Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2024; 24:e230010
https://doi.org/10.1590/pboci.2024.012
ISSN 1519-0501 / eISSN 1983-4632

ORIGINAL ARTICLE

Photobiomodulation for Oral Mucositis – A Microcosting and Budget Impact Analysis from a Brazilian Perspective

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Academic Editor: Wilton Wilney Nascimento Padilha

Received: January 23, 2023 / **Review:** April 18, 2023 / **Accepted:** May 14, 2023

How to cite: Bezerra PMM, Lima TMNR, Moura ABR, Valença AMG, Lucena EHG, Cavalcanti YW, et al. Photobiomodulation for oral mucositis – A microcosting and budget impact analysis from a Brazilian perspective. Pesqui Bras Odontopediatria Clín Integr. 2024; 24:e230010. https://doi.org/10.1590/pboci.2024.012

ABSTRACT

Objective: To measure the costs of preventive and therapeutic protocols of Photobiomodulation (PBM) for oral mucositis (OM) and their budgetary impact on Brazil's Ministry of Health (BMH). **Material and Methods:** A partial economic analysis was performed to estimate the costs using a bottom-up approach from a social perspective. Monetary values were assigned in Brazilian reais (BRL). The costs of the preventive protocol were calculated for five, 30, and 33 consecutive PBM sessions, depending on the antineoplastic treatment instituted. The costs of the therapeutic protocol were calculated for 5 or 10 sessions. The annual financial and budgetary impact was calculated considering the groups of oncologic patients with a higher risk of development of OM, such as those with head and neck and hematological cancer and pediatric patients. **Results:** The cost of a PBM session was estimated at BRL 23.75. The financial impact of providing one preventive protocol per year for all oncologic patients would be BRL 14,282,680.00, 0.030% of the estimated budget for hospital and outpatient care of the BMH in 2022. The financial and budgetary impacts of providing one treatment for OM for all patients in one year would be BRL 2,225,630.31 (0.005%, most optimistic scenario) and BRL 4,451,355.63 (0.009%, most pessimistic scenario). **Conclusion:** The budgetary impact of implementing PBM protocols in the Brazilian Healthcare System is small, even in a pessimistic scenario.

Keywords: Low-Level Light Therapy; Stomatitis; Oncology Service, Hospital; Models, Economic.

Introduction

Cancer is a highly incident public health issue, especially in developing countries, and is the second leading cause of death worldwide [1]. According to data from the Global Cancer Observatory of the International Agency for Research on Cancer (IARC), through the database GLOBOCAN for 185 countries and 36 types of cancer, for the year 2020, there were estimated 19.3 million new cases and 10 million cancer deaths worldwide. Considering that national rates estimated remain constant, a burden of cancer incidence is predicted for 2040, with an increase of 47% worldwide [2,3].

The current oncological treatment modalities include surgery, chemotherapy, radiotherapy, or a combined approach. Radiotherapy and chemotherapy promote the inhibition of cell division in tumor cells but may also damage healthy cells [4]. The oral mucosa is sensitive to radiotherapy and some chemotherapy protocols, which often trigger the onset of oral mucositis (OM). OM consists of an acute and painful inflammation clinically manifested as erythema, scaling, or ulcers. It is one of the most debilitating comorbidities affecting cancer patients [5].

Patients experiencing severe oral mucositis (SOM) may need to interrupt the scheduled antineoplastic treatment and require support medication and parenteral nutrition, which frequently culminates in a more extended hospital stay and a more significant economic burden. Annually, at least 20% of cancer patients have their survival reduced by up to 5 years as a direct impact of OM. This condition alone is responsible for an annual increment of USD 4.9 billion in the costs of antineoplastic treatments [6]. Hence, the management of OM should be considered a priority in cancer care.

Previous studies have demonstrated that permanent oral health care reduces SOM-related interruptions in antineoplastic treatments [7]. To date, Photobiomodulation (PBM) using low-level light therapy is the most indicated intervention for preventing and treating OM [8]. The laser light induces a better response to mucosal inflammation while ameliorating painful symptoms and edema. As a result, it promotes biostimulation and wound healing [9,10].

The main advantage of PBM for the management of OM is its safety. In general, no adverse effects are reported, and the treatment is easy to apply, fast, non-invasive, and painless, which increases patient acceptability. However, adherence may be impaired in cases of limited mouth opening or among individuals with post-chemotherapy nausea and emesis [11]. In addition, psychological conditioning among pediatric patients may be required throughout the treatment course [12].

The Diagnostic and Therapeutic Guidelines for Head and Neck Cancer (Ordinance SAS/MS No. 516, of 17 June 2015) recommends using PBM to treat and prevent OM lesions. The intervention has been successfully implemented across several oncology centers in Brazil [7,13,14], considering that, among the possible therapies available to manage OM, it has the highest level of scientific evidence and is also recommended by the Multinational Association for Supportive Care in Cancer (MASCC) [12,15-17]. Economic analyses have indicated that PBM is cost-effective both for the prevention and treatment of OM, thereby optimizing the financial costs related to hospitalization, nutritional support, and the use of opioids [18].

In 2017, Brazil's Ministry of Health (BMH) team discussed, within the scope of the 55th Meeting of the National Committee for the Incorporation of Technologies (CONITEC), the incorporation of PBM as a standard procedure in the Brazilian Healthcare System (BHS). A budgetary impact analysis was recommended to incorporate this technology in the public health sector. From this perspective, this study developed a micro-cost and budgetary impact analysis of the implementation of PBM for the treatment/prevention of OM induced by radiotherapy or chemotherapy during permanent oral health care in cancer patients admitted to the BHS.

Material and Methods

Study Design

This study was designed as a partial economic assessment based on the collection of publicly available secondary data. The survey was conducted following the Methodological Guidelines for Economic Evaluations of the Brazilian Ministry of Health [19] and the Consolidated Standards for Reporting Health Economic Evaluations (CHEERS) [20].

Data Collection

A microcosting analysis with a bottom-up approach estimated the direct costs of PBM for OM. The perspective of the analysis was that of Brazil's Ministry of Health. The direct costs of each PBM session were estimated in three stages: identification, quantification, and monetization. A panel of specialists with five expert professionals was responsible for identifying the parameters and inputs needed to perform the technique within the scope of the BHS.

For the quantification of inputs, consumer goods [personal protective equipment (PPE) and disposable materials] were accounted for in each session. The low-power laser device, considered a durable good, had an estimated lifespan of 5 years [19]. Its percent usage was divided per session. The dentist's workforce was quantified by the quotient between the weekly working hours of a hospital dentist (30 hours) and the estimated time for each session. The duration of each PBM session was estimated at 20 minutes.

The monetization stage searched for Brazilian representative values for each necessary input. For consumer goods and durable goods, a price survey was carried out in the three major virtual stores of dental products nationwide (*Dental Cremer*, *Dental Speed*, and *Surya Dental*). The average of the prices obtained the estimated value for each item. For durable goods, the total value of each item was divided according to the quantification previously described. The professional workforce was valued based on the salary paid to a dentist by the Brazilian Company of Hospital Services (*Empresa Brasileira de Serviços Hospitalares* - EBSERH).

The total cost of the preventive and therapeutic PBM protocols for OM was calculated by multiplying the number of sessions by the monetary value of one session. Considering that the number of sessions varies according to the severity of the cases [11], the total treatment costs were estimated for a more optimistic scenario, where five sessions would be necessary for the remission of the condition, and for a more pessimistic scenario, in which ten sessions would be required for the complete remission of OM lesions. The costs of the preventive protocol were calculated for five sessions for patients undergoing chemotherapy treatments, 30 sessions for patients undergoing hematopoietic stem cell transplantation (HSCT), and 33 sessions for patients receiving radiotherapy in the head and neck region [12,14].

As this is a partial economic analysis, without a temporal context, discounts and corrections for inflation were not included. Furthermore, costs directly related to building maintenance and lost productivity or out-of-pocket costs for patients and their families were not considered.

Next, the financial impact of the PBM protocol on the annual budget of the Brazilian Ministry of Health was measured. For this purpose, the groups of cancer patients most affected by OM lesions were considered: head and neck cancer patients, those with hematological neoplasms (submitted or not to HSCT), and pediatric patients [21-23]. The annual incidence of each group of cancer in Brazil was estimated from the average of the incidences of five consecutive years obtained via the Hospital Records of Cancer (RHC) platform of the National Cancer Institute (*INCA*, in Portuguese). The years selected for the search were 2014 to 2018, the last year the records were fully updated. The number of patients undergoing HSCT in 2018 was obtained through the Brazilian Transplant Registry, the official vehicle of the Brazilian Association of Organ Transplantation.

The costs of the preventive PBM protocol were calculated for 100% of the patients undergoing cancer therapy and were also simulated considering three possibilities (one, three, and six protocols per year). Patients with head and neck cancer and those undergoing HSCT are not eligible for more than one protocol per year.

For the therapeutic protocol, the incidence for each tumor group was determined through literature searches. It was estimated at 80% for patients with head and neck tumors [24], 28.5% among those with hematological neoplasms not submitted to HSCT [25], 85% for patients with hematological cancer submitted to HSCT [26], and 60% in pediatric cancer patients [27]. The estimated number of patients needing PBM was calculated by the product of the prevalence of OM by the annual incidence of each type of tumor.

The estimated number of patients affected annually by OM was multiplied by the costs of treatment protocols in both scenarios. Nevertheless, most patients undergoing antineoplastic protocols are affected by OM more than once a year; hence, the costs were calculated for patients considering three different possibilities, as follows: one, three, and six PBM protocols per year.

The financial and budgetary impacts of the preventive and therapeutic PBM protocols were calculated considering the budget for hospital and outpatient care in the year 2022 (BRL 47.097 billion), according to data from the Transparency Portal (https://www.portaltransparencia.gov.br/funcoes/10-saude?ano =2022).

Results

PBM requires a few inputs, as shown in Table 1. Financial investment is required to acquire a low-power device, hire qualified personnel, and buy biosafety items. Despite its high investment value, the laser device has the lowest percentage of the final cost of the session (1.14% - BRL 0.27). Professional labor is the component that most impacts the costs (90.36% - BRL 21.46). The total estimated cost of a PBM session was BRL 23.75.

Table 1. Microcosting analysis of a single PBM session for the treatment of OM lesions.

Input	Amount	Cost Quotes			Average Cost (BRL)	Individual Amount (BRL)
		Store 1	Store 2	Store 3		
Laser Device + Glasses	1	4389	4389	4389	4389	0.27
Professional Labor*	20	-	-	-	5793.43	21.46
PVC	1 m	21.84	20.9	22.93	21.89	0.18
Alcohol	2 ml	11.9	8	10.49	10.13	0.02
Cotton	2 g	25.9	21.9	23.7	23.83	0.24
Liquid Soap	2 ml	59.27	59.9	28.74	49.30	0.02
Glove	2	29.9	19.99	54.9	34.93	0.70
Cap	1	13.9	19.9	13.8	15.87	0.16
Mask	1	39.9	29.9	32.99	34.26	0.69
Coat	1	69.99	88.99	77	78.66	0.02
Total						23.75

*Quotation of the dentist's work hours: monthly salary corresponding to 30 hours paid by the Brazilian Company of Hospital Services – EBSERH; BRL: Brazilian reais.

The total cost of PBM depends on the number of required sessions. Regarding the preventive protocol, for patients with cancer in the head and neck region needing 33 preventive sessions, the costs of OM prevention will be BRL 783.75. As for adult patients undergoing transplantation, requiring 30 consecutive preventative sessions, the costs will be BRL 712.50. Considering the other adult and pediatric cancer patients for whom a preventive protocol of 5 sessions is adopted, the fees will be BRL 118.75. The costs of the therapeutic protocol in a more optimistic scenario were estimated at BRL 118.75, compared to BRL 237.50 in a more pessimistic scenario. Table 2 shows the sensitivity analysis performed to evaluate the treatment in different contexts.

Table 2. Sensitivity analysis of the cost (BRL) of the complete PBM protocol for OM lesions in two alternative scenarios.

Single Session	Complete Treatment	
	More Optimistic Scenario (5 Sessions)	More Pessimistic Scenario (10 Sessions)
23.75	118.75	237.50

BRL: Brazilian reais.

The budgetary impact of OM management varies for each type of cancer, according to the prevalence of OM, and it also depends on the number of sessions instituted. Supposing that all individuals with hematological neoplasms (not transplanted) and childhood cancer were submitted to a PBM preventive protocol with five sessions, all individuals with head and neck cancer to 33 sessions, and all transplanted patients to 30 sessions, the budgetary impact of offer one protocol per year would be BRL 14,282,680.00. This amount corresponds to 0.030% of the budget for hospital and outpatient care in the Brazilian healthcare system in 2022 (Table 3). Considering steady cancer incidence rates and the worst-case scenario (6 treatments per year), implementing the preventive protocol for five years would have an estimated cost of BRL 399,944,775.00.

Table 3. The annual budgetary impact of a preventive protocol for OM (five PBM sessions). The main groups of cancer patients were considered, and the analysis was carried out from the perspective of the Brazilian Healthcare System.

Group	Annual Incidence	Number of Sessions	Annual Financial Impact (BRL)		
			1 Treatment	3 Treatments	6 Treatments
Head and Neck Tumors	14,797	33	11,597,148.75	-	-
Hematological Tumors (without HSCT)	9,522	5	1,130,737.50	3,392,212.50	6,784,425.00
Hematological Tumors (HSCT)	1,335	30	951,187.50	-	-
Childhood Cancer	5,083	5	603,606.25	1,810,818.75	3,621,637.50
Total			3,650,018.75	10,950,056.25	21,900,112.50
Budget for hospital and outpatient care in the year 2022 (BRL 47,169,726,961.56)			0.030%	0.038%	0.049%

BRL: Brazilian reais.

In Brazil, an average of 14,797 patients with head and neck tumors are treated annually, of which 11,838 are estimated to be affected by OM. If these patients undergo PBM therapy (five sessions) at least once a year, the financial impact on the Ministry of Health's budget would be BRL 1,405,715.00. In a more pessimistic scenario, in which patients need 10 PBM sessions to remission lesions, the total cost would be BRL 2,811,525.00. If there is a need for more than one treatment per year, the impact increases, as seen in Tables 4 (most optimistic scenario) and 5 (most pessimistic scenario).

In Brazil, hematological neoplasms affect an average of 10,857 adult patients yearly. Among them, 1,335 individuals need HSCT. These patients have a very high incidence of OM: approximately 1135 individuals will develop severe degrees of OM annually. The cost to ensure they receive the PBM therapeutic protocol is BRL 134,751.56 (5 sessions) and BRL 269,503.13 (10 sessions).

Childhood cancer affects an average of 5,083 children and adolescents (0-19 years) per year, with a higher prevalence of OM than that in adult patients. The estimates indicate that 3,050 Brazilian pediatric patients experience OM each year. Treating them would have an approximate cost of BRL 362,163.75 for a 5-session treatment and BRL 724,327.50 for a 10-session treatment.

From the perspective of the BHS, in a more optimistic scenario, one annual PBM treatment would have a financial and budgetary impact of BRL 2.225.630.31 and 0.005%. Considering the most pessimistic scenario, the economic and budgetary impact would be of BRL 4,451,355.63 and 0.010%, double (Tables 4 and 5).

Table 4. The annual financial impact of a 5-session PBM protocol for OM lesions (most optimist scenario), considering three groups of cancer patients, from the perspective of the Brazilian Healthcare System.

Group	Annual Incidence (N)	OM Incidence (%)	Need for PBM (N)	Annual Financial Impact (BRL)		
				1 Treatment	3 Treatments	6 Treatments
Head and Neck Tumors	14,797	80	11,838	1,405,715.00	4,217,145.00	8,434,290.00
Hematological Tumors (Without HSCT)	9,522	28.5	2,720	323,000.00	969,000.00	1,938,000.00
Hematological Tumors (HSCT)	1,335	85	1,135	134,751.56	-	-
Childhood Cancer	5,083	60.0	3,050	362,163.75	1,086,491.25	2,172,982.50
Total			18,743	2,225,630.31	6,272,636.25	12,545,272.50
Budget for hospital and outpatient care in the year 2022 (BRL 47,169,726,961.56)				0.005%	0.013%	0.027%

BRL: Brazilian reais.

Table 5. The annual financial impact of a 10-session PBM protocol for OM lesions (most pessimistic scenario), considering three groups of cancer patients, from the perspective of the Brazilian Healthcare System.

Group	Annual Incidence (N)	OM Incidence (%)	Need for PBM (N)	Annual Financial Impact (BRL)		
				1 Treatment	3 Treatments	6 Treatments
Head and Neck Tumors	14,797	41.9	11,838	2,811,525.00	8,434,575.00	16,869,150.00
Hematological Tumors (without HSCT)	9,522	28.5	2,720	646,000.00	1,938,000.00	3,876,000.00
Hematological Tumors (HSCT)	1,335	85	1,135	269,503.13	-	-
Childhood Cancer	5,083	60.0	3,050	724,327.50	2,172,982.50	4,345,965.00
Total			18,743	4,451,355.63	12,545,557.50	25,091,115.00
Budget for hospital and outpatient care in the year 2022 (BRL 47,169,726,961.56)				0.010%	0.027%	0.053%

BRL: Brazilian reais.

Discussion

The results of our study indicate that implementing PBM protocols into the Brazilian healthcare system would have a small budgetary impact. Even considering the most pessimistic scenario, in which the patient undergoes six annual treatments for a more severe condition, needing ten PBM sessions, the estimated budgetary impact would not exceed 0.053%. Likewise, the preventive protocol was also estimated to have a little economic burden. This scenario reveals that administering PBM for OM has excellent potential and viability for the healthcare system.

The benefits of this technology are well established. Campos et al. [28] investigated the cost-effectiveness of the PBM to oral mucositis in patients with head and neck cancer. They demonstrated that the group submitted to preventive PBM had an incremental effectiveness of 132.2 compared to the placebo group. They found that the laser treatment costs were approximately US$ 7.22 per case avoided [28]. Another study revealed that a specialized oral care program with PBM for patients undergoing HSCT reduced hospital costs and the frequency of severe degrees of OM [29]. The PBM is also related to the decrease in radiotherapy interruptions due to OM and in scores of oral health-related quality of life in patients with head and neck cancer [30].

Although the costs of the preventive protocol exceed the costs of OM treatment, other expenditures are associated with the occurrence of OM. The dissemination of PBM for the prevention and treatment of cancer-related comorbidities can improve the patient's quality of life [31], reduce the need for nasogastric or parenteral

nutrition [32], maintain the patient's body weight [33], shorter hospital stays [7,34] and, consequently, reduce hospital-related costs [18]. Further statistical models should simulate the cost-opportunity relationship of the administration of PBM in patients undergoing cancer therapy.

The incremental costs associated with comorbidities related to cancer therapy are estimated at 4.9 billion US dollars [6]. Hence, preventing and treating OM in patients undergoing antineoplastic treatment can significantly reduce hospital-associated costs. The amount spent on PBM is substantially lower than the costs associated with the increase in hospital stay and other morbidities associated with the progression of OM lesions. Future studies should demonstrate the savings obtained with the implementation of this technology.

There are some challenges to the implementation of this treatment in the Brazilian healthcare system, such as (i) the incorporation of PBM in the table of procedures of the healthcare system, (ii) the acquisition of equipment by oncological hospital units, and (iii) the training of professionals capable of handling low-power laser equipment.

The incorporation of the protocols into the healthcare system will allow hospital units to register the procedures and agree on the transfer of resources between the federative departments. This can be a strategic approach to save and optimize financial resources. As for acquiring equipment, an initial investment in capital resources is required. Therefore, hospital units or outpatient clinics should raise capital resources in the approximate amount of BRL 5,000.00 (five thousand Brazilian *reais*) for each piece of equipment to be acquired. Although the capital acquisition resources are low, some services may experience difficulty obtaining the devices due to the item's origin or the bureaucracy for purchase via the public service.

The protocols can be incorporated into the healthcare system in different hospital modalities (hospitalization, day hospital, outpatient clinic). Furthermore, an additional percentage of the calculated amount should be added to account for inflationary losses, given the long periodicity with which the table of procedures is updated. Considering that the budgetary impact is small, the protocols can be registered in the table of procedures with approximately 25% of the amount estimated by the microcosting technique. When considering the procedure with a 25% higher amount (BRL 29.69), the financial and budgetary impact of the preventive protocol applied six times per year would be BRL 28,695,307.89 (0.06% of the budget), which is considered to be very low.

Previous studies have demonstrated the importance of having a dentist in the interdisciplinary team in reference to cancer hospitals. This strategy ensures specialized oral care surveillance for cancer patients, enabling the administration of preventive and therapeutic protocols for OM. The patient has a better prognosis when OM lesions are diagnosed and treated early [7,34]. Thus, dental professionals should be qualified and trained on the peculiarities of cancer care, particularly regarding protocol indications, energy dosage, and device handling, as they should be trained on the management of OM with laser photobiomodulation, for instance, via online education platforms such as the *UNA-SUS* (in Portuguese), in Brazil.

Conclusion

The implementation of photobiomodulation for the treatment and prevention of oral mucositis would have very low financial and budgetary impacts on the Brazilian Healthcare system. Hence, the incorporation of PBM in this context is economically viable. The challenges posed by disseminating this technology from the healthcare system's perspective are manageable and can be overcome with effective management and education measures.

Authors' Contributions

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All authors declare that they contributed to a critical review of intellectual content and approval of the final version to be published.

Financial Support

The present study received a research grant from the Coordination of Superior Level Staff Improvement (CAPES) of the Ministry of Education – Brazil.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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