

Cost-effectiveness of telemedicine and the regulation of teleneurology in Brazil

Custo efetividade da telemedicina e a regulação de teleneurologia no Brasil

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ABSTRACT

Introduction: The COVID-19 pandemic has significantly increased the interest and practice of telemedicine among Brazilian neurologists. Before the pandemic, only 18.5% used it, but this number rose to 56.2% after its onset. Telemedicine offers several benefits, such as reduced no-show rates, decreased average consultation time, high patient and physician satisfaction, and considerable cost reduction.

Objective: To review the literature on the cost-effectiveness of telemedicine in neurology and discuss pathways for its regulation in the Brazilian health system.

Method: This systematic review followed a rigorous methodological process. Databases such as PubMed, Medline (BVS), and Science Direct were used. The articles were filtered based on the evaluation of patients through teleneurology and the analysis of the costs and effectiveness of this service. Only original studies and clinical trials in English or Spanish were included, while duplicate and review articles were excluded.

Result: A total of 29 articles focused on the topic were included in this review.

Conclusion: Telemedicine in neurology is cost-effective and offers several advantages, such as cost reduction, improved patient quality of life, and increased access to specialists, and holds promise for improving care in rural and remote areas. However, adequate regulation, standardization of clinical and technical protocols, and financial sustainability of programs are essential for its successful implementation. Evidence suggests that teleneurology can and should be integrated into mainstream health services to optimize neurological care and reduce disparities in access to treatment.

KEYWORDS: Cost-effectiveness. Telemedicine. Teleneurology.

Central Message

The cost-effectiveness analysis of telemedicine is crucial to assess its economic and clinical impact, especially in the context of teleneurology. This modality uses digital technologies to offer neurological diagnoses and treatments at a distance, and it is essential to consider how regulation in Brazil influences its implementation.

Perspective

The regulation of teleneurology in Brazil is a key point to ensure its efficiency and safety. Studies show that adequate regulation can promote the reduction of health costs, improve access to specialists, and optimize the management of neurological diseases, proving to be essential to maximize the benefits of telemedicine in the country.

RESUMO

Introdução: A pandemia de COVID-19 aumentou significativamente o interesse e a prática da telemedicina entre os neurologistas brasileiros. Antes da pandemia, apenas 18,5% a utilizavam, mas esse número subiu para 56,2% após seu início. A telemedicina oferece vários benefícios, como redução da taxa de não comparecimento, diminuição do tempo médio de consulta, alta satisfação de pacientes e médicos, e considerável redução de custos.

Objetivo: Revisar a literatura sobre o custo-efetividade da telemedicina na neurologia e discutir os caminhos para sua regulamentação no sistema de saúde brasileiro.

Método: Esta revisão sistemática seguiu rigoroso processo metodológico. Foram utilizadas bases de dados como PubMed, Medline (BVS) e Science Direct. Os artigos foram filtrados com base na avaliação de pacientes através da teleneurologia e a análise dos custos e da efetividade desse serviço. Apenas estudos originais e ensaios clínicos em inglês ou espanhol foram incluídos, enquanto artigos duplicados e de revisão foram excluídos.

Resultado: Foram incluídos nesta revisão 29 artigos focados no tema.

Conclusão: A telemedicina na neurologia é custo-efetiva e oferece várias vantagens, como redução de custos, melhoria na qualidade de vida dos pacientes e maior acesso a especialistas e promissora para melhorar o atendimento em áreas rurais e remotas. No entanto, a regulamentação adequada, a padronização dos protocolos clínicos e técnicos, e a sustentabilidade financeira dos programas são essenciais para a sua implementação bem-sucedida. A evidência sugere que a teleneurologia pode e deve ser integrada nos principais serviços de saúde para otimizar o cuidado neurológico e reduzir disparidades no acesso ao tratamento.

PALAVRAS-CHAVE: Custo efetividade. Telemedicina. Teleneurologia.

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INTRODUCTION

The COVID-19 pandemic has increased the interest and practice of telemedicine among Brazilian neurologists. A survey conducted in 2020 showed that 56.2% of neurologists started working with telemedicine after the beginning of the pandemic, while only 18.5% worked with telemedicine before it.¹

Such benefits can be measured by indicators such as the no-show rate, the average time spent in consultations, the satisfaction scale, and the effects on patients' health. Additionally, the average cost per virtual consultation was estimated to be \$30, compared to \$150 per face-to-face consultation. In addition², patient and physician satisfaction with virtual consultations, using a scale of 1 to 5, was high, with an average of 4.7, while physician satisfaction was similar, with an average of 4.5. Telemedicine can reduce healthcare costs by up to 20% by reducing hospital admissions, patient transfers, face-to-face consultations, and overdiagnosis.³ An increase in the quality of life of patients by up to 30% was also noted by improving access to health services, reducing waiting times, avoiding commuting, and facilitating follow-up. Concomitantly, it improved the accuracy of the diagnosis of neurological diseases by up to 40% by allowing the evaluation of specialists at a distance, in addition to improving adherence to the treatment of neurological diseases by up to 50% by offering continuous support and guidance to patients.

In Europe, there is also evidence of the effectiveness and acceptance of telemedicine in neurology. In France⁴, its impact on the quality of neurological care in a rural region involved 12 general practitioners and 12 neurologists who carried out consultations by videoconference for 1 year. The study showed that teleneurology improved patient access to specialists, reduced waiting and travel times, increased patient and physician satisfaction, and did not compromise the quality of neurological care.

Thus, the objective of this review was to find evidence in the literature about the cost-effectiveness of telemedicine applied to neurology, as well as the ways to regulate this practice in the health service

METHOD

This article is a systematic review of the literature, a methodological analysis method that gathers evidence for clinical practice, through the search, evaluation and synthesis of available information on the specific topic to be analyzed. To carry out the present study, the following methodological steps were followed: identification of the theme and guiding question of the research; definition of inclusion and exclusion criteria; identification of the information to be extracted from the selected articles; analysis and interpretation of the results and presentation of the review. At first, the theme "Teleneurology and its cost-benefit for the health system" was established. Next, the guiding question was defined "Is teleneurology

cost-effective enough to be regulated and used in the main health services in Brazil?". For scientific basis, searches were carried out in the PubMed, Medline (BVS) and Science Direct databases.

The articles were filtered in summary and included if they presented as a proposal the evaluation of patients through teleneurology, as well as the evaluation of the costs and effectiveness of this service. Based on this, articles that did not address the relationship between cost and benefits, that did not deal directly with patients treated by telemedicine, and studies that did not mention the regulation of teleneurology were excluded.

The search results were selected based on the exclusion and inclusion criteria that were applied to the articles made available in full. Only original studies related to the theme were included, focusing on clinical trials and randomized studies that answered the guiding question in English or Spanish. At the same time, duplicate articles, review articles, and those that did not fit the theme of this review were excluded.

DISCUSSION

A pilot randomized controlled trial in patients with Parkinson's disease showed that telemedicine can improve patients' quality of life and motor performance. Patients who received ongoing care via telemedicine had follow-up rates of up to 97%, and 13 of the 14 patients chose to receive more specialized care via telemedicine. Interobserver agreement in the remote assessment of patients with Parkinson's disease using telemedicine was excellent for postural stability, gait, and standing up from a chair; good for speech evaluation, facial expression, tremor at rest, hand and body bradykinesia; and fair for finger touches, hand grip and action shake. Remote stiffness assessment could not be performed as well.¹ The study presents a retrospective analysis of data on the implementation of a teleneurology network that was established to improve access to neurologists in rural areas and reduce the number of transfers of stroke patients to tertiary centers. During the 10-year study period, a total of 4296 stroke patients were evaluated through the teleneurology and telestroke network. Of these, 2493 were evaluated before the implementation of the teleneurology network and 1803 evaluated after its implementation. Patients evaluated before the implementation of the teleneurology network were older (66.4 years) compared to patients evaluated after (67.8 years). However, there were no significant differences in baseline characteristics between the 2 groups. The results showed that patients evaluated before the implementation of the teleneurology network were more likely to be transferred to the tertiary center (29.4%) compared to those evaluated after its implementation (20.2%). It was associated with significant reduction in stroke care costs, with an estimated average cost reduction of \$4997 per patient.²

One study showed that telemedicine can reduce the waiting time for care for patients with neurological diseases by up to 50%. Another reported that it can reduce travel costs by up to 80% for patients living in remote areas. A systematic review study showed that telemedicine can improve the quality of care and patient satisfaction compared to face-to-face care. Another reported that telemedicine may be a viable option for the care of patients with Alzheimer's disease, especially for those who have mobility difficulties or live in remote areas. A systematic review highlighted the importance of evaluating the efficacy and effectiveness of telemedicine for the care of patients with neurological diseases, including Alzheimer's.³

According to Access 2022, a Canadian initiative to improve access to healthcare services, telemedicine can save up to \$1.3 billion in healthcare costs per year. According to Canada Health Infoway, 77% of Canadian physicians reported using some form of digital health technology in 2018, a 14% increase from 2016. A 2017 Accenture report found that telemedicine could save up to \$10 billion in healthcare costs in the United States. OTN, a Canadian telemedicine organization, reported that virtual visits can save up to 4 h of travel time for patients living in rural areas.⁴ In question 5 of the questionnaire, 57.4% of neurologists answered that before the beginning of the COVID-19 pandemic they did not seek studies and scientific evidence in the areas of teleneurology and neurological examination through telemedicine, while 42.6% answered that they did. In question 6 of the questionnaire, 57.4% of neurologists answered that before the beginning of the COVID-19 pandemic they had not participated in face-to-face or online scientific event(s) on telemedicine or teleneurology, while 42.6% answered yes. In question 11 of the questionnaire, 56.2% of neurologists answered that after the beginning of the COVID-19 pandemic they started working with telemedicine, while 43.8% answered that they did not. The survey showed that 63.6% of neurologists said they worked with telemedicine during the pandemic, while only 18.5% worked with telemedicine before the pandemic.⁵

The article mentions that telemedicine can reduce stroke treatment time by up to 15 minutes, which can save up to 30 million neurons. The article mentions that telemedicine can increase access to neurology specialists in rural or remote areas, where the average ratio of neurologists per 100,000 inhabitants is only 0.033. The article reports that telemedicine can improve the quality of life of patients with Parkinson's disease, reducing face-to-face visits by 67% and transportation costs by 40%. The article states that telemedicine can facilitate the diagnosis and management of epilepsy, allowing electroencephalograms (EEGs) to be performed at a distance, with a sensitivity of 96% and specificity of 94%. The article concludes that telemedicine is a promising tool to improve the care of patients with neurological diseases, especially in remote or

resource-scarce areas.⁶

"The growing demand for neurological consultations around the world has driven the development of new ways to reach more patients. Telemedicine can provide accessible, low-cost, and high-quality health services." A growing body of evidence supports the feasibility and effectiveness of telemedicine tools for Parkinson's disease and other movement disorders." "Studies from different countries have shown that individuals with Parkinson's disease experienced worsening of motor and non-motor symptoms during the COVID-19 pandemic." "Telemedicine was considered an efficient and acceptable tool, technically feasible and satisfactory for patients, neurologists and nurses". "Telemonitoring, along with video conferencing, appears to be useful in identifying patients who may be candidates for advanced therapies for Parkinson's disease."⁷

Several studies have reported cost savings: tele dermatology in Spain of 40% compared to conventional dermatology; telecardiology in Portugal of 50% compared to conventional cardiology; telepsychiatry in the USA of 24% compared to conventional psychiatry; telemedicine in oncology in Australia of 30% compared to conventional oncology.⁸

One study found that implementing a telemedicine program for stroke care in rural areas resulted in a significant reduction in the average time of care and in the number of patients transferred to larger hospitals. The average time of care was reduced from 120 to 45 min, and the number of patients transferred to larger hospitals was reduced from 50% to 10%.⁹ The study indicates that telemedicine can help in the evaluation and treatment of headache, providing a 50% reduction in the frequency of crises and a 75% increase in patient satisfaction. The work shows that telemedicine can contribute to the care of patients with dementia, offering a 20% improvement in treatment adherence and a 30% decrease in depressive symptoms. The work reveals that telemedicine can optimize the diagnosis and therapy of sleep disorders, achieving 90% agreement between the results obtained at a distance and those performed in person.¹⁰

According to the authors, telestroke has been shown to improve access to and quality of care for stroke patients, reduce geographic and socioeconomic disparities, increase the use of evidence-based therapies such as intravenous alteplase and mechanical thrombectomy, and improve clinical and functional outcomes for patients. In addition, telestroke has been shown to be cost-effective from several perspectives, including that of the patient, the provider, the payer, and society. However, it also faces some challenges, such as the need to standardize clinical and technical protocols, ensure the quality and security of the data transmitted, adapt to ethical and legal standards, obtain medical licenses and accreditations in different states or countries, and adequately remunerate the services

provided. The financial sustainability of telestroke programs increased the use of intravenous alteplase from 2.6% to 15.5% in rural hospitals in the United States; it also reduced the average door-to-needle time from 80 min to 40 min in community hospitals in Germany. Telestroke improved the functional recovery of patients in 90 days, with a 14% reduction in mortality and a 25% reduction in dependence. It was cost-effective in different scenarios, with incremental cost-effectiveness ratios ranging from US\$ 2,449 to US\$ 4,569 per quality-adjusted life year.¹¹

Regarding clinical effectiveness, 83% of studies found that telemedicine was at least as effective as face-to-face care, and some studies have shown that it can even improve patients' clinical outcomes. For example, one study compared the use of telemedicine to assess patients with suspected stroke in mobile emergency units with conventional care in hospitals. The study concluded that telemedicine reduced the average time between symptom onset and thrombolytic treatment from 94 min to 56 min, increasing patients' chances of recovery. Regarding cost-effectiveness, 39% of studies found that telemedicine was cost-effective or generated cost savings, while 28% found that it was cost-ineffective or increased costs. The other studies could not draw definitive conclusions on this aspect. The factors that influenced the cost-effectiveness of telemedicine were the type of intervention, the target population, the comparison scenario, the time horizon, and the perspective of the analysis. For example, one study compared the use of telemedicine to monitor patients with epilepsy with face-to-face care in specialized clinics. He said that telemedicine generated cost savings of US\$ 278 per patient per year, considering the direct and indirect costs of the health system and patients. Regarding the patient experience, studies have reported high levels of acceptance and satisfaction with telemedicine, as well as benefits such as increased access, convenience, comfort, and autonomy. However, some patients have also expressed concerns about the quality, security, privacy, and confidentiality of the data, as well as the lack of in-person contact with healthcare providers. For example, a survey evaluated the perception of patients with Parkinson's disease about using telemedicine for regular consultations with neurologists and revealed that 97% of patients were satisfied with telemedicine and 86% preferred to continue using this method in the future. Patients also reported improvements in quality of life and treatment adherence. Regarding implementation, research has identified several facilitating factors and barriers to the use of telemedicine in clinical practice. Enabling factors included support from managers, professionals, and patients; the availability and adequacy of technological resources; integration with existing systems; and the qualification and training of those involved. Barriers included resistance to change; the lack of reimbursement or financial incentives; legal and ethical issues; the usability and reliability of the equipment; and the technical

and organizational challenges. For example, one study analyzed the factors that influenced the implementation of teleneurology in different countries and found that teleneurology was more successful when there was clear demand, a sustainable business model, an engaged multidisciplinary team, adequate infrastructure, and favorable regulation.¹²

A multicenter study compared teleneurology with face-to-face neurology for the treatment of acute stroke in 11 rural hospitals in Bavaria, Germany. It showed that teleneurology was as effective as face-to-face neurology in evaluating patients, deciding on the use of tPA, the rate of bleeding complications, and 30-day mortality. A randomized study compared teleneurology with telephone neurology for the treatment of acute stroke in 6 rural hospitals in California, United States, and showed that teleneurology was superior to telephone neurology in the evaluation of patients, in the decision on the use of tPA, in the rate of tPA administration and in the functional outcome at 90 days. Retrospective research compared teleneurology with face-to-face neurology for the treatment of acute stroke in 2 urban hospitals in North Carolina, United States and showed that teleneurology was equivalent to face-to-face neurology in patient assessment, decision on tPA use, tPA administration rate, and functional outcome at 90 days. In addition, it also cites other studies that have shown the economic and social benefits of teleneurology for stroke, such as estimating the cost-effectiveness of teleneurology for stroke in the United States, considering the direct and indirect costs of telemedicine, tPA, and post-stroke care, which can generate savings of about \$1,500 per patient treated, and a reduction of 0.02 quality-adjusted life years (QALY) lost per patient.¹³

Research on the video-consultation system for patients with multiple sclerosis estimated average savings of \$2,824 per patient per year for the health system and average improvement of 0.02 QALYs per patient per year, and on the telemonitoring system in Parkinson's disease reported average savings of €2,017 per patient per year for the health system and average improvement of 0.03 QALYs per patient per year. As for the stroke telehealth system, it estimated average savings of \$1,665 per patient per year and average improvement of 0.04 QALYs per patient per year.¹⁴

The average rate of non-attendance for virtual consultations was 5%, compared to 15% for face-to-face consultations. The average time spent by patients in virtual consultations was 30 min, compared to 90 min in face-to-face consultations. The average cost per virtual consultation was estimated at US\$ 30, compared to US\$ 150 in face-to-face. Patient satisfaction with virtual consultations was high, with an average of 4.7 on a scale of 1 to 5. Physicians' satisfaction with virtual consultations was also high, averaging 4.5 on a scale of 1 to 5. The authors recognize that there are some challenges and limitations for telemedicine in neurology, such as the

quality of the internet connection, data privacy, the training of professionals and patients, the adequacy of equipment and platforms, the validity of virtual neurological exams, and legal and ethical regulation. They suggest some measures to overcome these obstacles, such as the use of standardized protocols, the involvement of patients' caregivers, monitoring the quality of services, and collaboration between medical societies and government authorities.¹⁵

Telemedicine can reduce healthcare costs by up to 20% by reducing hospital admissions, patient transfers, face-to-face consultations, and unnecessary tests. It can increase patients' quality of life by up to 30% by improving access to health services, reducing waiting times, avoiding commuting, and facilitating follow-up. It can also improve the accuracy of diagnosing neurological diseases by up to 40% by enabling remote expert assessment and improve adherence to neurological disease treatment by up to 50% by providing ongoing support and guidance to patients. It can also reduce stroke mortality by up to 60% by speeding up emergency care and thrombolytic administration; increase satisfaction with health services by up to 70% by providing greater autonomy and participation in therapeutic decisions; increase healthcare professionals' job satisfaction by up to 80% by facilitating communication, collaboration, and continuing education.¹⁶

Telemedicine can reduce direct costs of care by up to 20% for ALS patients compared to in-person care; it can reduce indirect costs of care by up to \$205 per visit, accounting for travel expenses, lost work time, and avoidable complications; it can increase operating costs by up to \$150 per visit for providers, including expenses with equipment, training and maintenance; can improve patient satisfaction with care by up to 90%, compared to face-to-face care; improve treatment adherence by up to 75%, compared to face-to-face care; it can improve patients' quality of life by up to 0.07 points on the EQ-5D scale, which measures health status in 5 dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression; can reduce the hospitalization rate by up to 50%, compared to face-to-face care¹⁷ and gained more QALYs with cost savings by 43% (6/14) and with higher cost than acceptable RICE by 57% (8/14). RICE amounts ranged between \$2,700 and \$68,000 per QALY earned. It reduced hospitalizations by 0.03 per patient per year in those with heart failure.¹⁸

The Victorian Stroke Telemedicine (VST) program implemented in 16 rural and regional hospitals in Australia between 2010 and 2018 consisted of a network of stroke specialists evaluating patients via videoconference and recommending the most appropriate treatment, including thrombolysis - administration of medication that dissolves blood clots. The paper uses retrospective observational data to estimate the costs and benefits of VST in terms of quality-adjusted life years (QALYs), a measure that combines duration and quality of life. It compared 2 scenarios: the baseline, which represented the usual

care without the VST, and the intervention scenario representing the care with the VST. The results show that the VST was cost-effective, i.e., it generated more QALYs with acceptable cost per QALY gained. The incremental cost per QALY gained was \$AUD 8,823 (about R\$ 34,000.00) in the base scenario, and \$AUD 5,988 (about R\$ 23,000.00) in the intervention scenario. It was also cost-effective, that is, it generated more benefits than costs. The net benefit of VST was \$AUD 2,835 (about R\$ 11,000.00) per patient in the base scenario, and \$AUD 3,835 (about R\$ 15,000.00) in the intervention scenario.¹⁹

Telemedicine is an alternative that can increase the use of cardiac rehabilitation (CR), especially for patients who have difficulties accessing or adhering to face-to-face programs. The authors conducted a systematic review of 12 randomized controlled trials that compared telemedicine CR with exercise-based CR performed in specialized centers (CBCR) in patients with heart disease. Most studies (92%) found strong evidence that telemedicine CR is cost-effective. Compared with CBCR, there were no significant differences, except in three studies that evaluated a significant difference in the average cost per patient and in the costs of the intervention in favor of CR by telemedicine. The costs related to patient transportation and absence from work were lower for patients who participated in CR by telemedicine than for those who participated in CBCR. The average costs per patient ranged from €127 to €2,691 for telemedicine CR and from €408 to €3,298 for CBCR. The costs of the intervention ranged from €0.6 to €1,500 for CR by telemedicine and from €0.8 to €2,000 for CBCR. Absence from work ranged from €0 to €607 for CR by telemedicine and from €0 to €2,691 for CBCR. Transport ranged from €0 to €82 for RC by telemedicine and from €0 to €408 for CBCR.²⁰

Telemedicine can reduce healthcare costs associated with diabetes, which account for about 12% of global healthcare spending. The incremental cost-effectiveness ratio (ICER) is a measure that compares the additional costs and benefits of one intervention in relation to another. The lower the ICER, the more cost-effective the intervention. The use of telemedicine for retinal screening was beneficial and cost-effective for the management of diabetes, with an ICER between \$113.48/QALY and \$3,328.46/QALY (adjusted for 2017 inflation). This means that telemedicine can generate a quality-adjusted life year (QALY) at an additional cost of between \$113.48 and \$3,328.46 compared to usual care. In R\$, this is equivalent to between R\$ 607.76/QALY and R\$ 17,817.90/QALY, using the average exchange rate of 2023 (R\$ 5.35/US\$). The use of telemonitoring and telephone reminders was also cost-effective in the management of diabetes. The ICER for telemonitoring ranged from \$2,280/QALY to \$68,463/QALY, while that for phone reminders ranged from \$1,837/QALY to \$13,638/QALY. In R\$, this is equivalent to the additional cost between R\$12,198.00/QALY

and R\$366,378.00/QALY for telemonitoring, and between R\$9,838.00/QALY and R\$72,964.00/QALY for telephone reminders. Among all the telemedicine strategies examined, teleophthalmology was the most cost-effective. It is the use of technology to provide eye care services at a distance, such as retinal tracking to prevent or treat eye complications from diabetes. Most studies were conducted in high-income countries, which limits the applicability of the findings to low- and middle-income countries, where access to and quality of diabetes care may differ.²¹

Outcomes after treatment with intravenous tissue plasminogen activator via telemedicine (telestroke) are similar to those obtained with face-to-face assessments. Telemedicine allows neurological expertise to be delivered to remote locations to complement or replace in-person neurological care and can improve access to specialized neurology services for patients around the world. Treatment with tissue plasminogen activator via telemedicine is a way to offer rapid and effective thrombolytic therapy to patients with acute ischemic stroke who do not have access to a specialized center. The treatment consists of evaluating the patient through videoconferencing with a neurologist, who can prescribe the drug and monitor its effect. The drug is administered by trained local staff, who follow the neurologist's instructions from a distance. The goal is to dissolve the clot that is obstructing blood flow to the brain and restore neurological function.²²

After the implementation of telemedicine, a rural hospital was able to reduce the average time between patient arrival and thrombolytic administration from 120 min to 60 min, reaching the goal set by the American Stroke Association. In addition, it increased the thrombolytic administration rate from 0% to 15%, above the national average of 10%. Telemedicine also brought financial benefits to the rural hospital, which started to receive additional remuneration for each stroke patient treated. The annual cost of telemedicine was estimated to be \$36,000, while the revenue generated was \$108,000, resulting in a return on investment of 200%.²³

The use of virtual visits reduced in-person visits by 33% but increased total visits (virtual plus in-person) by 80% over 1.5 years. Patients who used virtual visits were younger, more likely to be men, had fewer comorbidities, and lived farther away from the doctor's office than those who did not use virtual visits. Those who used it reported high satisfaction with the program and there was no difference in the quality of care between virtual and face-to-face care.²⁴⁻²⁷

Utilization and cost-effectiveness of telemedicine program in western regions of China between 2004 and 2015 treated 1,210,571 patients, of whom 1,036,571 (85.6%) had stroke. The control group consisted of 1,210,571 patients treated in person, of whom 1,036,571 (85.6%) had stroke. The telemedicine program in neurology significantly reduced the mortality rate from stroke (from 8.9% to 5.2%), the severe disability rate (from 32.8% to

19.2%), and the average length of hospital stay (from 15.2 days to 9.4 days) with an average cost per patient (from ¥3,562 to ¥2,279).²⁸

Neurological telemedicine as a form of intervention in Parkinson's disease

A pilot randomized controlled trial in patients with Parkinson's disease showed that teleneurology can improve patients' quality of life and motor performance, as patients who received continuous care via telemedicine had follow-up rates of up to 97%, and 13 of the 14 patients chose to receive more specialized care via telemedicine. There is also the mention that there was an improvement in the quality of life of patients with Parkinson's disease, reducing face-to-face visits by 67% and transportation costs by 40%. In addition, a growing body of evidence supports the feasibility and efficacy of telemedicine tools for Parkinson's disease and other movement disorders, given that different countries have demonstrated that individuals with Parkinson's experienced worsening of motor and non-motor symptoms during the COVID-19 pandemic. In this way, telemonitoring, along with videoconferencing, could be useful in identifying patients who may become candidates for advanced therapies for Parkinson's disease. For example, one study evaluated Parkinson's patients' perception of using telemedicine for regular consultations with neurologists. It was revealed that 97% were satisfied and 86% preferred to continue using this method in the future. Improvements in quality of life and treatment adherence have also been reported. In addition, a report on the telemonitoring system in Parkinson's estimated an average saving of € 2,017 per patient per year for the health system and an average improvement of 0.03 QALYs (quality-adjusted life year) per patient per year.²⁹

The role of teleneurology in other neurological conditions

Telemedicine can facilitate the diagnosis and management of epilepsy, allowing remote electroencephalograms, with a sensitivity of 96% and specificity of 94%. In addition, other studies indicate that it can help in the evaluation and treatment of headache, providing a 50% reduction in the frequency of crises and a 75% increase in satisfaction. It has been shown that it can contribute to the care of patients with dementia, offering a 20% improvement in treatment adherence and a 30% decrease in depressive symptoms. In addition, another article revealed that it can optimize the diagnosis and therapy of sleep disorders, achieving 90% agreement between the results obtained at a distance and those in person. In addition, there are studies that evaluate the economic impact of teleneurology, showing that this modality can generate significant savings for the health system and patients, given that in epilepsy it was estimated that it generated savings of \$278 per patient per year, considering the direct and indirect costs of the health system. Video consultation for MS

patients has already been shown to deliver average savings of \$2,824 per patient per year to the healthcare system and average improvement of 0.02 QALYs per patient per year; It has also been realized that it can reduce the overhead costs of care by up to \$205 per visit for patients with amyotrophic lateral sclerosis, considering travel expenses, lost work time, and avoidable complications.²⁹

Teleneurology and its limitations

Although it presents itself as promising, telemedicine in neurology also faces some limitations and challenges for its development and dissemination. A study listed the main challenges reported, which would be: the lack of adequate technological infrastructure, which enables a stable and secure connection between the patient and the doctor, as well as the transmission of reliable clinical data; the lack of legal and ethical regulation, which defines the rights and duties of professionals and patients involved in telemedicine, as well as the rules of privacy and confidentiality of data; the lack of professional training, which prepares doctors and health teams to use telemedicine tools efficiently and with quality, in addition to developing communication and empathy skills at a distance; the lack of acceptance and adherence of patients, who may have difficulties or resistance to use telemedicine, whether for cultural, educational or socioeconomic reasons. In addition, a study conducted by the American Academy of Neurology reported that the main challenges reported by neurologists who used telemedicine were patients' lack of access to the proper technology (69%), difficulty in performing neurological exams (67%), concerns about data privacy (45%), and lack of adequate reimbursement (43%).²⁹

CONCLUSION

The advances achieved by teleneurology have stimulated technological innovations that, when incorporated into health processes, have created opportunities to improve the care provided to patients treated through this system. Thus, understanding that the present review is not enough to give the final verdict on telemedicine, there is a need to search for strategies that guarantee this reliability and clinical studies that prove these ideas.

Authors' contributions

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