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Economic evaluation in oral health: rehabilitation of a single prosthetic space

Avaliação econômica em saúde bucal: reabilitação de um único espaço protético

Evaluación económica en salud bucal: rehabilitación de un espacio protésico único

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Abstract

Objective: To evaluate the allocative efficiency, financial impact, and cost-effectiveness of rehabilitation of a single tooth by means of a 3-unit fixed dental prosthesis and of a dental

implant from the perspective of the Commercial Social Service - SESC ("Serviço Social do Comércio"). Methods: An economic analysis of the cost-effectiveness type was designed. A Markov model was developed to capture long-term clinical and economic outcomes considering the temporal horizon of 25 years. Results: Within this temporal horizon it would be possible to perform 308 more procedures with a saving of R$ 351,737.49, if rehabilitation by means of the one-unit implant were chosen. Conclusion: The implant technique with an implant and an implant-supported prosthesis was dominant; that is, it had lower cost and higher effectiveness and its allocative efficiency allowed a much higher number of persons to have access to treatment.

Keywords: Costs and cost analysis; Cost-benefit analysis; Efficiency; Health care economics and organizations; Oral health.

Resumo

Objetivo: Avaliar a eficiência alocativa, o impacto financeiro e o custo-efetividade da reabilitação de um único dente por meio de uma prótese dentária fixa de 3 unidades e de um implante dentário na perspectiva do Serviço Social do Comércio - SESC ("Serviço Social do Comércio"). Métodos: Foi elaborada uma análise econômica do tipo custo-efetividade. Um modelo de Markov foi desenvolvido para capturar resultados clínicos e econômicos de longo prazo considerando o horizonte temporal de 25 anos. Resultados: Nesse horizonte temporal seria possível realizar mais 308 procedimentos com economia de R$ 351.737,49, caso fosse escolhida a reabilitação por meio de implante unitário. Conclusão: A técnica de implante com uma prótese implanto-suportada foi dominante; ou seja, tinha menor custo e maior eficácia e sua eficiência alocativa permitia que um número muito maior de pessoas tivesse acesso ao tratamento.

Palavras-chave: Custos e análise de custos; Análise de custo-benefício; Eficiência; Economia e Organizações de Saúde; Saúde bucal.

Resumen

Objetivo: Evaluar la eficiencia asignativa, el impacto económico y la rentabilidad de la rehabilitación de un solo diente mediante una prótesis dental fija de 3 unidades y de un implante dental desde la perspectiva del Servicio Social Comercial - SESC ("Serviço Social do Comércio"). Métodos: Se diseñó un análisis económico del tipo costo-efectividad. Se desarrolló un modelo de Markov para capturar resultados clínicos y económicos a largo plazo considerando el horizonte temporal de 25 años. Resultados: Dentro de este horizonte temporal

sería posible realizar 308 procedimientos más con un ahorro de R$ 351.737,49, si se optara por la rehabilitación mediante el implante unitario. Conclusión: La técnica de implante con un implante y una prótesis implanto soportada fue dominante; es decir, tenía un costo más bajo y una efectividad más alta y su eficiencia de asignación permitió que un número mucho mayor de personas tuviera acceso al tratamiento.

Palabras clave: Costos y análisis de costos; Análisis coste-beneficio; Eficiencia; Economía y organizaciones sanitarias; Salud bucal.

1. Introduction

The global burden of the morbidity related to oral diseases on society in both developed and developing countries is significant (Mathur et al., 2015; Peres et al., 2019). There are various oral health conditions recognized as having high impact on populations because of their prevalence, severity, individual and community impact, costs to health systems and the existence of effective methods of prevention and treatment (Antunes et al., 2016). Among them, untreated dental caries is considered the most prevalent morbid health condition worldwide, and severe periodontal disease is ranked the sixth (Kassebaum et al., 2014, 2015).

In addition to maxillofacial traumas, these conditions are the main causes of extractions performed in dental offices. Tooth loss, in turn, results in difficulties with chewing and eating, speech and muscular imbalance (Haikal et al., 2011). However, apart from the functional perspective, it implies a severe social problem, because it compromises the esthetic appearance and social interaction of patients (Elani et al., 2017).

Recovering the space after extractions by means of dental prostheses represents an important contribution to patients' quality of life. The decision about the method of recovery is made by the patient together with the professional, but depends on various factors, among them, the cost of each type of procedure. For example, the fixed tooth-supported prosthesis for rehabilitating the space of a single tooth, involves two abutment teeth to support the unit that will replace the lost tooth, but could be the option of choice, if the patient is not in a position to bear the costs of an implant supported dental prosthesis (Zitzmann et al., 2013). The implant-supported prosthesis is more effective and does not compromise the other teeth, therefore preserves the patient's oral health to a larger extent.

The cost-effectiveness ratio between different technologies may be changed according to the economic scenarios and characteristics of the dental services. The aim of this study was

to evaluate the allocative efficiency, financial impact, and cost-effectiveness of rehabilitation of a single tooth by means of a 3-unit fixed dental prosthesis (FP) and of a dental Implant (IMP) from the perspective of the Commercial Social Service - SESC ("Serviço Social do Comércio").

2. Methods

Research Question

What is the incremental cost-effectiveness ratio, considering the temporal horizon of 25 years from the perspective of the Commercial Social Service (SESC - parastate nonprofit organization), for performing rehabilitation of a single tooth space with a dental implant in comparison with a 3-unit fixed dental prosthesis?

Type of Study

This was an economic analysis of the cost-effectiveness type designed in accordance with the Brazilian Health Technology Assessment Network (REBRATS) Guidelines. (Diretrizes de Avaliação Econômica da Rede Brasileira de Avaliação de Tecnologias em Saúde - REBRATS") (Brasil, 2014).

Target Population

Employees of SESC MS, with loss of a single tooth, men and women between 18 and 83 years of age.

Interventions

For rehabilitating the space of a single tooth, the following possibilities were considered:

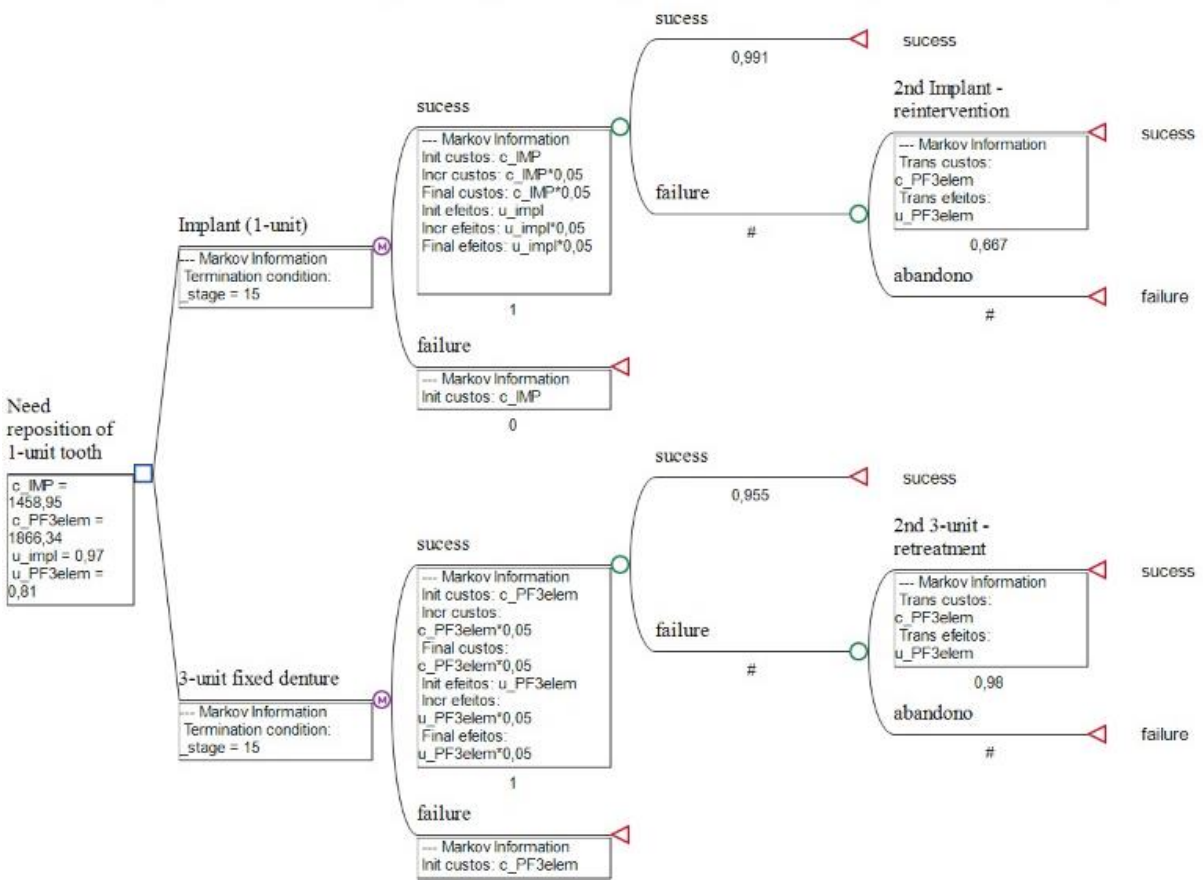
a) IMP - one-unit implant

b) FP - Three-unit fixed Prosthesis

Temporal horizon and discount rate

The temporal horizon was defined as 15 years and the discount rate applied was 5% per annum for cost effectiveness, in accordance with the REBRATS guidelines (Brasil, 2014).The mode was based on the decision tree, as follows on Figure 1.

Figure 1. Structure of Model Lost tooth may be replaced by single implant or 3-unit fixed denture**.**



Source: Data from our study.

Effectiveness Measure and Costs

Effectiveness was considered the number of procedures performed. The health statuses were established in the mathematical model and the probabilities of transition were based on the SESC information system data and other information retrieved from the literature. Only the direct costs were considered, namely: Clinical time worked by the Dentist and Oral Health Assistant, materials, equipment and payment of outsourced services (dental prosthesis laboratory). For all the calculations in the micro cost spreadsheet, one year consisting of 264

working days (22 working days/month) were considered. The prices of inputs not stated in the records of tenders were obtained from the Dental Cremer site (www.dentalcremer.com.br) in period contained between October 3 and 9, 2019.

Main presuppositions assumed in the model

The aim of this analysis was to estimate the differences in costs and effectiveness of two treatments, and calculate the incremental cost-effective ratios (ICERs). For this purpose, we assumed the following:

As the aim was to estimate the cost and effectiveness of two treatments, we assumed some presuppositions, namely:

1. Loss of a single tooth, irrespective of reason (dental caries, trauma or other).
2. Rehabilitation in a random area, either maxilla or mandible.
3. Healthy patient, apt to undergo implant placement surgery, without any medical contra-indications.
4. Previously performed imaging exam (tomography or panoramic radiography), of which costs were not considered in this analysis.
5. Abutment teeth of 3-unit fixed dental prosthesis, which had been submitted to endodontic treatment to receive cast metal cores (endodontic treatment costs not considered in this analysis).
6. Implant placement performed in ideal conditions, no need for grafting and membrane was considered.
7. Implant reference: Brazilian brand Systhex, external hexagon platform 4.1, diameter 4.0 – 11 mm.
8. Dentist working 40 hours dedicated to the specialty of dental prosthesis and only performing procedures related to the cited technologies. In the same way, the dentist is dedicated to the specialty of Implant Dentistry and Prosthesis.
9. A percentage of 10% of clinical time lost was considered, taking into account the possibility of breakdown of equipment, and professional taking ill, patients missing appointments, etc.

Financial Impact Analysis

To calculate the financial impact, micro costing calculations of each technique were

used and the allocative efficiency was evaluated (number of procedures possible to perform in the period). The financial impact took into consideration the sensitivity analysis.

Allocative Efficiency

Allocative efficiency was consider the number of treatments performed for each technology, at all times using the same amount of time.

Sensitivity Analysis

To draw up the Deterministic Sensitivity Analysis of financial impact, two scenarios were constructed; one most optimistic, in which the possibility of costs being up to 20% lower; and the other most pessimistic, with costs up to 20% higher, were considered.

3. Results

Table 1 presents the costs of the different interventions, including discrimination of the different stages of treatments. Rehabilitation by means of a one-unit implant resulted in a final cost of R$ 1,458.95. In turn, the total cost of rehabilitation by means of a 3-unit fixed dental prosthesis was R$ 1,866.34.

Table 1. Micro cost of Single Dental Implant and 3-Unit Fixed Prosthesis for rehabilitation a tooth, from the perspective of SESC, 2019.

Single implant		**Three-unit fixed Prosthesis**	
Intervention Stage	**Cost Calculated**	**Intervention Stage**	**Cost Calculated**
Pre-surgery Session	R$ 71.44	First Clinical Session	R$ 70.66
Surgical Session	R$ 331.02	Second Clinical Session	R$ 205.17
Pre-prosthetic Session	R$ 93.93	Third Clinical Session	R$ 134.93
Prosthetic Session	R$ 429.95	Fourth Clinical Session	R$ 109.59
Laboratory Stage	R$ 532.61	Fifth Clinical Session	R$ 38.07
-	-	Laboratory Stage	R$ 1,307.91
TOTAL	**R$ 1,458.95**	**TOTAL**	**R$ 1,866.34**

Source: Data from our study.

Table 2 presents the costs of treatments and allocative efficiency considering the temporal horizon of 15 years. Within this temporal horizon it would be possible to perform 308 more procedures with a saving of R$ 351,737.49, if rehabilitation by means of the one-unit implant were chosen. Therefore, the latter technology was dominant.

Table 2. Allocational Efficiency and Costs of the two technologies (period of 15 years).

Hours[a]	Minutes	Technique	No. of prostheses Month[b]	LOT No. Year	No. of prostheses in period[c]	Value of Technology	Difference in no. of procedures	Difference in Cost	Impact
40	2400	IMP	10.3	123.4	1851.4	1892.09	-	R$ 3,503,069.49	
		FP	12	144.0	2160.0	1458.95	308.6	R$ 3,151,332.00	R$ 351,737.49

Single unit implant
FP Three-unit fixed Prosthesis
a: no. of hours worked per week
B: presupposition of 10% loss due to absences
c: period of 15 years
Source: Data from our study.

Deterministic sensitivity analysis of the financial impact showed that in the most pessimistic scenario, the savings could reach R$ 422,084.98. Sensitivity analysis considering most positive (20% lower costs) and most pessimistic (20% higher costs) scenarios are presented in Table 3.

Table 3. Sensitivity analysis considering most positive (20% lower costs) and most tic (20% higher costs) scenarios.

Technique	Cost	Impact	Most pessimistic scenario	Impact	Most optimistic scenario	Impact
IMP	R$ 3,503,069.49		R$ 4,203,683.38		R$ 3,362,946.71	
FP	R$ 3,151,332.00	R$ 351,737.49	R$ 3,781,598.40	R$ 422,084.98	R$ 3,025,278.72	R$ 337,667.99

IMP: e unit implant
FP Three-unit fixed Prosthesis
Source: Data from our study.

Cost-effectiveness Analysis

The cost-effectiveness ratio (CER) of each treatment corresponded to the division between its cost and effectiveness. The one-unit implant technique showed a CER of R$1,682.22 per procedure, while rehabilitation by means of a 3-unit fixed dental prosthesis showed a CER of R$2,407.90 per procedure performed. The incremental cost-effectiveness ratio (ICER) consists of division between the incremental cost and incremental effectiveness of the technique of rehabilitation with a one-unit implant in comparison with the reference strategy, rehabilitation with a 3-unit fixed dental prosthesis that represented a value of -R$1,982.53, as presented in Table 4.

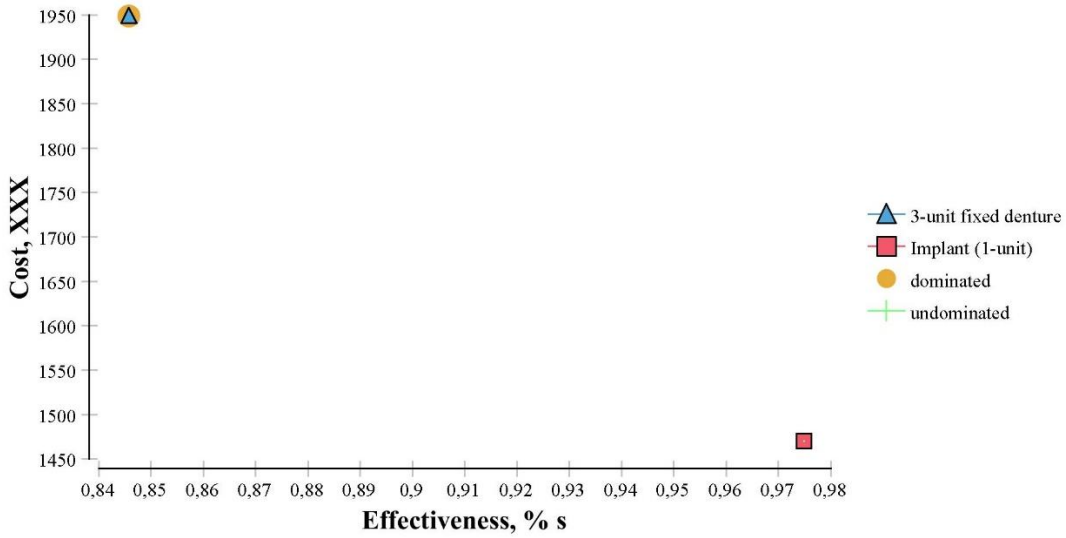
Table 4. Cost-effectiveness Analysis.

Strategy	Cost	Effectiveness	CER	Difference in costs	Difference in effectiveness	ICER	NMB*	
Excluding the denominated								
Dental implant.	1,630.947	0.9695205	1,682.22				-1,630.95	
All Technologies								
Dental implant.	1,630.947	0.9695205	1,682.22 per procedure	0	0	0	-1,630.95	dominant
Fixed Prosthesis (three-unit)	1,948.646	0.809271	2,407.902 per procedure	317.6987	-0.16024948	-1,982.53	-1,948.65	dominated

CER: Cost-effectiveness Ratio
ICER Incremental Cost-effectiveness Ratio
*NMB (Net Monetary Benefit) = E.λ – C E.λ corresponds to the amount the payer is willing to pay for the effectiveness of the technology and C corresponds to the value of the technology in question.
Source: Data from our study.

The mathematical model demonstrated that the one-unit implant technique was dominant in comparison with the technique of rehabilitation by means of a 3-unit fixed dental prosthesis as shown in Figure 1.

Figure 1. Cost-effectiveness analysis.



Source: Data from our study.

4. Discussion

The results of this economic analysis showed that rehabilitation with a one-unit implant was extremely cost-effective in comparison with rehabilitation with a 3-unit fixed dental prosthesis, leading to significant savings for the payer, a situation similar to that found by Brägger et al (Brägger et al., 2005), who showed that in private services, the cost-

effectiveness of treatment with implants and implant-supported dentures was superior to conventional treatment with 3-unit fixed dental prostheses.

For the perspective adopted in the present study, results similar to those of Zitzmann et al were found (Zitzmann et al., 2013) relative to the difference in initial costs and those relative to the high cost of the laboratory stage, for the two techniques. The laboratory cost for fabrication the conventional fixed prosthesis in the reality of SESC is 2.45 times higher than the laboratory stage of the implant-supported dental prosthesis at the same institution; a situation of laboratory costs similar to those found by Brägger et al (Brägger et al., 2005).

In an economic evaluation that considered the perspective of the patient, and - apart from the medical expenditures - included expenses with transport and maintenance consultations to compose the value to be paid for rehabilitation of the space of a single tooth, Kim et al (11) concluded that the treatment with an implant and an implant-supported prosthesis (ISP) had a cost ranging between 19.05 and 33.34% higher than those of conventional fixed dental prostheses. In contrast, the implant survival rate was 10;4% higher, and in the reality of South Korea, with limited budgets for health, the patients preferred treatments that would be more effective, irrespective of having a higher cost.

From the perspective of SESC, in addition to the higher level of effectiveness, the value to be paid by the client was 23.2% lower in the case of rehabilitation by means of screw-retained implant supported dental prosthesis, when compared with the price to be paid for the conventional technique of fixed 3-unit bridge. Thus, from the point of view of less invasive dentistry, the treatment by means of dental implant was shown to be far more conservative, as it caused no impact on teeth adjacent to the space to be rehabilitated. This is contrary to the situation that occurs with a 3-unit fixed bridge, which requires wear of dental tissue, prior endodontic treatments and insertion of cast metal cores (CMC) to provide support. Therefore, allied to the savings presented, this treatment was shown to be a better alternative for the patient, from the point of view of both oral health and savings.

Considering the hypothetic scenario in SESC, even if there were no need for insertion of the cast metal cores in the abutment teeth, the cost of producing a 3-unit fixed prosthesis would be 7.9% higher than the cost to produce an implant supported denture. In this same scenario, the price applied to the client would still remain 12.9% higher if a 3-unit fixed prosthesis were fabricated.

For the purpose of reducing laboratory costs, SESC could prospect new prosthetic service providers, or even renegotiate prices that have been applied up to the time of conducting the study. Another option would be to invest in a CAD/CAM (scanner and milling

unit) for internal production of the required prosthetic parts, however, this decision would require feasibility studies due to the high value of these types of equipment.

The higher cost of production measured in the micro costing analysis was related to the consumable dental materials, mainly related to the addition silicone used in impression taking, which requires a higher degree of fidelity for producing the two technologies evaluated. In some stages of production of the 3-unit fixed bridge, the value referring to this impression taking material is equivalent to 83.3% of the total value of consumable materials used. Therefore, substitution of impression taking with addition silicone could be considered as a possibility for reducing operating costs.

For this purpose, there are two possibilities of different technique: a) substitution of the impression taking material – use of de condensation silicone, which could generate a reduction in production costs, however, this would require more in depth study, also to evaluate whether there would be loss of quality in the result of each stage of impression taking; or b) substitution of the technique for obtaining the models - use of oral scanner (CAD system). Digital dentistry may become a tool for reducing costs and optimizing resources, but would also require further studies in view of the high investment in items of equipment and their consecutive ROI - Return on Investment.

As regards time of treatment for the two techniques for rehabilitation of the space of a single tooth in SESC, the prosthetist would fabricate an implant supported prosthesis in a 14.3% faster time than that required to produce a 3-unit fixed dental prosthesis. This result was similar to that presented by Brägger et al (Brägger et al., 2005), who mentioned the time required for producing an implant-supported dental prosthesis as being somewhere between 3.1 and 5.7 working hours. Whereas for the fixed prosthesis 3.8 to 6.4 working hours would be needed.

The present study demonstrated that within the interval of one year it would be possible to perform 20.6 additional rehabilitations of the space of a single tooth by using the implant and implant-supported prosthesis technique instead of the 3-unit fixed dental prosthesis technique. The allocative efficiency of the implant technique would allow much higher number of persons to have access to treatment. In a period of 15 years, another 309 persons could be attended. Moreover, the use of the dominant technique would save R$ 304.063.20 in the same period, or R$ 20,270.88 R$/year.

The main limitation of the results of this economic analysis is the impossibility of making generalizations, because it concerns the perspective of SESC a parastatal nonprofit agency. Nevertheless, the findings may be used to guide decision-making and provide patients

with answers when they demand the type of rehabilitation evaluated. Furthermore, the model can be reproduced in other scenarios.

5. Conclusion

The implant technique with ISP was dominant; that is, it had lower cost and higher effectiveness and its allocative efficiency allowed a much higher number of persons to have access to treatment. That is, rehabilitation by means of the dental implant and implant-supported dental prosthesis technique was the most adequate for the profile of clients who have access to the dental service of SESC.

References

Antunes, J. L. F., Toporcov, T. N., Bastos, J. L., Frazão, P., Narvai, P. C., & Peres, M. A. (2016). Oral health in the agenda of priorities in public health. *Revista de Saúde Pública*, *50*(0), 1–9. https://doi.org/10.1590/S1518-8787.2016050007093

Brägger, U., Krenander, P., & Lang, N. P. (2005). Economic aspects of single-tooth replacement. *Clinical Oral Implants Research*, *16*(3), 335–341. https://doi.org/10.1111/j.1600-0501.2005.01112.x

Brasil. (2014). Ministério da Saúde (BR), Secretaria da Ciência, Tecnologia e Insumos Estratégicos, Departamento de Ciência e Tecnologia. Diretrizes metodológicas: diretriz de avaliação econômica [Internet]. (2nd ed.), Brasília: Ministério da Saúde; Disponível em http://bvsms.saude.gov.br/bvs/ct/PDF/dirtrizes_de_avaliacao_economica.pdf

Elani, H. W., Harper, S., Thomson, W. M., Espinoza, I. L., Mejia, G. C., Ju, X., Jamieson, L. M., Kawachi, I., & Kaufman, J. S. (2017). Social inequalities in tooth loss: A multinational comparison. *Community Dentistry and Oral Epidemiology*, *45*(3), 266–274. https://doi.org/10.1111/cdoe.12285

Haikal, D. S., Batista de Paula, A. M., Martins, A. M. E. de B. L., Moreira, A. N., & Ferreira e Ferreira, E. (2011). Autopercepção da saúde bucal e impacto na qualidade de vida do idoso: uma abordagem quanti-qualitativa. *Cien Saude Colet*, *16*(7), 3317–3329.

https://doi.org/10.1590/S1413-81232011000800031

Kassebaum, N. J., Bernabé, E., Dahiya, M., Bhandari, B., Murray, C. J. L., & Marcenes, W. (2014). Global burden of severe periodontitis in 1990-2010: A systematic review and meta-regression. *Journal of Dental Research*, *93*(11), 1045–1053. https://doi.org/10.1177/0022034514552491

Kassebaum, N. J., Bernabé, E., Dahiya, M., Bhandari, B., Murray, C. J. L., & Marcenes, W. (2015). Global burden of untreated caries: A systematic review and metaregression. *Journal of Dental Research*, *94*(5), 650–658. https://doi.org/10.1177/0022034515573272

Mathur, M., Singh, A., & Watt, R. (2015). Addressing inequalities in oral health in India: Need for skill mix in the dental workforce. *Journal of Family Medicine and Primary Care*, *4*(2), 200. https://doi.org/10.4103/2249-4863.154632

Peres, M. A., Macpherson, L. M. D., Weyant, R. J., Daly, B., Venturelli, R., Mathur, M. R., Listl, S., Celeste, R. K., Guarnizo-Herreño, C. C., Kearns, C., Benzian, H., Allison, P., & Watt, R. G. (2019). Oral diseases: a global public health challenge. *The Lancet*, *394*(10194), 249–260. https://doi.org/10.1016/S0140-6736(19)31146-8

Zitzmann, N. U., Krastl, G., Weiger, R., Kühl, S., & Sendi, P. (2013). Cost-effectiveness of anterior implants versus fixed dental prostheses. *Journal of Dental Research*, *92*(12), 183–188. https://doi.org/10.1177/0022034513504927

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