself as a promising solution to further cancer care, but further innovation and research are needed to maximize its potential and provide equitable access for all patients.

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