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Economic Evaluation of a Telemedicine Service to expand Primary Health Care in Rio Grande do Sul: TeleOftalmo's microcosting analysis

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Abstract *This study evaluated the cost of public telediagnostic service in ophthalmology. The time-driven activity-based costing method (TDABC) was adopted to examine the cost components related to teleophthalmology. This method allowed us to establish the standard unit cost of telediagnosis, given the installed capacity and utilization of professionals. We considered data from one year of telediagnoses and evaluated the cost per telediagnosis change throughout technology adaptation in the system. The standard cost calculated by distance ophthalmic diagnosis was approximately R$ 119, considering the issuance of 1,080 monthly ophthalmic telediagnostic reports. We identified an imbalance between activities, which suggests the TDABC method's ability to guide management actions and improve resource allocation. The actual unit cost fell from R$ 783 to R$ 283 over one year – with room to approach the estimated standard cost. Partial economic evaluations contribute significantly to support the incorporation of new technologies. The TDABC method deserves prominence, as it enables us to retrieve more accurate information on the cost of technology, improving the scalability and management capacity of the healthcare system.*

Key words *Health Technology Assessment, Telemedicine, Teleophthalmology*

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Introduction

Telemedicine can be defined as the use of information and communication technologies in healthcare, enabling the provision of services related to improving patient access to care[1]. The emergence of new technological capacities and their integration in health care delivery systems provides us with opportunities to improve clinical care, especially in cases where distance is a critical factor[1,2]. In a reality in which health systems are under pressure to reduce costs and, at the same time, improve the quality, access, and equity of the service[3], one must explore tools that prove to be an alternative to this changing scenario.

Growing concerns about sustainability and the expected scarcity of resources arouse interest in exploring the potential of telemedicine to deal with many challenges faced by primary health care (PHC)[4]. Among the values associated with the adoption of telemedicine services in PHC are collaboration, with the swift access of patients to high-complexity centers[5], higher resolution at the baseline level and a reduced number of referrals to other municipalities for specialized care[6], besides being an ally for monitoring and controlling the quality of patient care delivery[7].

Most telemedicine services that focus on diagnosis and clinical management are already routinely supplied in more developed countries. In this context, recent publications treat these services as effective in the management of patients with chronic diseases[8], such as, for example, ECG reports[9], screening for diabetic retinopathy[10,11] and glaucoma[12], patient guidance through mobile apps[13] and cardiac rehabilitation[14].

Brazil is a country with unique opportunities for the development and applications of telemedicine, given its geographical distribution and inability to meet the demand for face-to-face care[2,15,16]. Data from the management system of specialized outpatient appointments provided by the State Health Secretariat of Rio Grande do Sul reveal that, at the end of 2016, the number of people waiting for a specialized ophthalmology visit in the capital was about 10 times higher than the monthly offer of visits, translating into a maximum 19-month waiting period[17]. Telemedicine technologies can be a significant advance in the provision of health care in this context and can play a strategic role in the consolidation of Health Care Networks and improved health of the population[18].

Existing economic assessments of the subject are still recent and do not allow an assertive conclusion about the economic feasibility of the implementation in the Brazilian Health System[19]. It is known that the scientific and financial investments required to introduce these technologies into the system are high[20], enhancing the importance of conducting accurate economic analyses to guide decisions regarding the implementation of telemedicine services[16,20].

Understanding cost information is challenging in the assessment of technologies in the Brazilian public sector, and, while counterintuitive, the practice of measuring costs is not adequately disseminated among health centers[21]. One reason is the use of different costing methods, the lack of definition of standards, and a computerized cost system in public institutions, which hinders comparability between different health services[22]. The lack of a detailed understanding of the actual cost of providing care to the patient is commonly the central problem of scalability in health expenditures[23]. In this sense, micro-costing estimates are the gold standard for cost valuation as they provide a high degree of detail, especially for more complex services or where human resources are of higher weight[24], as is the case with telemedicine services.

Some micro-costing methods used in the health area since the 1980s are the absorption costing method and Activity-Based Costing (ABC), whose primary assumption is to correct some deficiencies in traditional methods, such as proportional apportionments[25]. However, the implementation of the traditional ABC model is challenging for many organizations due to the high implementation costs in interviewing people for the initial ABC method survey[26].

To overcome these limitations, Kaplan and Anderson developed the Time-Driven Activity-Based Costing (TDABC) method[26]. The TDABC aims to measure the cost of services from their actual consumption of resources. Since its initial proposal in 2007, it has been used in several health studies[22,27,28]. This method allows identifying individual taxpayers and accounting for the indirect costs necessary to support patient care[29]. The fundamental principle of this method is that it transforms the cost drivers into equations of time that represent the time required to perform a given activity[30]. Another advantage of using this method when it comes to implementing technologies is that it allows the identification of the standard cost, that is, the cost at the unit level of the service within the anticipated efficiency conditions, also acting as a metric for comparing productivity[31].

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This study aims to assess the cost of a telemedicine service (TelessaúdeRS-UFRGS) using the scope of telediagnosis in ophthalmology and, specifically, to assess the cost of learning related to the implementation of the service in PHC.

Methods

As it is a partial economic evaluation, providing information on cost without referring to effectiveness or comparison between alternatives, the organization of the study description was made following the conformities recommended by the Consolidated Health Economic Evaluation Reporting Standards (CHEERS)[32].

The study followed the eight-step structure suggested by Etges et al.[22] to implement costing based on activities in health services: (i) selecting the technology to be evaluated; (ii) mapping the telemedicine service process; (iii) identifying the primary resources used throughout the process; (iv) estimating total cost of each group of resources; (v) estimating the capacity of each resource and calculate the unit capacity cost rate (UCR – R$/h); (vi) analyzing time estimates for each resource used in an activity; (vii) calculating the total cost of patient care; (viii) analyzing cost data.

Selection of the technology to be evaluated

The Telehealth Center of the Federal University of Rio Grande do Sul (TelessaúdeRS-UFRGS) was selected as the telemedicine's study object[15,16], because combating eye diseases is a priority for the World Health Organization (WHO)[33] and because it demands greater interest among managers in knowing the real cost of the procedure. TeleOftalmo is a telemedicine research and service offering project that has been underway since July 2017 in the state of Rio Grande do Sul (RS), Brazil, which receives primary funding from the Ministry of Health, through the Program to Support the Institutional Development of the Unified Health System (PROADI-SUS). It has a command center at the headquarters of TelessaúdeRS-UFRGS and eight remote test rooms distributed in the state of Rio Grande do Sul State. Doctors working in PHC can request the service from their patients. The ophthalmologist issues a telediagnostic report to the requesting physician after evaluating the patient in the remote test room. The latter will then conduct the patient's case with the help of the information received in the report.

The study horizon used the project data from September 2017, which allowed us to conduct the analysis throughout its implementation and observe the impact of the learning factor on cost. The teleophthalmology command center, where ophthalmologists work, and two remote test rooms in the municipalities of Porto Alegre and Santa Rosa were evaluated. The two rooms studied were the first implemented, and were the only ones in operation at the time of the beginning of this study.

Measuring the actual costs of health technologies is a crucial step to identify their efficiency and subsequent guidance for decision-making[34]. Thus, the analysis was carried out from the perspective of the health system.

Mapping the teleophthalmology service process

The care delivery mapping details the patient's path within the service offered, in which a starting and ending point must be defined for each patient. The main activities that are part of the treatment flow and the routine activities of the patient are identified, illustrating the current state of a complex system[28,35]. This division is essential for the subsequent development of cost and resource allocation equations.

This stage involved interviews with the coordinator and the ophthalmologist plus observations from the service in operation. The map was presented to the professionals involved in the teleophthalmology service for validation. Four macro activities were defined to support the cost evaluation: regulation of the request, telephone contact for scheduling, evaluation of the ophthalmologist, and collection of tests (telediagnosis).

Identification of the primary resources used throughout the process

The resources necessary for its performance were listed for each activity from the details of the teleophthalmology service operation process. The resources were classified as the structure of the remote test room and structure of the teleophthalmology command center, and these consisted of fixed costs and a class of professionals (students, doctors, and nursing technicians).

Estimated total cost for each resource group

All cost items associated with each resource group must be estimated by the financial department of the TelessaúdeRS-UFRGS project.

The physical structure resource of the teleophthalmology command center was valued based on the structuring of the distribution of the fixed costs of the TelessaúdeRS-UFRGS project, which besides the teleophthalmology service has three other telediagnostic services, as well as teleconsulting and regulation. Besides the services, the project is also equipped with support and management departments. To distribute to fixed accounts student compensation, energy salaries, depreciation, rent, and maintenance, we considered, at first, the number of professionals of any class allocated to each department as an apportionment criterion. Subsequently, the costs attributed to the support and management departments were distributed to the departments that carry out some telediagnosis, teleconsulting, or regulation services considering the composition of the workload attributed to each service department as a cost driver. The sum of the direct cost attributed to the command center with that absorbed by the support and management departments represents the cost of the teleophthalmology center structure.

The remote test room structure resource was calculated from the survey of materials, professionals, and the cost of the physical structure of the state health secretariat, where the service takes place in each of the municipalities analyzed.

Estimating the capacity of each resource and calculating the unit capacity cost rate (UCR – R$/h)

The capacities were calculated as per the availability of the workload of professionals who carry out the activities and consume the resources of professionals and the structure, as they all demand human interaction. The macro activities of regulation and telephone contact are carried out by students in the structure of the telediagnosis center; ophthalmologists evaluate the command center, and the nursing technician collects tests in the remote test room.

Subsequently, the remuneration values for the students involved, salaries of salaried professionals, and other bills paid monthly were collected from the financial controller of Telessaúde, which were organized considering the classification made previously concerning the work activities of the professionals.

With the information on capacity and the monthly cost of the resources involved, the time unit contribution rates (UCR) were calculated in R$/h for each activity. Applying equation[1], the UCR of each activity was calculated, in which the denominator considers the costs of professionals and the structure consumed by each activity and the capacity and workload of professionals who perform each activity.

$$\text{UCR} = \frac{\text{(Fixed cost of personnel)}}{\text{(Professionals hourly capacity)}}$$

Analysis of time estimates for each resource used in an activity

The times required for each activity were estimated from observation and collection of times and movements. These studies can resort to on-site observations plus review by an expert to analyze the real-time during which different resources are devoted to each activity[36].

To this end, the production volume of each activity per hour was observed over two weeks during the working hours of TeleOftalmo and in alternating shifts, converging to an average of the unit time required for an activity unit.

Calculation of the total cost of patient care

The cost and time equations were structured, and the cost per service was calculated. The individual costs were estimated at standard target cost and the actual cost over the months of service operation. Concerning the calculation of the cost per standard service target, a modeling of the service volumes that should be carried out per month in each macro activity was made, based on the available hourly capacity. To get closer to the installed capacity of the service reality, we considered that a portion of 20% of the capacity of each activity is destined for other activities or expected idleness. The 20% share was defined in conjunction with the coordination of the service, which understands that this fraction of time should be dedicated to research activities by professionals. The actual costs were calculated considering the actual volume of attendance per activity performed over a year of follow-up.

Cost data analysis

With the actual and standard costs evaluated, an assessment was made of the capacity balance between activities, identifying opportunities for better distribution of professionals, and the consequent reduction in unit costs. Finally, the impact of the service in the state in which it is inserted was discussed, comparing the volume of attendances made by the teleophthalmology service with the demand for visits in the regions where the service is in operation. This analysis allows us to measure the effects of the scale of use on the costs of this technology, given the high fixed costs necessary to introduce the strategy in the system.

Values are expressed in Brazilian currency (Real – R$), and data from one year of service was monitored from September 2017 to September 2018, expressed as unadjusted values collected per month. For reference purposes, the mean price of international dollars by the Purchasing Power Parity rate in 2017 was 2.013[37].

Results

Mapping the process

The process was mapped from interviews with coordinators and implementers of the "TeleOftalmo Project – Olhar Gaúcho", which sought to understand the flow of activities performed, professionals and location involved, and the need to use specific resources. Figure 1 illustrates the mapped activities.

Structuring financial cost data by resources

When conducting the cost distribution, the teleophthalmology command center consolidated a total monthly cost of R$85,000, of which R$10,570 (12%) were for students, R$43,980 (52%) for salaried professionals, R$3,900 (5%) other fixed costs, and R$26,550 (31%) were absorbed from the support and management areas of the TelessaúdeRS-UFRGS center. This result is essential for the calculation of the unit cost rates that will be used in the time measurement equations of a telediagnosis cost. The remote test room cost was consolidated at R$20,600 per month.

Then, the monthly hourly capacity of the professionals who perform each activity was collected to calculate the UCRs. Table 1 describes the costing results for the stages of the teleophthalmology service flow.

Calculation of the cost of telediagnosis and analysis of service balancing

The identified times are shown in Table 2, which, together with the UCRs adjusted to R$/min, allow us to measure the estimated standard cost.

Table 2 indicates that the cost value that should be considered for telediagnosis is R$119. We identified that the system must operate 6,720 regulations, 1,824 calls, 1,080 assessments, and 422 telediagnoses per month in each of the offices, observing the existing capacity levels, to achieve this value and considering the capacity of professionals.

No month has recorded this level of production during the year of operation of the service. Figures 2, 3, and 4 show the professional production ratio and installed capacity not used by them over the months and the trend of the unit cost of each activity.

The analysis of one year of service stratified by activity allows identifying that the activity with the most significant imbalance and idle capacity is exercised by the scholars and represents, on average, 3% of the total cost. Medical professionals show an activity that gathers 57% of the costs and, although they are approaching the target cost over time, they still have the opportunity to issue more reports. Technical nursing professionals are the ones closest to operating at the maximum level of available capacity. These results suggest that there is an imbalance between the capacities of each activity, for example, the ability to collect tests should coincide with the ability to issue reports, and we were able to measure through this method that this does not occur in the sizing of the service.

The four activities were then consolidated into an individual cost of the teleophthalmology service to evaluate the unit component, and the following behavior of variation of unit costs over time was found (Figure 5). Over a year, the unit cost had a maximum amplitude in the period of R$611, mostly with a trend of nearing the fixed target standard cost.

Discussion

The applied method allowed detailing the costs associated with the adoption of a telemedicine service technology and to review the effectiveness of its implementation process. The standard measured cost for telediagnosis was R$119. A decreasing trend in the telediagnosis unit cost was observed during the evaluation period, which went from R$783 to R$283.30, characterizing the learning curve for the implementation of new technologies.

It is estimated that waiting for an appointment to receive a prescription for corrective len-

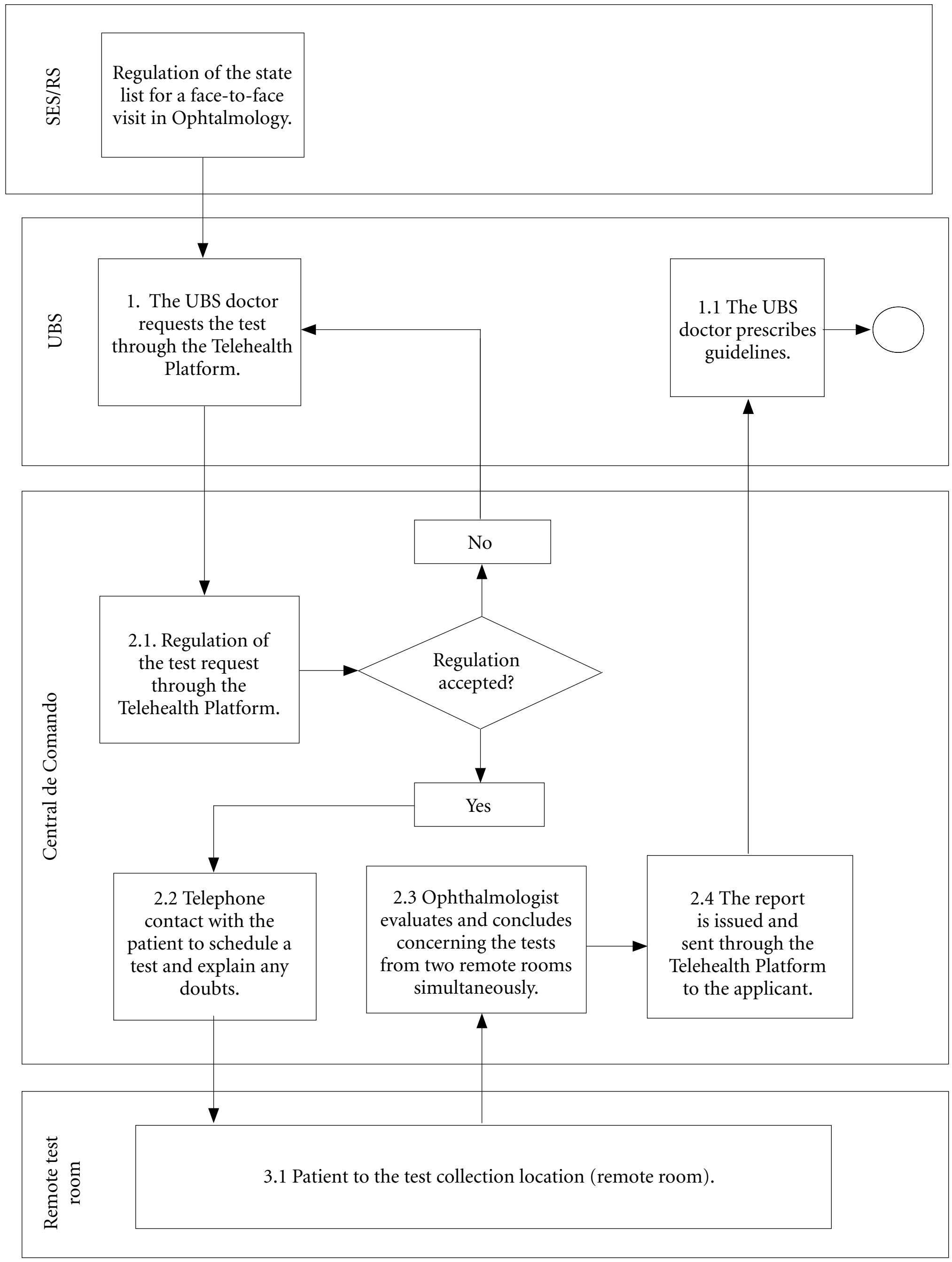

Figure 1. Mapping of the teleophthalmology process within the primary care system.
SES/RS = State Health Secretariat of Rio Grande do Sul; UBS = Basic Health Unit.

ses is more than one year in southern Brazil[16]. The lack of rational criteria in the ophthalmological appointment scheduling protocol, which causes an excessive delay in providing medical services, has the most severe consequence of irreparable loss of vision, in cases of glaucoma, diabetic retinopathy, among other pathologies. For another significant portion of patients diagnosed with cataracts and refraction, the delay will result in years of substantial loss of quality of life due to reduced visual acuity[38-40]. The advent of telemedicine has the potential to qualify health

Table 1. Costs of activities related to Teleophthalmological care.

Departamento	Atividade	Profissão	Capacidade Padrão (h)	Custo (R$)	TCU padrão (R$/h)
Teleophthalmology command center	Regulation of request	Scholars	112	5,490	49
	Telephone contact with the patient	Scholars	228	10,980	48
	Ophthalmologist's evaluation	Doctors	180	68,538	381
Remote test room	Test collection	Nursing Technician	422	20,606	49

Table 2. Standard cost of one telediagnosis.

Activity	Unit time (min)	Standard UCR (R$/h)	Cost/ unit
Regulation of request	1	0.82	R$ 0.80
Telephone contact for scheduling	7.5	0.8	R$ 6
Ophthalmologist's evaluation	10	6.35	R$ 63
Test collection	60	0,8	R$ 49
Goal standard (total)	78.5	-	R$ 119

UCR = Unit Cost Rate.

and improve access. A better resolution in primary care can reduce referrals to secondary and tertiary care services[7,38].

The cost behavior found in this study can be understood as the effect of learning on service provision. The maturity that can be acquired during the service's learning period contributes to a better alignment of availability of professionals by activity, making the service more balanced. The balance of the service allows guiding the restructuring of the hourly availability of health professionals who perform the service, allowing a reduction in expenses by telediagnosis and better use of each allocated resource[41-43].

Economic assessments, starting with accurate cost measurement, are great allies to guide policymakers and funders to determine whether the evidence supports a broader adoption of mobile health interventions and to understand the ideal conditions under which they should be implemented[24,44]. Technology must be continuously analyzed and improved so that its adoption occurs in a sustainable, transparent manner, and that favors its consolidation in the Brazilian public health system[34] to be subjected to evaluation. In this study, the evaluation included observation of the behavior curve of the implementation of the provision of such a service. Therefore, the need for compatibility and data integration becomes clear, thus allowing a continuous process of learning and improving information about the use of the health service.

The search for papers in the literature shows that the number of studies aimed at evaluating the cost of telemedicine services has increased in the last decade. The origin of costs is mostly secondary, originating from national tables, estimated prices, and averages. There was no detailed calculation of the amount invested for the installation or continuity of the telemedicine program. In the area of teleophthalmology, it was not uncommon for the authors to claim that gauging and detailing costs is necessary to attribute the indirect benefit of telemedicine in the health system[10,11,45]. However, only two of them made use of micro-costing methods in the variable of costs, both specific for screening for diabetic retinopathy. In the Brazilian scenario[46], studies on the implementation and cost-effectiveness of telemedicine in the field of cardiology have already been carried out, and likewise consider implementation costs separate from the others, given the period of adaptation of the technology and personnel involved. However, due to differences in methods, time of publication, and data collection, comparisons between results are limited and should be made with caution.

Among the limitations, we can mention the failure to carry out a complete economic evaluation, considering that insufficient outcome metrics were not included in the study to carry out a cost-effectiveness or cost-utility evaluation. It is also noteworthy that the use of these results for purposes of comparison with other States and services must consider that labour costs of Telehealth service is composed of scholarships and employment relations and, thus, can operate at a lower cost through telediagnosis.

This result is relevant for planning the provision of health services in the country, as it shows

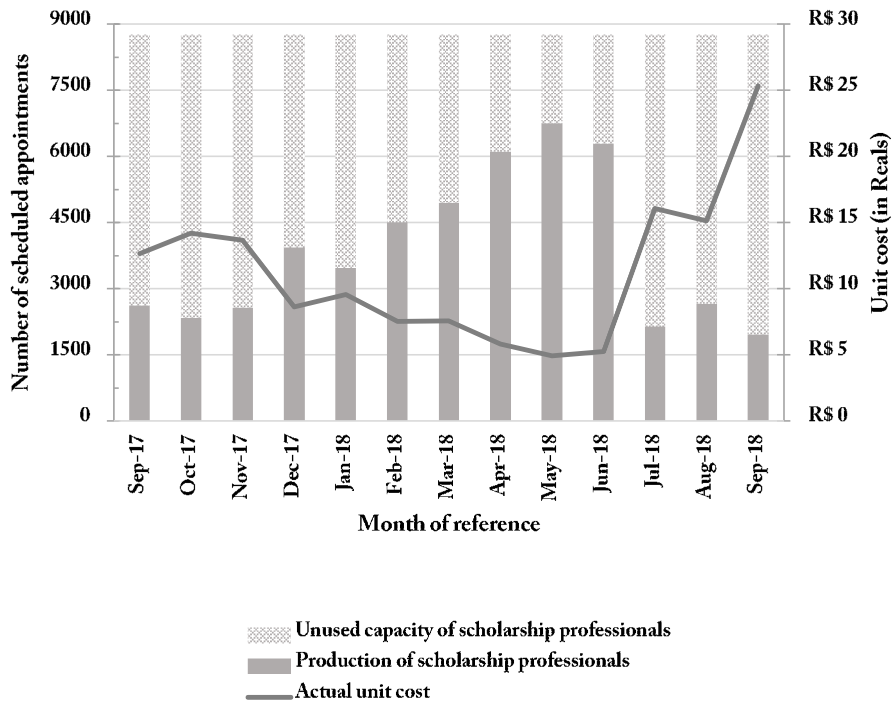

Figure 2. Relationship between the production of scholarship professionals with the unused capacity for regulation and connection activities and the trend of the unit cost of combined activities.

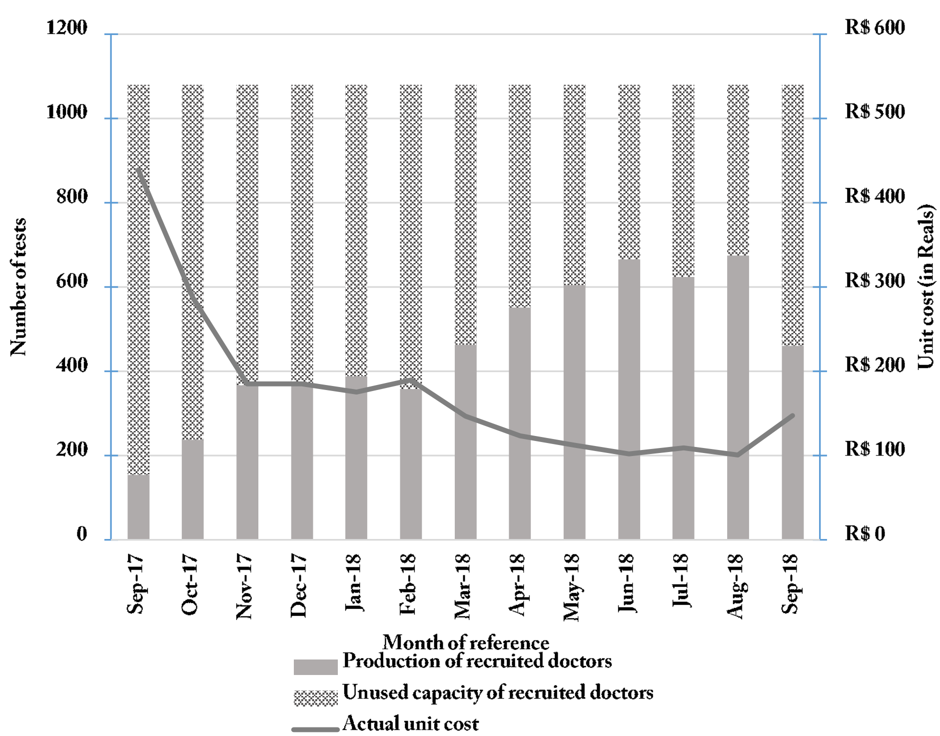

Figure 3. Relationship between doctors' production and unused capacity for ophthalmologist care activities and the trend of the unit cost of the activity.

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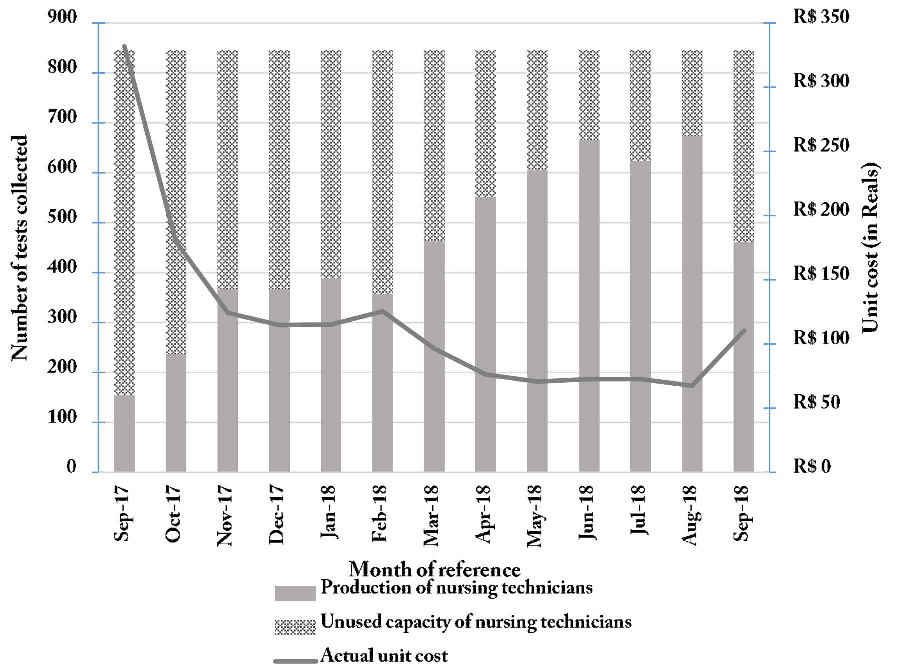

Figure 4. Relationship between nursing technicians' production and unused capacity for test collection activities and the trend of the unit cost of the activity.

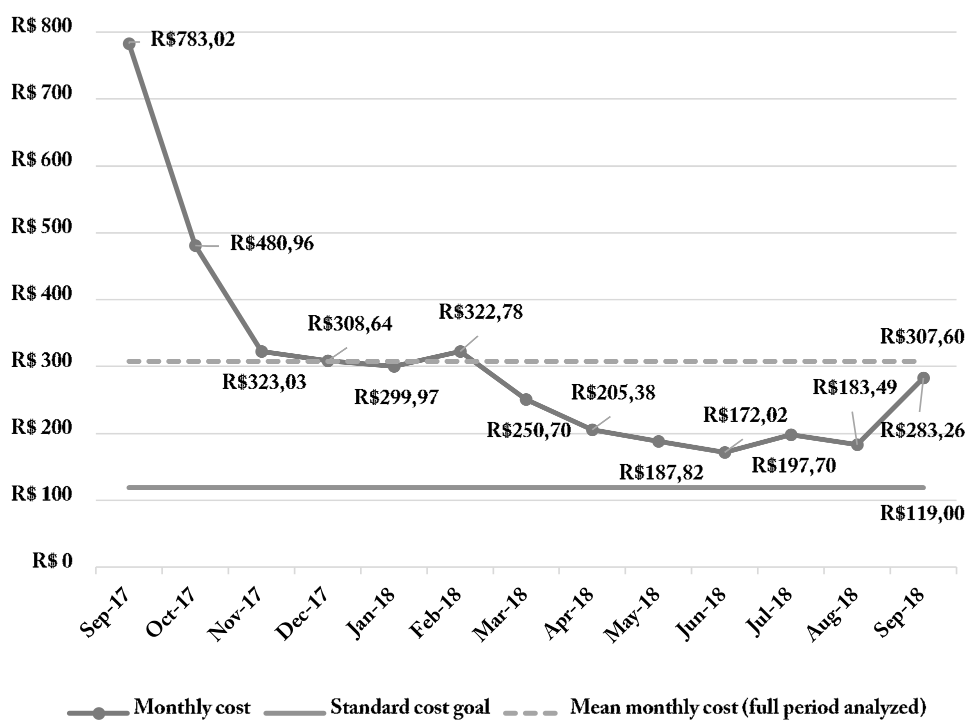

Figure 5. Monthly cost of ophthalmological telediagnosis over 12 months post-implementation.

that the implementation of teleophthalmology systems is feasible and has excellent potential to qualify the eye care waiting list in PHC. With scale gain, telemedicine will be essential to overcome the bottleneck of the waiting lists for highly complex procedures because it allows the risk classification, thus qualifying access to the specialty and the user's care[47].

Conclusions

This study is unprecedented in Brazil when evaluating the real costs of a telemedicine service, and it is believed that the multiplication of partial economic evaluation studies of these services is essential to support incorporation decisions. The use of TDABC is noteworthy to facilitate this and scalability, as it allows to obtain more accurate information on technology cost, improving the management capacity of the health organization. The case studied allowed us to identify how the implementation of new technology in the health system needs time to mature to measure the standard cost to be used to guide the decision on incorporating the technology. Applying methodologies that better enable the measurement and analysis of financial information becomes essential for strategic health management and subsequent guidance for decision-making. Future cost-effectiveness studies will be carried out as a continuation of this economic assessment.

Collaborations

BS Zanotto and APBS Etges participated in data collection and monitoring; analysis and interpretation of results; and writing of the manuscript. AC Siqueira and C Bastos participated in data collection and monitoring. RS Silva participated in data collection and monitoring; and writing of the manuscript. AL Araujo participated in data collection and monitoring; and final review of the analysis and manuscript. TC Moreira, L Maturro and M Gonçalves participated in final review of the analysis and manuscript. CA Polanczyk participated in analysis and interpretation of results; writing of the manuscript; and final review of the analysis and manuscript.

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