

Analysis of micro-costing through the Time-Driven Activity-Based Costing (TDABC) method in viscosupplementation procedures in different application regimens

Análise do microcusteio por meio de método Time-Driven Activity-Based Costing (TDABC) nos procedimentos de viscosuplementação do joelho em diferentes regimes de aplicação

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ABSTRACT

Objective: To evaluate the micro-costing of viscosupplementation procedures compared to different infiltration regimens. **Methods:** This study compared, through the Time-Driven Activity-Based Costing method, the micro-costing of these different application regimens using national cost averages as a basis for calculation in a medium-sized outpatient service. **Results:** The results demonstrated that the difference in costs with the single application is 31.47% less for three and 119.13% for five applications. **Conclusions:** No study showed a superiority of the five-application regimen over the three-application regimen, which leads one to believe that there is no justification for this procedure from an economic or quality-of-life point of view.

RESUMO

Objective: Avaliar o microcusteio dos procedimentos de viscosuplementação do joelho em diferentes regimes de aplicação. **Métodos:** Este estudo comparou, por meio do método *Time-Driven Activity-Based Costing*, o microcusteio desses diferentes regimes de aplicação, usando com base de cálculo médias nacionais de custo em um serviço ambulatorial de porte médio. **Resultados:** Os resultados encontrados demonstraram que a diferença nos custos com a aplicação única é 31,47% menor para três aplicações e 119,13% para cinco aplicações. **Conclusão:** Em nenhum estudo houve superioridade do regime de cinco aplicações ao regime de três, fato que leva a acreditar que não há nenhuma justificativa para esse procedimento do ponto de vista econômico ou de qualidade de vida do paciente.

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Introduction

Osteoarthritis (OA) is a highly prevalent condition, and as the world population is aging, about twenty-five percent of it will be affected by this disease. For this reason, it will become a major cause of morbidity and restricted mobility in individuals over the age of forty, according to some authors. Hip and knee OA is a significant contributor to global disability-adjusted life years (DALYs) being one of the leading causes of disability by life years in the Global Burden of Disease study in 2010 (Cross *et al.*, 2014; Helmick *et al.*, 2008).

There are several described forms of treatment for knee OA. Among the non-surgical options are outpatient knee infiltration procedures. Infiltration can be performed with several substances, such as corticosteroid medications, platelet-rich plasma, and hyaluronic acid (HA). The latter is widely used in our field. HA is a high-viscosity glycosaminoglycan polysaccharide naturally produced by the synovial membrane. It can be found in different forms when related to its molecular weight: "Low molecular weight", between 0.5 and 1×10^6 Da, "Intermediate molecular weight", between 1 and 1.8×10^6 Da, and "High molecular weight", when it weighs over 6×10^6 Da. Molecular weight, concentration, and the presence of cross-links are factors that have a positive influence on the results of HA infiltration (Milas *et al.*, 2001).

There are some discussions about the physicochemical functions related directly to molecular weight. However, the primary evidence comes from *in vitro* experiments, without the same confirmation of this effect *in vivo*, precisely because the excessive molecular weight would prevent hyaluronic acid from passing from the intra-articular to the intercellular medium, not acting directly on the articular cells (Ghosh & Guidolin, 2002).

Intra-articular infiltration of HA is called viscosupplementation (VS) and has three primary purposes: 1) to improve the rheological properties of the synovial fluid, serving both as a lubricant and as a cushion; 2) analgesia; 3) and the improvement of joint homeostasis by decreasing inflammation and positively stimulating chondrocytes (Bannuru *et al.*, 2019; de Rezende & de Campos, 2012).

VS can be performed in application regimens varying according to the HA infiltration volume and concentration. They can be divided into single applications, 3 or 5 weekly applications. Some studies indicate that serial applications have better results in pain control, but no study has shown improvement in function and quality of life. A recent systematic review could not point to the superiority of any of these application regimens, demonstrating the need for more studies of sound scientific evidence (de Campos *et al.*, 2019; Zóboli *et al.*, 2013; McElheny *et al.*, 2019; Campbell *et al.* 2015; Divine *et al.* 2007).

The increased health care expenditures worldwide have resulted in continuous scientific advances in management and innovation. However, understanding the expenditures related to deploying modern technologies is essential for all levels of

health care, whether for the public manager, the private manager, or the patient. Economic evaluations are helpful and sometimes even mandatory to inform the decision-making about reimbursement and treatment implementation. They provide information about the effects and associated treatment costs to public health policy and healthcare decision-makers with pertinent information to support their decisions.

With the promising arrival of new value-based healthcare models, creating cost evaluation methods based on quality-of-life outcomes is required to encourage continuous improvement in the quality of care provided to patients and for better control of healthcare costs (Hermans *et al.*, 2018; Steinmann *et al.*, 2020). The study of micro-costing through bottom-up evaluations provides the best accuracy and precision in estimating the actual values of the processes in health, especially the Time-Driven Activity-Based Costing method (TDABC), which is already an established method in the industry (Keel *et al.*, 2017).

Treatment with intra-articular HA in patients with knee OA is cost-effective compared to treatments with analgesic and anti-inflammatory medications associated with physical therapy in conventional treatments (Hermans *et al.*, 2018). Thus, this paper will evaluate the micro-costing of VS procedures compared to different infiltration regimens.

Methods

Since this is a micro-cost economic analysis of HA viscosupplementation, we compared three administration regimens: single application, three applications, and five applications. Since the results in the literature regarding clinical outcomes are similar for the three forms and their use is diverse in our area, this study is based on cost evaluation to assist decision making. We chose the time-driven activity-based costing (TDABC) method for the cost evaluation.

TDABC was introduced by Kaplan in 2004 as a modified version of ABC that had already demonstrated some success in manufacturing and service industries but is highly complex and time-consuming to implement (Kaplan & Anderson, 2004). TDABC, on the other hand, is less resource-intensive, requiring only two key parameters: the capacity cost rate (CCR), and the time needed to perform the activities to deliver the service, hence the name "time-driven". In 2011, Robert Kaplan and Michael Porter published a paper on the seven steps necessary to apply TDABC in healthcare settings as the solution to the cost crisis: select the medical condition, define the service chain, and develop a map that includes all patient care activity incorporating all deployed resources, obtain the time estimate of each process, estimate the cost for each resource deployed to the patient, estimate the capacity of each resource and calculate the capacity cost rate (CCR), and then calculate the total cost per patient (Keel *et al.*, 2017; Kaplan & Porter, 2011; Etges *et al.*, 2020).

The capacity rate was measured by adding the availability of use (hours/day) of the procedure room, consulting room, and professionals involved and multiplied by the amount available. The monthly capacity in minutes was obtained from the daily capacities multiplied by the number of days in the month. It was counted as 20 days per month, considering that the outpatient clinic works from Monday to Friday and does not take patients on holidays.

We interviewed the supervisors responsible for outpatient administration, nursing supervision, and attending physicians of sizeable private outpatient services in São Paulo. The average annual number of patients treated with VS was also counted to determine the patients' flow mapping throughout the VS process.

To define the estimated time needed for each step of the process, we timed twenty randomly selected calls on different days and calculated the median of these times for each step. After these stages, a mapping of the activities contemplated all the resources in a diagram organizing the activities based on the person responsible for each process step (Figure 1).

The costs of consumables were extracted through market research in the city of São Paulo, in the May 2021 time-frame, in Brazilian currency (Brazilian Real, BRL) and US dollars (USD) using the official exchange rate of the same period of data collection. The average values found at three suppliers were considered (Table 1).

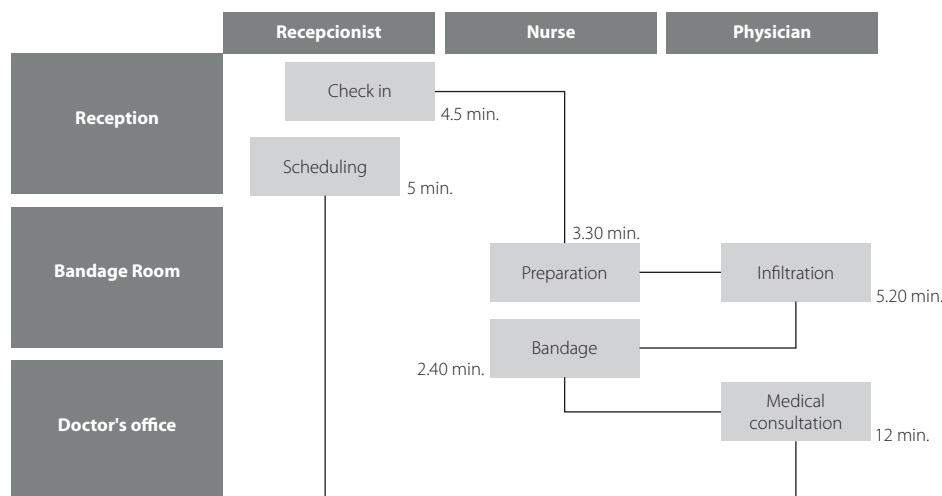


Figure 1. Viscosupplementation's process map

Table 1. Consumables

	Supplier 1		Supplier 2		Supplier 3		Average Price	
	BRL	USD	BRL	USD	BRL	USD	BRL	USD
Disposable glove	1.15	0.22	1.21	0.23	1.25	0.24	1.20	0.23
Sterile glove	2.45	0.46	2.31	0.44	2.56	0.48	2.44	0.46
Chlorhexidine Gluconate 0,5% – solution – 300 mL	2.41	0.46	4.09	0.77	3.30	0.63	3.27	0.62
Chlorhexidine Gluconate 2% – soap – 300 mL	2.50	0.47	2.73	0.52	2.89	0.55	2.71	0.51
Sterile Gauze Sponges – 01 pack	0.56	0.11	0.61	0.12	0.65	0.12	0.61	0.11
Sterile disposable fenestrated surgical drapes	3.19	0.60	3.38	0.64	3.53	0.67	3.37	0.64
Needle 30x07 mm	0.19	0.04	0.20	0.04	0.25	0.05	0.21	0.04
Needle 40x10 mm	0.15	0.03	0.24	0.05	0.29	0.05	0.23	0.04
Plastic 10 ml Injection Syringe	0.63	0.12	0.63	0.12	0.69	0.13	0.65	0.12
Sticking plaster	0.11	0.02	0.11	0.02	0.09	0.02	0.10	0.02
Sum							14.78	2.80

Table 2. Cost per professional

Category	Cost ^a	Capacity ^b	CCR ^c	Total cost per procedure ^a
Receptionist	2,214.90 (419.48)	9.600	0.23 (0.04)	2.26 (0.43)
Nurse	3,514.39 (665.60)	9.600	0.36 (1.93)	2.22 (0.42)
Physician*	64.78 (12.23)		64.78 (12.23)	64.78 (12.23)

* Value per procedure; ^a BRL (USD); ^b Minutes; ^c BRL (USD) per minute.

The average salary values for each professional class involved in the care flow of patients submitted for examinations were gathered from the National Employment Website table (www.trabalhabrasil.com.br), and the average values for the whole category of medium-sized companies were considered. For the value of the medical care, the values referring to the payment of the infiltration procedure of a health plan referring to the average values practiced in the reference service were considered. The professional class included the labor charges, adding 36.5% to the average salary (Table 2) (Veiga *et al.*, 2016).

We will call "cost E" the outpatient cost, which are the related direct costs – depreciation, energy, taxes, printing, and disallowances. In this way, we can keep the hospital's strategic information confidential, making it applicable to any service that wants to apply the formula to evaluate its cost.

After collecting the average values, these are divided by the capacity cost rate (CCR), thus providing the unit cost rate. The sum of the various activities' costs that make up the service results in the service cost, the TDABC objective.

Results

After holding meetings with managers and professionals from the hospital's orthopedic outpatient department, the patient flow for the procedure was established. In the last year, the average number of patients treated with VS was 782. The flow was mapped and shown in Figure 1. After the assistant physician indicates the procedure, the patient goes to the reception desk. The same professional who starts the service is responsible for forwarding the documents for the health insurance company releasing and scheduling. The patient returns on the scheduled day, and the receptionist starts the service and invites the patient to go to the waiting room for the procedure.

The nursing technician is responsible for receiving the patient in the procedure room, measuring vital data, performing asepsis, separating the materials, and notifying the physician. The physician conducts a brief anamnesis and applies the hyaluronic acid. Finally, the nursing technician performs the bandage, measures the vital data once more, and discharges the patient. The patient is taken to the physician's office for return instructions, medication prescription, and direct care. After the appointment, the patient is discharged and leaves the outpatient service.

After defining the flow, each process term was measured, with the median of each step identified in Figure 1 and used to multiply the unit cost rate to determine the final cost.

The consumables are listed in Table 1, and the average values were from three suppliers. The total consumables per procedure were BRL 14.78 (USD 2.80).

The medications' value was obtained from three retail suppliers for Hilano G-F 20 in two presentations, 20 mg/2 mL and 2 mg/06 mL, for which the average values were unit cost rates of BRL 196.21 (USD 37.16) and BRL 588.62 (USD 111.48).

The salary amounts are listed in Table 2, as are the unit cost rate calculations, with the caveat that the physician fee is for the procedure only and therefore has not been time equated.

After the determination of the unit cost rates and the sum of the expenses with consumables, we obtained the final cost values for the single application, three applications, and five weekly applications, respectively: BRL 698.56 (USD 132.27), BRL 918.45 (USD 173.84), BRL 1530.75 (USD 289.73) (Table 3). The results show that the difference in costs with the single application is 31.47% less for three applications and 119.13% less for five. In a hypothetical scenario, if all patients treated in the last year in this service, used as the basis for this research, had received the single application regimen compared to three and five applications, we would observe savings of BRL 171,953.98 (USD 32,509.70) and BRL 650,772.58 (USD 123,137.69), respectively.

Discussion

The great paradigm of health management in our times is the need to generate methods of financing the production of services so that the resources are used in the best way possible. The patient's best interest must always be on the horizon of decisions. Given this scenario, strategies linked to value-based management began to be discussed more frequently since 1999, when the attention of health researchers focused on pay-for-performance initiatives (Kaplan & Porter, 2011). Then the need to control and analyze costs arises so that everyone involved in patient care acts synergistically and clearly so that the entire system works.

This article presents the cost of the VS procedure based on real-world data in an outpatient knee surgery service of a large hospital in southeastern Brazil. The total cost value

Table 3. Cost per dosing regimens of hyaluronic acid injections

	03 Injections		05 Injections		Single Injection	
	BRL	USD	BRL	USD	BRL	USD
Professionals						
Receptionist	6.78	1.29	11.3	2.15	2.26	0.43
Nurse	6.66	1.26	11.1	2.1	2.22	0.42
Physician	194.34	36.69	323.9	61.15	64.78	12.23
Consumables	44.34	8.4	73.9	14	14.78	2.8
Drugs						
Hilano G20 – 20 mg/2 mL ^a	588.63	111.48	981.05	185.80		
Hilano G20 – 20 mg/06 mL					588.62	111.48
Lidocain 5% 2 mL	77.7	14.72	129.5	24.53	25.9	4.91
Total	918.45	173.84	1530.75	289.73	698.56	132.27

^a Unit cost: BRL 196.21/USD 37.16.

for VS application following all patient safety steps was BRL 698.56 (USD 132.27), BRL 918.45 (USD 173.84), and BRL 1530.75 (USD 289.73) for one, three, and five applications, respectively. Until the writing of this article, we have not found any study that evaluates the micro-costing of this procedure by comparing the different application regimens.

VS is an essential therapeutic procedure in the treatment of patients with knee OA; and has shown promising results in controlling pain and increasing joint mobility and has a low incidence of adverse reactions (Campbell *et al.*, 2015; Divine *et al.*, 2007; de Campos *et al.*, 2019; Zóboli *et al.*, 2013; Bellamy *et al.*, 2005; Bellamy *et al.*, 2006). Hermans *et al.* were the first to analyze the cost-utility of VS treatment and conventional non-surgical treatments. They observed a gain in quality of life (QALY), resulting in a cost-utility ratio of about €9,100/QALY from a societal perspective and €8,700/QALY gained from a health perspective. It concluded that VS treatment in patients with knee OA is cost-effective for the Dutch health situation, with VS cost-effectiveness of 64% from a social point of view and 86% from a medical point of view, considering the maximum willingness to pay €20,000/QALY for conditions like knee OA (Hermans *et al.*, 2018).

In another study, Thomas *et al.* analyzed the cost-utility of VS and drug treatment with non-hormonal anti-inflammatory drugs (NSAIDs). They observed a half-month equivalent QALY gain after six months of follow-up. NSAIDs consumption decreased in the group that underwent the VS, resulting in a better ratio of benefit to estimated risk. They then concluded that VS did not generate additional cost to the health care system and was associated with the patients' functional knee OA improvement and their quality of life (Thomas *et al.*, 2017).

When studying the application regimens, it is observed in the literature that there is no consistent difference in the results reported by patients. HA stays in the joint for approximately seven days. Thus, the classical regimens involve

weekly injections with three to five applications, allowing a total action time in the joint of about one month. However, the five-application formulations do not seem superior to the three-application formulations and have a slightly increased risk of complications. Also, based on currently available data, there appears to be similar efficacy with the possibility of greater cost-effectiveness and minor inconvenience to the patient with single-injection formulations. However, no studies in the literature have compared these application regimens through a complete economic analysis (McElheny *et al.*, 2019).

This study showed that costs with a single application are 31.47% less for three and 119.13% less for five applications. In no study, where the objective was to evaluate the clinical outcome of VS, was there a superiority of the five-application regimen over the three-application regimen, which leads one to believe that there is no justification for this procedure from an economic or quality of life perspective for the patient (de Campos *et al.*, 2019; Zóboli *et al.*, 2013; McElheny *et al.*, 2019; Thomas *et al.*, 2017; Rosen *et al.*, 2016). When we project the costs for different regimens in the year, considering the outpatient service used as a model in this study, we observe a difference of BRL 171,953.98 (USD 32,509.70) and BRL 650,772.58 (USD 123,137.69) for three and five applications. If evaluated from the point of view of the clinical outcome, it makes the advantage of the single infiltration application regimen even more evident.

The literature shows that the presence of so-called cross-links in formulations dramatically increases the product's longevity in the joint because it hinders resorption. Thus, single-dose use has been validated for high molecular weight (Hilano-G20). Furthermore, some authors describe a lower pain control capacity with no difference in joint range of motion and subjective evaluation surveys (de Campos *et al.*, 2019; Zóboli *et al.*, 2013; Chevalier *et al.*, 2010).

The 31.47% cost difference between the single-application and three-application regimens in individuals with similar quality of life, plus the fact that patients undergo fewer invasive procedures that cause discomfort, may be plausible justifications for using VS single-dose.

OA is a condition that causes loss of function and generates substantial public health costs. Our country's public services have huge waiting lists for surgical procedures, such as total knee arthroplasty. Incorporating VS into primary care can help reduce the waiting list for these procedures, mitigate patient suffering, and improve quality of life (Ferreira *et al.*, 2018). It calls for the evaluation of new health technologies that comprises a multidisciplinary process in which all the information about clinical, social, economic, ethical, and organizational issues related to the referred technology use is added. This evaluation should be impartial, transparent, and systematic, providing adequate methods for decision-making (Brasil, 2016). Understanding the micro-costing of the VS will allow strategies to reorganize the flow of patients. It will also support the purchase and availability of supplies and medications to optimize the process, improving the cost-benefit ratio of this procedure to the point of composing a broader project to be incorporated into the Brazilian public health system (SUS).

Not incorporating structure-related values into the costing evaluation in this study allows this analysis to be applied to any service-providing unit regardless of its size. However, it does not provide more accurate costing data as intended by the TDABC evaluations.

Another limitation of the study is that it does not use the values practiced in the service, but retail market averages, especially those related to HA, which can be changed, affecting the analysis.

This study is the first one that has set out to evaluate the costs of VS procedures and has shown that single applications are the least costly and can be adopted as the standard. On the other hand, the five-application regimen does not offer any good relationships supporting their use. However, a cost-minimization analysis should be conducted to compare these several types of VS application regimens.

Conclusions

This study has shown that single applications are the least costly and can be adopted as the standard. On the other hand, the five-application regimen does not offer any good relationships supporting their use.

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