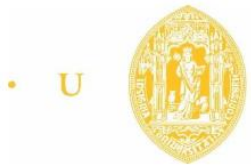

FMUC FACULDADE DE MEDICINA
UNIVERSIDADE DE COIMBRA

Mestrado Integrado em Medicina Dentária

Validity of Self-Reported Periodontal Disease: A Systematic Literature Update and Pilot Study

Inês Ourives

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Coimbra

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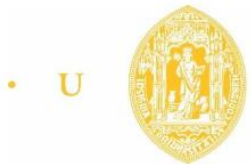

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Validity of Self-Reported Periodontal Disease: A Systematic Literature Update and Pilot Study

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Summary

I. Resumo

Introdução: A doença periodontal representa um problema de saúde pública. A sua relação com algumas doenças sistémicas é um dos motivos para que haja um crescente interesse e empenho da parte dos médicos na triagem de problemas orais. É nesse contexto que surgem as medidas periodontais auto-reportadas, já que, se válidas, podem revelar-se úteis na previsão da história da doença periodontal, representando uma ferramenta económica e simples no diagnóstico de doença periodontal.

Objetivos: Estabelecer um padrão para compreender as mudanças sofridas nos questionários de doença periodontal auto-reportada nos últimos anos e entender o que é necessário para o realizar da forma mais precisa possível, de forma a que possa ser aplicado em populações de alto risco, como a população com artrite reumatóide.

Metodologia: Pesquisa adaptada da revisão sistemática de Abbood et al., atualizada para incluir estudos de janeiro de 2016 a abril de 2018, realizada na PubMed e Embase. Todos os tipos de estudos, em inglês, foram incluídos, exceto estudos caso-controlo. Estudos que utilizaram medidas auto-reportadas, mas não validadas, foram excluídos. O estudo piloto realizado foi parte de um estudo transversal e os pacientes foram selecionados sequencialmente da *coorte* de doentes com Artrite Reumatóide do Departamento de Reumatologia do Centro Hospitalar e Universitário de Coimbra. O questionário foi aplicado por meio de entrevista pessoal, seguido do exame clínico com base no *Periodontal Screening Index*. Para avaliar a possível associação entre cada questão e o diagnóstico de periodontite, foi utilizado o teste exato de Fisher. O teste T-student para amostras independentes foi aplicado para determinar a existência de diferenças estatisticamente significativas entre os dois grupos.

Resultados: Apenas sete artigos obedeceram aos critérios de inclusão e validaram as medidas auto-reportadas. A sensibilidade das trinta questões avaliadas foi menor que a especificidade, variando entre os estudos. Oito perguntas obtiveram boa validade, prevendo casos de periodontite ou perda óssea severa. Vinte pacientes participaram do estudo piloto, treze saudáveis e sete com periodontite. Nenhuma das questões demonstrou uma forte associação ao diagnóstico de periodontite, e o *score* total não apresentou diferenças estatisticamente significativas entre os dois grupos.

Discussão: A inclusão exclusiva de questões diretamente relacionadas com a doença periodontal pode não ser sinónimo de precisão. Assim, incorporando questões relativas a fatores de risco, como idade, sexo, hábitos tabágicos, demonstrou indicar maior precisão na incidência de periodontite. Prevemos que questões relacionadas com fatores de risco e doenças sistémicas serão cada vez mais aplicadas, dada a relação entre doença periodontal

e doenças sistémicas, e fatores de risco comuns. No estudo piloto, o questionário mostrou baixa capacidade discriminativa para o diagnóstico de periodontite. Acreditamos que isso seja atribuído ao tamanho da amostra utilizada e, apesar dos resultados, consideramos que um estudo com uma maior amostra deva ser conduzido.

Conclusão: A utilização de medidas de doença periodontal auto-reportada apresenta resultados inconsistentes, mas promissores. Será potencialmente possível obter um questionário auto-reportado padronizado que considere as diferenças culturais e socio-demográficas e inclua os principais preditores de periodontite. Assim, torna-se exequível um diagnóstico com precisão e com capacidade de ser aplicado em populações de risco, nomeadamente a que padece de artrite reumatóide.

Palavras-chave: *"periodontitite", "doenças sistémicas", "artrite reumatóide", "diagnóstico", "questionário", "medidas auto-reportadas", "validação"*

II. Abstract

Introduction: Periodontal disease represents a major public health issue. Its association with some systemic diseases poses a compelling reason for physicians to increase their role screening for oral problems. It is in this context that self-reported periodontal measures arise, since, if found to be valid, they could be very useful to provide a time-effective measure of periodontal disease history, representing a low-cost and low-resource way to periodontal disease diagnosis.

Aim: Establish a pattern for perceiving the changes undergone in self-report questions in recent years, to understand what it takes to accomplish a self-report questionnaire as accurate as possible, that can be applied to high-risk populations, such as Rheumatoid Arthritis' population.

Methodology: An electronic literature search was performed via PubMed and Embase, with a search strategy adapted from the systematic review by Abbood *et al.,* updated to include studies from January 2016 to April 2018. All types of studies, in English, were included, except for case-control design types. Studies that used self-report but did not validate these measures were discarded. The pilot study was part of a cross-sectional study and patients were sequentially selected from the Rheumatoid Arthritis cohort of *Centro Hospitalar e Universitário de Coimbra* Rheumatology Department. The questionnaire was applied via personal interview, followed by clinical examination using the Periodontal Screening Index. To assess the possible association between each question and the diagnosis of periodontitis Fisher's exact test was used. T-student test for independent samples was applied to evaluate the existence of statistically significant differences between both groups.

Results: Only seven papers obeyed the inclusion criteria and validated the self-report measures. The sensitivity of the thirty applied questions was lower than the specificity, and it varied greatly between studies. Eight questions had good validity predicting severe cases of periodontitis or severe bone loss. Twenty participants took part in the pilot study, thirteen healthy patients and seven patients with periodontitis. None of the questions was strongly associated with the diagnosis of periodontitis, and the total score did not present statistically significant differences between the two diagnostic groups.

Discussion: Incorporating only questions directly relating to periodontal disease may prove not to be as accurate. Thereby, including questions relating to risk factors such as age, gender, smoking behavior proved to indicate periodontitis incidence more precisely. We predict that questions regarding risk factors and systemic diseases will be more and more applied, given the known association between periodontal disease and systemic diseases, and its common risk factors. In the pilot study, the questionnaire showed low discriminative capacity

for the diagnosis of periodontitis. We believe this to be attributed to the sample size used, and despite the results we consider a larger study with a greater sample is in order.

Conclusion: The use of self-reported periodontal disease measures has inconsistent but promising results. One day it will probably be possible to have a standardized self-report questionnaire that considers cultural and socio-demographic differences and includes the main periodontitis' predictors, being able to accurately diagnose periodontitis, and, thus, able to be applied to high-risk populations such as people suffering from Rheumatoid Arthritis.

Keywords: *"periodontitis", "systemic diseases", "rheumatoid arthritis", "diagnoses", "questionnaire", "self-report measures", "validation"*

III. List of Abbreviations and Acronyms

ACD	Atherosclerotic Cardiovascular Disease
AD	Alzheimer's Disease
AL	Attachment Loss
AUC	Area Under the Curve
BMI	Body-Mass Index
CDC-AAP	Centre for Disease Control and Prevention and the American Academy of Periodontology
CGS	Clinical Gold Standard
CHUC	Centro Hospitalar e Universitário de Coimbra
CKD	Chronic Kidney Disease
CPITN	Community Periodontal Index of Treatment Needs
LDL	Low-density Lipoprotein
OP	Osteoporosis
PD	Pocket Depth
PdD	Periodontal Disease
PSI/PSR	Periodontal Screening Index/Periodontal Screening and Recording
RA	Rheumatoid Arthritis
ROC	Receiving Operating Characteristic
SE	Sensitivity
SP	Specificity
VDR	Vitamin D receptor

1. Introduction

1.1. Periodontal Disease

Periodontal disease (PdD) is a bacteria-induced chronic inflammatory process in which there is an inappropriate interaction between the host immune response and specific groups of bacterial pathogens. These events lead to the destruction of connective and bone tissues supporting the tooth (including the gingiva, periodontal ligament and alveolar bone), and potentially tooth loss. (1–3)These subgingival bacterial communities can directly cause tissue destruction or in turn trigger destructive immunopathologic host responses, being the ultimate result the same. (4)

Bacteria are necessary but insufficient by themselves to cause periodontal disease; individuals must also have a degree of susceptibility to tissue breakdown. However, since bacteria are the initiating factor, it is important to assess the degree of bacterial plaque present and advise patients on a proper plaque control. Any factor that might increase plaque retention needs to be addressed accordingly, namely lack of manual dexterity associated with arthritis or other conditions, reduced oral hygiene practices, tooth anatomy, among others. (2)

Other risk factors that contribute to the development of this disease have also been established, which include age, tobacco use and alcohol consumption, genetic factors, obesity, poorly controlled diabetes and psychological stress. (5)

Disease severity is the result of a balance of bacteria-host interactions conditioned by inherited and environmental factors in predisposed individuals. (5)

Periodontal disease is commonly regarded as a “silent disease” since patients often live with no or few symptoms for several decades before actually seeking medical attention. The question is whether PdD is indeed a silent condition, or if, more likely, the affected individuals truly perceive an impact on their oral health (2), but choose not to act upon it, either from lack of knowledge or interest. In fact, lack of awareness usually results in delayed PdD treatment. (5)

Earlier signs may include gingival bleeding and swelling, which might progress towards gingival recession, mobility and/or pathological migration of teeth due to loss of periodontal support. (5,6)

Consequently, if not treated, periodontal disease will have a major impact in quality of life, by reducing chewing function and impairing aesthetics, not to mention causing tooth loss and disability, being also responsible for a substantial proportion of edentulism and masticatory dysfunction. (5,7)

This chronic disease may have a possible impact on general health. (7) In fact, periodontal disease may trigger systemic inflammation that impacts overall health, and is

associated with an increased risk of systemic illness. (1) However, the idea that the rate of progression and severity of periodontitis is often determined by systemic risk factors is fairly recent. (4)

1.2. Periodontal Disease: A Systemic Disease

As already mentioned, periodontitis leads to the entry of bacteria in the bloodstream, which activates the host inflammatory response, by stimulating the synthesis and release of cytokines, proinflammatory mediators, and matrix metalloproteinases, ultimately resulting in tissue destruction. (7,8)

In fact, the host complex response focuses on containing the infectious stimulus and preventing bacterial invasion into the tissues. If the infection cannot be contained, the local release of proinflammatory cytokines and tissue-degrading enzymes causes damage to the hard and soft tissues around the tooth. (2)

Patients with periodontitis generally have disease associated metabolic markers, namely antibodies, proteases and other enzymes (including the matrix metalloproteinases - MMPs), proinflammatory cytokines (IL-1β, IL-6, IL-7, TNF-α), and other molecules in the different inflammatory cascades (prostaglandin E_2). Substances that measure tissue metabolism include markers of cell necrosis (for example the enzymes lactate dehydrogenase and aspartate transaminase), molecules that play a role in the response to oxidative stress (glutathione), growth factors (like transforming growth factor β), and markers of bone remodeling and turnover (RANK and RANK-l and osteoprotegerin). (2)

Several of these markers have been evaluated for their tight relationship with active and progressive periodontitis. (2) Indeed, the progression and severity of the disease depend on the balance between the aggressiveness of the subgingival plaque biofilm and the individual host immune response, further modulated by the genetic and epigenetic context and by environmental factors, like smoking and oral care, as well as by gender and age. (3,9)

Dissemination of pathogens, toxins, and immune-complexes from and to periodontal lesions is at the basis of the increasingly recognized association between PdD and various systemic disorders, including cancer, diabetes mellitus, rheumatoid arthritis, cardiovascular diseases and preterm birth. (3)

Periodontal pathogens may promote systemic diseases through two main routes. On one side there is colonization of distal tissues, induction of local inflammatory events and direct dissemination from oral sites to the bloodstream, penetrating the vascular endothelium and causing damage and inflammation. On the other side, there is systemic chronic inflammation

induced by bacteremia or circulating pro-inflammatory cytokines generated in periodontal lesions. (3)

A bidirectional link between periodontal and systemic diseases, representing a risk factor, is quite likely, and there is a consistent number of literature reports that mention periodontal diseases to be a crucial risk factor for numerous systemic disorders. (3)

There are several common risk factors to periodontal disease and many systemic diseases, therefore it is within reason to suggest that the control of these common risk factors may reduce mortality and morbidity of the associated diseases. Change of common risk factors will have clinically significant effects on periodontal disease, heart disease, diabetes and cancer, and hence it is important to implement common risk factor modification into dental practice. Still, mere associations of a factor with the disease do not necessarily prove causality. Causality requires evidence that the factor precedes the disease, the knowledge of the mechanism of action of the risk factor on the disease and the evidence that modification of the risk factor will prevent or moderate the disease. (4) The association between a given factor and a health effect cannot be extrapolated to imply that the factor causes the specific disease. (10)

Furthermore, there are common genetically determined pathways behind various complex inflammatory diseases, and since periodontitis is a complex disease, it is likely that multiple genes contribute to disease susceptibility. (2,7)

1.3. Systemic Diseases associated with Periodontal Disease

Some of the systemic diseases mentioned bellow, though weakly associated with periodontitis, may have a stronger relation than suggested by studies thus far, especially considering the confounding factors when trying to pinpoint the relationship between some of these diseases and periodontitis. (10,11) In fact, one must contemplate that *"the absence of evidence is not evidence of absence"* (Altman and Bland 1995). (11)

In fact, any given disease can be caused by more than one mechanism, and every causal mechanism involves the joint action of a multitude of components. Moreover, there are other explanations, such as common genetic factors, that could be associated with both susceptibility to periodontitis and other diseases. Alternatively, periodontitis may be a phenotype of low socioeconomic status reflecting factors such as smoking, poverty, and low education and may develop in parallel with other diseases, which reflect a disadvantaged lifestyle. (11)

1.3.1. Diabetes Mellitus

Both type 1 and 2 of diabetes mellitus are risk factors for periodontal disease. (4)

Patients with diabetes mellitus have a hyperactive inflammatory response. Adding the bacterial challenge of periodontal infection will lead to an exaggerated inflammation and periodontal tissue destruction. The receptors for advanced glycation end products are elevated in patients with diabetes. Periodontal infection results in increased levels of these advanced glycation end products, which activate their receptors resulting in production of increased levels of pro-inflammatory cytokines, leading to more periodontal disease. (4)

Less is known about the mechanisms which account for the effects of periodontal disease on worsening glycemic control and increasing complications in patients with diabetes. However, systemic inflammatory responses as seen in periodontal disease may contribute to insulin resistance and hyperglycemia. The systemic inflammatory response associated with periodontal disease has a negative impact on glycemic control, as well as increased risk of cardiovascular and renal complications. (4) In fact, patients with severe periodontitis at baseline had over 6 times the risk of developing poor glycemic control over 2 years as compared to those with diabetes and little periodontal disease at baseline. (12) Additionally, patients with type 2 diabetes and periodontitis are more likely to die from heart and kidney disease than those with diabetes and little or no periodontal disease. (4)

There is evidence for a reduction in healing in patients with diabetes, for example, due to increased fibroblast apoptosis. Altered immune responses are present in patients with diabetes; impaired functions such as impaired phagocytosis and neutrophil chemotaxis may predispose patients with diabetes to more severe periodontal disease. (9)

Knowing the two-way relationship between PdD and diabetes, it is important to ascertain the effects of periodontal therapy on glycemic control in patients with both diabetes and periodontal disease. In fact, it has been proved that there is a statistically significant decrease in HbA1c of 0.36%-0.65% in the treated group, which is comparable to the reduction of HbA1c that occurs when a second anti-glycemic medication is added to the standard metformin, hence clinically significant. Moreover, studies show that an average reduction in HbA1c of 0.2% is associated with a reduction in mortality of approximately 10%. (13) The clinical significance of reducing HbA1c levels lies with controlling micro-vascular complications such as retinopathy and nephropathy. (4)

1.3.2. Cardiovascular Disease

The term “cardiovascular disease” encompasses numerous disorders affecting the heart and/or blood vessels. They share the multifactorial inflammatory trait, common risk factors (type 2 diabetes, smoking, obesity) and the key involvement of inflammation on the progression of the disease with periodontal disease. (3)

A diagnosis of periodontitis may contribute to cardiovascular risk stratification if shown to improve cardiovascular risk prediction over and above currently established prediction models. In fact, there is some evidence that periodontal treatment can reduce systemic inflammation, as evidenced by the reduction in C-reactive protein and improvement of clinical measures. (7)

Indeed, consistent and strong epidemiologic evidence shows that periodontitis imparts increased risk for future cardiovascular events. (7) In particular, *P.gingivalis* infection may be a risk factor in the development of atherosclerosis, since it was found to cause foam cell production and platelet aggregation in vitro and to accelerate atherogenic plaque formation after systemic infection in mice. (3)

On the other hand, many of the risk factors for heart disease and stroke also increase the risk for periodontitis. These include smoking, obesity, diabetes, unhealthy diets and harmful use of alcohol.

One of the most common manifestations of cardiovascular disease is atherosclerotic cardiovascular disease (ACD), which can include coronary heart disease (angina, myocardial infarction), ischemic cerebrovascular disease (stroke) and peripheral arterial disease. In ACD, endothelial injury and subsequent inflammatory response lead to plaque formation in the medium-large arteries. (3,7)

The host immune response to periodontitis favors atheroma formation, maturation, and exacerbation. Moreover, translocated circulating oral microbiota may directly or indirectly induce systemic inflammation that impacts the pathogenesis of atherothrombogenesis. (7)

Antibodies produced in response to plaque bacteria can be pro-inflammatory, cross-reacting with endothelial cells and with modified low-density lipoprotein (LDL) to enhance incorporation of lipids into inflammatory cells within the vessel wall. Some of these antibodies, as well as inflammatory cytokines, can promote type I helper (TH1) responses within the atheroma to increase activation of macrophages to enhance inflammation in the atheroma. (7)

The statistically significant excess risk for ACD in individuals with periodontitis was reported to be independent of established cardiovascular risk factors. (7)

Patients with ACD should receive a periodontal evaluation, and patients with moderate to severe periodontitis should be informed about their potential increased risk for atherosclerosis. (1)

1.3.3. Adverse Pregnancy Outcomes

Infertility is a common condition and a major issue for couples of reproductive ages all over the world. The general definition of infertility is failure to achieve a clinical pregnancy after 12 months or more of regular unprotected sexual intercourse. (3)

Infertility is also associated with an elevated risk of adverse pregnancy outcome. Several risk factors for infertility and preterm-delivery or low-birth-weight are the same or share a close relationship with periodontal disease, namely tobacco use, low socioeconomic status and poor oral hygiene, diabetes, chronic inflammation and infections (3)

Regarding adverse pregnancy outcome, there are two possible mechanisms in which periodontitis can play a role. On one hand, systemic oral bacterial dissemination and high levels of pro-inflammatory cytokines produced and released in the systemic circulation during inflammation, inducing contraction of myocytes and preterm pregnancy. *P. gingivalis* and *F. nucleatum* have been found in amniotic fluid or placenta samples from mothers with premature labor and periodontitis, while *P. gingivalis* and *A. actionomycetemcomitans* were detected in the amniotic fluid of pregnant woman with periodontitis. On the other hand, there is evidence that placental and oral microbiomes are very similar, which supports the speculation that oral bacteria can reach and colonize the maternal-fetal unit, hence inducing infertility and gestational disorders. (3)

1.3.4. Osteoporosis

Osteoporosis (OP) is associated with increased bone fragility and susceptibility to fractures. (6)

Periodontitis and OP share several risk factors, such as aging, sex hormones' deficiency, and genetics. Both are bone destructive and it has been theorized that vitamin D deficiency and the presence of recognized polymorphisms in the VDR gene (vitamin D receptor), may also be a risk factor for developing chronic periodontal disease. (14) It is known that pro-inflammatory cytokines can modulate bone resorption by tuning the osteoblast-osteoclast system. (3)

OP could be a risk factor for the progression of PdD and vice versa since OP could accelerate alveolar bone resorption. Infections by periodontal pathogens could promote directly and indirectly a systemic inflammatory status, which activates the osteoclast activity. (15) In this perspective, PdD treatment could provide protection for OP and vice versa. (3)

1.3.5. Rheumatoid Arthritis

Rheumatoid arthritis (RA), which has been estimated to affect 0.5-1.0% of the world population, is an autoimmune disease characterized by chronic, painful inflammation of the joints, which eventually leads to joint destruction, disability, and increased mortality. (16)

PdD and RA are reportedly related, being both diseases characterized by the dysregulation of inflammatory response and increase of the secretion of inflammatory mediators, leading to the destruction of the periodontium and the synovium. (3)

It has been hypothesized that oral bacteria could be responsible for the beginning and/or progression of RA in a genetically susceptible host. Studies are being performed that aim to evaluate the contribution of periodontal therapy to prevent the onset of clinical RA or to reduce RA symptoms. A successful prevention and treatment of PdD in arthritis will likely promise a better quality of life. (3) In fact, it seems that non-surgical periodontal treatment of subjects with RA and periodontitis may result in a reduction in the severity of RA over a 6-week period. (11)

1.3.6. Chronic Kidney Disease

In chronic kidney disease (CKD) there is damage to the kidney with a decreased function for 3 months or more. It is generally associated with aging, diabetes, hypertension, obesity and cardiovascular disease. (11)

Periodontal disease was independently associated with CKD in a bidirectional relationship mediated by diabetes duration. A prospective study in subjects with type 2 diabetes found that periodontal disease predicted the development of overt nephropathy, as indicated by microalbuminuria and end-stage renal disease. Also, studies have shown that high levels of antibodies to the periodontal pathogens *P. gingivalis*, *T. denticola* and *A. actionomycetemcomitans* were associated with CKD, and therefore, periodontitis. (11)

The reported association between periodontitis and CKD is complicated by the presence of diabetes. (11)

1.3.7. Alzheimer's Disease

Alzheimer's disease (AD) is a progressive, fatal, neurodegenerative disease and a major health problem for the elderly worldwide. Clinically it is characterized by progressive cognitive impairment, psycho-behavioral alterations, and language disability. (3)

The early-onset AD is considered genetically determined, while late-onset sporadic AD derives from the interaction between genetic and environmental factors, including diabetes. (3)

Periodontitis is considered a risk factor for AD. On one hand, subjects suffering from AD have increased risk to develop PdD, most likely due to poorer oral hygiene as the disease progresses. On the other hand, AD and PdD share the same features of chronic inflammatory diseases and inflammation has been proposed to be the elusive link that connects both diseases, thus PdD could contribute to a systemic inflammation acting as a possible risk factor for perpetuating the neurodegenerative process in AD. (3,17)

A study followed subjects who were cognitively normal at baseline over a 10-year period. Those who developed AD had increased levels of antibody to *T. denticola* and *P. gingivalis*, - strong markers of periodontal infections. (11)

1.3.8. Obesity

Obesity is defined as abnormal or excessive fat accumulation that presents a risk to health. (9) It is associated with diabetes, heart disease, and some cancers.

The mechanisms that explain the relationship between periodontitis and obesity are likely the same as that for the effect of obesity on other chronic diseases, namely an increase of systemic inflammation from adipose tissue. There are also studies which suggest that the oral flora in obese individuals have higher levels of *T. forsynthia* as compared to non-obese individuals. (4,18)

Saxlin *et al.* 2010 found that in never smokers diabetes-free, body weight was weakly and non-significantly associated with the development of periodontal infection. Periodontitis in this context could be related to life-styles associated with adiposity, which may be a marker of unhealthy lifestyle resulting in an increased risk of periodontitis and of other conditions such as type 2 diabetes. (11)

1.3.9. Differences in Gender

Another aspect that needs to be taken into account is the fact that although the underlying mechanisms of periodontal disease are similar between genders, there are some differences that may explain the increased susceptibility of women to certain systemic diseases, associated with existing periodontal disease. First, age-associated reductions in sex steroids provide insight into temporal increases in susceptibility to periodontitis and alveolar bone loss, through an increased vasodilation and capillary permeability. (3) Moreover, the

increase of gram-negative anaerobic bacteria (PdD) is associated with increased progesterone levels. Gingivitis during menstrual cycles typically occurs right before a woman's period and clears up once her period has started. (19) In menopause, there is a decrease in the levels of circulating progesterone and estrogens, and common consequences are oral problems such as pain, burning, dryness, bone loss due to osteoporosis, and periodontitis relapse or worsening. (20)

Gender differences have been already proven in disorders associated with immune and cardiovascular systems, neurodevelopment and cancers. Indeed, sex hormones affect not only their typical target tissues but also the immune system, adipose tissue, bone, and brain. (3)

1.4. Diagnosis of Periodontal Disease

The diagnosis of any disorder is the result of a chain of events where patients and clinicians interact conditioned by the disease and the health system. (5) Specifically when dealing with individuals with periodontitis, they do not seek treatment for periodontal disease until it is at an advanced stage, in which tooth loss is common. (21)

Periodontal disease is characterized by periods of active tissue destruction separated by periods of inactive disease. However, current diagnostic methodologies do not enable us to accurately predict which periodontal sites, teeth or individuals are susceptible to further periodontal breakdown. (2)

Clinical signs and symptoms thus play a critical role in establishing a diagnosis. Diagnostic tests are used adjunctively to provide information that is not available from clinical findings. (2)

A true periodontal pocket occurs when there has been apical migration of the junctional epithelium and loss of supporting tissues of the tooth. When recurring to periodontal probing (while using clinical attachment loss – CAL – to diagnose periodontitis), the clinician must consider many variables related to the anatomy (such as crown curvatures), the examiner's experience (for instance probing force), probe design (probe thickness and angulation and manual or electronic probe) and the clinical periodontal status (tonus of the gingiva and the strength of epithelial attachment, presence of calculus). (2)

Electronic probes, such as the Florida probe, have some advantages, such as controlling insertion force and higher resolution than the manual probes, nevertheless they underestimate probing depth and clinical attachment level in untreated patients. Manual probes are, therefore, perfectly acceptable for routine periodontal examinations. (22)

Indexes like the CPITN (Community Periodontal Index of Treatment Needs) or the PSR Index (Periodontal Screening and Recording) aim to estimate periodontal disease prevalence

and severity based on probing depth and the condition of supporting tissues. Both are virtually identical, since they use a common evaluation method based on gingival bleeding on probing, calculus accumulation and probing depth. Periodontal depth is measured using a manual probe with a ball tip (it distributes the force applied during probing over a larger surface area) and a colored band, which is designed to rapidly differentiate 'normal' from 'abnormal'. Probing is done on six different sites per tooth, and each tooth is scored from Code 0 to 4, but only the highest score of the sextant is recorded. (23)

However, both indexes may under or overestimate existing periodontal conditions, since they don't measure epithelial attachment, which is an approximation of the loss of connective tissue attachment to the root surface; instead, they use probing depth to estimate attachment loss. Thus both provide a screening examination but should not be considered as an alternative to an in-depth periodontal evaluation; in fact, if a problem is identified using any of these methods, a full periodontal protocol must be performed. (23)

The main difference between them is that PSR records the presence of furcation involvement, tooth mobility, mucogingival problems and gingival recessions exceeding 3.5mm. (23)

Furthermore, the position and architecture of the alveolar bone crest is obtained from radiographs. Notwithstanding, a successfully treated case of periodontitis is likely to have similar pretreatment and posttreatment levels of radiographic bone loss (2)

Other supplemental diagnostic tests, like microbial testing, may not be currently used to establish a periodontal diagnosis *per se*. (2)

Knowing the potential impact of periodontal disease and oral inflammation on diseases and disorders at distant sites, a diagnostic test based on the presence of important inflammatory mediators may offer a quantitative measure of the oral inflammatory burden. It would guide the clinician concerned with the effect of periodontal inflammation on morbidity associated with systemic diseases. The test could be used to assess whether periodontal therapy has successfully reduced this risk. (2)

Finally, one aspect that needs to be considered, especially regarding epidemiological studies, is the substantial variability in the definitions of periodontitis used. (11)

1.5. Why Self-Reported Measures are Important

Periodontal disease represents a major public health issue. (7) The known association between some diseases and periodontal disease poses a compelling reason for physicians to increase their role in inquiring about oral health care and screening for oral problems (1)

Given the high prevalence of periodontal disease, its deleterious impact on oral health and its association with systemic disease, patients seeing internal medicine physicians may not be receiving the education and guidance needed. (1) In fact, although medical doctors may be aware of the close relationship between oral health and general health, and especially periodontitis and some systemic diseases – enough to recognize at least a few signs and symptoms – only some of them refer their patients to the dentist. (24)

Another aspect that must be considered is that medical doctors may have an advantageous position compared to dentists to provide early patient counseling about oral health, periodontal disease included. Early diagnosis of gingivitis and periodontitis by medical doctors, or at least referral to dental care, can improve oral and general health. (24) Hence the relevance of applying self-reported questionnaires that aim to diagnose periodontitis in the field of medical practice, since they do not possess the means, time and proper conditions to properly conduct an accurate periodontal diagnosis.

Thereby, self-reported periodontal measures, if found to be valid, could be very useful for surveys, surveillance, as well as large etiological epidemiological studies. They could provide a highly cost and time-effective measure of periodontal disease history. (25)

To build an accurate self-reported questionnaire, which may be used on a medical context, one must evaluate the diagnostic accuracy of many questions and identify specific questions on periodontal symptoms or self-perceived periodontal health that could be used as a valid tool of the history of chronic periodontitis. It is important that the questionnaire contains a variety of questions relating to signs and symptoms of periodontal disease as well as knowledge of periodontal disease history based on prior consultations. (25)

However, restricting the information to only incorporate questions directly relating to periodontal disease, not considering risk factors such as age, gender, smoking behavior, may prove not to be as accurate. Henceforth it is important to also incorporate these aspects, which can indicate periodontitis incidence more precisely. (26)

It is important to consider the limits of comparability between different oral health-related quality of life measures due to differences in values, expectations, and perceptions of health and disease or impairment in different cultures, which means the validity of specific self-reported measures may be different between these cultures. (6,25)

Above all, to test the validity of these self-reported questions, there must exist a gold standard diagnosis of periodontitis, which can be based on radiographic bone loss or using periodontal indexes such as the CPITN or the PSR Index. In addition, the fact that there is no universally accepted diagnostic threshold for periodontal disease is likely to be a major contributor to the possible low validity of single self-reported items. (25)

The American Dental Association recently stated that *"oral health is a functional, structural, aesthetic, physiologic and psychosocial state of well-being and is essential to an individual's general health and quality of life",* and in fact, periodontal disease has been linked to lower quality of life. Any intervention for improving periodontal knowledge should be focused on disease prevention, and knowledge related to prevention has a significant relationship with self-reported health behavior. (5,6,21)

Knowledge on periodontal risk factors and etiology may influence patient's perceived susceptibility. Information on periodontitis-related risks and knowledge on PD general aspects and on their signs and symptoms can change the perceived severity of the disorder. (5) This can work either way: both from a patient's point of view and a medical practitioner point of view.

2. Systematic Literature Update

2.1. Materials and Methods

The main goal was to identify all studies that evaluated the validity of self-reported periodontal disease, using clinical measures as the reference standard.

Search Strategy

An electronic literature search was performed via PubMed and Embase. The search strategy was adapted from the systematic review by Abbood *et al.* (27), and updated to include studies from January 2016 to April 2018.

The search strategy terms were grouped into three categories. Intra-group terms were combined with the Boolean term “AND”, and then each group was later combined by the Boolean term “OR”. Group 1 entailed terms describing periodontal disease (“gingivitis”, “gingival”, “gingival disease”, “periodontal” “periodontal disease”, “periodontitis”, “tooth mobility”, “loss of attachment”, “bleeding gums”), Group 2 contained terms capturing self-report (“questionnaire”, “self-assessment, self-report, self-reported”), and finally, Group 3 consisted of terms relating to validation (“comparison”, “compared”, “validity”, “validation”). (Fig. 1)

Figure 1. *PubMed and Embase search strategy*

PubMed search strategy	("gingivitis"[All Fields] OR "gingival"[All Fields] OR "gingival disease"[All Fields] OR "periodontal"[All Fields] OR "periodontal disease"[All Fields] OR "periodontitis"[All Fields] OR "tooth mobility"[All Fields] OR "loss of attachment"[All Fields] OR "bleeding gums"[All Fields]) AND ("questionnaire"[All Fields] OR "self-assessment"[All Fields] OR "self-report"[All Fields] OR "self-reported"[All Fields]) AND ("comparison"[All Fields] OR "compared"[All Fields] OR "validity"[All Fields] OR "validation"[All Fields]) AND ("2016/01/01"[PDAT] : "2018/04/31"[PDAT])
Embase search strategy	(‘gingivitis’/exp OR ‘periodontal disease’/exp OR ‘periodontitis’/exp OR ‘gingival’ OR ‘gingival disease’ OR ‘periodontal’ OR ‘tooth mobility’ OR ‘loss of attachment’ OR ‘bleeding gums’) AND (‘questionnaire’/exp OR ‘self evaluation’/exp OR ‘self report’/exp OR ‘patient-reported outcome’/exp) AND (‘comparative study’/exp OR ‘validity’/exp OR ‘validation process’/exp OR ‘compared’)

Selection Criteria

The titles and abstracts of the obtained articles were scanned to identify the ones that validated self-reported measures of periodontal disease.

All types of studies, which were mainly observational studies, were included, except for case-control design types. This decision was made derived from the fact that case-control design studies tend to exaggerate diagnostic accuracy via, on one hand, overestimation of sensitivity (selection of known disease), and on the other hand overestimation of specificity (selection of healthy controls). (27)

Only studies in English were included, and participants had to be randomly selected and blinded to the results of the clinical examination. Furthermore, to correctly validate the self-reported questions (no restrictions were made on the type or form that these questions were applied), there needed to be a comparison with a clinical gold standard. Studies that used self-report but did not validate these measures were discarded.

The clinical gold standard can be defined as the best acceptable test for diagnosis, which we determined to be a periodontal examination, especially periodontal depth (PD) and clinical attachment loss (AL). However, studies that included radiographic bone loss as the clinical gold standard were not excluded.

Additionally, it was important to correctly define periodontal disease. Therefore, we applied the Center for Disease Control and Prevention and the American Academy of Periodontology (CDC-AAP) definition, which classified the severity of periodontitis into mild, moderate and severe: mild periodontitis – ≥ 2 interproximal sites with clinical attachment loss (AL) ≥ 3 mm and ≥ 2 interproximal sites with probing depth (PD) ≥ 4 mm (not on the same tooth) or one site with PD ≥ 5 mm – moderate periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 4 mm or ≥ 2 interproximal sites (not on the same tooth) with PD ≥ 5 mm – severe periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 6 mm and ≥ 1 interproximal sites with PD ≥ 5 mm.

Nevertheless, studies that used indexes such as CPITN and PSR/PSI were also included, since they also use PD and AL as clinical gold standard. Both use codes to progressively define the severity of periodontitis.

Data Extraction

After completing the database search, each study was screened following the inclusion and exclusion criteria defined. After selection, information regarding population characteristics and sampling criteria, method of self-report, self-reported questions, clinical gold standards and results concerning validation were extracted from each study. Demographic and medical

characteristics of populations, as well as risk factors, although critical information, were not included.

This information was synthesized into two tables. Table I describes study population and self-report method used. Table II has self-report questions grouped according to topic, with exact wording provided by authors, clinical gold standard used for validation, and results reported by authors as well, although we have calculated additional statistics based on the manuscript when possible, and each of those calculations is accordingly marked throughout Table II.

Good validity level was based on sensitivity and specificity values. Both can be considered low when <60%, moderate when within 60% and 79%, and high when ≥ 80%, as suggested by Nelson *et al.* (28), which used a qualitative process to produce this validity classification, taking into account number of studies, consistency of findings, sample selection and strength of the statistical measures. In this context of validation of measures that could be used for etiologic studies, surveys, or surveillance, it is hard to know the relative importance of sensitivity (SE) and specificity (SP). Thus, it is important to look at the combination of sensitivity plus specificity, without overlooking any of them. (29) Therefore, the arbitrary value of 120% for combined sensitivity and specificity was chosen as representing adequate validity, since it was the one used in Blicher *et al.* (29).

Quality Assessment

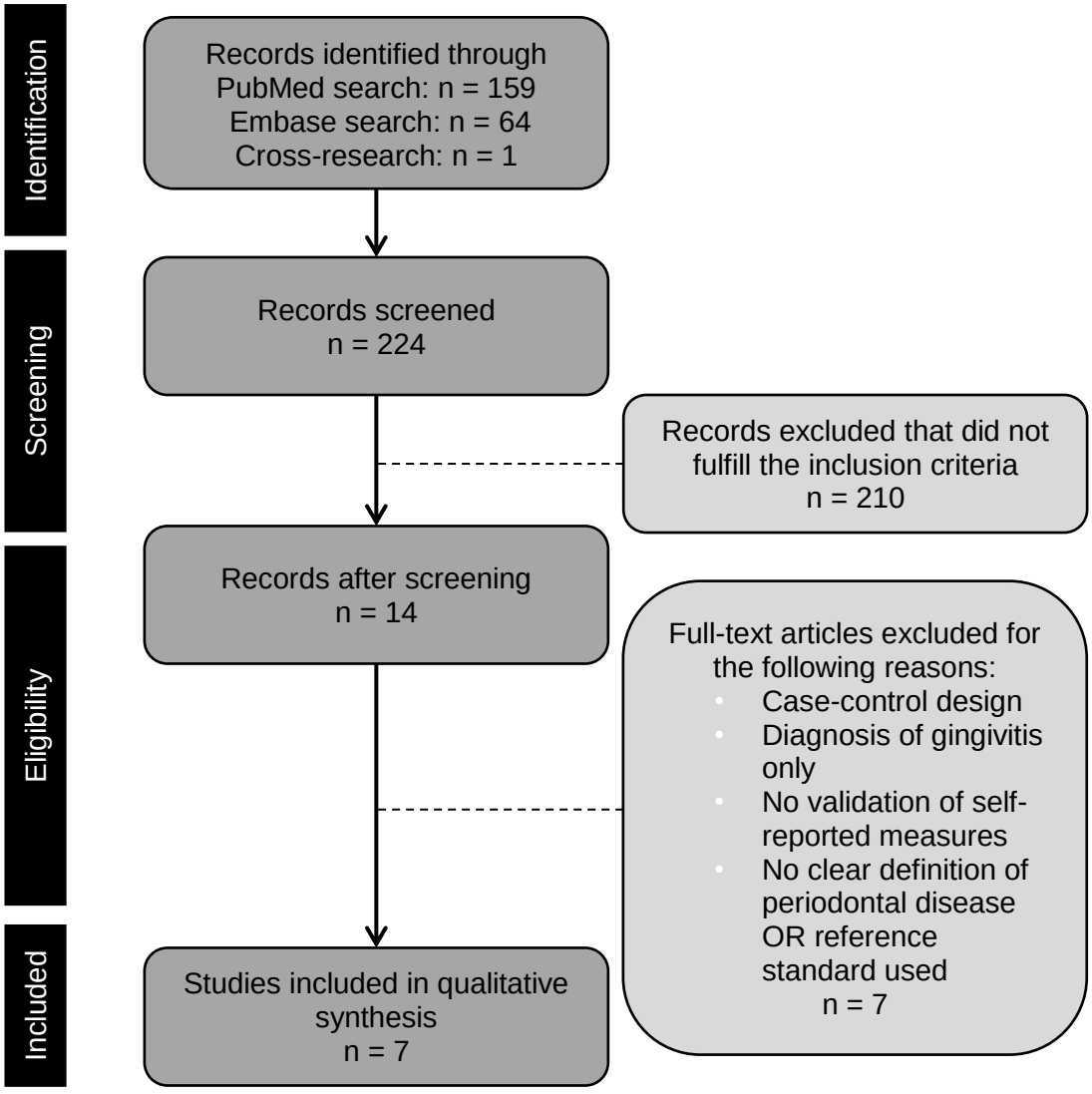
Similarly to the review by Abbood *et al.* (27), QUADAS-2 (30) was used to evaluate the risk of bias and applicability of primary diagnostic accuracy for each study selected. This tool consists of four key domains concerning patient selection, index test, reference standard and flow and timing. Each of these is assessed in terms of risk of bias (with signaling questions to assist that judgment) and the first three in terms of concerns regarding applicability. This information is regarded in Table III

Critical appraisal of the previous systematic review was conducted using AMSTAR (31). (Table IV)

2.2. Results

An electronic search of PubMed and Embase resulted in 223 papers. Another study was added after some cross-research, resulting in 224 papers in total. After title and abstract reading, 210 were excluded, since they did not fulfill the inclusion criteria, leaving us with 14 articles eligible for full-text reading. After doing so, 7 papers were excluded, since they didn't validate self-report measures or were not about periodontitis (Appendix, Table V), leaving us with 7 studies. (Fig. 2)

Figure 2. *Flow diagram of study selection and screening process for the systematic literature update on the validation of self-reported periodontal disease.*



All 7 included studies are briefly summarized in Table I, which describes the population used in the validation study, namely recruitment process, number and age of the participants and male/female ratio. Other information, such as country of study and type of study, were also included.

Of the included studies, two were conducted in the USA (32,33), three in Europe (26,34,35), and the remaining two in Brazil (36) and New-Zealand (37) (Table I).

Almost all studies were cross-sectional, with the exception of the study by Page at al.(37) and Chatzopoulos *et al.* (2018) (32), which was a cohort study. Heaton *et al.* (33) and Ramos *et al.* (36) studies can be considered cross-sectional sub-studies from a cohort study, since the sample selection was done from two ongoing cohort studies: Heaton *et al.* (33) selected patients from the "*Black Women's Health Study"* and Ramos *et al.* (36) recruited them from the "*EpiFloripa"* study. (Table I)

Sample sizes ranged from 75 (33) to 4890 (32) participants. Heaton *et al.* (33) was the only study in which the sample consisted of only female participants. Renatus *et al.* (26) did not specify the male/female ratio. Overall, participants were adults (over 18 years of age), with no specific systemic disease. (Table I)

Of the 7 reports, two used personal interview as self-report method (36,37), three did a questionnaire at the time of patient visit (26,32,34), Chatzopoulos *et al.* (2016) (35) conducted a telephone interview and Heaton *et al.* (33) mailed the questionnaires to the participants. Studies that conducted personal and telephone interview did not specify the timeline between self-report and validation, with the corresponding application of the clinical gold standard (Table I).

Table I. *Characteristics of Included Studies*

First author (Year of publication)	Country of study	Type of study	Population	Sample size	Male/Female ratio	Age of participants	Method of self-report
Chatzopoulos (2018) (32)	USA	Cohort	Adults who visited the University of Minnesota School of Dentistry between 2012 and 2016 seeking dental therapy and had full-mouth series of radiographs, 6 or more remaining teeth, with tobacco and medical history	4890	2575/2315	54,1 mean age	Questionnaire at time of patient visit
Carra (2018) (34)	France	Cross-sectional	Adults recruited during routine health examinations at the *Centre d'investigations préventives et cliniques* of Paris, able to read and understand French, not presenting any risk of infective endocarditis	232	138/93	46,17 mean age	Written questionnaire at time of patient visit
Heaton (2017) (33)	USA	Cross-sectional sub-study from cohort	Females recruited from the *Black Women's Health Study,* resident in Boston, who returned complete questionnaires and had at least 8 natural teeth	75	Only females	59 mean age	Mailed questionnaire
Chatzopoulos (2016) (35)	Greece	Cross-sectional	Untreated sample population who visited the Aristotle University of Thessaloniki Dental School, seeking dental therapy, and who responded to the telephone interview	535	247/288	50,1 mean age	Telephone interview
Ramos (2016) (36)	Brazil	Cross-sectional sub-study from cohort	Randomly selected from the *EpiFloripa* study	1140	498/642	22-61 range	Personal interview
Renatus (2016) (26)	Germany	Cross-sectional	Randomly selected untreated patients, over 18 years of age, who were not undergoing periodontal treatment, antibiotic therapy, were pregnant or disabled	200	-	>18	Questionnaire at time of patient visit
Page (2016) (37)	New-Zealand	Cohort	Recruited from the *Dunedin Multidisciplinary Health and Development Study (DMHDS)*	895	451/444	38	Personal interview

The results of the validation studies are presented in Table II.

Table II. *Results from validation of self-reported periodontal disease: validation parameters – sensitivity (SE) and specificity (SP) – for self-reported PdD.*

Self-report Questionnaire	Clinical Gold Standard	Results		Study Reference
Periodontal disease				
1. Do you think you might have gum disease?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 16,3%; [c]SP = 75,4% Severe Periodontitis: [c]SE = 28,7%; [c]SP = 86,1%	Moderate Periodontitis: [e]Σ = 91,7% Severe Periodontitis: [e]Σ = 114,8%	Carra (2018) (34)
		Moderate/Severe Periodontitis: [d]SE = 24%; [d]SP = 100% Severe Periodontitis: [d]SE = 33%; [d]SP = 84%	Moderate/Severe Periodontitis: [e]Σ = 124% Severe Periodontitis: [e]Σ = 117%	Heaton (2017) (33)
2. Have gum disease?		Moderate Periodontitis: ≥4 mm AL [d]SE = 51%; [d]SP = 82% ≥5 mm AL [d]SE = 61%; [d]SP = 87% Severe Periodontitis: [d]SE = 81%; [d]SP = 96%	Moderate Periodontitis: ≥4 mm AL [e]Σ = 133% ≥5 mm AL [e]Σ = 148% Severe Periodontitis: [e]Σ = 177%	Page (2016) (37)
Periodontal disease with bone loss				
3. Lost bone around your teeth?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: ≥4 mm AL [d]SE = 13%; [d]SP = 93% ≥5 mm AL [d]SE = 19%; [d]SP = 93% Severe Periodontitis: [d]SE = 33%; [d]SP = 93%	Moderate Periodontitis: ≥4 mm AL [e]Σ = 106% ≥5 mm AL [e]Σ = 112% Severe Periodontitis: [e]Σ = 126%	Page (2016) (37)
Professional diagnosis of periodontal disease				
4. Have you ever been told by a dental professional that you lost bone around your teeth?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 4,9%; [c]SP = 77,8% Severe Periodontitis: [c]SE = 25,7%; [c]SP = 95,9%	Moderate Periodontitis: [e]Σ = 82,7% Severe Periodontitis: [e]Σ = 121,6%	Carra (2018) (34)
		Moderate/Severe Periodontitis: [d]SE = 40%; [d]SP = 100% Severe Periodontitis: [d]SE = 56%; [d]SP = 72%	Moderate/Severe Periodontitis: [e]Σ = 140% Severe Periodontitis: [e]Σ = 128%	Heaton (2017) (33)
5. Have you ever been told by a dentist that you have periodontal/gum disease with bone loss?		Periodontitis: [d]SE = 46%; [d]SP = 90%	Periodontitis: [e]Σ = 136%	Chatzopoulos (2016) (35)

Self-report Questionnaire	Clinical Gold Standard	Results		Study Reference
Professional diagnosis of periodontal disease				
6. Has your dentist ever told you that you have gum disease?	≥6 mm PD and clinical AL ≥4 mm	In the same tooth, in at least one tooth: [d]SE = 51.7%; [d]SP = 78% Not necessarily in the same tooth: [d]SE = 50%; [d]SP = 78,4%	In the same tooth, in at least one tooth: [e]Σ = 129,7% Not necessarily in the same tooth: [e]Σ = 128,4%	Ramos (2016) (36)
Self-rating				
7. Is it important for you to keep your teeth?	Radiographic bone loss[b] Moderate bone loss: 26-50% bone loss in >30% of teeth Severe bone loss: >50% bone loss in >30% of teeth OR four or more posterior teeth with >50% of bone loss	Moderate bone loss: [c]SE = 84,8%; [c]SP = 11,7% Severe bone loss: [c]SE = 76,2%; [c]SP = 11,4%	Moderate bone loss: [e]Σ = 96,5% Severe bone loss: [e]Σ = 87,9%	Chatzopoulos (2018) (32)
8. During the past 3 months, have you noticed a tooth that doesn't look right?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 39%; [c]SP = 48,4% Severe Periodontitis: [c]SE = 52,2%; [c]SP = 60,7%	Moderate Periodontitis: [e]Σ = 87,4% Severe Periodontitis: [e]Σ = 112,9%	Carra (2018) (34)
		Moderate/Severe Periodontitis: [d]SE = 10%; [d]SP = 100% Severe Periodontitis: [d]SE = 12%; [d]SP = 93%	Moderate/Severe Periodontitis: [e]Σ = 110% Severe Periodontitis: [e]Σ = 105%	Heaton (2017) (33)
9. Overall, how would you rate the health of your teeth and gums?		Moderate/Severe Periodontitis: [d]SE = 84%; [d]SP = 100% Severe Periodontitis: [d]SE = 67%; [d]SP = 7%	Moderate/Severe Periodontitis: [e]Σ = 184% Severe Periodontitis: [e]Σ = 74%	

[a]CDC-AAP classified the severity of periodontitis into mild, moderate and severe: Mild Periodontitis – ≥ 2 interproximal sites with clinical attachment loss (AL) ≥ 3 mm and ≥ 2 interproximal sites with probing depth (PD) ≥ 4 mm (not on the same tooth) or one site with PD ≥ 5 mm – Moderate Periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 4 mm or ≥ 2 interproximal sites (not on the same tooth) with PD ≥ 5 mm – Severe Periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 6 mm and ≥ 1 interproximal sites with PD ≥ 5 mm

[b]None to mild group selected as a reference category for the comparisons with severe and moderate groups

[c]Calculations done by us from data provided in manuscript

[d]Sensitivity and specificity from manuscript with a confidence interval of 95 %

[e]Sum of sensitivity and specificity to evaluate validity (good validity ≥120%)

Table II. (cont.) *Results from validation of self-reported periodontal disease: validation parameters – sensitivity (SE) and specificity (SP) – for self-reported PdD.*

Self-report Questionnaire	Clinical Gold Standard	Results		Study Reference
Tooth mobility				
10. Have you noticed loosening of your teeth?	Radiographic bone loss[b] Moderate bone loss: 26-50% bone loss in >30% of teeth Severe bone loss: >50% bone loss in >30% of teeth OR four or more posterior teeth with >50% of bone loss	Moderate bone loss: [c]SE = 25,5%; [c]SP = 84,6% Severe bone loss: [c]SE = 57,3%; [c]SP = 86%	Moderate bone loss: [e]Σ = 110,1% Severe bone loss: [e]Σ = 143,3%	Chatzopoulos (2018) (32)
11. Have you ever had any teeth become loose on their own, without an injury?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 15,2%; [c]SP = 55,9% Severe Periodontitis: [c]SE = 47,7%; [c]SP = 83,7%	Moderate Periodontitis: [e]Σ = 71,1% Severe Periodontitis: [e]Σ = 131,4%	Carra (2018) (34)
		Moderate/Severe Periodontitis: [d]SE = 17%; [d]SP = 91% Severe Periodontitis: [d]SE = 22%; [d]SP = 86%	Moderate/Severe Periodontitis: [e]Σ = 108% Severe Periodontitis: [e]Σ = 118%	Heaton (2017) (33)
12. Think teeth loose or wobbly?		Periodontitis: [d]SE = 73%; [d]SP = 88%	Periodontitis: [e]Σ = 161%	Chatzopoulos (2016) (35)
13. Had teeth come loose?		Moderate Periodontitis: ≥4 mm AL [d]SE = 17%; [d]SP = 94% ≥5 mm AL [d]SE = 28%; [d]SP = 94% Severe Periodontitis: [d]SE = 34%; [d]SP = 92%	Moderate Periodontitis: ≥4 mm AL [e]Σ = 111% ≥5 mm AL [e]Σ = 122% Severe Periodontitis: [e]Σ = 126%	Page (2016) (37)
14. Do you have any wobbly teeth?	≥6 mm PD and clinical AL ≥4 mm	In the same tooth, in at least one tooth: [d]SE = 31%; [d]SP = 91.8% Not necessarily in the same tooth: [d]SE = 29,5%; [d]SP = 92%	In the same tooth, in at least one tooth: [e]Σ = 122,8% Not necessarily in the same tooth: [e]Σ = 121,5%	Ramos (2016) (36)
15. Please provide assessment on the movability of your teeth.	PSI or PSR (Periodontal Screening Index/Periodontal Screening and Recording): Periodontitis: PSI code 3 and 4	Periodontitis: [c]SE = 29%; [c]SP = 91%	Periodontitis: [e]Σ = 120%	Renatus (2016) (26)

Self-report Questionnaire	Clinical Gold Standard	Results		Study Reference
Bleeding gums				
16. Do your gums often bleed while brushing?	Radiographic bone loss[b] Moderate bone loss: 26-50% bone loss in >30% of teeth Severe bone loss: >50% bone loss in >30% of teeth OR four or more posterior teeth with >50% of bone loss	Moderate bone loss: [c]SE = 19,3%; [c]SP = 78,9% Severe bone loss: [c]SE = 34,4%; [c]SP = 80%	Moderate bone loss: [e]Σ = 98,2% Severe bone loss: [e]Σ = 114,4%	Chatzopoulos (2018) (32)
17. Have your gums bled recently?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 46,7%; [c]SP = 51,6% Severe Periodontitis: [c]SE = 52,2%; [c]SP = 56,6%	Moderate Periodontitis: [e]Σ = 98,3% Severe Periodontitis: [e]Σ = 108,8%	Carra (2018) (34)
18. Do your gums usually bleed?	≥6 mm PD and clinical AL ≥4 mm	In the same tooth, in at least one tooth: [d]SE = 6,9%; [d]SP = 97,1% Not necessarily in the same tooth: [d]SE = 9,1%; [d]SP = 97,2%	In the same tooth, in at least one tooth: [e]Σ = 104% Not necessarily in the same tooth: [e]Σ = 106,3%	Ramos (2016) (36)
19. Have you observed an increase in the incidence of bleeding gums?	PSI or PSR (Periodontal Screening Index/Periodontal Screening and Recording): Periodontitis: PSI code 3 and 4	Periodontitis: [c]SE = 34%; [c]SP = 91%	Periodontitis: [e]Σ = 125%	Renatus (2016) (26)
Recession				
20. Do you notice your teeth getting longer?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 21%; [c]SP = 56% Severe Periodontitis: [c]SE = 45,9%; [c]SP = 77,5%	Moderate Periodontitis: [e]Σ = 77% Severe Periodontitis: [e]Σ = 123,4%	Carra (2018) (34)
21. Think can see more of roots of teeth than in past?		Moderate Periodontitis: [c]SE = 23,8%; [c]SP = 62,9% Severe Periodontitis: [c]SE = 35,8%; [c]SP = 73,3%	Moderate Periodontitis: [e]Σ = 86,7% Severe Periodontitis: [e]Σ = 109,1%	
		Periodontitis: [d]SE = 43%; [d]SP = 78%	Periodontitis: [e]Σ = 121%	Chatzopoulos (2016) (35)

[a]CDC-AAP classified the severity of periodontitis into mild, moderate and severe: Mild Periodontitis – ≥ 2 interproximal sites with clinical attachment loss (AL) ≥ 3 mm and ≥ 2 interproximal sites with probing depth (PD) ≥ 4 mm (not on the same tooth) or one site with PD ≥ 5 mm – Moderate Periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 4 mm or ≥ 2 interproximal sites (not on the same tooth) with PD ≥ 5 mm – Severe Periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 6 mm and ≥ 1 interproximal sites with PD ≥ 5 mm

[b]None to mild group selected as a reference category for the comparisons with severe and moderate groups

[c]Calculations done by us from data provided in manuscript

[d]Sensitivity and specificity from manuscript with a confidence interval of 95 %

[e]Sum of sensitivity and specificity to evaluate validity (good validity ≥120%)

Table II. (cont.) *Results from validation of self-reported periodontal disease: validation parameters – sensitivity (SE) and specificity (SP) – for self-reported PdD.*

Self-report Questionnaire	Clinical Gold Standard	Results		Study Reference
Recession				
22. Have you noticed any increase in exposed root surfaces?	PSI or PSR (Periodontal Screening Index/Periodontal Screening and Recording): Periodontitis: PSI code 3 and 4	Periodontitis: [c]SE = 28%; [c]SP = 88%	Periodontitis: [e]Σ = 116%	Renatus (2016) (26)
Food impaction				
23. Does food frequently get caught in your teeth?	Radiographic bone loss[b] Moderate bone loss: 26-50% bone loss in >30% of teeth Severe bone loss: >50% bone loss in >30% of teeth OR four or more posterior teeth with >50% of bone loss	Moderate bone loss: [c]SE = 61,5%; [c]SP = 44,4% Severe bone loss: [c]SE = 72,4%; [c]SP = 44,7%	Moderate bone loss: [e]Σ = 105,9% Severe bone loss: [e]Σ = 117,1%	Chatzopoulos (2018) (32)
24. Do you have food impaction between your teeth?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 48,5%; [c]SP = 40,8% Severe Periodontitis: [c]SE = 62,6%; [c]SP = 52,9%	Moderate Periodontitis: [e]Σ = 89,3% Severe Periodontitis: [e]Σ = 115,5%	Carra (2018) (34)
Treatment				
25. Have you had gum treatment?	Radiographic bone loss[b] Moderate bone loss: 26-50% bone loss in >30% of teeth Severe bone loss: >50% bone loss in >30% of teeth OR four or more posterior teeth with >50% of bone loss	Moderate bone loss: [c]SE = 24,4%; [c]SP = 89% Severe bone loss: [c]SE = 26,9%; [c]SP = 87,9%	Moderate bone loss: [e]Σ = 113,4% Severe bone loss: [e]Σ = 114,8%	Chatzopoulos (2018) (32)
26. Have you ever had treatment for gum disease, such as scaling, root planing, sometimes called "deep" cleaning?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: [c]SE = 10,6%; [c]SP = 73,8% Severe Periodontitis: [c]SE = 28,7%; [c]SP = 89,3%	Moderate Periodontitis: [e]Σ = 84,4% Severe Periodontitis: [e]Σ = 118%	Carra (2018) (34)
		Moderate/Severe Periodontitis: [d]SE = 56%; [d]SP = 82% Severe Periodontitis: [d]SE = 78%; [d]SP = 59%	Moderate/Severe Periodontitis: [e]Σ = 138% Severe Periodontitis: [e]Σ = 137%	Heaton (2017) (33)
27. Have you ever had periodontal surgery?		Periodontitis: [d]SE = 5%; [d]SP = 100%	Periodontitis: [e]Σ = 105%	Chatzopoulos (2016) (35)

Self-report Questionnaire	Clinical Gold Standard	Results		Study Reference
Treatment				
28. Had scaling, root planning, surgery?	CDC-AAP Periodontitis definition[a]	Moderate Periodontitis: ≥4 mm AL [d]SE = 23%; [d]SP = 86% ≥5 mm AL [d]SE = 28%; [d]SP = 85% Severe Periodontitis: [d]SE = 38%; [d]SP = 84%	Moderate Periodontitis: ≥4 mm AL [e]Σ = 109% ≥5 mm AL [e]Σ = 113% Severe Periodontitis: [e]Σ = 122%	Page (2016) (37)
Hygiene habits				
29. Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use dental floss or any other device to clean between your teeth?	CDC-AAP Periodontitis definition[a]	Moderate/Severe Periodontitis: [d]SE = 5%; [d]SP = 100% Severe Periodontitis: [d]SE = 100%; [d]SP = 95%	Moderate/Severe Periodontitis: [e]Σ = 105% Severe Periodontitis: [e]Σ = 195%	Heaton (2017) (33)
30. Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use mouthwash or other dental rinse product that you use to treat dental disease or dental problems?		Moderate/Severe Periodontitis: [d]SE = 41%; [d]SP = 45% Severe Periodontitis: [d]SE = 33%; [d]SP = 54%	Moderate/Severe Periodontitis: [e]Σ = 86% Severe Periodontitis: [e]Σ = 87%	

[a]CDC-AAP classified the severity of periodontitis into mild, moderate and severe: Mild Periodontitis – ≥ 2 interproximal sites with clinical attachment loss (AL) ≥ 3 mm and ≥ 2 interproximal sites with probing depth (PD) ≥ 4 mm (not on the same tooth) or one site with PD ≥ 5 mm – Moderate Periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 4 mm or ≥ 2 interproximal sites (not on the same tooth) with PD ≥ 5 mm – Severe Periodontitis – ≥ 2 interproximal sites (not on the same tooth) with AL ≥ 6 mm and ≥ 1 interproximal sites with PD ≥ 5 mm

[b]None to mild group selected as a reference category for the comparisons with severe and moderate groups

[c]Calculations done by us from data provided in manuscript

[d]Sensitivity and specificity from manuscript with a confidence interval of 95 %

[e]Sum of sensitivity and specificity to evaluate validity (good validity ≥120%)

Most of the studies used the CDC-AAP definition of periodontitis severity. Two studies used other clinical gold standards, such as radiographic bone loss (32) and PSI/PSR definition of periodontitis (26). Ramos *et al.* (36) used clinical attachment loss and probing depth as clinical gold standard, considering ≥6 mm PD and clinical AL ≥4 mm or more as periodontitis.

As seen in Table II, self-report measures for periodontitis were grouped into several categories (disease awareness/perception as defined by the study participants – periodontal disease or periodontal disease with bone loss –; knowledge of professional diagnosis of periodontal disease; self-rating; symptoms of periodontal disease – tooth mobility, bleeding gums, recession, food impaction; treatment; hygiene habits) each of them with corresponding questions with exact wording provided by the authors.

Furthermore, this review update included thirty questions from the seven included studies. Some of them are shared between studies, namely questions 1 – *"Do you think you might have gum disease?"* –, 4 – "*Have you ever been told by a dental professional that you lost bone around your teeth?"* – and 8 – *"During the past 3 months, have you noticed a tooth that doesn't look right?"* – from Carra *et al.* (34) and Heaton *et al.* (33), and question 21 – *"Think can see more of roots of teeth than in past?"* – from Carra *et al.* (34) and Chatzopoulos *et al.* (2016) (35).

Three studies (26,32,34) did not provide SE and SP values for each question. Since all the information necessary to calculate both SE and SP for each question was presented, we did the calculations. However, it was only possible in questions of yes or no answer, which is why risk factors were not included in this review.

Regarding the questions included from the study by Renatus *et al.* (26), Table II only exhibits results from Perio 1 (PSI codes 0, 1, 2 considered non-periodontitis and codes 3 and 4 considered periodontitis), since Perio 2 and 3 only served to review the robustness of the screening test performed; we'll only discuss the results of Perio 1 here, the ones regarding patient self-reported symptoms.

The sensitivity (SE) of the questions analyzed ranged from 5% for the questions *"Have you ever had periodontal surgery?"* (35) and *"Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use dental floss or any other device to clean between your teeth?"* (33) for moderate periodontitis, as defined by the CDC-AAP, to 100% on the same question by Heaton *et al.* (33) but regarding severe periodontitis. In its turn, specificity (SP) of questions ranged from 7% for the question *"Overall how would you rate the health of your teeth and gums?"* (33) concerning moderate periodontitis to 100% on the same question but this time regarding severe periodontitis, and several others regarding disease awareness (33), professional diagnosis of periodontal disease (33), self-rating questions such as *"During the past 3 months, have you noticed a tooth that doesn't look right?"* (33), treatment (32) and hygiene (33).

Overall, most questions analyzed showed higher values of specificity than sensitivity, as per Nelson *et al.* (28) classification on good validity. In fact, nine questions showed low values of SP, and eight moderate to high values of SE, being that five of these questions, questions 7, 9, 23, 24 and 26 – *"Is it important for you to keep your teeth?", "Overall, how would you rate the health of your teeth and gums?", "Does food frequently get caught in your teeth?", "Do you have food impaction between your teeth?", "Have you ever had treatment for gum disease, such as scaling, root planing, sometimes called "deep" cleaning?"* – were the same, showing thereupon moderate/high values of SE and low values of SE. These questions practically cover all topics mentioned above and by which the questions are grouped.

A total of eight questions showed good validity (SE + SP ≥120%) only when referring to severe periodontitis or severe bone loss. Another eight questions showed good validity overall, either predicting moderate or severe periodontitis. Of the shared questions between studies, question 1 – *"Do you think you might have gum disease?"* – had good validity in the study conducted by Heaton *et al.* (33) when referring to moderate/severe periodontitis, but not in Carra *et al.* (34). Question 4 – "*Have you ever been told by a dental professional that you lost bone around your teeth?"* – , also shared by these studies, showed good validity overall in Heaton *et al.* (33), but only when predicting severe periodontitis in Carra at al. (34). Question 21 – *"Think can see more of roots of teeth than in past?"* – had good validity in Chatzopoulos *et al.* (2016) (35), but not in Carra *et al.* (34).

The results of quality assessment of the included studies are presented in Table III. Only Heaton *et al.* (33) presented bias in patient selection, since there was no random or consecutive sample or avoidance of inappropriate exclusions. Two studies did not mention whether the participants were blinded to their clinical diagnosis when they filled the questionnaires (32,37), and Page *et al.* (37), as well as Heaton *et al.* (33), did not mention if the clinical examiners were blinded to the participants' answers during periodontal examination. Moreover, four studies did not acknowledge whether there was an appropriate interval between periodontal examination and method of self-report (32,33,35,37), and this period should be as short as possible since gingival bleeding can develop in 14 days and could be resolved within a week. (27)

Table III. *Quality assessment for all included studies depending on QUADAS2*

			Chatzopoulos (2018) (32)	**Carra (2018)** (34)	**Heaton (2017)** (33)	**Chatzopoulos (2016)** (35)	**Ramos (2016)** (36)	**Renatus (2016)** (26)	**Page (2016)** (37)
DOMAIN 1 Patient Selection	**RISK** Could the selection of patients have introduced bias?	Consecutive or random sampling	Yes	Yes	No	Yes	Yes	Yes	Yes
		Case-control design avoided	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
		Inappropriate exclusions avoided	Yes	Yes	No	Yes	No	Yes	Yes
	CONCERN Are there concerns that the included patients do not match the review question?		Low	Low	Low	Low	Low	Low	Low
DOMAIN 2 Index Test	**RISK** Could the conduct or interpretation of the index test have introduced bias?	Were the index test results interpreted without knowledge of the results of the reference standard?	Unclear	Yes	Yes	Yes	Yes	Yes	Unclear
		If a threshold was used, was it prespecified?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	CONCERN Are there concerns that the index test, its conduct, or its interpretation differ from the review question?		Low	Low	Low	Low	Low	Low	Low

Table III. (cont.) *Quality assessment for all included studies depending on QUADAS2*

			Chatzopoulos (2018) (32)	**Carra (2018)** (34)	**Heaton (2017)** (33)	**Chatzopoulos (2016)** (35)	**Ramos (2016)** (36)	**Renatus (2016)** (26)	**Page (2016)** (37)
DOMAIN 3 Reference Standard	**RISK** Could the reference standard, its conduct, or its interpretation have introduced bias?	Reference standard likely to correctly classify the target condition	Unclear	Yes	Yes	Yes	Yes	Yes	Yes
		Reference standard results interpreted without knowledge of the results of the index test	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear
	CONCERN Are there concerns that the target condition as defined by the reference standard does not match the review question?		Low	Low	Low	Low	Low	Low	Low
DOMAIN 4 Flow and Timing	**RISK** Could the patient flow have introduced bias?	Appropriate interval between index test(s) and reference standard	Unclear	Yes	Unclear	Unclear	Yes	Yes	Unclear
		Did all patients receive a reference standard?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Did patients receive the same reference standard?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Were all patients included in the analysis?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Quality assessment of the systematic review by Abbood *et al.* (27) is depicted in Table IV. The review aim was clear, had appropriate selection criteria and inclusion and exclusion criteria. Regarding literature search, although extensive, Google Scholar database was added. Although some characteristics of the studies included were presented, most information was discarded in detriment of the performed meta-analysis. On the other hand, quality assessment of the listed and included studies in the review was performed.

Table IV. *Quality assessment of systematic review by Abbood et al.* (27) *using AMSTAR criteria*

1. Was an 'a priori' design provided?	Yes
2. Was there duplicate study selection and data extraction?	Yes
3. Was a comprehensive literature search performed?	Yes
4. Was the status of publication (i.e. grey literature) used as an inclusion criterion?	Can't answer
5. Was a list of studies (included and excluded) provided?	No
6. Were the characteristics of the included studies provided?	No
7. Was the scientific quality of the included studies assessed and documented?	Yes
8. Was the scientific quality of the included studies used appropriately in formulating conclusions?	Yes
9. Were the methods used to combine the findings of studies appropriate?	No
10. Was the likelihood of publication bias assessed?	No
11. Was the conflict of interest included?	No

2.3. Discussion

Periodontal disease diagnosis is primarily based on clinical and radiographic periodontal examinations. However, these methods are costly and time-consuming, and consequently, the development of low-cost and low-resource measures of periodontal disease would prove valuable to facilitate the diagnosis of periodontal disease in population-based studies. It is with this purpose in mind that self-reported measures arise. (32,34)

However, it is important to understand what self-reporting entails. It corresponds to a simple interview or questionnaire asking about a lay person's symptoms or presence of disease, and it should not be confused with other terms used in the dental literature, such as self-assessment, self-appraisal or recognition of symptoms or disease. (38)

This review update fundamentally aimed to evaluate self-report questions previously used and try to establish a pattern for perceiving the changes undergone in recent years, in order to accomplish a self-report questionnaire as accurate as possible in the future. Both Blicher *et al.* (29) and Abbood *et al.* (27) did the same thing. However, Abbood *et al.* (27), for instance, besides the systematic review, did a meta-analysis, which is actually difficult to achieve, considering the panoply of criteria used in each study; nevertheless, although some characteristics of the included studies were presented, most information was discarded in detriment of the performed meta-analysis, which means all attention was focused on the meta-analysis, neglecting the systematic review. It is precisely there that this review update is improved: similarly to Blicher *et al.* (29), and assuming the amount of data provided by the different including studies, we sought to describe and assess all questions used (neglecting the ones about risk factors) in all the seven included studies (26,32–37) to, again, understand which were the ones that indeed were useful to diagnose periodontitis and the ones that were not.

To evaluate the accuracy of the self-reported questions used in the seven included studies in this review, we used sensitivity and specificity values. It is important, notwithstanding, to understand their meaning in a medical context. Sensitivity refers to the test's ability to correctly detect ill patients who in fact have the disease, and specificity concerns the test's ability to correctly reject healthy patients. Questions that showed high values of SE are adequate to correctly identify patients with periodontitis, and in its turn, questions with high values of SP are good to correctly identify healthy patients. If the response to a question with high SE is negative, it will rule out the presence of periodontitis. If a response to a question with high SP is positive, then the probability of having periodontitis is also high. Hence, when dealing with SE and SP it is important to be critical and to consider the type of question and its objective.

It is also important to understand the fundamental purpose of a self-report questionnaire and the context in which it is applied, so that we can choose whether it is preferable that it correctly identifies the people who have periodontitis or that it correctly identifies those who do not have it. Naturally, ideally, we want a questionnaire that has good values of both SE and SP and that both correctly identify those who have and those who don't have periodontitis.

Chatzopoulos *et al.* (2018) (32) examined self-report questions, demographic characteristics and medical conditions, and verified that they were significantly associated with moderate and severe bone loss. Each individual variable demonstrated generally better predictive ability for severe compared with moderate bone loss.

Only three questions (question 4 – *"Have you ever been told by a dental professional that you lost bone around your teeth?"* –, 11 – *"Have you ever had any teeth become loose on their own, without an injury?"* – and 20 – *"Do you notice your teeth getting longer?"*) included from the study by Carra *et al.* (34) showed good validity predicting severe periodontitis. Questions 1 – *"Do you think you might have gum disease?"* – and question 21 – *"Think can see more of roots of teeth than in past?"* – are shared with Heaton *et al.* (33) and Chatzopoulos *et al.* (2016) (35) respectively, being that in those two studies each question shows good validity.

Questions relating to Chatzopoulos *et al.* (2016) (35) and presented in Table II show good validity predicting periodontitis, except question 27 – *"Have you ever had periodontal surgery?"* –. It is not possible, however, to discern the severity of the disease.

Overall, the questions used by Ramos *et al.* (36) showed good validity predicting periodontitis, except question 18 – *"Do your gums usually bleed?"* –. It is not possible, however, to discern the severity of the disease. Nevertheless, authors found that the prevalence of periodontitis based on the two self-reported items referring to tooth mobility and diagnosis (questions 6 – *"Has your dentist ever told you that you have gum disease?"* – and 14 – *"Do you have any wobbly teeth?"*), was higher than that found clinically, reflecting inconsistency between results. Regarding question 6 – *"Has your dentist ever told you that you have gum disease?"* –, authors have stated that this may have happened due to it being too broad a question, including all disease levels; therefore, more individuals were identified as having adverse periodontal conditions with this item, rendering higher SE values. Ramos *et al.* (36) used two different clinical criteria of periodontitis, but the results obtained were not statistically significant.

Regarding Page *et al.* (37), only one question showed good validity predicting moderate and severe periodontitis. The other three had good validity predicting severe periodontitis. Although the questions showed good validity, Page *et al.* (37) also stated that response rate was lower than that using similar questions in US population, which suggested that New-

Zealand adults did not respond well to these questions, maybe due to lack of awareness of periodontitis. Now, this shows that cultural background is just as important as other predictors, such as socioeconomic status.

Questions about disease awareness/perception as defined by the study participants showed high values of SP, which means that if there is a positive response, there is a high probability of having periodontitis.

All three questions relating to knowledge of professional diagnosis of PdD showed good validity and high levels of SP, which is not surprising, since this implies that if indeed the patient has been told that he has periodontal disease, then a positive response in any of these questions means that there is a high chance that periodontal disease is, in fact, present.

Questions regarding self-rating didn't show good validity, although Chatzopoulos *et al.* (2018) (32) defends that question 7 – *"Is it important for you to keep your teeth?"* – should be implemented in future studies. Indeed, Chatzopoulos *et al.* (2018) (32) is the only study with a question about self-perceived importance to maintain natural dentition. It was expected that patients who replied positively would be less likely to have moderate or severe bone loss, which was confirmed, since this question was significantly negatively associated with moderate and severe bone loss. It was the first time that this question was accessed and authors consider it to be useful in future self-report questionnaires.

As for self-perceived symptoms, questions regarding tooth mobility were, by far, the ones that showed greater validity, especially, but not exclusively, regarding severe periodontitis, which is adequate considering the timing of this symptom during the course of the disease. Concerning bleeding gums, only question 19 – *"Have you observed an increase in the incidence of bleeding gums?"* – showed good validity. About root-exposure, questions 20 – *"Do you notice your teeth getting longer?"* – and 21 – *"Think can see more of roots of teeth than in past?"* – showed good validity, again especially, but not exclusively, regarding severe periodontitis.

Food impaction can encompass two distinct symptoms: tooth migration and root exposure, since for there to be food impaction related to periodontitis, it is assumed that it is due to the increase of interdental spaces. Yet, questions regarding food impaction had moderate SE and low SP.

Concerning treatment, surprisingly, only one question (question 26 – *"Have you ever had treatment for gum disease, such as scaling, root planing, sometimes called "deep" cleaning?"*) showed good validity. It would be expected that at least questions that include periodontal surgery, which is a more invasive procedure, would be appropriate to diagnose periodontitis. Notwithstanding, question 27 – *"Have you ever had periodontal surgery?"* –, for instance, shows a SE of 5% and SP of 100%, which means that if there is a positive response to this question, there is a 100% chance that periodontitis is present.

Questions relating to flossing and use of mouthwash showed poor performance in Heaton *et al.* (33), and as suggested by authors, it can be removed from future self-report questionnaires, even though question 29 – *"Aside from brushing your teeth with a toothbrush, in the last 7 days, how many times did you use dental floss or any other device to clean between your teeth?"* – showed good validity when referring to severe periodontitis. This is not unreasonable, since the authors themselves report a flaw in the sample used. Besides age and geographical area, which have already been covered, these women had high dental care access and insurance. Therefore, questions related to treatment and interactions with dental care providers generated higher estimates of SE, compared to questions reflecting self-perceptions. This means that there were more positive responses on having received treatment than on self-perceived disease. Consequently, it makes sense that question 29 showed good validity in this population, since they will probably be more aware of the necessary hygienic maintenance at home.

Overall, the sensitivity of the thirty applied questions is lower than the specificity, suggesting that a portion of patients with PD may not be recognized with these questions. In fact, the sensitivity and specificity of the questions included vary greatly between studies.

Furthermore, eight of the thirty questions had good validity predicting severe cases of periodontitis or severe bone loss, which is not surprising since the more the severity the more aware patients are and the greater the probability for self-perceived notion on periodontal disease. Additionally, if the participants are volunteers, it is probable that only highly motivated individuals and diseased patients may be more willing to participate than healthy individuals, thus the high prevalence of severe disease observed.

The studies included showed, unsurprisingly, some limitations. Chatzopoulos *et al.* (2018) (32) used radiographic bone loss as the clinical gold standard. It would be preferable if the clinical gold standard had been according to CDC-AAP definition of periodontitis. However, we understand that the kind of sample used (which was representative of the population) was only possible because radiographic bone loss was used. Nevertheless, time between self-report questionnaire and clinical gold standard is not mentioned. In fact, radiographic bone loss was used, from the most recent full-mouth series of intraoral radiographs, but not once is mentioned what timeline is the most recent. And it was not possible to differentiate between the various types of periodontal diseases.

Heaton *et al.* (33) used a small sample, comprised of only African-American women from a single geographic area. It does not characterize population, even amongst African-American women, since the sample used is of older women. Furthermore, most of the questions evaluated in this study showed good validity, which may be misleading given the sample utilized (age, socioeconomic status).

One study included in this review was a cohort study, and the data was acquired when patients were 38 years of age, which is not representative of periodontitis' suffering population. (36)

Renatus *et al.* (26) selected 100 healthy patients and 100 patients with periodontal disease. This fits in the frame of case-control design, which tends to exaggerate diagnostic accuracy.

Given that there are two systematic reviews on this theme, and considering this review update, one can observe the changes and similarities that self-report measures have suffered over the years, and that are important to point out, since this is a changing topic. This can mostly be observed in two parameters: clinical gold standard and definition of periodontitis used to validate self-report questions, and risk factor acknowledgement.

Definition of periodontitis and clinical gold standard used to validate the self-report questions is progressively changing. Consequently, five studies (39–43) included in the systematic review by Blicher *et al.* (29) didn´t use any specific clinical gold standard or standardized definition of periodontitis. Radiographic bone loss is used as CGS in three studies (44–46) included in the systematic review by Blicher *et al.* (29), one study (25) in the systematic review by Abbood *et al.* (27), and in one of the included studies in this review update (32). The use of indexes such as CPITN, CPI and PSI/PSR have been used in five studies (38,47–50) included in the review by Blicher *et al.* (29), three studies (51–53) in the review by Abbood *et al.* (27) and in one study included in this review (26). Furthermore, the CGS and definition of periodontitis that seems to be growing in use is the CDC-AAP definition of periodontitis; it is not used in any studies included in Blicher *et al.* (29), but it is used in six studies (54–59) included in Abbood *et al.* (27) and in four of the included studies in this review (33–35,37).

In fact, when multiple definitions of periodontitis are used, it impacts the diagnostic accuracy of the self-report questionnaire, hampering the comparability of the results among different studies, which is exactly what we can gather from the seven studies included in this review.

Regarding risk factor acknowledgment and inclusion in self-report questionnaires, it is practically not mentioned in initial studies, but it is possible to observe its growing importance and appreciation over the years, being that only a few studies incorporate these factors in self-report questionnaires.

Moreover, recent studies have used two domain models and bivariate associations to incorporate other predictors of periodontitis to increase the questionnaire's accuracy. Indeed, single self-report items may not be accurate enough to discriminate between diseased and healthy individuals, and that's why models that seek to combine both self-report measures and some demographic characteristics appeared to have better SE and SP.

Both Carra *et al.* (34) and Renatus *et al.* (26) sought to incorporate known risk factors in self-report questionnaire.

In Carra *et al.* (34), the questionnaire was designed integrating a self-report model (questions regarding signs and symptoms of periodontitis) and a risk factor model (questions regarding demographic and clinical variables known to be potential risk factors). The self-report model showed a SE and SP of 71,8% and 70,9%, respectively, and the risk-factor model showed a SE and SP of 70,4% and 63,9%, respectively. The final questionnaire reached a SE of 77,2% and SP of 76,7%.

In its turn, Renatus *et al.* (26) incorporated not so known and used PdD predictors, such as nutrition, body-mass-index, dental prosthetics, alcohol consumption, stress and educational level. The authors showed that advanced age, male gender, body-mass-index, balanced nutrition, smoking behavior, family history and level of education were significant markers for periodontitis. Prosthetic systems worn by patients appeared to also have a substantial influence on the incidence of periodontitis.

Chatzoupoulos *et al.* (2018) (32) used bivariate associations between bone loss (the considered clinical gold standard) and each predictor. Predictors tested ranged from demographic characteristics and tobacco use, to systemic medical history, including a series of systemic diseases. Although the self-report questionnaire only uses questions regarding periodontal disease per se, the analysis clearly correlates them with PdD predictors.

Chatzopoulos *et al.* (2016) (35) also used a bivariate model to increase the accuracy of prediction of periodontitis, resorting to the combination of self-report measures from two distinct domains – dentist-diagnosed and self-assessed – thus minimizing the false negative responses and increasing the sensitivity. Age and gender were also added, and the final predictive model combining periodontitis risk indicators and self-report items (two-domain structure) had high values of SE and SP (82,1% and 82,2% respectively).

Finally, Page *et al.* (37) also used bivariate associations between self-report questions, which according to the authors, performed adequately; however, the strength of the smoking-periodontitis association was underestimated compared to clinical measures.

In other words, a universal prediction model for periodontal disease can hardly exist; the role of specific factors, such as ethnicity, nationality or age, not to mention smoking habits and other known predictors, must always be considered when applying the self-report questionnaire.

Indeed, we predict that in the future some questions will no longer be utilized and others regarding risk factors and systemic diseases will be more and more applied, which represents no surprise since we know that periodontal disease highly interacts with other systemic diseases and has associated many risk factors. Nevertheless, there are always two sides of a coin. On one hand, and as stated by Page *et al.* (37), one can question the utility of combining

items relating to socio-demographic and behavioral data with self-reported disease items, because the ultimate use of the latter will often be in investigating differences by the very characteristics that are being used to identify cases. On the other hand, we can understand why some studies avoid including participants with significant systemic diseases, and especially those that are intimately associated with PdD, since it is important to first validate questions that directly report to PdD, like the ones portrayed in Table II, and only then associate the ones reporting known risk factors, such as tobacco use. In fact, and as stated multiple times in this review, some studies have shown that self-report questionnaires were more accurate diagnosing PdD when all this information was requested. However, we cannot stop stressing the importance of doing this in phases, since the ultimate goal can be diagnosing specific populations with periodontal disease.

Finally, there are several reasons for dental professionals to ask lay people for their perceptions about dental health. On one hand, actual self-reporting is a part of the routine diagnostic procedure for a clinician; then, realistic assessment of treatment needs requires information not only about normative (professional) but also about perceived (lay defined) needs. Moreover, self-reporting is a measure which enables the assessment of people's awareness and knowledge about oral health. (38) Consequently, self-reported measures may be used to widen surveillance of periodontal disease among large adult populations when clinically based screening is unavailable or when a patient does not visit a dental professional because of economic or access to dental care. (32)

3. Pilot Study

3.1. Materials and Methods

The present pilot study, part of a cross-sectional study ("Cross-sectional study of the prevalence of Chronic Periodontitis and its correlates in patients with Rheumatoid Arthritis"), was approved by the Ethics Comité of Centro Hospitalar e Universitário de Coimbra (CHUC). All study participants were informed of its content and the use of personal data and confirmed their voluntary willingness to take part.

An adaptation of the previously developed questionnaire by Renatus *et al.* (26) was used. Translation to Portuguese language was performed, as well as some changes regarding socio-demographic characteristics and which are more suited to Portuguese culture. The clinical follow-up examination was conducted by the Periodontal Screening Index (PSI).

Patients

Patients were sequentially selected from the Rheumatoid Arthritis cohort of CHUC Rheumatology Department. This pilot study was comprised of 20 consenting patients with Rheumatoid Arthritis with more than 18 years old and capable of understanding the protocol.

Finally, for statistical analysis, participants were divided into two groups of non-periodontitis patients (PSI Codes 0, 1 and 2) and periodontitis patients (PSI Codes 3 and 4).

Reference Standard – Periodontal Screening Index

Similarly to Renatus *et al.*, PSI was used and registered based on a PCO 11.5B probe (Hu-Friedy®, Chicago, IL, USA). The set of teeth was divided into sextants, probing was done on six different sites per tooth, and each tooth was scored from Code 0 to 4, but only the highest score of the sextant was recorded. The PSI Codes (0 to 4) were, therefore, recorded (Code 0 = healthy; Code 1 = bleeding; Code 2 = supra or subgingival calculus; Code 3 = PD 3,5 to 5,5 mm; Code 4 = PD > 5,5 mm). Subjects with findings of Code 0 to Code 2 were considered as non-periodontitis subjects, whereas Codes 3 and 4 were classified as probable periodontitis subjects.

All clinical recordings were performed by the same experienced calibrated examiner.

Self-report Measure – Questionnaire

The questionnaire was executed considering self-report questionnaires previously used to diagnose periodontitis. A literature search was performed to identify the items that showed better validity on predicting periodontitis, comprising of self-report questions on periodontitis symptoms and questions regarding periodontal risk factors and indicators. Hence, a systematic literature update was completed beforehand. Renatus *et al.* (26) questionnaire was then chosen based on its discriminatory capacity to diagnose periodontitis (it had a AUC of 0,81), and its simplicity. Adaptation to Portuguese language was then performed, as well as some changes regarding socio-demographic characteristics and which are more suited to Portuguese culture.

The questionnaire was applied via personal interview, and clinical examination was performed immediately after.

Statistical Analysis

Each question was evaluated in a descriptive way, showing the absolute and relative frequencies obtained in each diagnostic group of periodontitis. The possible association between each question and the diagnosis of periodontitis was also assessed, using Fisher's exact test. The total score of the self-report questionnaires was obtained using the sum of all items, being that the existence of statistically significant differences between both groups, corresponding to the diagnosis of periodontitis, was determined by the t-student test for independent samples after the normality of the variables had been verified by the test Shapiro Wilk. The questionnaire's discriminative capacity was evaluated by means of ROC (Receiving Operating Characteristic) analysis, determining the area under the ROC curve (AUC).

Statistical analysis was performed using the IBM® SPSS® v24 program, and a p-values of 0.05 was assumed to be statistically significant for all statistical tests.

3.2. Results

A total of 20 participants took part in the pilot study, respectively comprising of 13 healthy patients and 7 patients with periodontitis, which the examiner did not know at the time of questionnaire application.

None of the questions was strongly associated with the diagnosis of periodontitis, and the total score does not present statistically significant differences between the two diagnostic groups. Thus, no statistically significant distinction ($p < 0,05$) relating to the patients' prevalent PSI was verified in all questions. All these results are presented in Table VI, as well as patients' answers to the questionnaire items.

Questions regarding nutrition, prevalent diseases, stress and dental care were the ones that showed lower p-values, followed by tooth mobility, gender and sex. Then questions about BMI, years of education, family history, smoking habits, bleeding gums, exposed root surfaces and dental prosthetics showed the highest p-values. Still, none of these questions had p-values $< 0,05$.

A ROC curve was performed to evaluate the discriminatory capacity of the questionnaire and to illustrate SE and SP. The area under the ROC curve (AUC) was then calculated – 0,615 (CI 95% [0,368; 0,863]). (Fig. 3)

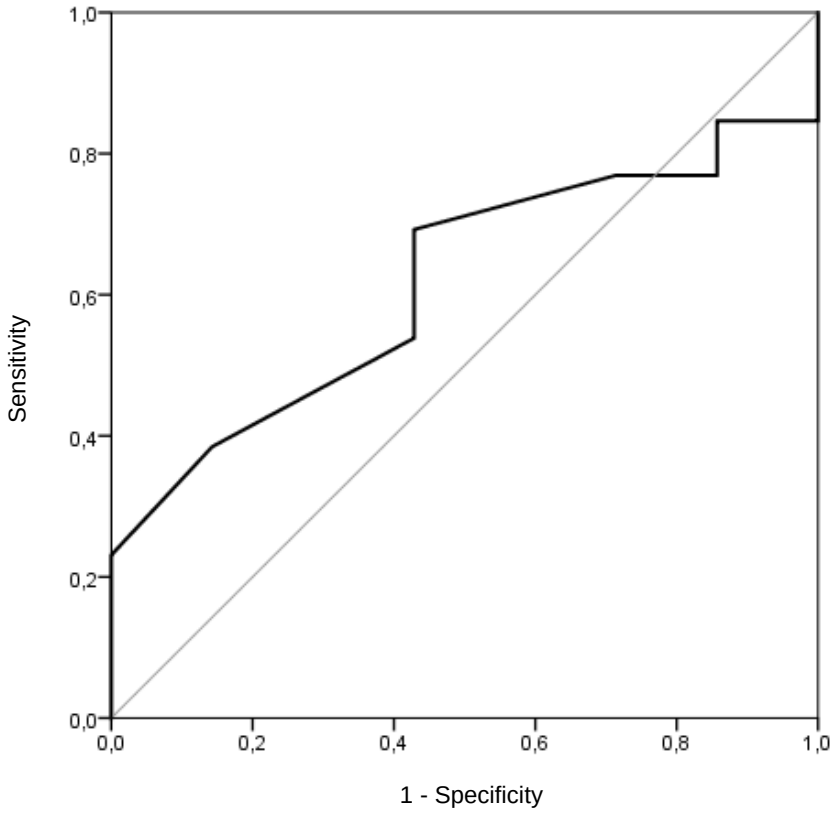
Table VI. *Questionnaire's answers and prevalence*

Questions	No periodontitis (n=13)	Periodontitis (n=7)	P*
Gender F/M	11/2 (84.6%/15.4%)	5/2 (71.4%/28.6%)	0.587
Age (year) < 35 35-65 >65	 2 (15.4%) 7 (53.8%) 4 (30.8%)	 0 (0.0%) 6 (85.7%) 1 (14.3%)	0.483
Body-mass Index (BMI) <25 25-30 >30	 8 (61.5%) 2 (15.4%(3 (23.1%)	 4 (57.1%) 2 (28.6%) 1 (14.3%)	0.837
Nutrition Unbalanced Normal	 1 (7.7%) 12 (92.3%)	 3 (42.9%) 4 (57.1%)	0.101
Years of Education University High School Middle School or less	 4 (30.8%) 2 (15.4%) 7 (53.8%)	 2 (28.6%) 0 (0.0%) 5 (71.4%)	0.808
Disease Unknown Depression, arthritis, arthritis or depression	 2 (15.4%) 11 (84.6%)	 3 (42.9%) 4 (57.1%)	0.290
Family/Parental History No	 10 (76.9%)	 6 (85.7%)	1.000

Yes	3 (23.1%)	1 (14.3%)	
Stress			
Low	7 (53.8%)	2 (28.6%)	0.233
Medium	2 (15.4%)	4 (57.1%)	
High	4 (30.8%)	1 (14.3%)	
Smoking Habits			
Non-smoker	10 (76.9%)	6 (85.7%)	1.000
Occasional or ex-smoker	1 (7.7%)	0 (0.0%)	
1o cigarettes/day	1 (7.7%)	0 (0.0%)	
Ex-heavy smoker or ≥ 10 cigarettes/day	1 (7.7%)	1 (14.3%)	
Alcohol			
Non or occasional	10 (76.9%)	5 (71.4%)	1.000
2-3 times/week	2 (15.4%)	1 (14.3%)	
≥ 4 times/week	1 (7.7%)	1 (14.3%)	
Dental care			
Regularly	2 (15.4%)	4 (57.1%)	0.233
Annually	7 (53.8%)	2 (28.6%)	
Avoidance	4 (30.8%)	1 (14.3%)	
Periodontal Therapy			
Never	13 (100%)	7 (100%)	-
Bleeding Gums			
No	10 (76.9%)	5 (71.4%)	1.000
Yes	3 (23.1%)	2 (28.6%)	
Exposed Root Surfaces			
No	12 (92.3%)	7 (100%)	1.000
Yes	1 (7.7%)	0 (0.0%)	
Tooth Mobility			
No	10 (76.9%)	6 (85.7%)	0.420
Position alteration	0 (0.0%)	1 (14.3%)	
Tooth loosening	1 (7.7%)	0 (0.0%(	
Tooth loss based on mobility	2 (15.4%)	0 (0.0%)	
Dental Prosthetics			
None	6 (46.2%)	4 (57.1%)	0.827
Fixed	1 (7.7%)	1 (14.3%)	
Removable	6 (46.2%)	2 (28.6%)	
Total Score (mean ± standard deviation)	**17.08 ± 6.73**	**15.57 ± 4.43**	**0.603[#]**

* Fisher's Exact Test; [#] T-student test for independent samples

Figure 3. *ROC curve*



3.3. Discussion

A pilot study is a small-scale version of the planned study conducted with a small group of participants similar to those to be recruited later in the larger scale study. This particular pilot study is comprised of a small sample of 20 participants. However, sample size should not be discouraging, since a well-designed and well-conducted pilot study is an important step in research that should not be overlooked, allowing researchers to assess the effectiveness of their planned data collection and analysis techniques, as well as detect anticipated problems with methods so changes can be made before the large-scale study is undertaken. (60)

Since there is a major discrepancy in study design and results concerning the addition of risk factors and indicators for periodontitis, an intentional and relatively rough subdivision of the point values was chosen, similarly to Renatus *et al.* (26), for the individual response options concerning the alleged degree of influence, ranging from zero to three. This means that indicators we assume are more related to periodontitis and present risk factors to its development are graded with three points, and so on; the greater the number of points the greater the assumed relation between the question to periodontitis, and the greater the total score of the questionnaire, the greater the probability of having periodontitis. The only exception was made in the evaluation of age, in which points were awarded from zero, to five and up to eight, since it is suspected that the patients' age acts as a multiplier of existing risk factors. (26)

As stated before, none of the questions showed good validity predicting periodontitis, and had no statistical significance. This can be attributed to many factors. The one we consider to be the culprit is the sample size used, but not the recruitment process, nor the analysis technique performed.

Furthermore, the AUC of 0,615 indicates a low discriminative capacity for the diagnosis of periodontitis with no statistical value, hence theoretically this questionnaire shows no capacity to diagnose periodontitis.

In fact, since this questionnaire was adapted from another that showed good accuracy and discriminatory power when diagnosing periodontitis, it was expected that the same would happen when we applied this questionnaire, or, at the very least, that the questions that showed greater power when predicting periodontitis in the other questionnaire – the ones regarding age, gender, BMI, nutrition, smoking behavior, family history, level of education, gum bleeding, exposed root surface, tooth loss and prior periodontal treatment – would be the ones that showed good values in this one. In the present study these associations could not be verified.

The underlying question for a pilot study is whether a larger study is practical. Despite the results shown here, we consider a larger study with a greater sample is in order.

Additionally, the main purpose of this questionnaire was to assess its capacity to diagnose periodontitis, in order to apply it in the future to a high-risk population, comprised by patients with rheumatoid arthritis, since it is hypothesized that self-perceived oral health and periodontal status are worse in patients with both periodontitis and RA compared to patients with periodontitis but without RA (61). Ultimately, this questionnaire would be applied by general medical practitioners in this high-risk population to correctly identify the ones at risk of having periodontitis, and hence forward them to a specialist, assuring correct and adequate care.

In a way, a successful pilot study does not assure the success of the full-scale study, then maybe an unsuccessful pilot study with great potential if applied to a larger population may have better results as a full-scale study.

4. Conclusion

The present systematic review update and pilot study showed that the use of self-reported periodontal disease measures has inconsistent but promising results, and the combination of periodontal screening questions with risk factors and socio-demographic characteristics may improve the capacity and accuracy to correctly diagnose periodontitis.

In fact, we found that demographic features (age, gender, smoking history, educational level), patient self-reported symptoms (tooth mobility, gum bleeding, root surface) and treatment history were predictive for periodontitis in most studies analyzed.

Self-reported measures may also be used to widen surveillance of periodontal disease among large adult populations when clinically based screening is unavailable or when a patient does not visit a dental professional because of economic or access to dental care.

Additionally, self-assessed intervention can result in a positive cognitive change with associated behavioral changes, since it forces people to come face-to-face with their disease. Plus, assuming there is a behavioral change, then maybe an improvement of periodontal status will also follow.

Finally, a screening test comprised of a questionnaire used by different clinicians could allow the correct and early diagnosis of periodontitis, especially in high risk populations, ensuring that they are directed to a specialist. It would also increase awareness and acceptance of prevention measures.

We are hopeful that in the future it will be possible to have a standardized self-report questionnaire that takes into account cultural and socio-demographic differences and includes the main periodontitis' predictors, being able to correctly and accurately diagnose periodontitis, and, thus, applied to high-risk populations such as Rheumatoid Arthritis' population.

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V. Appendix

Table V. *Publications excluded*

First Author (Year)	Type of Study	Reason for Exclusion
Mehmood *et al.* (2018)	Cross-sectional case-control	The main concern is not to diagnose periodontitis via self-report measures, but to evaluate its presence amongst intravenous heroin addicts
Javed *et al.* (2017)	Pilot Study	The main concern is not to diagnose periodontitis via self-report measures, but to evaluate its presence amongst cigarette-smoker individuals versus vaping-electronic cigarettes and never smokers
Quiroz *et al.* (2017)	Cross-sectional	Focus its attention on gingivitis, not periodontitis
He *et al.* (2017)	Cross-sectional	All patients were already diagnosed with periodontitis
Shizuma *et al.* (2017)	Cross-sectional	Only evaluates presence of bacterial plaque and gingivitis, not periodontitis
Weatherspoon *et al.* (2016)	Cross-sectional sub-study from cohort	No validation of self-report questionnaire was performed
Stelmakh *et al.* (2016)	Cross-sectional	The main concern is not to diagnose periodontitis via self-report measures, but to evaluate its presence amongst Dutch pregnant women

4.1. Doença Periodontal Auto-reportada

4.1.1. Questionário Doença Periodontal auto-reportada

(1) Sim ☐

(2) Não ☐

1. Sexo Masculino ou Feminino		**Score**
Feminino		0
Masculino		2
2. Idade		
Menos de 35		0
35-65		5
Mais de 65		8
3. Índice de Massa Corporal (____kg; _____m)		
Abaixo de 25		0
25-30		1
Mais de 30		2
4. Como descreveria os seus hábitos alimentares?		
Como de forma irregular e com pouca variedade		2
A minha dieta é normal		1
Mantenho uma dieta equilibrada e preocupo-me com a forma como a minha comida é preparada		0
5. Qual a sua escolaridade?		
9º ano ou menos		3
12º ano		1
Licenciatura/Mestrado/Doutoramento		0
6. Sofre de alguma destas doenças? (Pode assinalar várias respostas)		
Diabetes		3
Osteoporose		2
Doença cardíaca		1
Artrite Reumatóide		2
Depressão		2
Desconhece		0
7. Alguém na sua família (pais ou irmãos) sofrem de doença das gengivas?		
Sim		1
Não		0
8. Até que ponto acredita que sofre de stress crónico? (relacionado com o trabalho, família ou stress social)		
Não muito		0
Moderadamente		1
Severamente		2

FASE I

4. Questionário doença periodontal auto-reportada

CÓDIGO DE ESTUDO: _____

9. Relativamente ao seu comportamento tabágico		
Nunca fumei		0
Fui fumador ou sou fumador ocasional		1
Já fui um fumador pesado		3
Fumo até 10 cigarros por dia		2
Fumo mais de 10 cigarros por dia		3
10. Relativamente ao seu comportamento alcoólico		
Nunca bebi álcool, ou bebo muito raramente		0
Bebo álcool de forma mais frequente (2-3 vezes por semana)		1
Bebo frequentemente álcool (pelo menos 4 vezes por semana)		2
11. Com que frequência vai ao Dentista?		
Tento evitar ir ao Dentista		2
Vou anualmente para um check-up		1
Vou regularmente e faço limpezas dentárias profissionais		0
12. Alguma vez as suas gengivas foram tratadas?		
Nunca recebi tratamento		1
O meu último tratamento às gengivas foi há mais de 10 anos		3
Já recebi tratamento, mas não faço controlos regulares		2
Já recebi tratamento e desde aí que faço controlos regulares		0
13. Detectou algum aumento de hemorragia das suas gengivas?		
Sim		2
Não		0
14. Detectou algum aumento da exposição das raízes dos seus dentes?		
Sim		2
Não		0
15. Relativamente à mobilidade dos seus dentes:		
Nunca notei um aumento da mobilidade dos meus dentes		0
A posição dos meus dentes mudou		1
Alguns dentes estão "a abanar"		2
Já perdi dentes devido ao aumento da sua mobilidade ou a problemas gengivais		3
16. Relativamente à utilização de próteses dentárias:		
Não tenho quaisquer próteses dentárias		0
Tenho algumas coroas, pontes ou implantes		1
Tenho próteses removíveis		3
SCORE TOTAL		

VI. Acknowledgements

À minha orientadora, Prof. Doutora Isabel Poiares Baptista, que aceitou o desafio. Pela boa disposição e palavras de encorajamento, e pelo à vontade que sempre me deu para esclarecer qualquer dúvida.

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Às minhas companheiras de Tese, sem vocês o desespero, a vontade de bater com a cabeça no computador, e a busca do melhor cafezinho ou a melhor biblioteca para dar o corpo ao manifesto, não seria a mesma coisa. Uma amêndoa.

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A Coimbra… Até sempre!

(Até já, sou conimbricense)

VII. Index of Figures and Tables

VIII. Index