Micro-Costing of a Remotely Operated Referral Management System to Secondary Care in the Unified Health System in Brazil

Microcusteio de um Sistema de Regulação Remoto para o Cuidado Especializado no Sistema Único de Saúde no Brasil

Daniela Vianna Pachito (https://orcid.org/0000-0002-7052-7735) [1]

Ana Paula Beck da Silva Etges (https://orcid.org/0000-0002-6411-3480) [2,3]

Patrícia Roberta Berithe Pedrosa de Oliveira (https://orcid.org/0000-0002-2039-484X) [1]

Josué Basso (https://orcid.org/0000-0001-8078-579X) [1]

Ângela Maria Bagattini (https://orcid.org/0000-0003-4281-2536) [4]

Rachel Riera (https://orcid.org/0000-0002-9522-1871) [4,5]

Luana Gonçalves Gehres (https://orcid.org/0000-0003-1341-6710) [6]

Érica de Brito Mallmann (https://orcid.org/0000-0001-7095-799X) [6]

Átila Szczecinski Rodrigues (https://orcid.org/0000-0003-0194-0785) [6]

Sabrina Dalbosco Gadenz (https://orcid.org/0000-0002-8381-6093) [1]

[1] Regula Mais Brasil, Hospital Sírio-Libanês. R. Barata Ribeiro 142, Bela Vista. 01308-000 São Paulo Brasil. pachito@uol.com.br

[2] Faculdade de Tecnologia, Pontifícia Universidade Católica do Rio Grande do Sul. Porto Alegre RS Brasil.

[3] Instituto de Avaliação de Tecnologia em Saúde. Porto Alegre RS Brasil.

[4] Núcleo de Avaliação de Tecnologias em Saúde, Hospital Sírio-Libanês. São Paulo SP Brasil.

[5] Escola Paulista de Medicina, Universidade Federal de São Paulo. São Paulo SP Brasil.

[6] Secretaria Executiva, Ministério da Saúde. Brasília DF Brasil.

Abstract *Referral of cases from primary to secondary care in the Brazilian public healthcare system is one of the most important issues to be tackled. Telehealth strategies have been shown effective in avoiding unnecessary referrals. The objective of this study was to estimate cost per referred case by a remotely operated referral management system to further inform the decision making on the topic. Analysis of cost by applying time-driven activity-based costing. Cost analyses included comparisons between medical specialties, localities for which referrals were being conducted, and periods of time. Cost per referred case across localities ranged from R\$ 5.70 to R\$ 8.29. Cost per referred case across medical specialties ranged from R\$ 1.85 to R\$ 8.56. Strategies to optimize the management of referral cases to specialized care in public healthcare systems are still needed. Telehealth strategies may be advantageous, with cost estimates across localities ranging from R\$ 5.70 to R\$ 8.29, with additional observed variability related to the type of medical specialty.*

Key words *Referral and consultation, Telemedicine, Delivery of Health Care Integrated, Unified Health System*

Resumo *O encaminhamento de casos da atenção primária para a secundária no Sistema Único Brasileiro é uma das questões mais importantes a ser enfrentada. As estratégias de telessaúde têm se mostrado eficazes para evitar encaminhamentos desnecessários. O objetivo deste estudo foi estimar o custo por caso encaminhado por meio de um sistema de gerenciamento de referenciamentos operado remotamente para subsidiar a tomada de decisão sobre o tema. Análise de custo por meio da aplicação de custeio baseado em atividades orientado pelo tempo (time-driven activity-based costing ou TDABC). As análises de custo incluíram comparações entre especialidades médicas, localidades para as quais os encaminhamentos estavam sendo conduzidos e períodos de tempo. O custo por referenciamento em todas as localidades variou entre R\$ 5,70 a R\$ 8,29. O custo por referenciamento nas especialidades médicas variou entre R\$ 1,85 a R\$ 8,56. Estratégias para otimizar a gestão dos referenciamentos para a atenção especializada nos sistemas públicos de saúde ainda são necessárias. As estratégias de telessaúde podem ser vantajosas, com estimativas de custo entre as localidades variando entre R\$ 5,70 a R\$ 8,29, com variabilidade adicional observada relacionada ao tipo de especialidade médica.*

Palavras-chave *Encaminhamento e consulta, Telemedicina, Prestação Integrada de Cuidados de Saúde, Sistema Único de Saúde*

Introduction

The Brazilian public health system, the Unified Health System (SUS), was conceived to provide and organize healthcare across different levels of jurisdiction and to allow comprehensive and universal healthcare coverage. Currently, SUS provides the only alternative of healthcare coverage for approximately 71.5% of the country's population, representing one of the largest health systems in the world[1]. Management of the public healthcare system in Brazil is challenged by a diversity of issues, including the number of beneficiaries and the continental dimensions of the national territory, with a vast number of municipalities presenting socioeconomic and health disparities. Principles on which SUS were built on are universality, meaning universal access to health services at all levels of care; equity; and integrality, meaning completeness of care. Operational guidelines of SUS stress the need of decentralized management; regionalization and hierarchy; as well as social participation[2].

Integration of care is an essential element to ensure that individuals suffering from more complex health conditions have access to the appropriate healthcare resources. Referral of cases from primary to secondary care may take place within the same jurisdiction or across jurisdictions, since small municipalities usually lack the necessary resources related to specialized and more complex healthcare. This process is paramount for matching health demands and resource allocation in time and space, in a proportional and orderly manner. Additionally, this process provides individuals with health conditions associated to higher risks with prioritized access to healthcare resources, promoting equity to the system.

Alongside with underfunding issues, referral management has been considered one of the most important issues to be tackled for maximizing efficiency of SUS[3,4]. Innovative strategies to improve efficiency of the referral management system in SUS have been developed and investigated. Telehealth technologies, such as digitized and remotely operated referral management systems and tele-interconsultation between primary care physicians and specialists, have been locally applied in Brazil in the last few years[5-7]. These studies suggest that telehealth is effective in avoiding unnecessary referrals and is cost-effective when compared to traditional referral management systems, although measures of incurred costs by more precise methods, such as micro-costing, have not been performed[7].

Accurately measuring costs is a fundamental step for cost-effectiveness and budgetary impact analyses. Measurement of costs involves the identification of types of consumed resources and respective consumed units as well as the correct valuation of these resources[8]. This can be particularly challenging for complex interventions involving the consumption of multiple types of resources for which overhead costs need to be attributed[9]. Different methods have been applied for measuring costs, namely direct estimation of production costs including micro-costing, standardized resource assignment, and gross costing analysis[10].

In the healthcare sector, micro-costing can be defined as the "direct enumeration and costing out of every input consumed in the treatment of a particular patient"[11]. The granularity embedded in this approach underpins the high accuracy of cost measures associated to micro-costing, when compared to gross costing[12], but it is still dependent of methods applied for distributing indirect costs. The methodology of micro-costing based on activities and times, called time driven activity-based costing (TDABC), provides accurate and feasible measurement of costs[13,14], which explains why TDABC has been used for a diversity of healthcare settings[15-18]. The objective of this study was to estimate cost per referred case by a remotely operated referral management system, called *Regula Mais Brasil* and to investigate variability of times and costs related to medical specialty and locality, by applying a previously described methodology for TDABC[19].

Methods

Regula Mais Brasil is a referral management system remotely operated, designed to guide the referral of cases from primary care units to specialized care, by following standardized protocols for risk prioritization. The ultimate goal of *Regula Mais Brasil* is to enable patients with health conditions associated with higher risks to have prioritized access to health assistance, as well as to reduce waiting times and unnecessary referrals. The program was first instituted in October 2018. Remote operation takes place in a headquarters in São Paulo and two additional units located in Porto Alegre and Distrito Federal. As per the time of the study conception, these units were responsible for the referral management of cases from primary care to specialized care in four localities, namely Porto Alegre, Distrito Federal, Belo Hor-

izonte and Amazonas, in the following medical specialties: cardiology, neurology, rheumatology, neurosurgery, endocrinology, orthopedics, pneumology, psychiatry, gastroenterology, gynecology, vascular surgery, urology, proctology, pediatric orthopedics, and pediatric neurology.

Analysis of cost of *Regula Mais Brasil* was conducted by the TDABC methodology, as per the predefined study protocol. The following steps of TDABC were conducted: mapping of the involved processes; identification of the main resources; estimation of total cost of each resource; estimation of the capacity of each resource and calculation of the capacity cost rate; analysis of time estimates for each resource; calculation of total costs; and analysis of cost data[19].

The project was approved by the institutional Research Ethics Committee under the number 28453420.5.0000.5461.

Data collection

Mapping of the processes involved in activities for referral management was performed by interview and by direct observation (Figure 1). Briefly, physicians responsible for assessing the appropriateness of referral could approve, cancel, or devolve the case to the primary care unit (Time 1). In case of devolution, physicians of primary care units would have to provide more information in the referral management system that could justify the need of referring the case or could contact a non-medical attendant of *Regula Mais Brasil* (Time 2) for scheduling a tele-interconsultation to discuss the referral necessity and priority (Time 3). If the referral were still deemed ineligible, this process could be repeated more times. For practical reasons, further reassessments were considered indistinctly as Time 3.

Resources necessary for the conduction of mapped activities were classified into human resources, including all professional classes; and structural resources, including fixed costs and depreciation of equipment. A matrix of activities and consumed resources were built, to allow a comprehensive view of resources consumed by activity.

Cost items associated with each resource were estimated. Values of salaries were extracted for the period of July to December 2019. For the managerial and information technology staff, costs were distributed among all units, considering the number of professionals. Costs related to medical managers were distributed between two out of the three sites, where medical teams were based.

Costs per minute of medical and non-medical professionals were calculated considering contracted workloads. To account for depreciation of equipment, acquisition costs were diluted over five years and distributed equally among all units.

Data on the operational capacity of the involved departments were collected. After having assessed the capacities of resources, rate of cost per unit of time was calculated by dividing costs by resources, and further dividing it by the capacity of each resource.

Times needed for completion of each activity were collected by professionals, considering the type of activity (e.g., Time 1, Time 2, etc.), type of medical specialty for which the referral was made, and locality. Data collection was extended for a period of one month, totaling 819 observations. Mean time per activity was used as a basis for calculating cost per activity, followed by cost per referral by medical specialty.

Cost analysis

Cost analyses were performed in a descriptive way and included comparisons between medical specialties, localities for which referrals were being conducted, and periods of time. For medical specialties and localities, differences in cost were explored by analyzing differences in time consumed to perform referrals for each medical specialty and unit. Results were converted to U.S. dollars by purchasing power parities, using a conversion rate of 2.252[20].

Results

Costs of resources, capacities, and cost rates per time unit

Total costs related to structure and human resources for headquarters and the other two units were estimated. Total costs for the headquarters in São Paulo was R$ 83,583 per month. Total costs for the units in Porto Alegre and Distrito Federal were estimated in R$ 64,010 and R$ 41,542, respectively. Cost rate per minute related to structure resources were R$ 43.26 in São Paulo, R$ 47.09 in Porto Alegre, and R$ 25.02 in Distrito Federal. Allocation of fixed costs per unit, total working hours and computed cost rates per hour for each unit related to the structure resources are presented in Table 1. Average cost per minute of work of non-medical attendants and physicians was R$ 0.54 and R$ 3.22, respectively.

Analysis of times per activity

To determine the average time for a referral case, times of 819 referral cases were registered over a month. Average times in minutes per medical specialty, type of task (Time 1, Time 2, or Time 3), and locality are presented in Table 2. Considering all localities and medical specialties, duration of task in Time 1 ranged from 40.8 seconds to 3 min 12 sec. For Time 2, times ranged from 51 seconds to 4 minutes and for Time 3, times ranged from 1 to 4 minutes.

Analysis of cost per referred case

After having estimated cost of structural resources per unit of time and cost related to times spent in activities, the TDABC equation was applied, in which times of use of each resource are multiplied by the cost per unit of time, for each one of consumed resources. Costs per referred case, by site and tasks, are presented in Table 3.

Average unit cost by task and locality and average total cost per month, considering the number of referrals carried out throughout 2019,
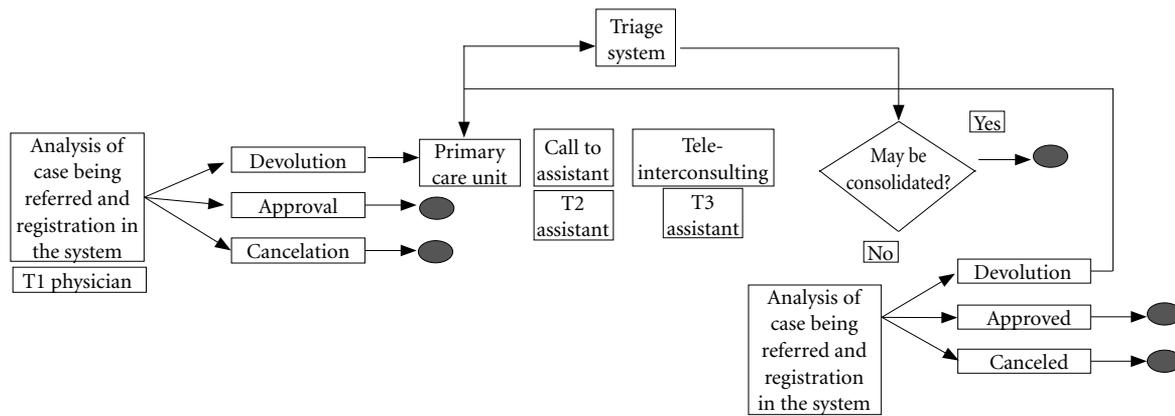
Figure 1. Mapping of processes involved in activities for referral management.

Source: Authors.

Table 1. Resources considered for estimates of fixed costs and computed cost rate per minute, in Brazilian reais.

Unit	SP	PA	DF
Number of professionals	27	16	10
Rental	NA	10,445.00	9,980.00
Infrastructure services	254.12	768.96	NA
Telephony	3,865.70	3,105.60	2,691.00
Cleaning	1,247.62	1,000.00	NA
Coordination of attendance activities	8,885.54	5,265.50	NA
Project management	36,549.16	21,658.76	18,675.74
IT professionals	22,051.47	13,067.54	8,167.21
Medical coordination	6,670.66	6,670.66	NA
Depreciation	4,059.06	2,029.53	2,029.53
Total	83,583.33	64,011.55	41,543.48
Mean working hours of medical doctors or attendants	1,931.75	1,359.60	1,660.00
Cost rate per hour related to structure resources (R$/h)	43.27	47.08	25.03
Cost rate per minute related to structure resources (R$/min)	0.72	0.78	0.42

DF: Distrito Federal; IT: information technology; NA: not applicable; PA: Porto Alegre; SP: São Paulo. Costs presented in Brazilian reais.

Source: Authors.

were computed. Average cost per unit was R$ 7.27 for Time 1, R$ 7.57 for Time 2, and R$ 8.76 for Time 3. Cost per referred case was R$ 8.24 in Belo Horizonte, R$ 8.29 in Porto Alegre, R$ 5.70 in Distrito Federal and R$ 7.70 in Amazonas.

Total cost was calculated by multiplying tasks performed per month for each locality. Average total cost per month was R$ 99,750 for Time 1, R$ 73,249 for Time 2 and R$ 65,945 for Time 3. Average costs by localities ranged from R$ 22,306 to R$ 121,997.

Table 2. Average times in minutes per medical specialty, locality, and task.

Locality	BH			PA			DF			AM		
Task/Medical specialty	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
Cardiology	-	-	-	1.68	2.11	2.50	0.73	0.98	0.93	0.92	1.99	-
Colonoscopy	-	-	-	-	-	-	-	-	-	2.00	-	-
Digestive endoscopy	-	-	-	-	-	-	-	-	-	-	1.50	2.00
Endocrinology	-	-	-	1.27	2.00		1.07	1.86	1.93	1.19	1.60	-
Gastrentherology	-	-	-	3.02	1.59	3.52	-	-	-	-	-	-
Neurology	2.75	-	-	1.37	0.85	1.00	0.68	1.17	-	-	-	-
Neurosurgery	-	-	-	2.75	1.83	-	-	-	-	-	-	-
Orthopedics	-	-	-	2.58	1.90	3.93	-	-	-	0.92	1.18	1.68
Proctology	-	-	-	1.21	1.90	1.61	-	-	-	-	4.00	-
Pneumology	-	-	-	1.69	-	-	-	-	-	2.56	-	-
Psychiatry	-	-	-	2.50	1.66	-	-	-	-	-	-	-
Rheumatology	2.81	-	-	-	-	-	-	-	-	1.50	-	-
Urology	1.06	1.50	-	2.90	2.08	2.14	-	-	-	1.12	1.71	4.00
Vascular surgery	-	-	-	1.67	3.02	1.04	1.29	1.78	-	-	-	-

AM: Amazonas; BH: Belo Horizonte; DF: Distrito Federal; PA: Porto Alegre. Empty cells indicate no registered cases for locality and task.

Source: Authors.

Table 3. Cost per referred case, by task and locality, in Brazilian reais.

Locality	BH			PA			DF			AM		
Task/Medical specialty	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3	Time 1	Time 2	Time 3
Cardiology	-	-	-	7.11	8.50	9.75	4.04	4.86	4.71	4.67	8.10	-
Vascular surgery	-	-	-	7.07	11.41	5.06	5.87	7.43	-	-	-	-
Endocrinology	-	-	-	5.81	8.14	-	5.16	7.68	7.93	5.53	6.85	-
Gastroenterology	-	-	-	11.42	6.83	13.01	-	-	-	-	-	-
Colonoscopy	-	-	-	-	-	-	-	-	8.14	-	-	-
Digestive endoscopy	-	-	-	-	-	-	-	-	-	-	6.53	8,14
Neurology	10.56	-	-	6.12	4.43	4.92	3.90	5.46	-	-	-	-
Orthopaedics	-	-	-	10.01	7.82	14.35	-	-	-	4.67	5.51	7.12
Proctology	-	-	-	5.61	7.82	6.88	-	-	-	-	14.57	-
Pneumology	-	-	-	7.14	-	-	-	-	-	9.93	-	-
Psychiatry	-	-	-	9.75	7.05	-	-	-	-	-	-	-
Rheumatology	10.76	-	-	-	-	-	-	-	-	6.53	-	-
Urology	5.11	6.53	-	11.05	8.39	8.61	-	-	-	5.32	7.20	14.57
Neurosurgery	-	-	-	10.55	7.61	-	-	-	-	-	-	-
Mean cost	8.81	6.53	-	8.33	7.80	8.94	4.74	6.36	6.32	6.40	8.13	9.95
Non-medical cost (%)	19%	26%	-	21%	22%	19%	36%	27%	27%	27%	21%	17%

AM: Amazonas; BH: Belo Horizonte; DF: Distrito Federal; PA: Porto Alegre. Empty cells indicate no registered cases for locality and task.

Source: Authors.

Average monthly cost per medical specialty over time

Average monthly cost per medical specialty presented high variability due to the differences in terms of number of cases. Medical specialties associated with higher costs were Orthopedics, Urology and Neurology. Cost incurred for each medical specialty and the average number of regulations per specialty over the months of 2019 are presented in Table 4. Cost per referred case ranged from R$ 1.85 for cases referred to digestive endoscopy to R$ 8.56 for cases referred to Orthopedics (median=5.27, IQR=3.47 to 7.30).

Discussion

The first step to understand the economic impact of a remotely operated referral management system in a national public health system was achieved in this study, by the evaluation of cost per referred case. TDABC has been used for several studies in health care to identify opportunities to drive the care management to value[21-26]. Precise cost estimates are especially necessary for healthcare systems in which the modality of bundled payment is in place or being implemented. TDABC has been applied for estimating costs related to specific alternatives of treatment[24], for estimating costs related to the full cycle of care of diseases requiring long-term management[22,25] and to evaluate costs incurred by health services[23,26]. Although the TDABC has been applied to a vast myriad of health conditions and health services, we did not find any study that have estimate costs related to the operation of referral management systems by the use of TDABC, which precluded the confrontation of our results to other studies.

By applying this method to evaluate the cost of a remotely operated referral management system, we were able not only to identify the component costs but also to identify the cost variability by task and locality. When cost by locality was analyzed, cost per referred case varied from R$ 5.70 to R$ 8.29. Analysis of cost per medical specialty showed variability from R$ 1.85 to R$ 8.56 per referred case, with a median of R$ 5.54.

A few distinctions could be observed. As expected, times for completion of tasks were not homogeneous. Medical reassessment (Time 3) demands more time and therefore is more expensive than the first medical assessment (Time 1). This understanding is important since most cases are resolved in Time 1, but there is a substantial proportion of cases that requires reassessment, which could be avoidable if referral requests were properly reported.

Differences related to cost by locality were additionally observed. Times of completion of tasks observed for Distrito Federal were shorter, and most of referrals in this locality involved only tasks in Time 1, contributing to lower cost per referred case observed for this locality. Porto Alegre was the service with a higher number of referrals

Table 4. Average monthly cost per medical specialty, in Brazilian reais.

	Average monthly cost	Average monthly number of referrals	Average cost per referral
Cardiology	19,292.48	3,880	4.97
Colonoscopy	35.01	9	3.76
Digestive endoscopy	135.11	73	1.85
Endocrinology	12,296.11	2,220	5.54
Gastroenterology	6,290.85	2,705	2.33
Neurology	34,341.36	5,559	6.18
Neurosurgery	1,900.51	444	4.28
Orthopedics	69,643.90	8,149	8.55
Proctology	8,419.38	1,254	6.71
Psychiatry	8,450.35	2,307	3.66
Pulmonology	1,313.64	463	2.84
Rheumatology	15,764.81	1,912	8.24
Urology	47,185.67	6,255	7.54
Vascular surgery	13,877.56	1,973	7.03

Source: Authors.

on average, but despite being the more active unit in terms of volume of cases, it was not associated with lower costs. Reasons underpinning this variability are probably associated to the complexity embed in referrals for each specialty, and the quality of the information provided at the first time by each region.

Another important finding of this study is the estimate of cost of teleconsultation and the impact of the learning period over costs. Telemedicine services involve innovative solutions, and as any innovation, is exposed to risks and time to achieve a maturity[27,28]. The opportunity of continually measure costs and outcomes of a healthcare service is necessary to create a constant improvement cycle[29,30]. At this time, this study introduced a framework to assess costs incurred in teleconsultations, as well as the understanding that cost analysis per medical specialty can generate valid formation to guide future decisions on how resources can be better allocated.

To the best of our knowledge, this is the first study to apply TDABC for measuring costs incurred in a remotely operated referral management system, within the context of a national universal healthcare system. Data from three operational units, responsible for referral management in four locations were included. Costs were analyzed over time to account for the possibility of variability over time.

Limitations of the present study refers to the generalization of its results. Although data were collected at three different locations, these locations were all components of the same project. It is logical to assume that different types of implementation and operational characteristics may impact on costs. An economic evaluation, comparing resulting costs with costs incurred in conventional referral management system as well as considering the effectiveness of referrals in both systems, was beyond the scope of the present study and will be accomplished in the future.

Altogether, our findings provide qualified information for the optimization of referral management in public healthcare systems that are commonly challenged by high demand to specialized care and relatively insufficient resources, which results in long waiting times and ultimately compromises health assistance.

In conclusion, strategies to optimize management of referral cases to specialized care in public healthcare systems are still needed. Telehealth strategies may be advantageous in this context, which stresses the need of accurate estimates of costs to underpin decision making. Cost per case referred by *Regula Mais Brasil* varied across localities from R$ 5.70 to R$ 8.29, with additional observed variability related to medical specialties.

Collaborations

DV Pachito worked on conceptualization; methodology; investigation; writing - original draft; visualization. APBS Etges worked on conceptualization; methodology; formal analysis; investigation; writing - original draft; visualization. PRBP Oliveira worked on validation; investigation; data curation; writing - review & editing. J Basso worked on conceptualization; validation; investigation; data curation; writing - review & editing. ÂM Bagattini worked on methodology; writing - review & editing; supervision. R Riera worked on conceptualization; methodology; writing - review & editing; supervision. LG Gehres worked on resources; writing - review & editing; supervision. ÉB Mallmann worked on resources; writing - review & editing; supervision. ÁS Rodrigues worked on resources; writing - review & editing; supervision. SD Gadenz worked on conceptualization; methodology; writing - review & editing; supervision; project administration.

Acknowledgements

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