



Oral health complications in Brazilian and French diabetic older people: A comparative study

Danilo L.F. Lima^{a,b}, Maria V.L. Saintrain^a, Giovanna R. Neri^{a,b,*}, Oscar Beck^c, Pierre Malet^c, Jean A.H. Moizan^c, Jean Doucet^d

^a School of Dentistry, University of Fortaleza – UNIFOR, Fortaleza, Brazil

^b School of Dentistry, Christus University Center – UNICHISTUS, Fortaleza, Brazil

^c Dental Care Department, Rouen University Hospital, Saint Julien Hospital, Rouen, France

^d Department of Internal Medicine, Geriatrics and Therapeutics, Saint Julien Hospital, Rouen University Hospital, Rouen, France

ARTICLE INFO

Keywords:

Epidemiology
Diabetes mellitus
Oral health
Older adults
Comparative study

ABSTRACT

Introduction: Diabetes mellitus (DM) is a risk factor for periodontitis for over 40 years and novel evidence suggests that periodontitis has an impact on glycemic control in patients with diabetes. This study aimed to compare oral health complications in diabetic older patients from Brazil and France.

Methods: This cross-sectional study included 120 patients aged 65 and over diagnosed with type 2 diabetes. Sixty patients were admitted to a center for diabetes and hypertension care in Brazil and 60 patients were admitted to the Rouen University hospital. Dental conditions were assessed through the decayed, missing and filled teeth index and periodontal condition was assessed using the Community Periodontal Index. The significance threshold was $p < 0.05$.

Results: Decayed teeth differed statistically between the groups ($p = 0.001$). The French group presented more tooth mobility, gingival recession and furcation involvement ($p < 0.001$). Tooth brushing frequency differed significantly between the groups ($p < 0.030$). The main cause of missing teeth was periodontitis in the French group and caries and periodontitis in the Brazilian group ($p < 0.001$). Statistical significance was found for use of fixed upper ($p = 0.013$) and lower ($p = 0.013$) dentures in the French group. The French group needed upper denture rehabilitation ($p = 0.010$) while the Brazilian group needed lower denture rehabilitation ($p = 0.003$).

Conclusion: Edentulism was prevalent in diabetic older people in both countries. However, the French participants presented with better oral health.

1. Introduction

The world's older population continues to grow, and the proportions of older people increase in many countries every year. This includes a large number of countries, regardless of their level of development (United Nations, 2015). This phenomenon has been linked to reasons such as economic evaluation and better educational situations and their impact on health care (Dang, Likhari, & Alok, 2016; Kinge et al., 2015).

The ultimate concern of the present time is not with living longer, but with the quality of such longevity. Aging with quality of life requires the adoption of a healthy lifestyle to prevent the early onset of certain chronic diseases (Marques, Schneider, & D'orsi, 2016). However, it is known that the longer the life of an individual, the greater the chances of developing chronic diseases that affect their functional capacity and generate associated comorbidities (Palma et al., 2014).

The majority of the studies (21/28) analyzed in a systematic review reported that more than half of people with diabetes were unaware of the link between diabetes and oral health and their increased risk for oral health complications (Poudel et al., 2018).

Thus, the established link between diabetes and oral health calls for increased effort to study ways to control both diseases, particularly among populations with health disparities and limited access to oral and health care (Leite, Marlow, Fernandes, & Hermayer, 2013).

Diabetes mellitus (DM) is one of the most common aging-associated chronic diseases affecting the adult population worldwide. According to the World Health Organization Global Report on Diabetes, the estimated prevalence of adults with DM was 8.3% in the Americas and 7.3% in Europe in 2014. In addition, the report revealed that circa 422 million people had diabetes in 2014 (World Health Organization, 2016).

* Corresponding author at: University of Fortaleza, School of Dentistry, Washington Soares Avenue 1321, 60.811-905, Fortaleza, CE, Brazil.
E-mail address: jiovanna@hotmail.com (J.R. Neri).

<https://doi.org/10.1016/j.archger.2019.103905>

Received 26 March 2019; Received in revised form 10 June 2019; Accepted 26 June 2019

Available online 27 June 2019

0167-4943/ © 2019 Elsevier B.V. All rights reserved.

DM is traditionally recognized as a risk factor for macrovascular complications (coronary heart disease, cerebrovascular disease and peripheral vascular disease), microvascular complications (retinopathy, nephropathy and neuropathy), and, in the older population, geriatric syndromes including impairment of multiple physiologic systems that can lead to functional disability, frailty, falls, depression, dementia, and incontinence (Corriere, Rooparinesingh, & Kalyani, 2013).

Oral cavity is also affected by DM through different mechanisms. The main oral disease associated with diabetes is periodontitis (Bascones-Martínez, Arias-Herrera, Criado-Cámara, Bascones-Ilundáin, & Bascones-Ilundáin, 2012). Periodontitis is the inflammation of the gingiva and the adjacent attachment apparatus caused by specific types of bacteria and is characterized by loss of clinical attachment due to destruction of the periodontal ligament and its adjacent alveolar bone (American Academy of Periodontology, 2000). This complication is one of the main causes of tooth loss. Over the last 30 years, extensive studies have associated periodontitis with coronary artery disease (Orlandi et al., 2014), premature and low birth weight babies (Basha, Shivalinga Swamy, & Noor Mohamed, 2015), and nosocomial pneumonias (Souto, Silva-Boghossian, & Colombo, 2014).

DM has been recognized as a risk factor for periodontitis for over 40 years and novel evidence suggests that periodontitis has an impact on glycemic control in patients with diabetes (Costa et al., 2017). In addition to periodontitis, diabetic patients may present a decrease in salivary flow, xerostomia, and mucosal lesions (Takeuchi et al., 2015; World Health Organization, 2013).

The present study aimed to compare oral health complications in diabetic older patients from Brazil (Fortaleza Hospital, Ceará, Brazil) and France (Rouen University Hospital, Normandy, France).

2. Methods and materials

The study was approved by the Ethics Committee of the University of Fortaleza under Approval No. 788.534. All the procedures performed in the present study involving human participants were in accordance with the ethical standards of the national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

This quantitative cross-sectional study included 120 patients aged 65 and over, of both genders (women – 50%), who had been diagnosed with type 2 diabetes for at least one year. Sixty patients were enrolled for treatment at the Integrated Center for Diabetes and Hypertension of Ceará (CIHD), a center of excellence and reference in the care of patients with hypertension and diabetes in the city of Fortaleza, Ceará, Northeastern Brazil. The other 60 patients were consecutively recruited from the Department of Internal and Geriatric Medicine of the Rouen University hospital.

Sociodemographic data (gender, profession, marital status, education, employment status, household income, tobacco use, and social security) were collected in addition to specific information. Dental conditions were assessed through the decayed, missing and filled teeth index (DMFT index). The score range 0–32 was used to determine dental conditions.¹⁸ Functional tooth units and cause of missing teeth were also investigated. Use of complete upper and lower dentures, use of removable upper and lower dentures, use of fixed upper and lower dentures, need for upper and lower prosthetic rehabilitation, frequency of denture cleaning, and frequency of tooth brushing were also assessed.

Examination of periodontal condition was carried out using the Community Periodontal Index (CPI), an indicator recommended by the World Health Organization. CPI assessment was carried out using a periodontal probe with a ball tip of 0.5 mm, with a black band between 3.5 mm and 5.5 mm, as well as black rings at 8.5 mm and 11.5 mm. Six registrations were made, one for each sextant, indicating the highest score in the appropriate field using the codes: 0- healthy sextant; 1-

Table 1

Distribution of socioeconomic parameters of diabetic elderly according to place of origin.

Variables	Fortaleza n = 60	Rouen n = 60	PR (95%CI)	p- value
Gender				
Female	30 (50)	30 (50)	1 (0.7–1.43)	1.000 ^a
Male	30 (50)	30 (50)	1	
Age groups				
65–74 years	34 (56.7)	15 (25.0)	6.01 (2.04–17.72)	< 0.001
75–84 years	23 (38.3)	22 (36.7)	4.43 (1.47–13.33)	
85 or older	3 (5.0)	23 (38.3)	1	
Level of Education				
Illiterate	10 (16.7)	2 (3.3)	1.25 (0.74–2.12)	0.054 ^b
Primary	38 (63.3)	48 (80.0)	0.66 (0.39–1.11)	
Secondary	6 (10.0)	7 (11.7)	0.69 (0.33–1.46)	
Higher education	6 (10.0)	3 (5.0)	1	

^a Chi-square test.

^b Fisher's exact test.

sextant with bleeding; 2- calculus; 3- pocket from 4 to 5 mm (gingival margin in the black area of the probe); 4- pocket of 6 mm or more (black area of the probe is not visible); X- excluded sextant (less than two teeth).¹⁸ Asterisk is used when there is mobility, gingival recession, and furcation involvement.

All the data were collected by four examiners (two from France and two from Brazil) who received extensive training in Brazil and were accompanied by other trained personnel at all times to ensure accuracy and consistency in data collection.

The data were tabulated and statistical calculations were performed using the Statistical Package for the Social Sciences (SPSS), version 22.0 (SPSS Inc., Chicago, USA). The older patients with diabetes from Fortaleza and Rouen were compared using the Chi-squared test and the Fisher's exact test for categorical variables and the Mann-Whitney test for numerical variables. The significance threshold was set at $p < .05$.

3. Results

Participants' mean age was 77.1 ± 7.9 years (73.8 ± 6.4 in the Brazilian group and 80.4 ± 7.9 in the French group). The French group was significantly older (Table 1). The percentages of patients who received insulin did not differ between the 2 groups (around 73%).

The mean number of teeth was 9.0 ± 8.5 : 7.5 ± 8.4 in the Brazilian group and 10.6 ± 8.7 in the French group ($p = 0.047$). Only the parameter decayed teeth differed statistically between the French group and the Brazilian group ($p = 0.001$). With regard to the number of existing teeth, the French participants had more teeth ($p = 0.047$) and more teeth in the maxillary jaw than the Brazilian participants ($p = 0.010$) (Table 2).

The CPI results showed a worse periodontal condition in the French group compared to the Brazilian group. The French group presented with more periodontal pockets (CPI 3 and 4) compared to the Brazilian group. The latter presented a predominance of local plaque retentive factors such as calculus (CPI 2). The number of missing teeth was high in almost all sextants, except in the 5th sextant in both countries. The French participants presented more tooth mobility, gingival recession and furcation involvement than the Brazilian participants ($p < 0.001$) (Table 3).

The tooth brushing frequency among older adults from Fortaleza was significantly different from that among older adults from Rouen ($p < 0.030$). The main cause of missing teeth was periodontitis in the French group and caries and periodontitis in the Brazilian group ($p < 0.001$) (Table 4).

With regard to the prosthetic status and the need for prosthetic

Table 2
Distribution of the DMFT index and mean of teeth present in older people with diabetes according to place of origin.

DMFT	Fortaleza	Rouen	Total	p-value
Decayed	0.5 ± 1.2	1.7 ± 2.9	1.1 ± 2.3	0.001
Missed	24.2 ± 8.1	21.3 ± 8.7	22.8 ± 8.5	0.065
Filled	2.6 ± 3.8	3.1 ± 4.1	2.8 ± 3.9	0.317
General Index	27.1 ± 5.4	25.8 ± 6	26.5 ± 5.7	0.234

Teeth	Fortaleza	Rouen	Total	p-value
Maxillary jaw	2.7 ± 4.3	4.6 ± 4.4	3.6 ± 4.4	0.010
Mandibular jaw	4.8 ± 4.5	6.0 ± 5.1	5.4 ± 4.8	0.170
Total	7.5 ± 8.0	10.6 ± 8.7	8.7 ± 8.5	0.047

Mann-Whitney Test.

rehabilitation in the older adults analyzed, statistical significance was found for use of fixed upper (p = 0.013) and lower (p = 0.013) dentures in the French group. On the other hand, the Brazilian group presented with statistical significance for use of complete upper denture (p = 0.028). The French group needed upper denture rehabilitation (p = 0.010), while the Brazilian group needed lower denture rehabilitation (p = 0.003) (Table 5).

4. Discussion

DM is one of the major chronic diseases affecting older people and one of the most important epidemic diseases of this century. According to the International Diabetes Federation, the prevalence of DM among adults in France is 7.4%. In that country, DM is one of 30 chronic diseases fully covered by the statutory health insurance (SHI) based on the French “ALD” (*affections de longue durée*) scheme (Chevreul, Brigham, & Bouché, 2014). In Brazil, 10.3% of the population is estimated to have diabetes – the country ranks 4th in disease prevalence and has an estimated 13.4 million diabetic inhabitants. It is estimated that the number of Brazilians over 65 years old with diabetes exceeds 20% of the population (Mendes et al., 2011). In older people, diabetes has been associated with major geriatric syndromes and increased risk of premature death (Prado, Francisco, & Barros, 2016; Telo et al., 2016). The analysis of the health care of older diabetic patients now consider both diabetic and geriatric parameters, but rarely the oral health status (Doucet, Le Floch, Bauduceau, & Verny, 2012).

Table 3
Distribution of the CPI Index in older people with diabetes according to place of origin.

Sextant	Place	CPI						p-value
		0	1	2	3	4	Missing	
1th	Fortaleza	3.3	5.0	25.0	1.7	1.7	63.3	0.090 ^a
	Rouen	0.0	0.0	10.0	11.7	6.7	71.7	
2nd	Fortaleza	1.7	13.3	15.0	3.3	0.0	66.7	0.076 ^a
	Rouen	10.0	5.0	13.3	23.3	5.0	43.3	
3rd	Fortaleza	1.7	1.7	23.3	6.7	1.7	65.0	0.284 ^a
	Rouen	0.0	1.7	3.3	25.0	1.7	68.3	
4th	Fortaleza	6.7	10.0	26.7	3.3	0.0	53.3	0.084 ^a
	Rouen	5.0	0.0	11.7	20.0	3.3	60.0	
5th	Fortaleza	8.3	8.3	43.3	3.3	0.0	36.7	0.069 ^a
	Rouen	3.3	0.0	33.3	20.0	8.3	35.0	
6th	Fortaleza	6.7	6.7	31.7	0.0	0.0	55.0	0.113 ^a
	Rouen	5.0	1.7	8.3	21.7	3.3	60.0	
Asterisk	Fortaleza	Rouen		PR (95%CI)				< 0.001 ^b
Yes	21 (35.0)	40 (66.7)		052 (0.35–0.77)				
No	39 (65.0)	20 (33.3) 1						

^a Mann-Whitney Test.

^b Chi-square test.

Table 4
Distribution of functional dental units, cause of missing teeth, tooth brushing frequency, denture brushing frequency and tobacco use in older people with diabetes according to place of origin.

Variables	Fortaleza n = 60; %	Rouen n = 60; %	PR (95%CI)	p-value
Functional dental units				
0	42 (70.0)	30 (50.0)	175 (1.04–2.95)	0.057 ^a
< 4	7 (11.7)	8 (13.3)	1,4 (0.68–2.89)	
> 4	11 (18.3)	22 (36.7)	1	
Cause of missing teeth				
Caries	30 (50.0)	23 (38.3)	623 (1.63–23.83)	< 0.001 ^a
Both (caries and periodontitis)	28 (46.7)	17 (28.3)	684 (1.79–26.16)	
Periodontitis	2 (3.3)	20 (33.3)	1	
Tooth brushing frequency				
Once a Day	38 (100.0)	38 (84.4)	–	< 0.030 ^b
Once a week	–	4 (8.9)	–	
Never	–	3 (6.7)	–	
Denture brushing frequency				
Once a Day	53 (100.0)	34 (97.1)	–	0.398 ^b
Once a week	–	1 (2.9)	–	
Tobacco use				
Never smoked	39 (65)	32 (53.3)	–	0.063 ^b
Ex-smoker	21 (35)	23 (38.3)	–	
Smoker	–	5 (8.4)	–	

^a Chi-square test.

^b Fisher’s exact test.

The comparative analysis of the oral health complications in Brazilian and French older people with diabetes mellitus (DM) is a highlight of the present study, which analyzes variables related to the social and epidemiological aspects of the two countries.

Diabetes has been recognized for its impact on oral health. The disease has been associated with xerostomia and oral candidiasis. However, periodontitis is the most common pathology associated with DM, which has been recognized as one of its risk factors (Yamashita, Moura-Grec, Capelari, Sales-Peres, & Sales-Peres, 2013). In addition, individuals affected by diabetes show a deterioration of glycemic control if also affected by periodontitis and significantly higher prevalence

Table 5
Distribution of denture use and need for denture rehabilitation in older people with diabetes according to place of origin.

Variables	Fortaleza n = 60	Rouen n = 60	RP (IC 95%)	Valor p
Upper TP				
Yes	34 (56.7)	22 (36.7)	1.49 (1.04–2.15)	0.028^a
No	26 (43.3)	38 (63.3)	1	
Upper RP				
Yes	16 (26.7)	12 (20)	1.19 (0.81–1.76)	0.388 ^a
No	44 (73.3)	48 (80)	1	
Upper FP				
Yes	–	7 (11.7)	–	0.013^b
No	60 (100)	53 (88.3)	–	
Need for upper denture rehabilitation				
Yes	8 (13.3)	20 (33.3)	0.51 (0.27–0.93)	0.010^a
No	52 (86.7)	40 (66.7)	1	
Lower TP				
Yes	11 (18.3)	13 (21.7)	0.9 (0.56–1.45)	0.648 ^a
No	49 (81.7)	47 (78.3)	1	
Lower RP				
Yes	11 (18.3)	13 (21.7)	0.9 (0.56–1.45)	0.648 ^a
No	49 (81.7)	47 (78.3)	1	
Lower FP				
Yes	–	7 (11.7)	–	0.013^b
No	60 (100)	53 (88.3)	–	
Need for lower denture rehabilitation				
Yes	38 (63.3)	22 (36.7)	1.73 (1.18–2.54)	0.003^a
No	22 (36.7)	38 (63.3)	1	

TP (total prosthesis); RP (removable prosthesis); FP (fixed prosthesis).

^a Chi-square test.

^b Fisher's exact test.

of diabetes-related complications (Graziani, Gennai, Solini, & Petrini, 2018).

Over the past years, studies have demonstrated a bidirectional relationship between DM and periodontitis, i.e., the hypothesis that diabetic people with periodontitis have a worse glycemic control has been tested (Casanova, Hughes, & Preshaw, 2014). Periodontitis is one of the leading causes of tooth loss in older people. Considering that aging is also a risk factor for periodontitis, the group assessed in the present study was at an increased risk of presenting a worse condition and a higher possibility of tooth loss (Natto, Aladmawya, Alasqaha, & Papasc, 2014). However, it should be considered that the French group – despite having an older mean age – presented a significant reduction in tooth loss in the maxillary jaw ($p = 0.010$). This implies greater possibility of periodontal disease.

The Brazilian respondents reported having lost teeth mostly due to caries while the French participants claimed to have lost teeth mostly due to periodontitis or the association of the two pathologies ($p < 0.001$). Tooth loss due to dental caries usually occurs in younger people. On the other hand, tooth loss due to periodontal disease occurs, preferably, among older people. Such a situation may be associated with differences in the dental health care between the two countries.

With regard to people aged 65 or older, the Brazilians in this age group had less access to dental treatments. The country could only experience a more effective oral health program with the inclusion of the oral health team in the Family Health Strategy in 2000 and the creation of the Dental Specialties Centers by the National Oral Health Policy – Smiling Brazil Project – in 2004. All these programs are linked to Brazil's National Health Care System, also known as the Unified Health System (*Sistema Único de Saúde – SUS*) (Antunes & Narvai, 2010).

In contrast, access to dental treatment provided by France's public health system has existed for decades, which explains the low number of missing teeth assessed through the DMFT index. However,

improvements in Brazil's public health system can be observed through the significantly lower number of decayed teeth found in the Brazilian older people with diabetes ($p = 0.001$); these people have access to dental treatment in the health care center where they receive diabetes treatment (Table 2).

Tooth loss should not be considered a result of the most prevalent oral diseases – caries and periodontal disease – only, but also a consequence of a person's oral health care throughout life and a reflection of socioeconomic and cultural factors (Souza et al., 2016). Brazil's economic development over the last two decades and more effective preventive actions such as water fluoridation and the presence of fluoride in almost all types of dentifrice have improved the oral health conditions of the population (Leitão et al., 2012). Thus, the Brazilian older people were more vulnerable to tooth loss.

Dental calculus was higher in Brazilians when compared to the French participants. The latter presented more periodontal pockets and statistical significance ($p < 0.001$) for the presence of tooth mobility, gingival recession and furcation involvement assessed through the CPI index.

The aggravation of periodontitis – an infectious disease – can be prevented through dental plaque control. The French participants presented a significantly lower frequency of tooth brushing ($p < 0.030$). This situation may also be associated with aging. Older people are more likely to present more functional problems, which can lead to greater dependence in activities of daily living, including body hygiene activities (Colón-Emeric, Whitson, Pavon, & Hoenig, 2013; Saintrain et al., 2018).

The rehabilitation of edentulous people through the Smiling Brazil Project – considered the largest oral health program in the world – allowed many to have access complete dentures, which explains the significantly higher number of complete upper dentures found in Brazilian older people ($p = 0.028$) in the present study. An increased need for lower denture was also found among Brazilians ($p = 0.003$) and is line with studies carried out in the country (Leitão et al., 2012; Mesas, Andrade, & Cabrera, 2006). Such a situation may occur due to retention and adaptation problems related to complete lower dentures, which lead older people to abandon their use (Souza et al., 2016).

The findings show that the French participants had more teeth and, significantly, more fixed dentures ($p = 0.013$). This is probably because of their easier access to oral health care due to better economic issues and an effective oral health system that has been running on for a long time.

The significant differences found between older age groups points to an increased life expectancy in France of 83 years (79 years for men and 86 for women) (World Health Organization Regional Office for Europe, 2017). In Brazil, life expectancy is 75 years (71 for men and 79 for women). Although much smaller than in France, the growth in the number of older people aged 65 and over in Brazil has almost doubled in 20 years – 4.8% in 1991, 5.9% in 2000, and 7.4% in 2010 (Duarte & Barreto, 2012; World Health Organization Website, 2017).

According to estimates from WHO, France spends 12% of its Gross Domestic Product (GDP) on health while Brazil's total expenditure is 8.3% of its GDP (Mesas et al., 2006; World Health Organization Regional Office for Europe, 2017). The amount each country invests in its health system is of the utmost importance for the well-being of the population. Brazil is a continental and complex country that has undergone an abrupt epidemiological change. While France waited 115 years to see its older population double (from 7.0% to 14.0%), Brazil took only 40 years to see the same change (from 5.1% to 10.8%). France has, historically, one of the most efficient public health systems in the world, which has already been considered the best public health system in the world by WHO (World Health Organization, 2000). However, regardless of the level of development of each country, the fact that people are increasingly aging stands out as a warning to governments about the health burden and social security of this population.

Differences in education level should be highlighted. Brazil stands out for a higher percentage of illiterate older people (16.7% versus 3.3%) and a lower percentage of older people with elementary education (63.3% versus 80.0%) compared to France. A person's education level has a direct impact on health care and is one of the factors that determine the onset of diseases (Zimmerman, Woolf, & Haley, 2015). The vast majority of reports and surveys conclude that people with higher levels of education are healthier and live longer (Baker, Leon, Greenaway, Collins, & Movit, 2011).

The demographic transition, triggered by different factors such as decreased fertility and mortality rates and, especially, improved living conditions, has led to the replacement of infectious diseases by chronic and degenerative diseases – such as DM – as major causes of death. In this context, variables such as age, systemic health and education are key to understanding the trends in the oral health status of older people with DM between the two populations, since they are determining factors.

Because the examinations related to the present research coincided with the same period of medical appointments, many older people feared missing their consultations. Although this strategy was adopted to facilitate access to research, both the Brazilian and French older people presented difficulties in adhering to the examinations. In addition, the difficulties in performing oral examinations in older people resulted in a small sample, which can be considered a limitation of the present study. However, the methodological rigor adopted in the research allowed to assess oral health complications in older people with DM, highlighting the importance of attitudes towards oral health policies in both countries.

Further research could benefit from the valuable exchange of knowledge which can lead to successful interventions and feasible strategies to promote better access to health care, particularly oral health care, by older adults with chronic diseases.

5. Conclusion

The main oral health complication associated with diabetes mellitus in older people in both countries was edentulism. However, the French participants – despite being older – presented with better oral health than their Brazilian peers. The French presented greater number of teeth and greater rehabilitation with the use of dentures. Such a situation may be a result of a public health system that has been internationally recognized as one of the best in the world. The different aspects shared by both countries, demonstrated by equality in oral conditions, reflect a progress in oral health care in Brazil, especially over the last 15 years.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Antunes, J. L. F., & Narvai, P. C. (2010). Políticas de saúde bucal no Brasil e seu impacto sobre as desigualdades em saúde. *Revista de Saude Publica*, 44, 360–365.

Baker, D. P., Leon, J., Greenaway, E. G. S., Collins, J., & Movit, M. (2011). The education effect on population health: A reassessment. *Population and Development Review*, 37, 307–332.

Bascones-Martínez, A., Arias-Herrera, S., Criado-Cámara, E., Bascones-Ilundáin, J., & Bascones-Ilundáin, C. (2012). Periodontal disease and diabetes. *Advances in Experimental Medicine and Biology*, 771, 76–87.

Basha, S., Shivalinga Swamy, H., & Noor Mohamed, R. (2015). Maternal periodontitis as a possible risk factor for preterm birth and low birth weight—a prospective study. *Oral Health & Preventive Dentistry*, 13, 537–544.

Casanova, L., Hughes, F. J., & Preshaw, P. M. (2014). Diabetes and periodontal disease: A two-way relationship. *British Dental Journal*, 217, 433–437.

Chevreur, K., Brigham, K. B., & Bouché, C. (2014). The burden and treatment of diabetes in France. *Globalization and Health*, 10, 6.

Colón-Emeric, C. S., Whitson, H. E., Pavon, J., & Hoenig, H. (2013). Functional decline in

older adults. *American Family Physician*, 88, 388–394.

Corriere, M., Rooparinesingh, N., & Kalyani, R. R. (2013). Epidemiology of diabetes and diabetes complications in the elderly: An emerging public health burden discussion. *Current Diabetes Reports*, 13, 1–14.

Costa, K. L., Taboza, Z. A., Angelino, G. B., Silveira, V. R., Montenegro, R. J. R., Haas, A. N., et al. (2017). Influence of periodontal disease on changes of glycated hemoglobin levels in patients with type 2 diabetes mellitus: A retrospective cohort study. *Journal of Periodontology*, 88, 17–25.

Dang, A., Likhari, N., & Alok, U. (2016). Importance of economic evaluation in health care: An Indian perspective. *Value in Health Regional Issues*, 9, 78–83.

Doucet, J., Le Floch, J. P., Bauduceau, B., & Verny, C. (2012). GERODIAB: Glycaemic control and 5-year morbidity/mortality of type 2 diabetic patients aged 70 years and older: Description of the population at inclusion. *Diabetes & Metabolism*, 38, 523–530.

Duarte, E. C., & Barreto, S. M. (2012). Transição demográfica e epidemiológica: a Epidemiologia e Serviços de Saúde revisita e atualiza o tema. *Epidemiologia E Serviços de Saude: Revista Do Sistema Unico de Saude Do Brasil*, 21, 529–532.

Data and Statistics: France (2017). *World health organization regional office for Europe website*. (Accessed 1 February 2017) <http://www.euro.who.int/en/countries/france/data-and-statistics>.

Graziani, F., Gennai, S., Solini, A., & Petrini, M. (2018). A systematic review and meta-analysis of epidemiologic observational evidence on the effect of periodontitis on diabetes. *Journal of Clinical Periodontology*, 45, 167–187.

Kinge, J. M., Steingrimsdóttir, Ó. A., Moe, J. O., Skirbekk, V., Næss, Ø., & Strand, B. H. (2015). Educational differences in life expectancy over five decades among the oldest old in Norway. *Age and Ageing*, 44, 1040–1045.

Leitão, R. F. A., Azevedo, A. C., Bonan, R. F., Bonan, P. R. F., Forte, F. D. S., & Batista, A. U. D. (2012). Fatores Socioeconômicos Associados à Necessidade de Prótese, Condições Odontológicas e Autopercepção de Saúde Bucal em População Idosa Institucionalizada. *Pesquisa Brasileira em Odontopediatria e Clínica Integrada*, 12, 179–175.

Leite, R. S., Marlow, N. M., Fernandes, J. K., & Hermayer, K. (2013). Oral health and type 2 diabetes. *The American Journal of the Medical Sciences*, 345, 271–273.

Prado, M. A. M. B., Francisco, P. M. S. B., & Barros, M. B. A. (2016). Diabetes in the elderly: Drug use and the risk of drug interaction. *Ciencia & Saude Coletiva*, 21, 3447–3458.

Marques, L. P., Schneider, I. J., & D'orsi, E. (2016). Quality of life and its association with work, the Internet, participation in groups and physical activity among the elderly from the EpiFloripa survey, Florianópolis, Santa Catarina State, Brazil. *Cadernos de Saude Pública*, 32, 1–11.

Mendes, T. A. B., Goldbaum, M., Segri, N. J., Barros, M. B. A., Cesar, C. L. G., Carandina, L., et al. (2011). Diabetes mellitus: Factors associated with prevalence in the elderly, control measures and practices, and health services utilization in São Paulo, Brazil. *Cadernos de Saude Pública*, 27, 1233–1243.

Mesas, A. E., Andrade, S. M., & Cabrera, M. A. (2006). Condições de saúde bucal de idosos de comunidade urbana de Londrina, Paraná. *Revista Brasileira de Epidemiologia*, 9, 471–480.

Nattoa, Z. S., Aladmawya, M., Alasqaha, M., & Papasc, A. (2014). Factors contributing to tooth loss among the elderly: A cross sectional study. *Singapore Dental Journal*, 35(17), 22.

Orlandi, M., Suvan, J., Petrie, A., Donos, N., Masi, S., Hingorani, A., et al. (2014). Association between periodontal disease and its treatment, flow-mediated dilatation and carotid intima-media thickness: A systematic review and meta-analysis. *Atherosclerosis*, 236, 39–46.

Palma, R., Conti, M. H. S., Quintino, N. M., Gatti, M. A. N., Simeão, S. F. A. P., & Vitta, A. (2014). Functional capacity and its associated factors in the elderly with low back pain. *Acta Ortopedica Brasileira*, 22, 295–299.

Poudel, P., Griffiths, R., Wong, V. W., Arora, A., Flack, J. R., Khoo, C. L., et al. (2018). Oral health knowledge, attitudes and care practices of people with diabetes: A systematic review. *BMC Public Health*, 18, 577.

Saintrain, M. V. L., Saintrain, S. V., Sampaio, E. G. M., Ferreira, B. S. P., Nepomuceno, T. C., Frota, M. A., et al. (2018). Older adults' dependence in activities of daily living: Implications for oral health. *Public Health Nursing*, 35, 473–481.

Souto, R., Silva-Boghossian, C. M., & Colombo, A. P. (2014). Prevalence of Pseudomonas aeruginosa and Acinetobacter spp. in subgingival biofilm and saliva of subjects with chronic periodontal infection. *Brazilian Journal of Microbiology*, 45, 495–501.

Souza, J. G. S., Souza, S. E., Sampaio, A. A., Silveira, M. F., Ferreira, E. F., & Martins, A. M. E. B. L. (2016). Self-perception of the need for full dental prosthesis among toothless elderly Brazilians. *Ciencia & Saude Coletiva*, 21, 3407–3415.

Takeuchi, K., Furuta, M., Takeshita, T., Shibata, Y., Shimazaki, Y., Akifusa, S., et al. (2015). Risk factors for reduced salivary flow rate in a Japanese population: The Hisayama Study. *BioMed Research International*, 7, 1–8.

Telo, G. H., Cureau, F. V., Souza, M. S., Andrade, T. S., Copês, F., & Schaun, B. D. (2016). Prevalence of diabetes in Brazil over time: A systematic review with metaanalysis. *Diabetologia & Metabolic Syndrome*, 8, 65.

Yamashita, J. M., Moura-Grec, P. G., Capelari, M. M., Sales-Peres, A., & Sales-Peres, S. H. C. (2013). Manifestações bucais em pacientes portadores de Diabetes Mellitus: uma revisão sistemática. *Revista de Odontologia Da UNESP*, 42, 211–220.

Zimmerman, E. B., Woolf, S. H., & Haley, A. (2015). *Understanding the relationship between education and health: A review of the evidence and an examination of community perspectives*. Rockville: Agency for Healthcare Research and Quality Content last reviewed September 2015 Available at: <https://www.ahrq.gov/professionals/education/curriculum-tools/population-health/zimmerman.html> (Accessed 1 February 2017).

United Nations (2015). *World population ageing 2015: Highlights*. New York: United Nations.

World Health Organization (2016). *Global report on diabetes* Geneva: World Health

Organization.
American Academy of Periodontology (2000). Parameter on chronic periodontitis with advanced loss of periodontal support. *Journal of Periodontology*, 71, 856–858.
World Health Organization (2013). *Oral health surveys basic methods* (5th edition). Geneva: World Health Organization.

Statistics: Brazil (2017). *World health organization website*. (Accessed 1 February 2017) <http://www.who.int/countries/bra/en/>.
World Health Organization (2000). *Measuring overall health system performance for 191 countries*. Geneva: World Health Organization.