

Does metabolic syndrome interfere with oral health? An integrative review**A síndrome metabólica interfere na saúde bucal? Uma revisão integrativa****¿Interfiere el síndrome metabólico en la salud bucodental? Una revisión integradora****Waleska Fernanda Souto Nóbrega¹****Vitor Nascimento Góes²****Maria Ruhama Ferreira Alves³****Mateus Araújo Andrade⁴****Julia Tavares Palmeira⁵****Milena Edite Casé de Oliveira⁶****Received: 08/05/2020****Approved: 10/03/2021****Published: 21/06/2021**

The aim of this study was to verify, through a review, the relationship between metabolic syndrome and conditions related to oral health, as well as the prevalence of these alterations. The search was carried out in 2020, considering the period from 2015 to 2019, in PubMed and Capes Journal Portal, using the descriptors "metabolic syndrome" (and) "oral health" (or) "oral consequences". The content was organized in a single textual corpus, building a Word Cloud and subsequently, the thematic-category content analysis proposed by Bardin was carried out. 16 articles were considered. In the word cloud of the corpus, the words: "*Síndrome Metabólica*" (Metabolic Syndrome), "*associação*" (association) and from these: "*longitudinal, relação e significativamente*" (longitudinal, relationship and significantly) were considered, as well as, "*perda dentária*" (tooth loss), "*peridontite*" (periodontitis), "*saúde bucal*" (oral health,) "*tabagismo*" (smoking), "*cáries*" (cavities), "*obesidade*" (obesity) and "*idade*" (age). Also bringing the word "*japonês*" (Japanese), which refers to the most evaluated population. Three categories emerged: *Oral Health*, *Risk Factors for Metabolic Syndrome* and *Quality of Life*. An association was found between metabolic syndrome and the number of teeth affected by cavities, between different stages of periodontal disease with metabolic factors such as obesity, between the time since diagnosis of metabolic syndrome and the number of teeth remaining in the oral cavity and its impact on quality of life. It was also verified: association between metabolic syndrome and oral health condition, however, there are few studies, mainly in the western population, for the clarity of this association.

Descriptors: Metabolic syndrome; Oral health; Quality of life.

O objetivo deste estudo foi verificar através de revisão, a relação entre a síndrome metabólica e condições referentes à saúde bucal, bem como, a prevalência dessas alterações. A busca foi realizada em 2020, considerando o período de 2015 a 2019, na PubMed e no Portal de periódicos Capes, através dos descritores "*metabolic syndrome*" (and) "*oral health*" (or) "*oral consequences*". O conteúdo foi organizado em um único *corpus* textual, construindo-se uma Nuvem de Palavras e posteriormente, realizou-se a análise de conteúdo temático-categorial proposta por Bardin. Foram considerados 16 artigos. Na nuvem de palavras do *corpus*, considerou-se as palavras: "*Síndrome Metabólica*", "*associação*" e destas: "*longitudinal, relação e significativamente*", bem como, *perda dentária, periodontite, saúde bucal, tabagismo, cárie, obesidade e idade*. Trazendo ainda, a palavra "*japonês*", que remete à população mais avaliada. Três categorias emergiram: *Saúde Bucal, Fatores de Risco para Síndrome Metabólica e Qualidade de Vida*. Foi encontrada associação entre a síndrome metabólica e a quantidade de dentes afetados pela cárie, entre diferentes estágios da doença periodontal com os fatores metabólicos como obesidade, entre o tempo de diagnóstico da síndrome metabólica e a quantidade de dentes remanescentes na cavidade oral e seu impacto na qualidade de vida. Também verificou-se: associação entre a síndrome metabólica e a condição de saúde bucal, entretanto há escassez de estudos, essencialmente na população ocidental, para a clareza tal associação.

Descritores: Síndrome metabólica; Saúde bucal; Qualidade de vida.

El objetivo de este estudio fue comprobar mediante una revisión la relación entre el síndrome metabólico y las afecciones relacionadas con la salud bucodental, así como la prevalencia de estas alteraciones. La búsqueda se realizó en 2020, considerando el período de 2015 a 2019, en PubMed y en el Portal de periódicos Capes, a través de los descriptores "*metabolic syndrome*" (and) "*oral health*" (or) "*oral consequences*". El contenido se organizó en un único *corpus* textual, construyendo una Nube de Palabras y luego se realizó el análisis de contenido temático-categorial propuesto por Bardin. Se consideraron 16 artículos. En la nube de palabras del *corpus*, se consideraron las palabras: "*Síndrome Metabólico*", "*asociación*" y de éstas: "*longitudinal, relación y significativamente*", *así como, pérdida de dientes, periodontitis, salud bucodental, tabaquismo, caries, obesidad y edad*. También trae la palabra "*japonés*", que se refiere a la población más evaluada. Surgieron tres categorías: *Salud Bucodental, Factores de Riesgo del Síndrome Metabólico y Calidad de Vida*. Se encontró una asociación entre el síndrome metabólico y la cantidad de dientes afectados por la caries entre los diferentes estadios de la enfermedad periodontal con los factores metabólicos como la obesidad, entre el momento del diagnóstico del síndrome metabólico y la cantidad de dientes restantes en la cavidad oral y su impacto en la calidad de vida. También se verificó la asociación entre el síndrome metabólico y la condición de salud bucodental, sin embargo faltan estudios, esencialmente en la población occidental, para aclarar dicha asociación.

Descriptorios: Síndrome metabólico; Salud bucal; Calidad de vida.

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INTRODUCTION

Metabolic syndrome (MS) is defined as a complex compilation of metabolic disorders that involve high risk for the development of type 2 Diabetes Mellitus (DM2) and cardiovascular diseases (CVD), which can be characterized by hyperglycemia, hypertension, high levels of triglycerides, decreased values of high-density cholesterol, and abdominal obesity¹.

Several diagnostic parameters have been established over time, but with some variations in relation to the criteria and reference values of the metabolic aspects involved in the syndrome². The first agency to propose a diagnostic criterion was the World Health Organization (WHO), in 1999, advocating that the detection of DM² is mandatory in MS, in addition to the determination of the Body Mass Index (BMI) for evaluation of obesity and assessment of dyslipidemia^{3,4}.

The Third Report of The National Cholesterol Education Program (NCEP-ATP III), a definition recommended by the I Brazilian Guidelines on the Diagnosis and Treatment of Metabolic Syndrome, in turn, defends the presence of changes in 3 of the 5 risk factors such as: abdominal obesity with waist circumference (WC) >102cm for men and >88cm for women; triglyceride (TGL) levels ≥ 150 mg/dl; HDL cholesterol levels < 40mg/dl for men and <50mg/dl for women; blood pressure (BP) $\geq 130/85$ mmHg; and an increase in fasting blood glucose levels ≥ 110 mg/dl would characterize the diagnosis of MS, without prioritizing any of them in particular⁵. As a requirement of the International Diabetes Federation (IDF), it indicates the measurement of altered abdominal circumference, in addition to two other factors^{6,7}.

The diagnostic components of MS are verified through clinical and laboratory investigation, which include the individual's clinical history, physical examination (measurement of abdominal circumference, weight, height, BMI, skin evaluation and blood pressure measurement), in addition to carrying out cardiovascular tests, fasting blood glucose, cholesterol and triglyceride levels⁵.

Currently, in order to reduce the prevalence of MS and its associated health risks, there is a constant demand for the development of strategic actions that include, in particular: lifestyle modification, and the presence of multidisciplinary approaches that include different areas in public health services^{8,9}.

Given its diverse nature, metabolic diseases has a relationship with oral health, defined as bidirectional, being determined by greater insulin resistance in the presence of local inflammation and the prevalence of changes in the oral mucosa and salivary glands in decompensated patients. Therefore, the presence of changes in the oral environment of patients with metabolic pathology can directly affect the masticatory function, notwithstanding the nutrition of patients, negatively impacting glycemic control¹⁰.

Thus, physicians and dentists need to know in depth the mechanisms involved in the pathophysiology of oral changes related to metabolic changes, in order to develop early and effective preventive and therapeutic measures¹¹. With regard to Dentistry, studies that assess the impact of MS on diseases of the oral cavity are rare, and it is essential to develop investigations that elucidate issues such as the influence of this clinical entity on oral health outcomes¹².

Thus, the aim of this study was to verify, through a review, the relationship between metabolic syndrome and conditions related to oral health, as well as the prevalence of these alterations.

METHODS

An integrative review was carried out, conceptualized as the type of research that encompasses a variety of studies on a given subject, produced with different methodologies,

taking into account experimental and non-experimental aspects, with a view to synthesized knowledge and improve clinical practice¹³.

This type of review is carried out in 6 phases: (1) Definition of the guiding question that serves as a guide in choosing the bibliography for the review; (2) Search for literature in the various existing media; (3) Data collection with a previously prepared instrument; (4) Critical analysis of the articles covered; (5) Discussion of results after analysis of articles and comparison with opinions and conclusions; and, (6) Organization of the data collected, with a view to clarifying the theme raised¹³.

The guiding question was elaborated: “*What are the most prevalent oral alterations in patients with metabolic syndrome?*” Based on this, the search for related articles was carried out in the Capes Journal Portal and in the PubMed database, using the descriptors “metabolic syndrome” (and) “oral health” (or) “oral consequences”, adding the filter “last 5 years” and “original articles”. The survey was conducted from November to December 2019, considering the period from 2015 to 2019.

Data analysis was performed with the aid of the computer program IRAMUTEQ (R interface pour les Analyzes Multidimensionnelles de Textes et de Questionnaires) version 0.7. The content was organized in a single textual corpus, building a Word Cloud and later, the thematic-category content analysis proposed by Bardin¹⁴ was carried out, seeking to infer knowledge regarding the content of the information obtained.

RESULTS

After reading the title and abstract, 16 original articles that responded to the main objective of this review were counted. Most of the analyzed studies sought, in addition to presenting what MS is and metabolic factors associated with its presence, to identify its relationship with tooth decay, periodontal disease and tooth loss. Most of the studies addressed the middle-aged population, between 33 and 99 years of age, essentially Asian (Japanese and Korean). Chart 1 shows the articles used, presenting the year and journal of publication and their purpose (Table 1).

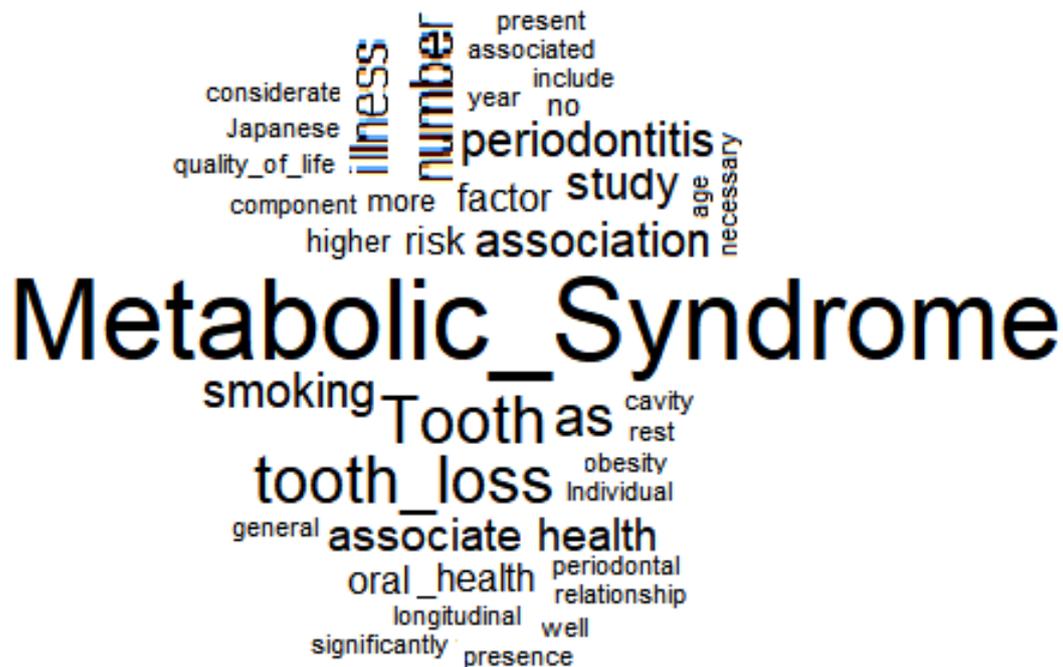
In the corpus Word Cloud, the words were grouped and organized graphically, considering the frequency they appear in the text (Figure 1). The word “*Síndrome Metabólica*” (Metabolic Syndrome) as the center of the analyzes carried out is justified by the very purpose of the study, which sought to analyze research related to Metabolic Syndrome and Oral Health.

Next, the other term often considered is “*associação*” (association). This is due to the most prevalent types of analysis among the survey results, which examined the relationship between Metabolic Syndrome and Oral Health. This statement is related to three other words presented in the cloud, which are: “*longitudinal, relação e significativamente*” (longitudinal, relationship and significantly). This is because most of the studies presented suggested an association between the two variables; they, however, failed to establish a causal or predictive relationship between them, proposing the construction of future longitudinal investigations, capable of better understanding this relationship.

Also, the main factors associated with Metabolic Syndrome appear, among them: “*perda dentária*” (tooth loss), “*peridontite*” (periodontitis), “*saúde bucal*” (oral health,) “*tabagismo*” (smoking), “*cáries*” (cavities), “*obesidade*” (obesity) and “*idade*” (age) Also bringing the word “*japonês*” (Japanese), which refers to the most evaluated population among the surveys found.

Table 1. Articles considered according to year, purpose and journal. Paraíba, 2020

N	Main author	Title	Year	Journal	Purpose
1	Min-Jeong Cho, <i>et al.</i> ¹⁵	Presence of Metabolic Syndrome Components Is Associated with Tooth Loss in Middle-Aged Adults	2019	Yonsei Medical journal YMJ	Examine the relationship between cardiovascular and metabolic diseases and oral diseases
2	Takahiro Iwasaki, <i>et al.</i> ¹⁶	Associations between caries experience, dietary habits, and metabolic syndrome in Japanese adults	2019	Journal of Oral Science	To investigate the relationship between decayed, missing and filled (DMF) teeth and metabolic syndrome in Japanese adults
3	Cati Reckelberg Azambuja, <i>et al.</i> ¹⁷	<i>O diagnóstico da síndrome metabólica analisado sob diferentes critérios de definição</i> (O diagnóstico da síndrome metabólica analisado sob diferentes critérios de definição)	2015	Revista Baiana de Saúde Pública	Trace the anthropometric, biochemical and hemodynamic profile of patients with metabolic syndrome
4	Y. Kawashita, <i>et al.</i> ¹⁸	Relationship between Metabolic Syndrome and Number of Teeth in Japan	2016	International & American Associations for Dental Research	Investigated the relationship between tooth loss and metabolic syndrome
5	Ji-Soo Kim, <i>et al.</i> ¹⁹	Association between Periodontitis and Metabolic Syndrome in a Korean Nationally Representative Sample of Adults Aged 35–79 Years	2019	Int. J. Environ. Res. Public Health	Evaluate the association between metabolic syndrome and periodontitis
6	Ira B. Lamster, <i>et al.</i> ²⁰	Periodontal disease and the metabolic syndrome	2016	International Dental Journal	Evaluated the relationship between periodontitis and metabolic syndrome, based on systemic oxidative stress and inflammatory processes
7	M Furuta, <i>et al.</i> ²¹	Tooth loss and metabolic syndrome in middle-aged Japanese adults	2016	Journal of Clinical Periodontology	Examined the relationship between metabolic syndrome, periodontal disease and/or tooth decay
8	Marta L. Musskopf, <i>et al.</i> ²²	Metabolic syndrome as a risk indicator for periodontal disease and tooth loss	2016	Clinical Oral Investigations	Evaluate the association of metabolic syndrome with periodontitis and tooth loss
9	Takahiro Iwasaki, <i>et al.</i> ²³	Association between number of pairs of opposing posterior teeth, metabolic syndrome, and obesity	2018	Odontology	Investigation of the relationship between posterior masticatory potential, metabolic syndrome and obesity
10	Hyo-Eun Park, <i>et al.</i> ²⁴	Number of remaining teeth and health-related quality of life: the Korean National Health and Nutrition Examination Survey 2010–2012	2019	Health and Quality of Life Outcomes	Association between the number of remaining teeth and health-related quality of life
11	Mizuki Saito, <i>et al.</i> ²⁵	Number of Teeth, Oral Self-care, Eating Speed, and Metabolic Syndrome in an Aged Japanese Population	2018	Journal of Epidemiology	Examine the correlations between oral health, lifestyle factors and metabolic syndrome in elderly participants
12	Miki Ojima, <i>et al.</i> ²⁶	Relationship Between Decayed Teeth and Metabolic Syndrome: Data From 4716 Middle-Aged Male Japanese Employees	2015	Journal of Epidemiology	Evaluate the relationship between decayed teeth and components of the metabolic syndrome
13	Salamonowicz, <i>et al.</i> ²⁷	Oral consequences of obesity and metabolic syndrome in children and adolescents	2019	Dental and Medical Problems	Relationship between obesity/metabolic syndrome and changes in the oral environment in children and adolescents
14	E.K. Kaye, <i>et al.</i> ²⁸	Metabolic Syndrome and Periodontal Disease Progression in Men	2016	Journal of Dental Research	Determine whether metabolic syndrome predicts tooth loss and worsening in teeth condition and periodontal disease
15	Paula Tegelberg, <i>et al.</i> ²⁹	Long-term metabolic syndrome is associated with periodontal pockets and alveolar bone loss	2019	Journal of Clinical Periodontology	Investigate whether metabolic syndrome is associated with periodontal problems and alveolar bone loss.
16	Yong Zhu, <i>et al.</i> ³⁰	Associations between the number of natural teeth and metabolic syndrome in adults	2015	Journal of Clinical Periodontology	Explore associations between the number of natural teeth and metabolic syndrome in adults.

Figure 1. Textual Corpus Word Cloud. Paraíba, 2020.

The analysis of the selected articles, through the Descending Hierarchical Classification, pointed out the following thematic-categorical classes: *Oral Health*, *Risk Factors for Metabolic Syndrome* and *Quality of Life* (Table 2).

Table 2. Thematic Categories of the analyzed Textual Corpus. Paraíba, 2020.

Categories	Components	Examples
<i>Oral Health</i>	<ul style="list-style-type: none"> - Dental cavity. - Tooth loss. - Periodonditis 	<p>“Positive association between Metabolic Syndrome and dental caries in Japanese adults.”¹⁶</p> <p>“At least one component of the Metabolic Syndrome is associated with tooth loss.”¹⁵</p> <p>“Long-term Metabolic Syndrome has been associated with periodontal disease.”¹⁹</p>
<i>Risk Factors for Methabolic Syndrome</i>	<ul style="list-style-type: none"> - Age - Family income - Education - Smoking - Alcohol - Toothbrushing - Food 	<p>“Age, family income, education level, smoking, alcohol intake and frequency of daily brushing were associated with Metabolic Syndrome.”²¹</p> <p>“There was a positive association between Metabolic Syndrome and the speed at which the person eats, and the frequency of use of oral care products.”²⁸</p>
<i>Quality of Life</i>	<ul style="list-style-type: none"> - Number of teeth 	<p>“The number of remaining teeth was associated with Quality of Life, and individuals who had more teeth had higher Quality of life.”²⁷</p>

DISCUSSION

MS is defined as a set of risk factors that increase the chances of developing diabetes, stroke and heart problems, represented by a set of factors that include atherogenic dyslipidemia, abnormal glucose tolerance, hypertension and visceral obesity, conditions that are closely associated with insulin resistance¹⁷.

The diagnosis of MS is made through physical examination, essentially the recording of blood pressure and abdominal circumference, coupled with complementary laboratory tests.

The main risk factors for metabolic syndrome are: obesity, sedentary lifestyle, insulin resistance, advancing age, hormonal imbalance and genetic predisposition, so it is extremely important to evaluate hereditary history, bad habits, practice of healthy activities and the current status of health²⁰. A study showed results similar to those presented here, and it is possible to associate metabolic syndrome and factors related to it with oral cavity problems³⁰.

One study evaluated the infection by *estreptococos mutans* as one of the known causes of dental caries²³, which induces the production of inflammatory cytokines that accumulate in the walls of blood vessels, leading to a risk of obesity and MS²³. Also, there was a possible influence of some foods, such as: coffee, which showed a significantly negative association with MS, indicating that the daily consumption of this substance can reduce the risk of MS²³.

Another study, seeking to assess the association between periodontitis, MS and associated risk factors in the same population (middle-aged Koreans), found that demographic and socioeconomic factors, systemic behaviors and those related to oral health can interfere as confounding factors in this association¹⁹. However, isolating the confounding variables through logistic regression, it can be inferred that the frequency of daily brushing of teeth and periodontitis were associated with MS in men and women.

Patients with MS showed greater periodontal involvement. This is because these conditions are interconnected by complex multifactorial pathophysiologicals³¹. Studies show an association between periodontitis and increased systemic inflammation and dyslipidemia, which may contribute to the development of MS, that is, the prominently impaired glucose metabolism has an adverse impact on periodontal disease^{32,33}.

A study carried out in Korea in 2014, aiming to investigate the prevalence of MS and its association with tooth loss in Korean adults, found that the risk for both increases with age. The study showed that women, aged between 50-64 years old, with at least one MS component are more likely to have tooth loss¹⁵.

Other studies with similar methodologies also identified a relationship between MS and tooth loss, highlighting the need for health professionals to be always prepared to identify significant predisposing factors^{18,23,26}.

MS is associated with periodontal disease and tooth decay, and metabolic factors can be related to tooth loss, which is the end point of these two diseases²¹. A survey shows that, in a period of 5 years, at least 10% of the participants lost at least one tooth, and when compared to those without metabolic components, participants with MS had three times greater risk of tooth loss²¹. Thus, it is important to promote studies that analyze this relationship, in order to propose action strategies that aim to reduce the negative repercussions for public health.

There was an association between long-term exposure to MS and a fall in the level of alveolar bone, confirmed by data from a birth cohort of a North Finnish population, so that bone loss above 5mm is believed to be strongly associated with exposure to MS for 15 years or more²⁹.

A study carried out in Korea between 2010 and 2012 brings as a differential the assessment of the quality of life of MS patients related to oral health²³ because Korean MS patients had a smaller number of remaining dental elements, consequently, they presented a higher quality of life²⁴.

Nevertheless, health measures, such as the number of remaining teeth, frequency of use of secondary oral hygiene products are associated with MS, essentially in the elderly population²⁵. Maintaining oral health and healthy lifestyle habits are key factors in preventing MS and its complications.

CONCLUSION

Overall, the study allows us to conclude that patients with metabolic syndrome have a higher prevalence of periodontal disease, tooth decay, tooth loss and bone loss, as well as loss

of dental implants. Furthermore, it is possible to notice that the maintenance of oral health is a key factor for the prevention of MS and its complications.

It is necessary to carry out more studies about MS and its influence on oral cavity, essentially in the Western population, aiming at the evidence-based practice, so that dental surgeons can perform adequate treatment and assist in the prevention of complications, through counseling on oral hygiene and diet, and referral, considering that it is a multifactorial disease and requires multiprofessional treatment.

Most of the scenarios presented were from international contexts, which may be a reflection of the non-inclusion of important databases for the screening of Latin American and Caribbean literature, namely: Scielo, BVS, Redalyc, Web of Science. Thus, this consideration is presented as a limitation of the present study.

However, in order to reduce this limitation, Pubmed was listed for this review, considered one of the largest databases for publications in international health, as well as the CAPES journal, which includes several health journals in Brazil and in the world.

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CONTRIBUTIONS

Julia Tavares Palmeira, Mateus Araújo Andrade, Mateus Araújo Andrade, Maria Ruhama Ferreira Alves and **Vitor Nascimento Góes** contributed to the collection and analysis of data and writing. **Milena Edite Casé de Oliveira** participated in data collection and analysis, writing and reviewing. **Waleska Fernanda Souto Nóbrega** collaborated in the design, collection and analysis of data, writing and reviewing.

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