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**LUÍSA HELENA DO NASCIMENTO TÔRRES**

**FATORES DE RISCO PARA A SAÚDE GERAL E BUCAL EM  
IDOSOS INDEPENDENTES, COM ÊNFASE NO ESTADO  
NUTRICIONAL E NA FRAGILIDADE:  
ESTUDO DE COORTE DE BASE POPULACIONAL**

**RISK FACTORS FOR GENERAL AND ORAL HEALTH AMONG  
INDEPENDENTLY LIVING OLDER ADULTS WITH EMPHASIS ON  
THE NUTRITIONAL STATUS AND FRAILTY:  
A POPULATION-BASED COHORT STUDY**

PIRACICABA  
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UNIVERSIDADE ESTADUAL DE CAMPINAS  
FACULDADE DE ODONTOLOGIA DE PIRACICABA

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Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Doutora em Odontologia, na Área de Saúde Coletiva.

Thesis presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Doctor in Dentistry, in Public Health área.

Orientadora: Profa Dra Maria da Luz Rosário de Sousa

Coorientador: Prof Dr Fernando Neves Hugo

Este exemplar corresponde à versão final da tese defendida por Luísa Helena do Nascimento Tôrres e orientada pela Profa. Dra. Maria da Luz Rosário de Sousa

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## Resumo

O objetivo deste estudo foi avaliar determinantes de agravos à saúde geral e bucal em uma coorte de idosos independentes residentes em Carlos Barbosa, RS. No capítulo 1 foi realizada uma revisão sistemática para verificar os fatores de saúde bucal associados com fragilidade. Para os demais capítulos, utilizaram-se dados do estudo longitudinal em idosos de Carlos Barbosa, RS (2004). Foram coletadas informações sócio-demográficas, comportamentais, de acesso aos serviços, de história médica, depressão, atividade física e exame bucal, antropométrico e fragilidade. No capítulo 2, em estudo exploratório transversal aninhado em uma coorte, o objetivo foi investigar se saúde bucal precária age como fator associado para a fragilidade. No capítulo 3, o objetivo foi verificar se saúde bucal precária contribui para o desenvolvimento de obesidade geral (BMI) e central (WC). No capítulo 4, o objetivo foi determinar incidência de perda dentária após 8 anos e seus preditores. Análise descritiva e bivariadas foram realizadas. Associações com os desfechos foram realizadas por meio de regressão logística binária, regressão logística multivariada e análise longitudinal multinível e regressão de Poisson ajustando para variáveis de confundimento. No capítulo 1, de 12 estudos incluídos, 07 eram transversais e 05 longitudinais. Foram considerados de boa qualidade 41,7% (n=5) dos artigos selecionados e 8,3% (n=1) de baixa. No capítulo 2, dos 389 idosos estudados, após controle da idade, renda familiar e estado civil, aqueles que precisavam de prótese dentária apresentaram duas vezes mais chance de ser pré-frágil/ frágil do que aqueles que não precisavam (OR = 2,0, IC95% 1,1-3,7); assim como, aqueles com um maior número de dentes perdidos (OR = 1,0, IC95% 1,0-1,1), aqueles que fumaram pelo menos cem cigarros na vida (OR = 2,5, IC95% 1,4-4,7) e aqueles que estavam deprimidos (OR = 2,8, IC95% 1,2-6,9). No capítulo 3 participaram 633 idosos independentes. As pessoas que nunca visitaram um dentista eram mais propensas a serem obesas (OR = 3,02 IC 95% 1,25-7,26), de acordo com o IMC e a necessidade de prótese inferior total aumentou o risco de ser obeso de acordo com a CC (OR = 4,38, 95% CI 1,34-14,32). Em relação ao IMC, os indivíduos edêntulos com próteses totais em ambos os arcos (OR = 0,23, 95% CI 0,06-0,84) e aqueles que percebiam sua saúde bucal como insatisfatória, de acordo com a CC (OR = 0,43 IC 95% 0,19-0,88 ),

apresentaram uma menor chance de serem obesos. No capítulo 4 o número médio de dentes no baseline foi 10,50 ( $\pm 7,09$ ) e a média de dentes presentes ao final foi 9,06 ( $\pm 7,3$ ). Dados completos estavam disponíveis para 193 participantes. Ser do sexo feminino (RR = 0,65, 95% CI 0,49-0,86), não usar uma prótese parcial removível (RR = 0,73, 95% CI 0,56-0,97) foram associados com menor risco de perda dentária. Ter mais sítios de sangramento foi associado com maior risco de perda dentária (RR = 1,008, IC 95% 1,003-1,01). Saúde bucal precária apresenta relação com fragilidade e é fator de risco para obesidade central e geral e também para perda dentária.

Palavras-chave: Odontologia Geriátrica, Obesidade, Perda de Dente, Idoso Fragilizado.



## Abstract

The aim of this study is to evaluate determinants of general and oral health among a cohort of independently living older adults residents in Carlos Barbosa, Brazil. In chapter 1 it was performed a systematic review to assess the oral health measures that were related to frailty. To the other chapters it was used data from the study about the elderly population of Carlos Barbosa held in 2004. The measures comprised a questionnaire with information about socio-demographic, behavioral, access to services, medical history, depression, physical activity and oral examination, also anthropometric and frailty assessments. In chapter 2, a cross-sectional exploratory study nested in a major cohort, the aim was to investigate if poor oral health acts as a associate factor for the presence of frailty. In chapter 3, the aim was to investigate if poor oral health status contributes to the development of general (BMI) and central obesity (WC). In chapter 4 the aim was to determine tooth loss incidence after 8 years and its predictors among community-living older adults in a southern Brazilian city. Descriptive and bivariate analysis were performed Associations with the outcomes will be assessed using binary logistic regression, multinomial logistic regression, longitudinal multilevel regression and negative binomial regression adjusting for confounding variables. Twelve studies met the inclusion criteria, 07 of them were cross-sectional and 05 were cohort studies. From the 12 papers, 41.7% (n=5) were rated as GOOD and 8.3% (n=1) as POOR. In chapter 2, 389 elders participated and after controlling for age, family income and marital status the analysis found that those who needed dental prosthesis were 2 times more likely to be prefrail/frail when compared to those who did not need (OR=2.0, CI95% 1.1-3.7) as well as those with a higher number of missing teeth (OR=1.0, CI95% 1.0-1.1), those who smoked at least a hundred cigarettes in (OR=2.5, CI95% 1.4-4.7) and those who were depressed (OR=2.8, CI95% 1.2-6.9). For chapter 3 a total of 633 independently-living elders participated. Individuals who never visited a dentist were more likely to be obese (OR=3.02, 95%CI:1.25-7.26) according to the BMI and the need for a full mandibular denture increased the risk for being obese according to their waist-circumference ratio-WC (OR=4.38, 95%CI:1.34-14.32). Regarding BMI, edentulous subjects with full dentures in both arches (OR=0.23, 95%CI:0.06-0.84) and those who

perceived their oral health as unsatisfactory, according to the WC (OR=0.43, 95%CI:0.19-0.88), had a lower likelihood of being obese. In chapter 4 the mean number of teeth in risk (baseline mean number of teeth) was  $10.50 \pm 7.09$  and mean teeth present at 8-years follow-up was  $9.06 \pm 7.3$ . Complete data was available for 193 participants. Being female (RR=0.65, 95%CI 0.49-0.86), not using a partial removable prosthesis (RR=0.73, 95%CI 0.56-0.97) were associated with lower risk of tooth loss. Having more bleeding sites was associated with higher risk of tooth loss (RR=1.008, 95%CI 1.003-1.01). Poor oral health is associated with frailty and it is a risk factor for central and general obesity and also for tooth loss.

Keywords: Geriatric dentistry, Obesity, Tooth loss, Frail elderly.

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## **Lista de Abreviaturas e Siglas**

ADA - American Dental Association  
BAI - body-adiposity index  
BMI - Body mass Index  
CBCS - The Carlos Barbosa Cohort Study  
CC- Circunferência cintura  
CI - confidence interval  
DALYs - disability-adjusted life-years  
DMFT - Decayed, missing, and filled teeth index  
FFI - Fried Frailty Index  
GDS - Geriatric Depression Scale  
HRQOL - health related quality of life  
IMC - Índice de Massa Corporal  
OHRQoL - oral health related quality of life  
OR - odds ratio  
PAHO - Pan-American Health Organization  
RCQ- Relação cintura-quadril  
SPOH - Self-perception of oral health  
WC - Waist circumference ratio  
WHO - World Health Organization  
WHOQOL - World Health Organization Quality of Life  
WHR - waist-hip ratio  
WHtR - waist-height ratio



## **Introdução**

A saúde dos idosos passou a ser um tema de maior interesse nos últimos anos devido principalmente às transições epidemiológica e demográfica com aumento da expectativa de vida. Assim, doenças crônicas podem interferir no seu dia-a-dia, muitas vezes comprometendo inclusive seu grau de dependência (Alves et al, 2007).

O envelhecimento saudável é resultado da interação multidimensional entre saúde física, saúde mental, independência na vida diária, integração social, suporte familiar e independência econômica (Ramos, 2003). Neste contexto a saúde bucal parece também estar relacionada com a qualidade de vida dos idosos (Hugo et al, 2009), estando ligada tanto aos aspectos sociais quanto aos funcionais.

As alterações decorrentes de problemas dentários trazem desconforto e incapacidade. Assim, além de dor, problemas estéticos, perda da auto-estima e dificuldades mastigatórias, uma dentição considerada precária pode provocar afastamento dos indivíduos idosos de suas atividades rotineiras e alteração na seleção de alimentos. Outros fatores que devem ser levados em consideração são a baixa escolaridade, contribuindo para o limitado conhecimento do idoso quanto ao cuidado para a manutenção de sua saúde bucal e, conseqüentemente, a baixa capacidade de percepção da sua condição bucal, a dificuldade de acesso aos serviços de saúde odontológicos (Moreira et al, 2005) e a persistente prática mutiladora dos mesmos.

As conseqüências a longo prazo da perda dentária e do uso de prótese na saúde geral ainda não estão bem esclarecidas na literatura, especialmente quando resultam em uma dieta pobre em nutrientes. Sabe-se que a dieta desempenha um importante papel na vida dos idosos, e a escolha por alimentos fáceis de mastigar, apesar de ser uma solução para idosos com precária saúde bucal pode ter conseqüências indesejáveis, pois pode levar à exclusão de alimentos (Morais et al, 2013). Em estudo com idosos japoneses, o auto-relato de incapacidade mastigatória esteve associado com incapacidade geral ou declínio na saúde (Nakanishi et al, 2005). Em outro estudo realizado com idosos independentes do Sul do Brasil, os que apresentavam perda dentária parcial ou total, sem reabilitação protética, eram mais freqüentemente obesos do que os com dentes naturais (Hilgert et al, 2009). Tôrres et

al. (2013) também observaram esta associação entre edentulismo sem reabilitação e obesidade em idosos de Campinas, SP.

Idosos, que apresentam dificuldade mastigatória, tendem a trocar os alimentos mais duros como frutas e vegetais por outros ricos em calorias e de mais fácil mastigação. Estudos como o de Sahyoun e colaboradores (Sahyoun et al, 2003) mostraram que os idosos com dentição precária apresentavam menor consumo de frutas e mais baixas concentrações séricas de betacaroteno e ácido ascórbico, importantes indicadores do estado nutricional no organismo. Essas mudanças no consumo de alimentos podem provocar alterações no Índice de Massa Corporal (IMC) trazendo consequências como baixo peso, sobrepeso e obesidade.

Essas variações no IMC dos idosos podem gerar dependência e predispor o organismo a uma série de doenças e incapacidades resultando em grande ônus ao sistema de saúde. Com o aumento da expectativa de vida e com as mudanças no estilo de vida, direcionadas cada vez mais ao sedentarismo, a tendência é que estas condições se tornem um grave problema de saúde pública em nível mundial, principalmente quando se considera o risco aumentado para co-morbidades e mortalidade resultantes da presença das mesmas (Nagai et al, 2010). Jansson et al. (2002) identificaram a saúde bucal precária como potencial indicador de risco para mortalidade, apontando o estilo de vida como possível contribuinte para esta correlação.

Sendo a fragilidade uma combinação de mudanças biológicas, fisiológicas, sociais e ambientais que ocorrem com o avanço da idade (Nourhashémi et al, 2001), o uso de prótese pode ser um importante determinante de nutrição precária na trajetória biológica rumo à fragilidade, devido ao consumo deficiente de certos nutrientes e vitaminas (Semba et al, 2006). O que torna importante a identificação dos idosos principalmente em estágio de transição, a pré-fragilidade. Sendo assim, é fundamental ressaltar que saúde geral precária e saúde bucal precária estão inter-relacionadas, especialmente entre idosos, principalmente por causa de fatores de risco comuns (Elter et al, 2003).

A necessidade de inclusão de medidas que permitam intervenções comportamentais e que foquem no controle do peso e na manutenção tanto da saúde geral quanto da bucal, apesar de necessárias, representam um desafio para o setor saúde.

No Brasil, de acordo com a literatura, este é um dos poucos trabalhos de que temos conhecimento que estuda a saúde bucal dos idosos de uma coorte e seus fatores associados. Nesse contexto, estudos transversais e, principalmente, longitudinais são importantes para a identificação de indicadores ligados a problemas prevalentes na população idosa, como fragilidade, obesidade e perda dentária, e contribuem de maneira significativa para um conhecimento mais abrangente das particularidades deste grupo etário que se encontra em crescimento, e que requer cuidados direcionados às peculiaridades oriundas do próprio processo de envelhecimento.

Este estudo foi realizado em Carlos Barbosa, cidade criada em 1959 localizada à 117 Km de Porto Alegre. Segundo dados do IBGE (2010) apresenta IDH considerado alto de 0,796, o 2º. do Estado, apresentando 20,6% da população na zona rural. Em 2010 contava com população de 25.192 e com aproximadamente 3.162 idosos, representando 12,55% da população e uma expectativa de vida ao nascer de 78,84 anos (2009).

O objetivo geral deste estudo é avaliar determinantes de agravos à saúde geral e bucal em uma coorte de idosos independentes residentes em Carlos Barbosa, RS. Os objetivos específicos serão apresentados na forma de artigos que correspondem aos seguintes capítulos: capítulo 1 tem como objetivo avaliar criticamente toda a evidência relacionada com a associação entre saúde bucal precária e fragilidade; o capítulo 2, avaliar se saúde bucal precária atua como fator associado à fragilidade; no capítulo 3 o objetivo é investigar se saúde bucal precária contribui para o desenvolvimento de obesidade geral e central medida pelo IMC e CC; e no 4o. capítulo o objetivo é determinar preditores de perda dentária após 8 anos entre idosos independentes vivendo na comunidade.



## Capítulo 1

### **Frailty, Frailty components and Oral Health: a Systematic Review**

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## **Abstract**

A systematic review was conducted to assess the relationship between frailty or one of its components and poor oral health. A search strategy was developed to identify papers related to the research question in the PubMed, EMBASE, Cochrane, LILACS, and SciELO databases that were published in English, Spanish, or Brazilian Portuguese from 1991 to July 2013. Thirty-five studies were identified and 12 met the inclusion criteria, of which seven were cross-sectional and five were cohort studies. Of the 12 papers, 41.7% (n = 5) were rated as good, 50% (n = 6) as fair, and 8.3% (n = 1) as poor quality. The published studies applied different oral health and frailty criteria measures. The variations in the definitions of outcome measures and study designs limited the ability to draw strong conclusions about the relationship between frailty/prefrailty and poor oral health. None of the studies evaluated longitudinally demonstrated whether poor oral health increases the likelihood of developing signs of frailty however, the studies suggest that there may be an association between frailty and oral health. More longitudinal studies are needed to understand the relationship between frailty and oral health better.

**Key words:** Frail elderly, Oral health, Aged.

## **Introduction**

Frailty may be a physiologic precursor and an etiologic factor of disability in the elderly, and it has been reported to be a predictor of mortality and functional limitations in this population<sup>1</sup>. Various measurements exist for assessing frailty. One commonly measure is the Fried Frailty Index (FFI)<sup>1</sup>, which classifies frailty according to the presence of three or more of the following items: weight loss, low physical activity, low handgrip strength, slow walking speed, and exhaustion. The increases in life expectancy and in the number of elderly people have made frailty a critical component of total health expenditure in developed and developing countries. A Canadian study that evaluated functional decline and resources spent at the end of life found that organ failure and frailty patients consumed



similar amounts of resources in the last 19–24 months of life, which were five times that of the sudden death group<sup>2</sup>.

Various studies in the literature have assessed the role of frailty's components in the elderly. For example, handgrip strength can be used as a measure of sarcopenia (muscle wasting) and was shown to predict accelerated decline in activities of daily living, disability, and decreased cognition, which contribute to increased dependency<sup>3</sup>. In addition, a rapid decline in walking speed has been associated with a high risk of all-cause mortality<sup>4</sup>, and impaired mobility and physical inactivity have been shown to predict subsequent dependence and death in the elderly<sup>5</sup>. Weight loss can also be a signal for higher morbidity and mortality<sup>6</sup>. Finally, fatigue can reduce the level of daily activities and has been associated with slowed speed of cognitive processing<sup>7</sup>.

The relationship between poor oral health and frailty has rarely been evaluated. General health and oral health are interrelated and have a complex and multifaceted relationship, especially in the elderly<sup>8</sup>. Oral health is instrumental to older people's health, life satisfaction, quality of life, and self-perception<sup>9</sup>. Oral infections may have biological consequences that manifest in health problems in later life<sup>10</sup>. In addition, oral status can also contribute to changes in diet, weight<sup>11-13</sup>, and physical function<sup>13</sup>. Hence, poor oral health can affect an individual's overall well-being, and due to the cumulative burden of oral diseases<sup>26</sup>, elderly individuals may experience more dental problems, such as tooth loss and edentulism.

The aim of this systematic review was to critically appraise all evidence related to the association between poor oral health and frailty. Our research question was as follows, "Is there evidence of an association between frailty or frailty's components with poor oral health among subjects who are 60 years of age or older?" This systematic review will examine current evidence on the relationship between frailty and oral health and will help understand the oral health pathway towards frailty.

## **Methods**

A search strategy was developed to identify papers that were related to the research question. The following databases were searched: PubMed, Cochrane, EMBASE, LILACS, and SciELO. Also the reference lists of the selected papers were manually searched for additional potentially eligible studies. Initially, the relevance of the reports was assessed through their titles and abstracts. Inclusion and exclusion criteria were developed and primary (frailty) and secondary outcomes (prefrailty) were defined. The inclusion criteria comprised the following: human subjects; 60 years or older; peer reviewed journals; studies published in English, Spanish, or Brazilian Portuguese; all types of study designs; and frailty definition. The exclusion criteria were as follows: small sample size, outcomes (frailty and its components) not well defined, and results not shown. The outcome considered in this study was frailty or its components. If the title and/or abstract were unclear, then the full text was obtained and reviewed. The reference lists of eligible papers were also reviewed.

Frailty is defined as a syndrome that corresponds to a combination of biological, physiological, social, and environmental changes that occur with advancing age,<sup>14</sup> and it is a predictor of risk of adverse outcomes, such as falls, hospitalization, disability, and death<sup>1</sup>. A person is classified as frail when three or more of the following criteria are present: unintentional weight loss, self-reported exhaustion, weakness (low grip strength), slow walking speed, and low physical activity. Moreover, one or two of the criteria mentioned above classify the subject as prefrail<sup>1</sup>. The decision to limit the search to the frailty phenotype defined by Fried et al.<sup>1</sup> was prespecified before the search was undertaken.

Due to the limitations in terms of the number of prospective studies published on this topic, all study designs were considered for this analysis. This review was restricted to full reports, excluding editorials, abstracts, theses, and dissertations. Duplicate publications from the same group of authors were counted only once (i.e., when the same data were presented in two different papers, the data were included only once in this study).

### *Search strategy*

The systematic search strategy included combined Medical Subject Headings (MeSH) and free text terms, such as the following, and was used to query the PubMed

database: ((elder\*) OR ("old people") OR (senior resident\*) OR (senior\*) OR ("old age") OR (old\* AND subjects) OR (aged)) AND (("loss of teeth") OR ("lack of teeth") OR (edentul\*) OR ("oral health") OR ("tooth loss") OR ("number of teeth") OR ("absence of teeth")) AND ((frail\*) OR ("frailty phenotype") OR ("pre frail") OR ("intermediate frail status") OR ("phenotype of frailty") OR ("syndrome of frailty") OR (prefrail) OR ("frailty syndrome") OR (exhaustion) OR ("poor endurance") OR ("poor energy") OR (fatigue) OR ("weight loss") OR (sarcopenia) OR (shrinking) OR ("weight reduction") OR ("physical activity") OR ("low activity") OR (sedentarism) OR (exercise) OR ("walk time") OR (slowness) OR ("slow walk") OR ("slow locomotion") OR ("grip strength") OR (weakness) OR ("hand strength") OR ("handgrip strength")). In addition, a filter was used to limit the search by age, language, and publication date. Only articles from 1991 to July 2013 were considered because the term "frail" was indexed as a MeSH term in 1991 (i.e., older adults or aged individuals who are lacking in general strength and are unusually susceptible to disease or to other infirmity). In addition, language restriction to studies published in English, Spanish, and Portuguese was applied. Only studies in which the participants were 60 years of age or older were selected. The search strategies used in other databases were derived from the primary search in PubMed (Fig. 1).

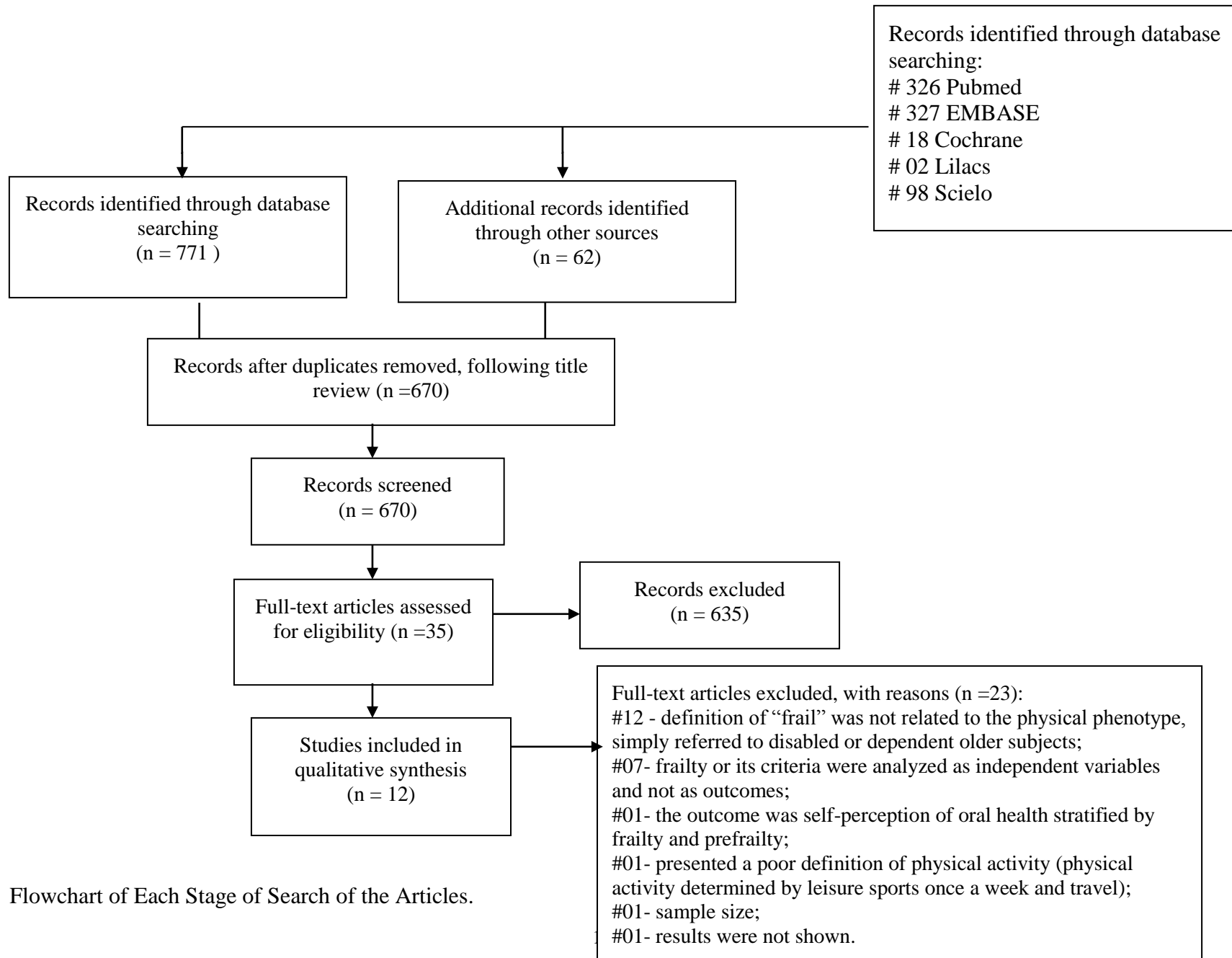


Figure 1: Flowchart of Each Stage of Search of the Articles.

*Quality assessment*

The data were extracted by one review author (LT) and checked independently by another author (MT). Decisions were made by consensus, and all discrepancies were discussed until the authors reached an agreement. The quality of the papers was assessed using a checklist based on those designed by Loney at al.<sup>15</sup>, the Manchester appraisal<sup>16</sup>, the Cardiff appraisal<sup>17</sup>, Heller et al.<sup>18</sup>, and the American Dental Association (ADA)<sup>19</sup>. Six methodological items were considered as shown in Table 1 for both cross-sectional and cohort studies. The studies were rated as good (met all criteria or did not meet one criterion), fair (did not meet 2 or 3 criteria) or poor (did not meet 4 to 6 criteria).

Table 1: Appraisal Criteria Created Based on Other Appraisals Found in the Literature.

Cross-sectional	Cohort
Are the study design and sampling method appropriate for the research question? (Loney at al, 2000)	Are the study design and sampling method appropriate for the research question? (Loney at al, 2000)
Sample selection: Is the sample representative of the population? (Manchester)	Sample selection: Is the sample representative of the population? (Manchester)
Did the study achieve a good response rate? (Weightman et al, 2004)	Maintenance of comparable groups (includes attrition, cross-overs, adherence, contamination) (ADA, 2009)
Are objective, suitable and standard criteria used for measurement of the health outcome? (Loney at al, 2000)	Are objective, suitable and standard criteria used for measurement of the health outcome? (Loney at al, 2000)
Is confounding and bias considered? (Weightman et al, 2004)	Is confounding and bias considered? (Weightman et al, 2004)
Are statistical tests appropriate and correct? (Heller et al, 2008)	Are statistical tests appropriate and correct? (Heller et al, 2008)

Data extracted from the studies were organized in tables. Prevalence information on main outcomes is presented as it is in the original studies or was generated from the absolute numbers provided. In one study<sup>14</sup>, the handgrip measurements in Newtons were converted to kg.

The  $\beta$  coefficient estimates from the regression models in the studies (log odds) were converted to odds ratios (OR) using VassarStats software (VassarStats: Website for Statistical Computation, Poughkeepsie, NY, USA). Both values are presented.

## **Results**

### *Overview*

Following the initial screening of titles and abstracts, 35 articles were selected. Of these studies, 23 were excluded with reasons. Thus, 12 reports were included in the study (Fig. 1). Among them, seven were cross-sectional<sup>20-26</sup> and five were longitudinal<sup>10,27-30</sup> studies. In relation to their frailty/prefrailty outcomes, one study measured fatigue using the Mobility-Tiredness Scale<sup>29</sup>, two adapted the FFI<sup>24,26</sup>, two used weight loss criteria<sup>27,28</sup>, and seven measured handgrip strength<sup>10,20-23,25,30</sup> (Table 2).

Table 2: Study Overview and Quality Appraisal Summary.

<b>Authors/ year</b>	<b>Count ry</b>	<b>n†</b>	<b>Study design</b>	<b>Gender (F:M)</b>	<b>Age† in years</b>	<b>Oral condition†</b>	<b>Frailty definition</b>	<b>Frailty or components prevalence †</b>	<b>Dropout † (%)</b>	<b>Quality</b>
Andrade et al, 2013	Brazil	1374	cross- sectional	59.7:40.3	≥60	Edentulous- 44.8% Dentate- 55.2%	FFI (modified)	Frail: 8.5% Prefrail: 40.7% Nonfrail:50.8%	NR	Good
Castrejón -Pérez et al, 2012	Mexico	838	cross- sectional	53.2:46.8	≥ 70	Edentulous- 23.5% Dentate- 76.5%	FFI (modified)	Frail: 15%	35.2%	Good
Moriya et al, 2012	Japan	354	cross- sectional	48.9:51.1	≥65	Mean number of remaining teeth - 14.6±10.3 GOHAI- 52.6±7.7	Handgrip strenght	Handgrip strenght (Kg) - 27.1±7.5	15.9%	Good

Table 2: Study Overview and Quality Appraisal Summary (*continued*).

<b>Authors/ year</b>	<b>Count ry</b>	<b>n†</b>	<b>Study design</b>	<b>Gender (F:M)</b>	<b>Age† in years</b>	<b>Oral condition†</b>	<b>Frailty definition</b>	<b>Frailty or components prevalence †</b>	<b>Dropout † (%)</b>	<b>Quality</b>
Avlund et al, 2011	Denmark	573	Cohort (baseline, 5Y, 10Y, 15Y)	51.7:48.3	70	Edentulous- 41.5% Dentate- 58.5%	Fatigue Scale (Avlund Mobility- Tiredness)	Fatigued: 50.1% Not fatigued:49.9%	48,8%	Good
Moriya et al, 2011	Japan	381	Cross- sectional	62.2:37.8	67-74	SAMA: Good- 66.7% Fair- 26.2% Poor- 7.1%	Handgrip strenght	NR	7.3%	Fair
Okuyama et al, 2011	Japan	348	Prospective cohort study (baseline, 8Y)	50.9:49.1	71	Occluding pairs- EI: (A)- 30.7% (B)- 44.8% (C)-24.4%	Handgrip strenght	Handgrip strength (Kg)- 32.5±8.9	92.3%	Poor



Table 2: Study Overview and Quality Appraisal Summary (*continued*).

<b>Authors/ year</b>	<b>Count ry</b>	<b>n †</b>	<b>Study design</b>	<b>Gender (F:M)</b>	<b>Age † in years</b>	<b>Oral condition †</b>	<b>Frailty definition</b>	<b>Frailty or components prevalence †</b>	<b>Dropou t † (%)</b>	<b>Quali ty</b>
Moriya et al, 2009	Japan	821	cross-sectional	56.3:43.7	65- 84	Occluding pairs: 4 zones- 17.3% 1-3 zones or anterior contact- 29.5% No contact- 53.2%	Handgrip strength	NR	82.5%	Fair
Weyant et al, 2004	US	1053	Prospective cohort study (baseline, 2Y)	50.3:49.7	≥65	Periodontal pockets with probing depth ≥6mm - 37%	Weight loss	Over 24 months: 5% Weight loss - 140 (13.4%)	42.9%	Fair
Hämäläinen et al, 2004	Finland	193	Cross-sectional / Prospective cohort study (baseline, 5Y)	baseline 71.5:28.5	80	Edentulous- 59% Dentate- 41%	Handgrip strength	Men handgrip strength- 35.07Kg Women handgrip strength -19.97kg	0%	Fair

Table 2: Study Overview and Quality Appraisal Summary (*continued*).

Authors/ year	Count ry	n†	Study design	Gender† (F:M)	Age†in years	Oral condition†	Frailty definition	Frailty or components prevalence	Dropout † (%)	Quality
Takata et al, 2004	Japan	697	Cross-sectional	60.3:39.7	80	Edentulous- 34.6% Dentate- 65.4%	Hand grip strength	Hand grip strength: 25.1 ±7.4 Kg Men 31.5 ±6.4kg Women 20.8 ±4.1 kg	45.6%	Fair
Yamaga et al, 2002	Japan	749	Cross-sectional	50.2:49.8	70 and 80	Occluding pairs -EI: 4 Zones/ No contact (class A/C) *70y - 26.2%/25.2% *80y- 7.8%/64.3 %	Hand grip strength	Hand grip strength (Kg): 70y - Men - 39.0 (±5.7) Womem 24.3 (±3.7) 80y - men 32.6 (±5.5) womem 19.4 (±3.8)	88.8%	Fair
Ritchie et al, 2000	US	1156	Prospective cohort study (baseline, 1Y)	57.9:42.1	≥70	Edentulous- 39% Dentate- 61%	Weigh loss of 4% and 10% over 1 year	Over 12 months: 33% - 4% weight loss 9% - 10% weight loss	Baseline- 43.8%	Good

†baseline; NR - not reported; SAMA- self-assessed mastigatory ability; EI- Eichner Index.

The studies examined more females or had an equal gender distribution. Four studies did not specify the study settings<sup>21-23,25</sup>, and in the majority data collection took place at least in part at the participant's home<sup>24,26,27,29</sup>. Three studies did not state if the subjects were dependent or not<sup>10,20,21</sup>, although in the study by Takata<sup>21</sup> some volunteers from one ward were invited to participate. The rest of the studies assessed independently living participants.

Three of the studies had the same first author<sup>22,23,25</sup>. Although the data collection for these studies took place on the same island in Japan, the data were recorded in different periods and obtained from partly different communities, so these studies were not duplicates. These three studies were the only studies that took place in rural communities.

### *Quality appraisal*

Of the 12 studies, 41.7% (n = 5) were rated as good, 50% (n = 6) as fair, and 8.3% (n = 1) as poor quality. The most common problem was the representativeness of the sample. The cross-sectional studies presented weaknesses in five out of six items (study design and sampling, sample selection representativeness, response rate, measurement of the outcome, confounding factors, and bias), with the representativeness of the sample being the most common problem. For the longitudinal studies, the most common weakness was also representativeness of the sample, whereas none of the studies accounted for confounding factors and presence of bias.

Regarding weight loss, one study was rated as fair<sup>28</sup> and one was considered of good quality.<sup>27</sup> The most common problem in these studies was the representativeness of the sample followed by measurement of the outcome. Both studies that applied the FFI were rated as good<sup>24,26</sup>, and the fatigue study was also rated as good<sup>29</sup>. Of the handgrip strength studies, one was rated as good<sup>25</sup>, five were rated as fair<sup>10,20-23</sup>, and one was rated as poor<sup>30</sup>. In the handgrip strength studies, the representativeness of the sample was the most problematic item, followed by the measurement of the outcome. Interestingly, four out of five of the high quality papers were the most recently published ones, which might be a consequence of the increasingly high standards for quality publications.

### *Prevalence of frailty/prefrailty*

In the two studies that used the FFI, the prevalence of frailty ranged from 8.5% (n = 117) to 15% (n = 105) for a Brazilian and a Mexican population, respectively<sup>24,26</sup>. For the studies that assessed only one criterion, approximately half of the participants (n = 287) felt fatigued at baseline and the proportion increased with age<sup>29</sup>. In the study that considered weight loss, the prevalence of  $\geq 10\%$  of weight loss over one year was 9% (n = 51)<sup>27</sup>, and the prevalence of 5% weight loss over two years was 13.4% (n = 140). Of the seven studies that measured handgrip strength, three studies<sup>10,20,21</sup> evaluated the outcomes in 80-year-old subjects, and the presented mean values ranged from 31.5 to 35.07 kg for men and from 19.4 to 20.8 kg for women.

### *Association of poor oral health and frailty/prefrailty*

The predictors and covariates found in the studies were number of teeth, masticatory ability, occluding pairs of teeth (Eichner Index), dental prosthesis, periodontal disease, dental service use, self-report of oral health, and Geriatric Oral Health Index Assessment (GOHAI)<sup>10,20-29</sup>. These predictor and covariates were assessed to verify their associations with the FFI or one of its criteria according to the methodology of each study (Table 3).

Table 3: Results of the Selected Articles.

Authors/ year	Independent predictor	Predictor	Description predictor	$\beta$	Adjusted OR (CI 95%)	p-value	R <sup>2</sup>
Andrade et al, 2013	Prefrailty	Need for dental prosthesis	Yes		1.46 (1.09-1.94)	0.01	
	Frailty	Need for dental prosthesis	Yes		1.84 (1.13-3.00)	0.01	
		Number of teeth (reference: 0)	$\geq 21$ teeth			0.25 (0.07-0.91)	0.04
Castrejón- Pérez et al, 2012	Frailty	Self-perception of Oral Health (reference: better)	same		1.76 (0.96-3.24)	0.07	
		Utilization of dental services	worse		3.23 (1.45-7.21)	0.004	
			no		2.10 (1.19-3.71)	0.01	
Moriya et al, 2012	Handgrip strength- model 1	GOHAI - total score		0.07	1.07	0.017	
	Handgrip strength- model 2	GOHAI - subdivision score: pain and discomfort		0.24	1.27	0.029	

Table 3: Results of the Selected Articles (*continued*).

<b>Authors/ year</b>	<b>Independent predictor</b>	<b>Predictor</b>	<b>Description predictor</b>	<b><math>\beta</math></b>	<b>Adjusted OR</b>	<b>p-value</b>	<b>R<sup>2</sup></b>	
Avlund et al, 2011	Fatigue- baseline  Fatigue- 5y  Fatigue- 10y		No association with any oral health predictor in the final model after adjustment					
Moriya et al, 2011	Handgrip Strength	Handgrip strength	By groups of SAMA  (poor, fair, good)  Good x poor SAMA			0.012   0.018		
Okuyama et al, 2011	Handgrip strength decline	Eichner Index (occlusion condition)	No association			NS		
Moriya et al, 2009	Hand Grip Strength 65-74 y-o  Hand Grip Strength 75-84 y-o	SAMA	Good/fair/poor  Good+ fair/ poor		-1.44  -2.30	0.24  0.1	p<0.01  p<0.01	0.69

Table 3: Results of the Selected Articles (*continued*).

<b>Authors/ year</b>	<b>Independent predictor</b>	<b>Predictor</b>	<b>Description predictor</b>	<b><math>\beta</math></b>	<b>Adjusted OR</b>	<b>p-value</b>	<b>R<sup>2</sup></b>
Weyant et al, 2004	Weight loss $\geq 5\%$ over 2 years	Periodontitis	site $\geq 6$ mm probing depth - best model		1.55 (1.36-1.78)		
Hämäläinen et al, 2004	Handgrip strength	Number of teeth (men)	>19 teeth			0.016	
	Change (decline) in handgrip strength	Periodontitis	Periodontitis (at baseline)			0.015	
Takata et al, 2004	Hand Grip strength (multiple regression)	Number of chewable foods Number of teeth		0.027 0.005	1.03 1	0.3449 0.8659	0.641
	Hand Grip strength (Logistic regression)	Number of chewable foods (reference:0-4)	5-9 10-14 15		0.542 (0.172-1.714) 0.687 (0.234-2.017) 1,001 (0.328-3.052)		

Table 3: Results of the Selected Articles (*continued*).

Authors/ year	Independent predictor	Predictor	Description predictor	$\beta$	Adjusted OR	p-value	R <sup>2</sup>
Takata et al, 2004 (cont)	Hand Grip strength (Logistic regression) (cont)	Number of teeth (reference: 0)	1-9 10-19 $\geq 20$		1.236 (0.656-2.329) 1.158 (0.564-2.377) 0.795 (0.355-1.779)		
Yamaga et al, 2002	Handgrip strength	No association with any oral health predictor in the final model					
Ritchie et al, 2000	4% weight loss over 1 year	edentulousness			1.63 (1.09-2.43)	p<0.05	
	10% weight loss over 1 year	edentulousness			2.03 (1.05-3.96)	p<0.05	

NR- not reported; SAMA- self-assessed mastigatory ability; EI- Eichner Index.



### Number of teeth

Six reports used number of teeth as the covariate. Having more teeth ( $\geq 20$  teeth) was associated with a lower chance of being frail when compared to edentulous subjects<sup>26</sup>, whereas the study by Castrejón-Pérez<sup>24</sup> did not observe an association between the number of teeth and frailty. Number of teeth was not associated with fatigue when the model was adjusted for either smoking or socioeconomic position<sup>29</sup>. Being edentulous was a risk factor for weight loss of 4% or 10% or more over 1 year<sup>27</sup>. Handgrip strength was positively associated with number of teeth only in men<sup>10</sup>. In contrast, Takata et al.<sup>21</sup> found that the association between handgrip strength and number of teeth was no longer significant after adjustment for confounders.

### Masticatory ability

Self-assessed masticatory ability was associated with handgrip strength in elders aged 65 to 74 years old<sup>22,23</sup>. However, one study<sup>21</sup> did not demonstrate an association between the number of chewable foods and grip strength after adjustment for various confounding factors although it reported an association between this oral health measure and other physical fitness assessment methods. In addition, the chewing surface (defined as the maximum number of intact functional units adjacent to each other) did not predict weight loss<sup>27</sup>, and chewing problems were not associated with frailty<sup>24</sup>.

### Occluding pairs of teeth

In three studies conducted in Japan<sup>20,22,30</sup>, no relationship was observed between occluding conditions and handgrip strength in the elderly. In addition, functional units did not predict weight loss<sup>27</sup>.

### Dental prosthesis (need/fit)

The need for dental prosthesis<sup>26</sup> was a covariate of prefrailty and frailty.

### Periodontal disease

Periodontitis was not associated with handgrip strength in both men and women in the cross-sectional analysis, but it was a predictor of handgrip strength decline over 5 years<sup>10</sup>. Frailty was not associated with severe periodontitis<sup>24</sup>, and gingival recession did not predict weight loss<sup>27</sup>. However, one study verified that a probing depth of  $\geq 6$  mm was the strongest predictor for  $\geq 5\%$  weight loss over a 2-year period<sup>28</sup>.

#### Dental service use

Those who did not use dental services in the previous year were more likely to be frail<sup>24</sup>.

#### Self-report of oral health

Self-report of worse oral health than peers was associated with an increased likelihood of being frail<sup>24</sup>.

#### Geriatric Oral Health Assessment Index (GOHAI)

Handgrip strength was correlated with the GOHAI and the scores for its pain and discomfort category<sup>25</sup>.

### **Discussion**

Due to the limitations in terms of the number of prospective studies published in this topic, for this analysis all study designs were considered. The limited number of articles available on this subject and the cross-sectional nature of some of these studies highlight the need to evaluate the association between oral health and frailty systematically.

The findings of this systematic review identified different oral health predictors and covariates that are associated with frailty or its components. Number of teeth was the oral health variable most often investigated in relation to frailty followed by periodontal disease, occluding pairs of teeth, and chewing ability. Although some studies considered occlusion to be a more reliable covariate to measure than number of teeth because it can vary among individuals with the same number of teeth<sup>20</sup>, there was no evidence of its association with handgrip strength<sup>20,22,30</sup>.

It is important to highlight that the assessment of oral health status and the results varied among the studies, which used different protocols and parameters. The small number of studies examining the frailty index and oral health is a major drawback. In addition, the lack of standardization limits comparisons and can result in over- or underestimations of the measures of association presented.

The results suggest that there is an association between frailty and oral health because the studies that assessed FFI observed an association with a need for dental prosthesis, self-report of oral health, and dental service use. The number of teeth was associated in one of the FFI studies<sup>26</sup> but not in the other<sup>24</sup>. Frailty prevalence estimates varied substantially between studies, ranging from 8.5%<sup>26</sup> (n = 117) to 15%<sup>24</sup> (n = 105). One possible explanation for this variation is that frailty is age related<sup>31</sup> and the studies assessed different age groups. In a systematic review that assessed the prevalence of frailty<sup>31</sup>, when comparing studies that used a frailty definition according to physical phenotype, the prevalence of frailty was found to range from 4% to 17%. According to a study by Castrejón-Pérez et al.<sup>24</sup>, poor oral health may be compensated for by patients, but if it is concomitant with the presence of deterioration of their general health, poor oral health may become an important factor in the development of anorexia and subsequent weight loss.

### *Fried's Frailty Index*

Participants that needed dental prosthesis were more likely to be frail and prefrail, and having functional dentition was related to having a lower chance of being frail compared to edentulous individuals<sup>26</sup>. In the same study, the use of dental prosthesis was not associated with either prefrailty or frailty, indicating that the need for dental prosthesis is a more reliable measure of functional oral impairment. The other study that used the FFI found an association between self-reports of having worse oral health and not utilizing dental services with a higher probability of being frail<sup>24</sup>. This result was explained by the fact that a lower perception of oral health reflects a decline in general health, and not utilizing oral health services may also reflect compromised general health and constriction of life space<sup>24</sup>. In this Mexican study<sup>24</sup>, there was no association between the number of

teeth or chewing problems with frailty in the final regression model. According to the authors, the lack of association between frailty and number of teeth might be due to the high proportion of overweight and obese individuals in the study, which might have hidden the effect<sup>24</sup>.

### *Handgrip strength*

Moriya et al.<sup>25</sup> not only assessed the relationship between handgrip strength and the number of teeth, but also examined the GOHAI and its dimensions. The authors observed an association between the GOHAI, its pain and discomfort dimensions, and handgrip strength with oral health problems, suggesting that oral health problems that are associated with pain and discomfort may be significant indicators of a decline in body muscle strength. These findings are also supported by another study<sup>10</sup>, which showed that older male subjects with well-fitting prostheses presented greater grip strength in comparison to those with ill-fitting prostheses because the latter can cause pain and discomfort. Another study by Moriya and colleagues<sup>23</sup> showed that self-assessed masticatory ability was associated with handgrip strength, and elderly people with lower masticatory strength could only chew soft or pureed food. Moreover, a decline in strength may be a consequence of other diseases developed by older subjects with poor oral health<sup>10</sup>.

Interestingly, there was no association between handgrip strength and the number of teeth in the study by Moriya et al.<sup>25</sup>. Moreover, Takata et al.<sup>21</sup> did not find an association between the number of teeth or the number of chewable foods with handgrip strength, but found associations between the number of chewable foods and other measures of physical fitness, suggesting that chewing ability may be related to skeletal muscle mass through nutritional status and nutrient intake<sup>22</sup>. Hence, improving chewing ability could improve the performance of activities of daily life and prevent disability<sup>21</sup>. In another study<sup>30</sup>, handgrip strength was not associated with the oral health measure used, the Eichner Index, which is an indicator of occlusal condition. Similar results were found by Yamaga et al.<sup>20</sup> and Moriya et al.<sup>22</sup>. These findings suggest that occluding pairs of teeth might be related to measures that represent static balance function<sup>20,22,30</sup> and might not be the best covariate for evaluating handgrip strength because other oral measures have been associated<sup>22</sup>.

Furthermore, another study observed a greater decline in handgrip strength in elders with periodontitis compared to individuals with a healthy periodontium, suggesting that inflammation may be responsible for loss of both strength and teeth<sup>10</sup>.

### *Fatigue*

There was only one study that assessed fatigue<sup>29</sup>. The association between the number of teeth and fatigue was not significant after adjustment, especially when adjusted for socioeconomic factors for both baseline and follow-up<sup>29</sup>. According to the authors, this result suggests that socioeconomic position early in life partly explains this relationship<sup>29</sup>.

### *Weight loss*

Weight loss may be a more sensitive and specific indicator of how oral health is related to nutritional problems<sup>32</sup>. Ritchie et al.<sup>27</sup> observed edentulousness to be associated with 4% or 10% weight loss over one year. In contrast, other measures of oral health like gingival recession, number of teeth, number of functional units, and chewing surface did not predict weight loss. The study also highlighted that almost all of the edentulous participants wore dentures, which did not alleviate the weight loss results. Although the condition of the dentures was not analyzed, the authors stated that old and poorly fitting dentures contribute to chewing difficulties and oral discomfort. Despite the findings of Ritchie et al., the presence and extent of periodontal disease seems to have an impact on weight loss independent of the number of teeth and other known risk factors, such as diabetes mellitus and smoking, suggesting the influence of inflammatory mechanisms rather than a masticatory effect<sup>28</sup>. According to Sullivan et al.<sup>32</sup>, older subjects normally can compensate for their poor oral health status, but in the presence of worsening general health, oral health may become an important factor that contributes to the development of anorexia followed by weight loss.

The loss of teeth decreases occlusal force and affects masticatory ability, which may lead older subjects to change their food selection and affect their nutrient intake<sup>33</sup>. The difficulty in maintaining a nutritious diet may cause the increased incidence of physical disability and mortality in edentulous people without dentures<sup>34</sup>, suggesting that functional

occlusion has a great impact on the lives of elderly people. In addition, oral health is linked to different medical conditions due to its association with nutrition<sup>28</sup>.

#### *Physical activity and walking speed*

No study that met our inclusion and exclusion criteria showed a relationship between walking speed or physical activity with oral health. However, there is evidence in the literature<sup>34</sup> that edentulous subjects without dentures had a significant risk of mobility impairments. Shimazaki et al.<sup>34</sup> also found that physical health disorders derived from poor dentition conditions might lead to death in edentulous individuals due to the difficulty in maintaining a balanced diet.

Mobility can compromise dental service use, and the absence of dental service use is linked to frailty<sup>24</sup>. Furthermore, an increased deterioration in dental state was associated with decreased walking speed and low physical activity, suggesting that dental state is a marker of functional capacity<sup>35</sup>.

#### *Strengths and weakness of this systematic review*

To our knowledge, we conducted the first systematic review about the association between frailty or one of its components and poor oral health. All of the studies included in this review presented different designs and data collection methods, and these aspects might have influenced the conclusions reached. Several factors may affect both the internal and external validity of the results including inconsistencies among researchers in the measurement of frailty, frailty components, and the different oral health predictors evaluated in the studies; the lack of representative study samples; and dropout rates higher than 50%. Additionally, the fact that not only articles published in English were screened decreases the possibility of bias, although only articles in English met the inclusion criteria in this review. It is also worth mentioning that none of the articles that assessed FFI<sup>24,26</sup> were longitudinal in nature. Prospective studies may contribute to a better understanding of the relationship between oral health indicators and frailty.

A meta-analysis could not be performed given the limited standardization of methods and parameters across studies. Finally, the checklist for methodological quality appraisal

was drawn from different publications. Both the scales developed by Heller et al.<sup>18</sup> and Loney et al.<sup>15</sup> were not checked for reliability although the content was validated<sup>36</sup>. Scales for measuring the quality of cross-sectional studies have not been properly developed and further limit the results of the present study.

Frailty has different components. Besides nutrition, the relationship between poor oral health and frailty may have other intermediate factors<sup>26</sup> that should be explored, such as socioeconomic status, smoking, and chronic diseases<sup>29</sup>. The best-rated papers also support the role of the number of natural teeth present in the mouth<sup>26,29</sup> and the use and need of dental prosthesis<sup>25,26,27</sup> when studying the association between frailty or its components and impaired oral health. Likewise, severe tooth loss results in the exclusion of sextants when assessing periodontal disease, which affects its evaluation and prevalence and decreases its power in the analysis. Therefore, there is a need to explore the presence and severity of periodontal disease further because it can lead to energy imbalance, increased levels of inflammatory markers<sup>24</sup>, and additional tooth loss<sup>29</sup>.

Despite the fact that most studies reported a relationship between frailty/prefrailty and poor oral health, the study designs limited the ability to draw strong conclusions. So, to perform a quantitative assessment of the studies found we would need studies with standardized methodology. Therefore, there is a need for additional longitudinal studies to understand the relationship between frailty and oral health more fully, to develop strategies to prevent oral diseases, and to rehabilitate people in need among the growing elderly population.

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## Capítulo 2

### **Is poor oral health an indicator of frailty in the elderly? - an exploratory study**

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## **Abstract**

A few studies have assessed the association between frailty and oral health. The aim of this exploratory study was to investigate if poor oral health acts as an associated factor for frailty. This is a cross-sectional study nested in a major cohort study, The Carlos Barbosa Study (CBCS). The sample consisted of those individuals that participated in the baseline (2004) and accepted to participate in the second follow-up (2012). The measures comprised an interview administered structured questionnaire with information about socio-demographic and behavioral factors, access to health services, medical history, depression and oral examination, also anthropometric and frailty assessments. Complete data was available for 339 participants. After controlling for age, family income and marital status the analysis found that those who need dental prosthesis were 2 times more likely to be prefrail/frail when compared to those who did not need (OR=2.0, CI95% 1.1-3.7); those with a higher number of missing teeth were 1 time more likely to be prefrail/frail than those with more present teeth (OR=1.0, CI95% 1.0-1.1), those who smoked at least a hundred cigarettes in life were 2.5 times more likely to be prefrail/frail when compared to those who had never smoked (OR=2.5, CI95% 1.4-4.7) and those who are depressed were 2.8 times more likely to be prefrail/frail than those who were not depressed (OR=2.8, CI95% 1.2-6.9). Therefore, the results suggest an association between frailty and poor oral health represented by the lack of teeth and rehabilitation. Focusing on mental and oral preventive care as well as the improvement of quality of care can prevent the pathway towards frailty and promote a better life spam.

**Key words:** Frail elderly, Oral health, Aged.

## **Introduction**

Frailty is characterized by a reduced complexity of physiologic responses and diminished energy reserves on which the ability of the body to respond to new stressors is compromised. It is a common condition among the elderly and is associated with fractures,

falls and mortality<sup>1</sup>. It is considered as a pre-stage to disability<sup>1</sup> and if left undiagnosed or untreated it can potentially lead to an irreversible pathway towards disability<sup>2</sup>. Therefore, it is necessary to intervene in all possible risk indicators and associated factors to restore health.

Few studies have assessed the association between frailty's criteria and oral health<sup>3,4</sup>. Castrejón-Pérez et al<sup>3</sup> proposed an explanatory approach of oral health with frailty in a four-element model, which consists of: a) therapeutic decisions and utilization of services; b) functional ability of the mouth; c) psychosocial process of the subject and d) a physiologic and biologic component. In this model, these components emerge from the deterioration of oral health and, the use or not of dental service can result in different outcomes affecting functionality and quality of life. Moreover, oral health related quality of life (OHRQoL) has been demonstrated to be associated with frailty, use and need of dental prosthesis and functional dentition<sup>5</sup>.

Mental problems, as chronic stress and depression, may also affect health related quality of life (HRQOL) in elderly patients. Depression can influence physical outcomes and its association with frailty has been demonstrated in studies<sup>6</sup> possible due to an overlap of coexistent characteristics<sup>7</sup>. Also Hugo et al<sup>8</sup> observed the effects of psychological reactions in the development of oral infections, since depression has been associated with untreated dental caries.

Oral diseases and treatment needs can interfere in mental and general health and result in consequences that can distress the elders. Likewise, as individuals get older, general health status and the use of several medications affect them more often and impact in their ability to speak, to taste and to swallow generating pain and discomfort<sup>9</sup>. In evaluating the Brazilian elderly, a study found that frail subjects were more likely to present an increased number of comorbidities<sup>7</sup>. The reduction of mobility and the development of disability or dependence, conditions linked to frailty<sup>3</sup> may also affect dental care and the use of dental services.

The aim of this exploratory study was to investigate if poor oral health acts as an associated factor for frailty. Our hypothesis is that independently-living older individuals

with partial or complete tooth loss, which is not rehabilitated with dental prosthesis, low self-perception of oral health, and chewing problems are more likely to be prefrail/frail.

### **Methods:**

This cross-sectional study nested in a major cohort study, The Carlos Barbosa Study (CBCS), about the association between oral conditions on the general health of independent-living older subjects, was conducted from March to September 2012 in Carlos Barbosa, southern Brazil.

In 2004 a sampling strategy was used to select participants from the municipality registers of independent-living individuals aged 60 years or more in 2004. Potential participants were invited to take part in the study through phone or letter and those who refused to participate were replaced randomly. The baseline study comprised a representative sample of 872 independently-living older individuals and in 2008 it was conducted the first-follow-up which included 587 participants. The second follow-up was conducted in 2012 and 389 subjects participated. For the current study, data from the second follow-up was used.

The Committee of Ethics in Research of the Piracicaba Dental School (CEP-FOP/UNICAMP protocol nº 017/2011) and the Municipal Health Council approved the conduct of the study.

### **Study Design**

Participants were contacted to take part in the study through phone calls and visits. It was also used the contact record from the Health Unit and the city's telephone book. The sample consisted of those individuals that participated in the first study about the elderly population of Carlos Barbosa held in 2004 (N=872). A 145 individuals died since the first survey in 2004, and in 2012 seventy-three were not located, 51 were excluded due to severe illness/dependency, 11 have moved from Carlos Barbosa and 203 refused to participate.

The research interview including oral examinations was conducted at the dental clinics of the municipal health units, community or at clubhouses or at the participant's homes. Two trained and experienced dentists performed the oral examinations. Duplicate dental inspections were conducted on 10% of the participants for reliability. The inter and



intra-examiner reliability coefficients for the DMFT index and other oral health outcomes were calculated using Kappa coefficients (Kappa=0.985). Inter-examiner agreement between two dentists was conducted by duplicate examinations on 40 persons.

## **Measures**

For this study the measures comprised an interview administered structured questionnaire with information about socio-demographic and behavioral factors, access to health services, medical history and depression. The interview was completed with an oral examination, anthropometric and frailty assessments. The oral status assessment comprised an oral examination under standardized illumination. The dental condition was assessed through DMFT index and dental prosthesis need according to the WHO criteria<sup>10</sup>.

### *Sociodemographic data*

The sociodemographic questionnaire included age, gender (female/male), geographical location of the participant's home (urban/rural), marital status, "people living in the dwelling" and schooling. The variables age and schooling (in years) were used as continuous variables. Marital status was coded as married (married/living with a companion/stable union) and not married (single/widow/ divorced), "people living in the dwelling" variable was dichotomized as live with others (live with companion/family) and alone. Family income was collected as a continuous variable and was dichotomized as 0 - 2 minimum Brazilian wage (MW) and > 02 MW.

### *Behavioral data*

Smoking history was assessed by asking the following question: "Have you smoked more than a hundred cigarettes in your life?", and drinking alcohol behavior was assessed by asking the question: "Do you drink alcohol beverages?". Both with possible answers yes and no. Frequency of dental visits was dichotomized in occasionally (occasionally/regularly) and in never (never/problem-oriented).

### *General health data*

For depression (Geriatric Depression Scale - GDS)<sup>11</sup> the cut-off point considered was 6-15 for depression and 0-5 for no depression. All the prescribed medication taken

daily was asked and the sum of the amount of the medications was considered as a continuous variable. Also the presence of hypertension, arthritis, osteoporosis, cancer, heart disease, stroke, lung disease and diabetes was recorded if reported that a physician had previously diagnosed it. A new variable indicative of the count of diseases was generated after summing them when present.

Height and weight measurements were used to derive BMI (Body Mass Index) as weight in kilograms (Tanita body fat monitor; scale TBF-612; Tanita Corp., Maeno-Cho Itabashi-Ku, Tokyo, Japan) divided by height in squared meters ( $\text{kg}/\text{m}^2$ ). Participants were classified as underweight ( $<23 \text{ kg}/\text{m}^2$ ), eutrophic ( $23\text{--}27.99 \text{ kg}/\text{m}^2$ ), overweight ( $28\text{--}29.99 \text{ kg}/\text{m}^2$ ), and obese ( $\geq 30 \text{ kg}/\text{m}^2$ ).

#### *Quality of life*

Quality of life was assessed through the validated version of WHOQOL-Bref<sup>12</sup> and its dimensions (physical, psychological, environment, social relations) in Portuguese. Each dimension was considered as continuous variables.

#### *Oral health data*

Dental prosthesis need in upper and/or lower arches was dichotomized into need (need for one-unit prosthesis; multi-unit prosthesis; combination of one and/or multi-unit prostheses; full-arch prosthesis) versus no need for any dental prosthesis according to the WHO criteria. Chewing satisfaction was assessed using the question "How satisfied are you with your chewing ability?" and was dichotomized in satisfied (very satisfied/ satisfied) and unsatisfied (unsatisfied/very unsatisfied). Using each individual's DMFT (decayed, missing and filled) count, functional dentition was categorized in edentulous, 01-19 teeth and 20-32 present teeth. Missing, decayed and filled teeth of the DMFT were used as continuous variables.

Self-perception of oral health (SPOH) was assessed through the question "Compared to other people your age, how would you rate your mouth and teeth?" and the possible answers were dichotomized as good (excellent/ very good/ good) and bad (fair/bad). Type of dental service used was considered private (private/ dental plans) and public.

### *Frailty*

A person was classified as frail when three or more of the following criteria were present<sup>1</sup>: unintentional weight loss ( $\geq 4,5\text{Kg}$  or 5% body weight in the past year), self-reported exhaustion, weakness (grip strength- lowest 20% by gender and BMI), slow walking speed (4,6m plus 2,0 m to accelerate and more 2,0 m to slow down - lowest 20% by gender and height), and low physical activity (lowest 20% by gender). Prefrail was considered in the presence of one or two of these criteria and robust without any of them. Grip strength was measured using a dynamometer (Hydraulic Hand Dynamometer, SH5001, SAEHAN Corporation). Both slowness and handgrip strength were measured three times with one-minute interval among them. The ratio between the measures was calculated. Afterwards, the outcome was dichotomized in robust and prefrail/frail.

### **Analysis of Data**

For the analytical plan, descriptive analyses were conducted to check the distribution of the study variables. Bivariate analysis was performed and included chi-square tests and one-way ANOVA. All the variables with  $p < 0.20$  were selected to the multivariate models, backward logistic regression. Multicollinearity of the variables at each group was checked. To perform the analysis it was used SPSS version 21 (SPSS IBM, New York, USA). Interaction of frailty and the effect modifiers were analyzed by logistic regression.

### **Results:**

Key characteristics of the studied sample are presented in Tables 1 and 2. The prevalence of frail elders was 6.6% (n=26), pre-frail elders was 46% (n=182) and robust elder was 47.4% (n=188). Most of the study participants' were female (67.9%) and lived in the urban area (55.3%). Among both prefrail/frail and robust groups most of the elders were married and not depressed.

Table 1: Characteristics of the Study Sample by Frailty Criteria, Carlos Barbosa, Brazil, 2012 (n=389).

<i>Variables</i>		<i>Robust n (%)</i>	<i>Prefrail/Frail n (%)</i>	<i>p</i> <sup>*</sup>
People living in the dwelling <sup>a</sup>	Live with others	171 (92.4)	170 (83.7)	0.009
	Alone	14 (7.6)	33 (16.3)	
Location	Urban	94 (50.8)	121 (59.3)	0.09
	Rural	91 (49.2)	83 (40.7)	
Marital Status <sup>b</sup>	Married	144 (78.3)	117 (57.9)	<0.001
	Not married	40 (21.7)	85 (42.1)	
Family income <sup>c</sup>	>02 MW	91 (56.9)	80 (44)	0.02
	0-02 MW	69 (43.1)	102 (56)	
Gender	Male	59 (31.9)	66 (32.4)	0.92
	Female	126 (68.1)	138 (67.6)	
Smoking habit	No	154 (83.2)	155 (76)	0.08
	Yes	31 (16.8)	49 (24)	
Drinking alcohol behavior	No	96 (51.9)	125 (61.3)	0.06
	Yes	89 (48.1)	79 (38.7)	
Frequency of dental visits	Occasionally	43 (23.2)	35 (17.2)	0.13
	Never	142 (76.8)	169 (82.8)	
Depression (GDS)	Not depressed	173 (93.5)	180 (88.2)	0.07
	Depressed	12 (6.5)	24 (11.8)	
Functional Dentition	Edentulous	90 (48.6)	109 (53.4)	0.09
	01-19 teeth	78 (42.2)	86 (42.2)	
	20-32 teeth	17 (9.2)	09 (4.4)	
Dental Prosthesis Need <sup>a</sup>	No need	150 (81.1)	150 (73.9)	0.09
	Need prosthesis	35 (18.9)	53 (26.1)	
Chewing satisfaction	Satisfied	164 (88.6)	167 (81.9)	0.06
	Not satisfied	21 (11.4)	37 (18.1)	

\* $p < 0.20$

<sup>a</sup>data for 388 participants

<sup>b</sup>data for 386 participants

<sup>c</sup>data for 342 participants.

Table 2: Mean and Distribution of Associated Factors by Frailty Criteria.

<i>Variables</i>	<i>Mean±SD</i>	<i>Robust</i>	<i>Prefrail/Frail</i>	<i>p*</i>
		<i>Mean</i>	<i>Mean</i>	
Age	73.85±5.42	72.51±4.86	75.07±5.61	<0.001
Schooling (years) <sup>a</sup>	3.87±2.07	4.02±1.95	3.73±2.16	0.17
Number of medications <sup>b</sup>	3.89±2.87	3.56±2.67	4.20±3.02	0.03
Number of diseases <sup>c</sup>	2.22±1.57	1.42±0.10	1.66±0.12	0.003
WHOQOL- physical	14.43±1.59	1.38±0.10	1.75±0.12	0.09
WHOQOL- psychological	15.43±1.09	15.54±1.10	15.33±1.07	0.04
WHOQOL- environment	15.1±0.83	15.15±0.84	15.06±0.83	0.29
WHOQOL- social relations	15.45±1.05	15.47±0.94	15.43±1.14	1.12
D – decayed teeth	0.31±1.00	0.30±1.04	0.31±0.98	0.87
M – missing teeth	28.16±6.59	27.44±7.34	28.82±5.78	0.04
F – filled teeth	1.41±3.08	1.53±3.02	1.30±3.14	0.46

\* $p < 0.20$

<sup>a</sup>data for 385 participants.

<sup>b</sup>data for 380 participants.

<sup>c</sup>data for 379 participants.

The results of the associations between prefrailty/frailty and associated factors are presented in Table 3, regarding 339 elder participants due to missing in some variables. Logistic regression models showed that those who need dental prosthesis were 2 times more likely to be prefrail /frail when compared to those who did not need (OR=2.026, CI95% 1.10-3.72); those with a higher number of missing teeth (M) were 1 time more

likely to be prefrail/frail than those with more present teeth (OR=1.056, CI95% 1.01-1.10), although a marginally significant direct relationship between frailty and missing teeth; those who have smoked at least a hundred cigarettes in life were 2.5 times more likely to be prefrail /frail when compared to those who had never smoked (OR=2.585, CI95% 1.42-4.70) and those who are depressed were 2.8 times more likely to be prefrail/frail than those who are not depressed OR=2.896, CI95% 1.21-6.93), after controlling for age, family income and marital status.

Table 3: Logistic Regression Model for the Association between Prefrailty/Frailty and Associated Factors, Carlos Barbosa, Brazil (n=339).

Variables	Model 1 <sup>a</sup>		Model 2 <sup>a</sup>		Model 3 <sup>a</sup>		Model 4 <sup>a</sup>		Model 5 <sup>a</sup>	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
M - missing	1.045 (1.003-1.09)	<b>0.03</b>	1.047 (1.002-1.09)	<b>0.04</b>	1.049 (1.003-1.10)	<b>0.04</b>	1.048 (1.002-1.10)	<b>0.04</b>	1.056 (1.01-1.10)	<b>0.01</b>
Prosthesis need	1.904 (1.04-3.47)	<b>0.03</b>	1.922 (1.03-3.60)	<b>0.04</b>	2.054 (1.07-3.92)	<b>0.03</b>	2.021 (1.05-3.87)	<b>0.03</b>	2.026 (1.10-3.72)	<b>0.02</b>
Chewing satisfaction	1.319 (0.64-2.71)	0.45	1.225 (0.58-2.58)	0.59	1.140 (0.53-2.44)	0.73	1.046 (0.48-2.28)	0.91	-	-
SPOH compared	1.693 (0.92-3.10)	0.08	1.726 (0.93-3.20)	0.08	1.719 (0.91-3.24)	0.09	1.662 (0.87-3.16)	0.12	-	-
Frequency dental visits	-	-	1.088 (0.58-2.04)	0.79	1.083 (0.57-2.05)	0.81	0.116 (0.58-2.14)	0.74	-	-
Type of dental service	-	-	0.908 (0.51-1.62)	0.74	0.840 (0.47-1.51)	0.56	0.849 (0.47-1.53)	0.59	-	-
Smoking behavior	-	-	2.683 (1.44-5.00)	<b>0.002</b>	2.874 (1.50-5.49)	<b>0.001</b>	3.030 (1.57-5.85)	<b>0.001</b>	2.585 (1.42-4.70)	<b>0.002</b>
Drinking Alcohol	-	-	1.309 (0.78-2.19)	0.30	1.164 (0.69-1.97)	0.57	1.141 (0.67-1.94)	0.62	-	-
Depression	-	-	-	-	2.452 (0.96-6.26)	0.06	2.128 (0.79-5.74)	0.14	2.896 (1.21-6.93)	<b>0.02</b>
Number of diseases	-	-	-	-	1.127 (0.92-1.37)	0.24	1.081 (0.88-1.33)	0.46	-	-
Eutrophic	-	-	-	-	0.756 (0.34-1.67)	0.49	0.710 (0.32-1.58)	0.40	-	-
Overweight	-	-	-	-	0.459 (0.18-1.16)	0.09	0.415 (0.16-1.06)	0.07	-	-
Obese	--	-	-	-	0.815 (0.35-1.89)	0.63	0.768 (0.33-1.79)	0.54	-	-
WHOQOL - physical	-	-	-	-	-	-	0.908 (0.76-1.09)	0.29	-	-
WHOQOL - psychological	-	-	-	-	-	-	0.932 (0.72-1.21)	0.60	-	-
-2 Log likelihood	413.623		403.310		393.638		391.929		403.360	
Nagelkerke R <sup>2</sup>	0.196		0.231		0.262		0.267		0.234	

<sup>a</sup>All models adjusted for age, family income and marital status.

Reference categories: (low number of missing teeth, no need for dental prosthesis, satisfied with chewing, good perception of OH, high frequency of dental visits, private dental service, never smoked at least a 100 cigarettes, do not drink alcohol beverages, not depressed, low amount of diseases, underweight, low WHOQOL in psychological and low WHOQOL in physical dominium



## Discussion

High number of missing teeth and the need for dental prosthesis were associated with an increased likelihood of being frail. In this study 93.3% of the DMFT counts were represented by the missing component. The absence of teeth and the need for rehabilitation contribute to changes in diet and to the consumption of lower amounts of fruits and vegetables due to difficulties in chewing<sup>13</sup> and consequently, this change impact on nutritional health. In a study that assessed the relation among female denture wearers, frailty and mortality, the authors observed that among the ones that reported the use of dentures and difficulties in chewing or swallowing, a high proportion presented frailty. This finding suggested the decrease in the consumption of serum carotenoids found in fruits and vegetables and its role in the nutritional state and sarcopenia<sup>14</sup>. Not only tooth loss but also poor dentition and the presence of pain could limit food selection and the intake of important nutrients contributing to worsening malnutrition and leading to functional decline<sup>15</sup>.

Also the loss of teeth represents a lifetime history of not only dental disease but also access, use of dental services<sup>16</sup> and quality of dental care. Moreover the lack of dental services utilization in elders might reflect compromised general health and that may be related to frailty or even be a consequence of constriction to life space (the spatial mobility area), along with low expectations about oral health<sup>3</sup>. Another possible explanation for the association between frailty and poor oral health might be the fact that health attitudes and beliefs are likely to play a more important role in predicting the oral health behavior of frail elderly, than the need for some treatment<sup>17</sup>, since many elders believe that losing teeth is related to getting old. In addition, chewing satisfaction and self-perception of oral health were not related to frailty in this study even though one of the possible pathways towards frailty may be represented by the quality of nutrition. In addition, increased frailty reflects increased health problems and older people compare oral discomfort to other, more concerning, health problems, or attribute it to old age or genetic factors<sup>17</sup>.

Depression was also associated with frailty in this study, result that is consistent with other published research<sup>18</sup>. When frailty is related to depression, the term psychologically frail<sup>6</sup> is sometimes used. In this regard, the frailty development is promoted

by the overlap of depressive symptoms with disease burden, in the presence or not of antidepressant medication<sup>19</sup>.

We did not find an association in this analysis between the increase in the number of diseases and frailty even though the accumulation of deficits which represents the amount of problems individuals have, is supposed to be greater in frail subjects<sup>20</sup>, and other study with older population from Brazil have reported a positive association between comorbidities and frailty<sup>21</sup>. Frail elders are more prone to longer hospitalizations and hospital readmission rates and as a consequence increased risk of mortality<sup>22</sup>. Finding from previous study also showed that being overweight represents a protection in the elderly, since women classified as overweight presented the lowest rates of mortality<sup>23</sup>. Likewise, in this study the ones with normal or extra weight seem to be protected from frailty, even though the association was not significant.

Social network and other sociodemographic variables have an important role on frailty, since frailty and socioeconomic status have been demonstrated to be related to each other through different biological mechanisms<sup>24</sup>. Age (1.11 CI95% 1.05-1.17) and marital status (2.65 CI95% 1.55-4.54) were associated with frailty (data not shown). However, family income (1.37 CI95% 0.85-2.21) was not. Participant's age was associated with frailty possible due to the fact that frailty increases with age. Since frailty is considered a condition related to the accumulation of deficits it tends to be more frequent in older subjects. Also social network seems to be an important factor. A study conducted by Tsakos et al<sup>16</sup> showed the protective role of marriage on oral health of older adults<sup>16</sup> and on general health evaluated through hospitalizations<sup>25</sup>. Moreira & Lourenço<sup>21</sup> observed that widows and single individuals were more likely to be frail.

Regarding behaviors, the current study found that smoking was associated with higher odds of being frail, which corroborates the findings from other studies<sup>26</sup>. Smoking can lead to health problems and affect socialization; also its inflammatory response can reduce muscular mass, strength and physical capacity<sup>26</sup>. It has also being associated with higher risk of health decline leading to disability and death within a 11-year follow-up<sup>27</sup>. It is important to highlight that the variable smoking behavior can represent a present or past behavior, although even after quitting, smoking may exert an effect on the periodontium<sup>28</sup>,

since smoking also can increase the odds of having fewer teeth<sup>29</sup>, especially via the effect on periodontal disease<sup>30</sup>.

Although in this study there was no association between frailty and HRQOL it has been reported in the literature that the consequences of being frail may negatively impact this dimension<sup>27</sup>. Chang et al<sup>27</sup> observed that being frail was related to low scores in the physical and mental components of HRQOL. The value of having natural teeth was recognized by severely frail people as a contributor to people's HRQOL<sup>31</sup>.

In this study elderly in need of prosthetic rehabilitation presented a chance of becoming prefrail/frail, however the intervention to restore health of the elderly that present oral health problems is dependent on the access to dental services and its quality. This finding answers two out of the four elements proposed by Castrejon-Pérez et al<sup>3</sup> model: "Decisions and therapeutic utilization of services" and "functional ability of the mouth" and contributes to the knowledge of the role of oral health in the pathway towards frailty.

Finally, there are several limitations to be noted in this study. First, the prevalence of frailty was 6.6% in the current study. In the FIBRA Study which evaluated frailty in seven Brazilian municipalities, the reported prevalence was 9.1% and 51.8% for pre-frailty<sup>32</sup>. In Fried's study the prevalence of frailty was 6.9%<sup>1</sup>. The fact that only 26 of the participants were frail and therefore the prefrail and frail categories were collapsed might represent a limitation since it is not possible to determine which associated factors are related with the transitional and frailty categories. This would represent a more reliable result. Second, the cross-sectional nature of this study limits our ability to draw causal inferences. Third, the majority of the population studied was Caucasian (97.9%) and frailty has been reported to be associated with race as higher prevalence of frailty is seen among blacks<sup>33</sup>.

Focusing on mental and oral preventive care as well as the improvement of quality of care through the early detection of elderly people at high risk for future decline<sup>34</sup> can prevent the pathway towards frailty and promote a better life span. Especially when having almost half of the sample as pre-frail subjects, a transitional condition, like in this study. Also in the future older groups might present more teeth and therefore will need more

preventive actions to the maintenance of oral health and healthy behaviors and a high quality care which can also provide a proper rehabilitation when needed.

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### Capítulo 3

#### Oral health in obese Brazilian elders: a longitudinal study

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**Running Title:** Oral health in obese Brazilian elders

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## Abstract

*Objective:* The aim of this longitudinal study was to investigate if poor oral health status represented by frequency of dental service use, tooth loss, edentulism, lack of rehabilitation (edentulous without full dentures in both arches), need for dental rehabilitation, self-perception of oral health and dry mouth, contributes to the development of general (BMI) and central obesity (WC).

*Design and Methods:* We included in this analysis all participants who volunteered for at least two times in a cohort study entitled “The Carlos Barbosa Cohort Study-CBCS”. The interview questionnaire collected socio-demographic information, behavioral factors, medical history, oral and anthropometric assessment.

*Results:* A total of 633 independently-living elders participated. The baseline mean age was  $67.5 \pm 6.1$ . Individuals who never visited a dentist were more likely to be obese (OR=3.02, 95%CI:1.25-7.26) according to the BMI and the need for a full mandibular denture increased the risk for being obese according to their waist-circumference ratio-WC (OR=4.38, 95%CI:1.34-14.32). Regarding BMI, edentulous subjects with full dentures in both arches (OR=0.23, 95%CI:0.06-0.84) and those who perceived their oral health as unsatisfactory, according to the WC (OR=0.43, 95%CI:0.19-0.88), had a lower likelihood of being obese.

*Conclusions:* Poor oral health acts as predictors for general and central obesity.

**Key-words:** Obesity, abdominal obesity, oral health, tooth loss.

## Introduction

Good oral hygiene is essential for oral health. In the presence of pathogenic biofilm, caries<sup>1</sup> and periodontal disease may progress resulting in tooth loss. Full edentulousness can affect food choices and result in changes in diet and nutritional health<sup>2</sup>. Edentulous individuals refrain from eating hard foods and choose softer foods which may have lower nutritional value<sup>3,4</sup>. The consumption of fruits and vegetables,

which is a nutritional indicator<sup>5</sup> of a healthy diet, can be affected by full loss of teeth leading to negative health outcomes. Macro and micronutrient deficiencies are seen in both under and overweight elders and these deficiencies can be linked to a functional decline that may result in falls, fractures, infections and even dementia<sup>6</sup>. Studies with adults and older subjects have reported that more edentulous individuals experienced difficulty in eating all foods especially fruits and vegetables than dentates<sup>2,4,5</sup>. Diet low in fruits is responsible for 4.2% of global DALYs (disability-adjusted life years) and millions of deaths<sup>7</sup>; also overweight/obesity is responsible for 6.5% of DALYs in high-income countries<sup>8</sup>.

Tôrres et al (2012)<sup>9</sup> evaluated the BMI (Body Mass Index) in a Brazilian population and found that edentulous subjects wearing none or one denture had higher odds of being overweight/obese compared with dentate individuals regardless of physical activity. The current global epidemic of obesity is one of the most important problems that impact public health in both developed and developing countries because obesity and its predisposing factors are significant risk factors of other chronic diseases like diabetes, cardiovascular disease and some cancers<sup>10</sup>. Also, obesity plays a role in increased abdominal adiposity, which is associated to the risk of death<sup>11</sup>.

An increased accumulation of body fat in general is accompanied by increased total body mass in both men and women<sup>12</sup>. Body fat content, fat distribution or adiposity could be considered as indicators of health risk<sup>13</sup>. The BMI is one of the most used anthropometric indicators and it is easy to measure. However, BMI does not differentiate fat mass from lean mass and central from peripheral fat<sup>14</sup>. Other measures like body-adiposity index (BAI) and the ones that reflect abdominal adiposity like waist-circumference (WC), waist-hip ratio (WHR), waist-height ratio (WHtR) have been suggested<sup>15</sup> as alternatives or complements to BMI.

This paper presents the findings of a longitudinal study of the role of oral health status in adiposity using different measures like BMI and WC. The objective of this longitudinal study was to investigate if poor oral health status represented by frequency of dental service use, tooth loss, edentulism, lack of rehabilitation (edentulous without full dentures in both arches), need for dental rehabilitation, self-perception of oral health and dry mouth, contributes to the development of general (BMI) and central obesity (WC). Our hypothesis is that poor oral health increases the risk of developing obesity.

## **Methods and Procedures**

For this study we used the data from the baseline (2004), the first (2008) and the second follow-up (2012) of a cohort study entitled The Carlos Barbosa Cohort Study – CBCS, located in the city of Carlos Barbosa, southern Brazil. In the 2000 Census, the city had 20,519 inhabitants of whom 2,167 were aged 60 years or more. In 2004, a random sample of adults 60 years or older (n=872) was selected from the municipality registers of independent-living elderly individuals. Potential participants were invited to take part in the study through phone or letter and a randomly selected individual substituted those who refused to participate. Representativeness of the study participants was evaluated through the socio-demographic data of the overall population aged 60 years or more living in Carlos Barbosa and no significant differences were found between them and the study participants regarding age, gender, marital status and geographic location of their residences. Additional information can be found elsewhere (Hilgert et al, 2009)<sup>16</sup>.

### *Study Design*

For the first and second follow-up the same individuals from the baseline were contacted to take part in the study through phone calls and visits. From the baseline to the second follow-up 145 elders died and 100 were excluded due to illnesses (Figure 1).

The interview including oral examinations in both baseline and follow-up was conducted at the dental clinics of the health units provided by the municipality, or community clubhouses and at the participant's homes. In all waves two trained dentists by a gold standard examiner performed the oral examinations. The confidence of the oral examinations was verified for the three data collections and 10% of the participants were reexamined for reliability coefficients. The training ensured agreement of 90% and 10% of reexaminations conferred reliability in the three waves.

All the waves were approved by the Committee of Ethics in Research (Ethics Committee of the Piracicaba Dental School CEP-FOP/UNICAMP protocols n° 055/2004 and 017/2011 and in 2008 by the Committee of Ethics in Research of the Federal University of Rio Grande do Sul) and by the Carlos Barbosa's Health Council and all participants provided written informed consents. For this study we considered all participants that had been a volunteer in at least two out of the three waves. A total of

290 volunteers participated twice and 343 three times resulting in 633 participants for this study (Figure 1).

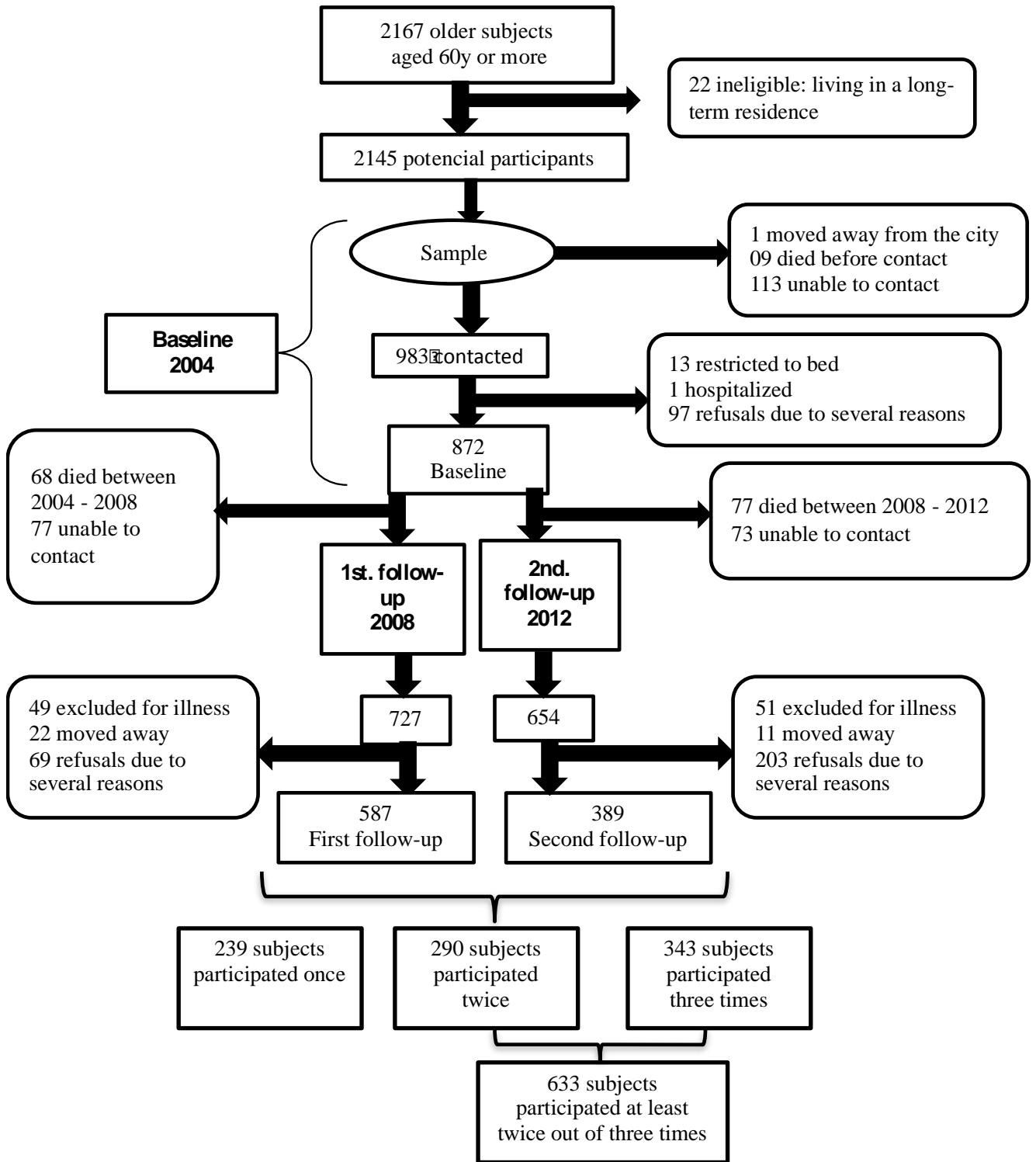


Figure 1: Flow chart of the sample procedure from the baseline to the second follow-up.

*Measures:*

Individuals were interviewed face-to-face and questioned about their socio-demographic and behavioral factors, medical history, and depression. An anthropometric assessment was conducted by measuring height, weight, and measures of hip and waist circumferences. An oral examination was conducted under standardized lighting and conditions such as the number of teeth and the use and need for dental prostheses were assessed according to WHO (World Health Organization) criteria<sup>17</sup>.

The sociodemographic questionnaire assessed age, gender, geographic location of the participant's home (area), marital status and monthly income (in Reais). The study variables were coded as follows: gender (female and male); area (urban or rural), marital status [married (married/living with a companion/stable union) and not married (single/widow/ divorced)], individual monthly income was collected as a continuous variable and was dichotomized as  $\leq 1$  Brazilian minimum wage (MW) and  $> 1$  MW, schooling ( $> 4$  years/  $\leq 4$  years of education) and ethnicity (white/others). The behavioral questions assessed drinking alcohol, smoking behaviors and physical activity. Drinking alcohol was assessed through the question "Do you drink alcohol beverages?" and smoking behavior was assessed through "Do you currently smoke?" (yes and no). It was also assessed frequency of dental visits [I never go to the dentist/ I go to the dentist when I have a problem and sometimes (regularly/occasionally)]. For the physical activity variable the ones that had weekly at least 120 minutes in vigorous activities or 150 minutes in moderate activities were considered active, less than that it was classified as sedentary. It was considered neither domestic activities nor passive leisure.

The medical history questionnaire assessed self-reports of chronic diseases and medications, even though participants were asked to bring their medications to the interview. Number of comorbidities and number of medications were used as continuous variables. The variable number of comorbidities was created based on the sum of the presence of self-reported hypertension, arthritis, osteoporosis, cancer, heart disease, lung disease and diabetes. In the absence of one of these diseases it was not counted for that disease. The number of medications was also summed to create the respective variable. Frailty was classified according to Fried's criteria (Fried et al, 2001)<sup>18</sup> where at least 3 out of 5 of the conditions, unintentional weight loss ( $\geq 4,5$  Kg or

5% body weight in the past year), self-reported exhaustion, weakness (grip strength-lowest 20% by gender and BMI), slow walking speed (4,6m - lowest 20% by gender and height), and low physical activity (lowest 20% by gender) are present. Prefrail in the presence of one or two of these criteria and robust without any of them.

The number of teeth (continuous variable) and self-report of dry mouth (yes and no) were assessed. The self-report of dry mouth was assessed through the question "Do you feel your mouth dry?". Self-perception of oral health (SPOH) was asked through the question "How do you evaluate your oral status?" [satisfied (very satisfied/satisfied) and unsatisfied (very unsatisfied/unsatisfied)]. In addition, a new variable ("prosthesis use") indicative of the presence of dental rehabilitation was generated as follows: edentulous with two full dentures/edentulous with one denture/ no use (did not use prosthesis or used other types of prosthesis). Prosthesis need was dichotomized in need and no need. Likewise the number of natural teeth present in the oral cavity was computed and was categorized as edentulous, 01-20 and 21-32 teeth.

Height and weight measurements were used to derive BMI as weight in kilograms divided by height in meters squared ( $\text{kg/m}^2$ ). For the height measure, a stretch-resistant tape measure 50 cm from the ground was used and the individual was asked to stand barefoot or with thin socks and wearing light clothing and head horizontal in the Frankfurt plane. Weight was measured using a digital personal scale on a hard level surface (Tanita body fat monitor; scale TBF-612; Tanita Corp., Maeno-Cho Itabashi-Ku, Tokyo, Japan).

The waist circumference measure was made in the midpoint between the lower margin of the last palpable rib and the top of the iliac crest (WHO, 2008a)<sup>15</sup>.

Increased BMI was considered a proxy of general body adiposity and WC as visceral/central adiposity. The cut-off point for BMI considered was established by the Pan-American Health Organization - PAHO in the Health, Well-Being and Aging Study - SABE<sup>19</sup> (obesity:  $\text{BMI} \geq 30\text{Kg/m}^2$ ) and for WC ( $>0.80$  for women and  $>0.94$  for men) were used by the WHO (WHO, 2000)<sup>20</sup>.

### *Data Analysis*

For the analytical plan, descriptive analyses were conducted to check the distribution of the study variables for the baseline and the follow-up. Bivariate analyses included chi-square tests for categorical variables and one-way ANOVA for continuous ones. All the variables with  $p < 0.05$  and the ones with conceptual plausibility were selected for the development of longitudinal data analysis. Logistic regression models assessed crude and adjusted odds ratios (OR) and 95% confidence interval (CI) using a mixed effect scheme considering two levels of data organization (Singer et al)<sup>21</sup>. All the models were adjusted for sociodemographic, behavioral and general health condition. The non-obese categories were used as the reference category and the outcomes were expressed for the obese category for both BMI and WC. The SPSS 18.0 software (SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.) and the STATA 12.1 2012 (Stata Corporation, College Station, TX) were used for the analyses.

## **Results**

Tables 1 presents the frequency distribution of the characteristics of the participants of the study and Table 2 presents the unadjusted assessment of covariates for the outcomes BMI and WC. A total of 633 elders participated in at least two waves. The baseline mean age of the participants in this study was  $67.5 \pm 6.1$ . In 2004, 66.2% females participated in the study. The majority of the sampled individuals were married (72.1%). The mean number of teeth was  $5.2 \pm 7.1$ . Mean BMI and WC were  $27.7 \pm 4.7$ ,  $97.62 \pm 11.18$ , respectively. In the follow-up the mean age was  $71.6 \pm 6.1$  and  $73.9 \pm 5.5$  (2008 and 2012, respectively), there were also more females in the study (65.5% in 2008 and 67.9% in 2012) and more married volunteers (65.4% and 67.6%) (Table 1). The mean number of teeth was similar to the baseline ( $4.8 \pm 7.1$  and  $5.0 \pm 7.0$ , respectively). Mean BMI and WC were respectively in 2008 and in 2012  $28.1 \pm 4.8$ ,  $28.2 \pm 5.1$  and  $100.36 \pm 11.70$ ,  $99.74 \pm 12.01$ . Almost half of the obese individuals were edentulous in the three waves for both outcomes (table 2). Only in 2004 the variable prosthesis use was associated with both outcomes.

### *Longitudinal data analysis*

Individuals who never visited a dentist were more likely to be obese (OR=3.02, 95%CI 1.25-7.26) according to the BMI and the need for a full mandibular denture



increased the risk for being obese according to their waist-circumference ratio (OR=4.38, 95%CI 1.34-14.32). Regarding BMI, edentulous subjects with full dentures in both arches (OR=0.23 95%CI 0.06-0.84) and those who perceived their oral health as unsatisfactory, according to the WC (OR=0.43 95%CI 0.19-0.88), had a lower likelihood of being obese than the other groups (table 3).

Table 1: Frequency and distribution of the elderly according to sociodemographic, behavioral, general health and obesity indicators, Carlos Barbosa, Brazil.

<i>Variables</i>		<i>2004</i>	<i>2008</i>	<i>2012</i>
		<i>n (%)*</i>	<i>n (%)*</i>	<i>n (%)*</i>
<i>Outcomes</i>				
BMI - Body Mass Index	Not obese	418 (71.7)	376 (69.2)	264 (68)
	Obese	165 (28.3)	167 (30.8)	124 (32)
WC - Waist circumference ratio	Not obese	95 (16.2)	83 (15.2)	55 (14.2)
	Obese	490 (83.8)	463 (84.8)	333 (85.8)
<i>Sociodemographic</i>				
Gender	Male	214 (33.8)	203 (34.5)	125 (32.1)
	Female	419 (66.2)	385 (65.5)	264 (67.9)
Marital Status	Married	455 (72.1)	382 (65.4)	261 (67.6)
	Not married	176 (27.9)	202 (34.6)	125 (32.4)
Schooling	>4 years	171 (27.1)	304 (52.2)	112 (28.8)
	≤4 years	459 (72.9)	278 (47.8)	277 (71.2)
Ethnicity	White	611 (97.9)	571 (99.7)	377 (59.6)
	Other	13 (2.1)	02 (0.3)	08 (2.1)
Area	Urban	300 (47.4)	-	215 (55.3)
	Rural	333 (52.6)	-	174 (44.7)
Income	>1 MW	272 (43.2)	281 (47.9)	150 (38.8)
	≤1 MW	358 (56.8)	306 (52.1)	237 (61.2)
<i>Behavioral</i>				
Drinking alcohol behavior	No	295 (46.7)	244 (41.6)	221 (56.8)
	Yes	337 (53.3)	342 (58.4)	168 (43.2)
Smoking habit	No	101 (74.8)	554 (94.5)	375 (96.4)
	Yes	34 (25.2)	32 (5.5)	14 (3.6)
Physical activity	Active	-	-	139 (35.7)
	Sedentary	-	-	250 (64.3)
<i>General Health</i>				
Comorbidities	0-1	372 (58.8)	-	176 (45.2)
	2-6	261 (41.2)	-	213 (54.8)
Amount of medication	0-1	88 (59.1)	196 (33.6)	83 (21.8)
	2-19	61 (40.9)	388 (66.4)	297 (78.2)

Frailty	Robust	-	-	185 (47.6)
	Pre-frail	-	-	178 (45.8)
	Frail	-	-	26 (6.7)

*\*The totals might not correspond to n=633 due to missing in some variables.*

Table 2: Univariate and mean of the independent variables by the outcomes Body Mass Index (BMI) and waist circumference (WC), Carlos Barbosa, Brazil.

<i>Variables</i>		<i>Year</i>	<i>BMI n (%)</i> <i>Non-obese</i>	<i>BMI n (%)</i> <i>Obese</i>	<i>p*</i>	<i>WC n (%)</i> <i>Non-obese</i>	<i>WC n (%)</i> <i>Obese</i>	<i>p*</i>
Dry mouth	Yes	2004	163 (39.2)	81 (49.1)	<b>0.03</b>	33 (34.7)	212 (43.4)	0.12
		2008	197 (52.5)	94 (56.3)	0.42	42 (51.2)	254 (54.9)	0.54
		2012	106 (40.2)	62 (50.0)	0.07	17 (30.9)	151 (45.3)	<b>0.04</b>
Functional dentition	1-20 teeth	2004	177 (42.3)	77 (46.7)	0.34	53 (55.8)	204 (41.6)	<b>&lt;0.001</b>
	21-32 teeth	2004	30 (7.2)	07 (4.2)		11 (11.6)	25 (5.1)	
	1-20 teeth	2008	148 (39.5)	73 (43.7)	0.48	34 (41.5)	190 (41.2)	0.98
	21-32 teeth	2008	20 (5.3)	11 (6.6)		05 (6.1)	26 (5.6)	
	1-20 teeth	2012	113 (42.8)	51 (41.1)	0.83	25 (45.5)	139 (41.7)	0.53
	21-32 teeth	2012	18 (6.8)	07 (5.6)		05 (9.1)	20 (6.0)	
Prosthesis need – upper arch	Need	2004	-	-	-	-	-	-
		2008	-	-	-	-	-	-
		2012	14 (5.3)	07 (5.6)	0.89	02 (3.6)	19 (5.7)	0.53
Prosthesis need – lower arch	Need	2004	-	-	-	-	-	-
		2008	-	-	-	-	-	-
		2012	47 (17.9)	34 (27.4)	<b>0.03</b>	10 (18.2)	71 (21.4)	0.59
Self-perception of oral health	Unsatisfied	2004	138 (33.0)	62 (37.8)	0.27	38 (40.0)	165 (33.7)	0.24
		2008	-	-	-	-	-	-
		2012	71 (26.9)	19 (15.3)	<b>0.01</b>	17 (30.9)	73 (21.9)	0.14
Frequency of dental service use	Never	2004	194 (47.0)	92 (56.4)	<b>0.02</b>	37 (38.9)	250 (51.8)	0.06
	Problem	2004	136 (32.9)	53 (32.5)		36 (37.9)	155 (32.1)	
	Never	2008	114 (30.6)	54 (32.5)	0.73	28 (34.1)	143 (31.1)	0.51
	Problem	2008	215 (57.6)	96 (57.8)		48 (58.5)	264 (57.4)	
	Never	2012	57 (21.6)	33 (26.6)	0.40	13 (23.6)	77 (23.1)	1.00
	Problem	2012	150 (56.8)	70 (56.5)		31 (56.4)	189 (56.8)	

Table 2: Univariate and mean of the independent variables by the outcomes Body Mass Index (BMI) and waist circumference (WC), Carlos Barbosa, Brazil. *Continued*

		<i>Year</i>	<i>BMI</i> <i>Non-obese</i> <i>n (%)</i>	<i>BMI</i> <i>Obese</i> <i>n (%)</i>	<i>p</i> *	<i>WC</i> <i>Non-obese</i> <i>n (%)</i>	<i>WC</i> <i>Obese</i> <i>n (%)</i>	<i>p</i> *
Prostheses use	Full prosthesis in one arch	2004	145 (34.8)	84 (50.9)	<b>0.001</b>	40 (42.6)	191 (39.0)	<b>0.003</b>
	Full prosthesis in both arches	2004	189 (45.3)	62 (37.6)		28 (29.8)	223 (45.5)	
	Full prosthesis in one arch	2008	120 (34.3)	72 (45.3)	0.06	30 (40.0)	166 (38)	0.91
	Full prosthesis in both arches	2008	185 (52.9)	70 (44)		37 (49.3)	218 (49.9)	
	Full prosthesis in one arch	2012	91 (34.6)	50 (40.3)	0.55	18 (32.7)	123 (37.0)	0.70
	Full prosthesis in both arches	2012	127 (48.3)	55 (44.4)		26 (47.3)	156 (47.0)	
Present teeth		2004	5.51±7.38	4.29±6.15	0.06	7.93±8.16	4.60±6.63	<b>&lt;0.001</b>
		2008	4.75±7.10	5.14±7.32	0.56	5.63±7.71	4.75±7.03	0.30
		2012	5.05±7.05	4.78±6.91	0.73	5.94±8.10	4.80±6.80	0.26

\**p*<0.05

Table 3: Crude and adjusted odds ratio (OR) and 95% confidence intervals (CI) by outcomes Body Mass Index (BMI), waist circumference (WC).

Variable	<i>BMI - Obese</i>			<i>WC- Obese</i>		
	Crude OR (CI 95%)	Adjusted* OR (CI 95%)	p†	Crude OR (CI 95%)	Adjusted** OR (CI 95%)	p†
Frequency of dental service use						
Never	3.23 (1.37-7.62)	3.02 (1.25-7.26)	<b>0.01</b>	-	-	-
Problem	2.36 (1.09-5.09)	2.08 (0.95-4.54)	0.07	-	-	
Sometimes	1	1				
Prosthesis need – lower arch						
Need	-	-	-	3.86 (1.04-14.31)	4.38(1.34-14.32)	<b>0.01</b>
No need				1	1	
Prostheses use						
Full in one arch	3.19 (1.01-10.13)	1.28 (0.38-4.27)	0.68	2.49 (0.87-7.12)	1.04 (0.37-2.96)	0.93
Full in both arches	0.93 (0.29-3.00)	0.23 (0.06-0.84)	<b>0.03</b>	3.12 (1.07-9.15)	0.49 (0.16-1.49)	0.21
Any+ others	1	1		1	1	
Self-perception of oral health						
Bad	-	-	-	0.43 (0.21-0.89)	0.41(0.19-0.88)	<b>0.02</b>
Good				1	1	
Functional dentition						
1-20 teeth	-	-	-	0.49 (0.22-1.08)	1.64 (0.71-3.78)	0.25
21-32 teeth	-	-	-	0.16 (0.03-0.83)	1.17 (0.22-6.11)	0.85
Edentulous				1	1	
Present teeth	-	-	-	0.95 (0.91-0.99)	1.01 (0.96-1.05)	0.77

\*Adjusted for gender, drinking alcohol behavior, smoking habit, comorbidities.

\*\*Adjusted for gender, marital status, drinking alcohol behavior, smoking habit, comorbidities, frailty, amount of medications.

†p<0.05

## Discussion

To our knowledge, this is the first study that evaluates the role of poor oral status and different anthropometric measures for central and general obesity longitudinally in elders of a developing country. The effect of food intake on nutritional status and oral health is cumulative and requires longer monitoring to capture trends and behaviors over time<sup>22</sup>. This longitudinal study showed that poor oral health represented by the need for rehabilitation and by disregarding the importance of going to the dentist regularly are risk factors for being obese. Also the findings suggest that being fully rehabilitated can be protective for weight accumulation as well as having a poor self-perception of oral health.

According to Lee et al<sup>23</sup>, chewing difficulties and pain increase the chance of nutritional imbalance and underweight, while having a bad self-perceived oral health might not contribute to a bad nutritional status and quality of life. Although poor perception of one's own oral health might be relayed to pain and discomfort or even eating restrictions, functional limitations<sup>24</sup> or depression. Using data from the Brazilian epidemiological assessment of elders, Martins et al.<sup>24</sup> found that the higher retention of natural teeth, the more negative the self-perception of oral status. Likewise, another study observed that people who reported deterioration in oral health complained more about pain associated with the use of partial dentures<sup>25</sup>. In contrast, a study with independently-living older women in the US<sup>26</sup> reported that the ones who wore denture and reported difficulty in chewing and swallowing had the lowest levels of plasma nutrients compared to the ones that did not wear dentures or wore it without complains, had the highest mortality levels suggesting that changes in eating habits due to ill-fitting denture use affect some nutrient concentration and can reflect in higher BMI.

In developing countries as Brazil there is a tendency not to use oral health care services in advanced age since individuals tend to become partially or completely edentate long before getting old since it reflects the oral health care model that was characterized by difficult access and was based on extraction rather than the maintenance of a good oral health. In another study conducted in Southern Brazil, not using dental service in the previous three years was related to not having any natural teeth due to the belief that the absence of teeth renders dental visits unnecessary<sup>27</sup>. In addition, the frequency of dental service use might reflect low income and schooling

since the higher the income the easier the access to private services, likewise higher education can be associated with having information about the importance of regular use of dental health services<sup>28</sup>. Thus, this findings suggest that difficult access, low income and schooling might contribute to weight gain throughout the years since many elders tend to change their eating habits to softer and less nutritional food. Also constriction of life space is a common feature in the elderly and is aggravated due to mobility limitations that restricts the displacements of the elders.

Previous cross-sectional studies with the same population found that edentulous wearing only an upper denture and dentates with a few teeth (1-8) had higher odds of being obese<sup>16</sup>, results similar to ours. The accumulating burden of oral diseases throughout the life course contributes to the gradual decline of oral health in dentate subjects<sup>5</sup>. Thus, a few inadequately distributed teeth can be more difficult to provide adequate function, and therefore to provide for an adequate and varied diet compared to edentulous subjects with full denture<sup>29</sup>. Although for Sheiham et al<sup>4</sup>, the retention of a few natural teeth is of some value in the intake of nutrients. Furthermore, dry mouth can affect both chewing, swallowing and the stabilization of the dental prosthesis since it contributes for mouth lubrication and food bolus formation, denture tolerance and stability<sup>2</sup>. Though, in the current study dry mouth got excluded from the final models.

When exploring the consistency of the results across the different outcome measures, none of the oral health measures were associated with both outcomes. In the literature, there is a discussion about the cut-off points for anthropometric measures especially BMI in the elderly since it is associated with health risks and mortality. According to Dolan and colleagues<sup>30</sup> a certain amount of adiposity confers a survival benefit in elderly women since the ones classified as overweight presented the lowest rates of mortality. Also there are sex differences in fat distribution between genders; women tend to accumulate more fat in the gluteo femoral region while men do in the upper-body and abdomen<sup>31</sup> although after menopause a redistribution of fat towards a more central region happens<sup>32</sup>.

Also the distribution of obesity considering the measures used, BMI and WC, is not similar, suggesting that there are more obese in the WC measure because of the less severe cut-off point chosen. The methods available for diagnosing obesity in the elderly are still not specific, considering the modifications in body composition due to the aging

process<sup>33</sup>. Cut-offs may vary between countries based on indices of sensitivity and specificity of disease risk and mortality<sup>34</sup>. A BMI of 30 or more is widely accepted to classify obese individuals<sup>20</sup> although there is not such consensus for the cut-off point for individuals at increased risk of obesity related illness identified through WC and it can be considered a limitation.

Obesity is a well-known risk factor for diseases and shares some risk factors like tobacco use, unhealthy diet, physical inactivity and harmful alcohol use with other diseases, such as cardiovascular disease, cancer, chronic obstructive pulmonary disease and diabetes<sup>35</sup>. Interestingly, different oral health covariates or categories of the covariates were associated with each outcome. Our results showed that independent variables representing oral health associated with different outcomes highlighting the importance of the obesity measure selected in oral health investigations<sup>36</sup> and the need for further investigation in the area especially due to the fact that obesity and periodontal disease are related to inflammation and in this study we did not assess periodontal disease. Data for physical activity was collected only in the follow-up and therefore it could have been a better adjusting measure. It represents a limitation of this study since physical activity is a major confounding factor for obesity. Also the quality of the dentures was not considered for this study neither a dietary questionnaire.

The results of the present study suggest that poor oral health acts as a predictor for general and central obesity. Moreover to increase the access to public dental services, with encouragement for regular use can contribute to conserving healthy teeth and mouth, which plays a key role in the maintenance of a balanced diet and consequently contributes to the prevention of body adiposity accumulation. Also, rehabilitation seems to play an important role in the nutritional status. Therefore, maintaining a healthy lifestyle and targeting multidisciplinary interventions can promote the prevention and treatment of obesity and ultimately a better quality of life and longer life span.

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## Capítulo 4

### **Oral health predictors of tooth loss in the Brazilian elderly: an eight-years follow-up.**

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**Running Title:** Eight-years follow-up of tooth loss

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## **Abstract**

**Objectives:** The aim of this study was to determine tooth loss incidence after 8 years and its predictors among community-living older adults in a southern Brazilian city. Our hypothesis is that demographic factors; primary determinants of health; behavioural; and clinical variables represent predictors of tooth loss.

**Methods:** This longitudinal study is part of a cohort study entitled The Carlos Barbosa Study (CBCS), about the association between oral conditions and general health of independent-living older subjects from Carlos Barbosa, southern Brazil. For this study the measures comprised a face-to-face interview – administered structured questionnaire with 205 dentate subjects with information about socio-demographic, behavioral, access to services and oral examination. It was used a multivariate Poisson model and the outcome considered was calculated using the difference between the number of teeth lost between 2004 and 2012 dichotomized into lost at least one tooth or not.

**Results:** The mean age of the sample was 65.51( $\pm$ 4.8) and the mean number of teeth in risk for tooth loss (baseline mean number of teeth) was 10.50( $\pm$ 7.09) and mean teeth present at 8-years follow-up 9.06 ( $\pm$ 7.3). Complete data was available for 193 participants. Being female (RR=0.65, 95%CI 0.49-0.86), not using a partial removable prosthesis (RR=0.73, 95%CI 0.56-0.97) were associated with lower risk of tooth loss. Having more bleeding sites was associated with higher risk of tooth loss (RR=1.008, 95%CI 1.003-1.01)

**Conclusion:** Therefore our data suggest that oral health status is an important determinant of tooth loss in the elderly since rehabilitation with removable partial denture and the presence of gingival bleeding are predictors for losing tooth over 8 years. Properly designed partial removable prosthesis and preventive oral health care measures focusing on maintaining a good oral health level can contribute to the retention of natural teeth in the mouth.

**Key-words:** Oral health, tooth loss, longitudinal study.

## **Introduction**

Severe tooth loss, that is the main cause of disability-adjusted life-years (DALYs) that is the sum of years lived with disability plus years of life lost due to premature mortality, among subjects over 60 years-old<sup>1</sup> due to oral conditions. In addition to that tooth loss can impact in quality of life regarding functional capacity, self-esteem and social relationships<sup>2</sup>. In old age both tooth loss and its health correlates are more prevalent and poor health risks collected throughout life are likely to have accumulated<sup>3</sup>.

The global prevalence and incidence rate of total tooth loss in the entire population decreased by 45% over the last 2 decades<sup>4</sup>. According to the epidemiological Brazilian survey the mean number of lost teeth in the age group 65 to 74 years-old was 25.29 in 2010<sup>5</sup> showing a small decrease (2,1%) from 2003<sup>6</sup> when it was 25.83. Although the efforts of health systems, tooth loss is quite prevalent worldwide, especially in developing countries as Brazil. The high prevalence of tooth loss represents the consequence of oral health problems, the oral health service access and the dental model which was based in extractions rather than in prevention and maintenance of good levels of oral health, representing the final outcome when preventive or conservative treatments failed or were not available<sup>1</sup>.

There are many studies in the literature that have assessed tooth loss although most of them are cross-sectional ones. The aim of this study was to determine tooth loss predictors after 8 years among community-living older adults in a southern Brazilian city. Our hypothesis is that demographic factors; primary determinants of health; behavioural; and clinical variables represent predictors of tooth loss.

## **Methods**

This longitudinal study is part of a cohort study entitled The Carlos Barbosa Study (CBCS), about the association between oral conditions and general health of independent-living older subjects from Carlos Barbosa, southern Brazil. In the year 2000 the city had 20,519 inhabitants of which 2,167 were aged 60 years or more. The water fluoridation began in 2001.

In 2004 a random selection was used to select participants from the municipality registers of independent-living individuals aged 60 years or more.

Potential participants were invited to take part in the study through phone or letter and those who refused to participate were replaced randomly. The baseline study comprised 872 independently-living older individuals and in 2008 it was conducted the first-follow-up which included 587 participants. The second follow-up was conducted in 2012 and 389 subjects participated although in the present study it will be considered only the 205 dentate elders. The baseline and the second follow-up were approved by the Ethics Committee of the Piracicaba Dental School (CEP-FOP/UNICAMP protocols n° 055/2004 and 017/2011) and by the Carlos Barbosa's Health Council. All the participants in the three waves were informed about the aim of the study and provided written informed consents.

### **Study Design**

In 2012 participants were recontacted to take part in the study through phone calls and visits; the ones that couldn't be contacted by phone it was used the contact record from the Health Unit and the city's telephone book. The sample consisted of those individuals that participated in the first study about the elderly population of Carlos Barbosa held in 2004. A hundred and forty-five had died from the baseline to 2012, 73 were not found, 51 were excluded due to illness/dependency, 11 have moved from Carlos Barbosa and 203 refused to participate. In addition, this study comprised only the dentate older subjects (n=205).

The research interview including oral examinations was conducted in the dental clinics of the health units provided by the municipality, community clubhouses and in the participant's homes. The oral examinations were performed by two trained and experienced dentists. Duplicate dental inspections were conducted on 10% of the participants for reliability. The inter and intra-examiner agreement of oral examination were calculated using the Kappa coefficient (Kappa=0.985). Inter-examiner agreement between two dentists was conducted by duplicate examinations on 40 persons.

### **Measures**

For this study the measures comprised a face-to-face interview – administered structured questionnaire with information about socio-demographic, behavioral, access to services and oral examination. The oral status assessment comprised an oral examination under standardized illumination. All the independent variables were assessed in the baseline.



The conceptual hierarchical model that analyzes data according to the blocks of variables (from exogenous to proximal) was based on Andersen and Davidson<sup>7</sup> according to the hypothesis of the study.

*Exogenous - First block of variables*

It was collected data regarding age (<70/ ≥70years-old) and gender (female/male).

*Primary determinants variables- Second block of variables*

Data regarding the geographical location of the participant's home (urban/rural), its marital status [married (married/ living with a companion/ stable union) /others (single, widow, divorced)] and schooling (it was collected in years and then dichotomized in <4years/ ≥4 years of study) were collected. Satisfaction with access to health services was assessed through the question "How satisfied are you with your access to health services?" taken from the WHOQOL (World Health Organization Quality of Life)<sup>8</sup> questionnaire. It was categorized into dissatisfied (dissatisfied/very dissatisfied), neither satisfied nor dissatisfied, satisfied(satisfied/ very satisfied).

*Oral Health Behaviour data - Third block of variables*

Smoking habit was assessed through the question "Have you smoked more than a hundred cigarettes in your life?" with possible answers yes or no. Frequency of dental visits was dichotomized in occasionally (occasionally/regularly) and never (never/ when facing a problem and need treatment). Toothbrushing was dichotomized into <once a day/ ≥once a day.

*Oral health data- Fourth block of variables*

DMFT (decayed, missing, and filled teeth) index was used to assess dental status (including third molars) and another variable was created based on the presence of caries. At least on tooth with caries either root and/or coronal was considered as having caries at the moment of the exam (yes/no). Gingival bleeding index was assessed according to the WHO (World Health Organization)<sup>9</sup> criteria and it was used as a continuous variable. Also the presence of dental prosthesis was assessed and it was

created a new variable with the presence of partial removable prosthesis (yes/ no). Stimulated saliva (5min chewing a piece of parafilm, on each 30s intervals till 5 min saliva was collected – 0.3g of Parafilm M laboratory film) was collected and used as a continuous variable.

### *Outcome*

The difference between the number of teeth lost between 2004 and 2012 was calculated and was dichotomized into lost at least one tooth or not. Disagreements regarding the absence of teeth at baseline and the presence in the follow-up were treated as baseline examiner bias. Their status was considered as present at both examinations, for analysis purpose.

### **Analysis of Data**

To perform the analysis it was used SPSS 21 (IBM Statistics). Bivariate analysis were performed and the variables with  $p < 0.20$  were selected. In the adjusted model 1 all the variables with  $p < 0.05$  were selected for the final model. In the final multivariate Poisson model, only variables with  $p < 0.05$  were considered significantly associated with the outcome and the ones that were epidemiologically important to the analysis. It was given the relative risk and its 95% confidence interval.

### **Results**

The mean age of the sample in 2004 was 65.51 ( $\pm 4.8$ ) and the mean number of teeth in risk (baseline mean number of teeth) was 10.50 ( $\pm 7.09$ ) and mean teeth present at 8-years follow-up 9.06 ( $\pm 7.3$ ). The prevalence of participants that lost at least one tooth was 48.3%. The married subjects represented 76.6% of the sample and 56.6% lived in urban area (table 1). Table 2 shows the crude and adjusted models according to the hierarchical framework where gender (exogenous variable block), gingival bleeding index and partial removable prosthesis (oral health measures block) were associated with tooth loss in each respective block.

Table 1: Characteristics of the studied sample, Carlos Barbosa, Brazil, 2004 (n=205).

Variables		% (n)
Tooth loss 2004-2012	Lost at least one teeth	48.3% (99)
Gender	Female	54.1% (111)
Age	< 70 years	78% (160)
Marital status	Others	23.4%(48)
Schooling	< 4 years	30.2% (62)
Geographic location	Urban	56.6% (116)
Satisfaction access health services	Dissatisfied	6.9% (14)
	Neither satisfied neither dissatisfied	10.8% (22)
Income	≤ 1 MW	47.8% (97)
Access to health services	Regularly	11.2% (23)
Smoking habit	No	92.6% (189)
Tooth brushing	≥ once a day	90.7% (186)
Partial removable prosthesis	No	51% (104)
Presence of caries	No	25.4% (52)
		Mean (±SD)
Saliva flow		3.88 (2.75)
Gingival Bleeding Index		49.5 (+-30.4)

*\*The totals might not corresponde to n=205 due to missing answers in some variables.*

Table 2: Multivariate Poisson regression for the predictors associated with tooth loss over 8 years in community-living older subjects from Carlos Barbosa, Brazil according to the conceptual hierarchical model proposed by Anderson and Davidson (1997). *Continued*

Variables	Crude		Adjusted 1		Adjusted 2	
	RR (95%CI)	p	RR (95%CI)	p	RR (95%CI)	p*
<b>Exogenous Variables</b>						
Gender	Female	0.63 (0.47-0.83)	0.001	0.63 (0.47-0.84)	<b>0.002</b>	
Age	< 70 years	0.83 (0.61-1.13)	0.25	0.86 (0.64-1.15)	0.31	
<b>Primary Determinants</b>						
Marital status	Others	0.93 (0.66-1.32)	0.70	0.93 (0.66-1.32)	0.68	1.06 (0.75-1.48) 0.74
Schooling	< 4 years	1.05 (0.78-1.42)	0.74	1.05 (0.78-1.42)	0.74	1.02 (0.77-1.37) 0.88
Geographic location	Urban	0.78 (0.59-1.04)	0.09	0.76 (0.57-1.01)	0.05	0.81 (0.61-1.08) 0.16
Satisfaction access health services	Dissatisfied	0.57 (0.25-1.33)	0.20	0.65 (0.29-1.45)	0.30	0.69 (0.30-1.58) 0.37
	Neither satisfied neither dissatisfied	1.00 (0.64-1.56)	1.00	0.97 (0.62-1.51)	0.88	0.98 (0.62-1.53) 0.92
Income	≤ 1 MW	0.95 (0.71-1.26)	0.71	0.89 (0.67-1.19)	0.44	1.02 (0.76-1.37) 0.90
<b>Behavioral variables</b>						
Access to health services	Regularly	1.31 (0.91-1.88)	0.15	1.28 (0.89-1.85)	0.18	1.31 (0.91-1.88) 0.15
Smoking habit	No	0.71 (0.48-1.04)	0.08	0.72 (0.48-1.09)	0.11	0.86 (0.58-1.27) 0.44
Tooth brushing	≥ once a day	0.82 (0.54-1.23)	0.34	0.86 (0.57-1.30)	0.47	0.97 (0.63-1.49) 0.89

Table 2: Multivariate Poisson regression for the predictors associated with tooth loss over 8 years in community-living older subjects from Carlos Barbosa, Brazil according to the conceptual hierarchical model proposed by Anderson and Davidson (1997). *Continued*

Variables		Crude RR (95%CI)	p	Adjusted 1 RR (95%CI)	p	Adjusted 2 RR (95%CI)	p*
Oral health Measures							
Partial removable prosthesis	No	0.72 (0.54-0.96)	0.03	0.75 (0.57-1.00)	0.05	0.73 (0.55-0.97)	<b>0.03</b>
Presence of caries	No	0.68 (0.46-1.01)	0.05	0.81 (0.55-1.20)	0.28	0.83 (0.57-1.22)	0.35
Saliva flow		1.03 (0.98-1.08)	0.21	1.03 (0.99-1.08)	0.12	1.02 (0.98-1.06)	0.36
Gingival Bleeding Index		1.01 (1.003-1.01)	0.002	1.01 (1.003-1.01)	<b>0.001</b>	1.01 (1.003-1.01)	<b>0.01</b>

\* $p < 0.05$

Table 3: Final multivariate Poisson regression for the predictors associated with tooth loss over 8 years in community-living older subjects from Carlos Barbosa, Brazil (n=193).

Variables		Crude		Adjusted	
		RR (95%CI)	p	RR (95%CI)	p*
Gender	Female	0.63 (0.47-0.83)	0.001	0.65 (0.49-0.86)	<b>0.003</b>
Partial removable prosthesis	No	0.72 (0.54-0.96)	0.03	0.73 (0.56-0.97)	<b>0.03</b>
Gingival Bleeding Index		1.01 (1.003-1.01)	0.002	1.008 (1.003-1.01)	<b>0.001</b>
Presence of caries	No	0.68 (0.46-1.01)	0.05	0.87 (0.60-1.26)	0.45

\* $p < 0.05$

Table 3 represents the final fully adjusted model with complete data for n=193 elders. Being female (RR=0.65, 95%CI 0.49-0.86) and not using a partial removable prosthesis (RR=0.73, 95%CI 0.56-0.97) were associated with lower risk of tooth loss. Having more bleeding sites was associated with higher risk of tooth loss (RR=1.008, 95%CI 1.003-1.01).

## **Discussion**

This study found that not using a partial removable prosthesis, being female and gingival bleeding are predictors of tooth loss in the Brazilian elderly. In another study with culturally diverse communities of older adults, multiple tooth loss was predicted by caries lesions, gingival attachment loss and the use of removable dentures. The authors considered that bacteria alone are not the major contributors to tooth loss in elders, since they present structurally and periodontally weakened teeth due to different interacting factors<sup>10</sup>. Properly planned and designed removable partial dentures may contribute to homogeneous distribution of occlusal forces, create regular adaptation of periodontal tissue and a decrease in tooth mobility<sup>11</sup>. Although the same study found that after a 5 years follow-up the use of removable partial denture increased tooth mobility<sup>11</sup>. In another longitudinal study, the authors found an increased tooth mobility and worse periodontal conditions of the abutment teeth and high extraction rate of both abutment and non-abutment teeth after 10 years of unsupervised use of removable partial dentures<sup>12</sup>.

Gender is related to biological sex differences, to behavior expressed by hygiene, smoking, diet and to socioeconomic status by income, education and occupation and thus they are all related to caries and periodontitis<sup>13</sup>. Women tend to visit the dentist more frequently than men, especially when aged 60 years-old or more<sup>14</sup> and although due to regular dental visits women might be more prone to be exposed to iatrogenic treatment as extraction, they are more likely to access preventive care, as dental checkups<sup>15</sup> and so in the present study females presented less tooth loss. Results in accordance with ours. Another study with a Iranian population also found an association with tooth loss and males. The author suggested that this association might be dental-disease-related, due to dental caries, periodontal disease, trauma, infection and behaviors like smoking and poor oral hygiene<sup>16</sup>.

Most likely older individuals lose their teeth due to dental caries. In addition, periodontal disease contribute as well to tooth loss. In this study gingival bleeding, which can be considered a chronic form of periodontal disease, was used as a proxy to improper oral hygiene and it seems that the ones that presented more bleeding sites were the ones that have lost more teeth. Periodontal disease is characterized by deepening of periodontal pockets and by losing of attachment caused by the presence of dental biofilm<sup>2</sup>. Also it can be linked to tooth loss since it is age-related<sup>16</sup>. In addition the use of partial removable prosthesis can contribute to the accumulation of plaque/biofilm in the remanent teeth if not properly cleaned.

In the first adjusted model, geographic location was close to the significance limit, although not reaching it in the adjusted model 2. Rural areas are usually places difficult to access, with scarce transportation, water supply, sanitation and public services, consequently presenting, elevated level of health need<sup>17</sup>. Also, tooth loss in this areas can be understood not only as a sequelae of oral diseases but also as a result of social exclusion throughout life<sup>17</sup> since poor elderly people are more likely to choose tooth extraction rather than preserving it<sup>18</sup>.

Interestingly, socioeconomic variables were not associated with the outcome. One possible explanation is that the economic condition might be related to tooth loss in the beginning of life until adulthood when they have already lost most of their teeth, suggesting that socioeconomic inequalities in tooth loss seem to manifest themselves early in the course of life<sup>19</sup> before becoming an elder. Also this is a homogeneous sample of older adults and most of them reported during the interview coming from areas with less resources where the access to education and oral health care measures were limited. Despite that, another study with the same sample analysed the incidence of tooth loss over 4 years and found an association between tooth loss and the same oral health measures as this study (gingival bleeding index, the presence of partial removable denture) plus five-minute stimulated saliva flow. The presence of caries at baselines was not significant as well<sup>20</sup>. The authors stated that most of the studies found a different result maybe due to the fact that they were carried out in industrialized countries suggesting the effect of sociodemographic variables and tooth loss in such an unequal country as Brazil. As mentioned before, our results didn't find an association between primary determinants and tooth loss possible due to early-life association.

In another study income and schooling were associated with tooth loss among the elderly<sup>21</sup>, results corroborated by Srisilapanan et al<sup>18</sup> who found an association between lower education, lower family income and owning non-luxury goods and having a few teeth. The reduction in a country's poverty is related to the improvement of life conditions and that positively impacts in health<sup>22</sup>. Although in the present study it was not possible to find this association.

Studied subjects were not benefited by the result of the improvement of the health system and the implementation of measures such as the use of fluoride to reduce tooth decay, as already observed today among adolescents and adults in the Brazilian surveys. It is projected that this cohort effect will be expressed in the reduction of edentulism in the elderly by 2050<sup>21</sup>.

Not having information about the reasons and when the teeth were extracted can be considered a limitation of this study. Also another limitation is the characteristic of the sample of not having a great amount of teeth, despite the fact that the mean number of teeth was higher than that found in the national survey for the elderly group. The strength is the longitudinal design, being the approach of choice for describing tooth loss and understanding its aetiology<sup>19</sup>. Also as far as we know there are just a few studies in Brazil<sup>23</sup> that have assessed tooth loss in such a long period of time. Still there is a need for more longitudinal studies in the future to better understand the predictors of tooth loss in the elderly which was exposed to an oral health preventive model. In addition there is a need to understand what would motivate these older subjects to keep visiting the dentist and taking good care of their oral health.

Therefore our data suggest that oral health condition is an important determinant of tooth loss in the elderly since rehabilitation with removable partial denture and the presence of gingival bleeding are predictors for losing tooth over 8 years. Properly designed partial removable prosthesis and preventive oral health care measures focusing on maintaining a good oral health level like reexaminations through frequent dental visits focusing on promoting a proper oral hygiene and prosthesis relining when necessary, can contribute to the retention of natural teeth in the mouth.

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## **Conclusão**

Neste estudo, fragilidade foi associada com necessitar de prótese e maior número de dentes perdidos. Obesidade geral esteve associada com idosos que não vão ao dentista e presença de reabilitação; já obesidade central associou-se com necessidade de prótese total na arcada inferior e perceber a saúde bucal como insatisfatória. Uso de prótese parcial removível esteve associado com perda dentária longitudinalmente. Assim, os objetivos e hipóteses apresentados em cada capítulo foram investigados e respondidos.

Este estudo demonstra que as condições bucais têm reflexos importantes não só para a própria piora da condição bucal mas também podem provocar mudanças na saúde sistêmica dos idosos. O uso e a necessidade de prótese apresentaram-se associados com todos os quatro desfechos estudados. A ausência de reabilitação parece ser um importante indicador para o desenvolvimento da fragilidade e da obesidade central. Já sua presença contribui para evitar o acúmulo de gordura distribuída pelo corpo. Entretanto, o uso de prótese parcial removível apresentou-se como fator de risco para a perda dentária, sugerindo que um adequado planejamento, manutenção e higiene de próteses podem trazer impactos positivos na saúde dos idosos. Assim, sugerem-se estudos que avaliem não só a presença de reabilitação e sua associação com saúde geral e bucal, mas também a verificação da qualidade destas reabilitações.

Quanto à fragilidade, faz-se necessário que outros estudos sejam realizados já que a evidência que existe na literatura é basicamente de estudos transversais, como o presente nesta tese, especialmente no que se refere ao uso de critérios e medidas mais uniformes para a avaliação desta relação. Assim, saúde bucal precária é um fator de risco para obesidade central e geral e para perda dentária, sendo também considerado

um indicador para fragilidade. Os resultados dos quatro artigos demonstram que há evidência que suporta a relação entre saúde bucal precária e fragilidade e obesidade central e abdominal.

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\*De acordo com as normas da UNICAMP/FOP, baseadas na padronização internacional Committee of Medical Journal Editors. Abreviatura dos periódicos em conformidade com o Medline.



## Apêndice 1

Appendix 1: Table of the Excluded Papers (chapter 1).

Authors/year	Reason to exclusion
Kikutani et al, 2013	No frailty or frailty's criteria definition
Katsoulis et al, 2012	No frailty or frailty's criteria definition
Christensen et al, 2012	No frailty or frailty's criteria definition
Wu et al, 2012	None of the frailty criteria as the dependent variable in relation to oral health measures
Silva et al, 2011	None of the frailty criteria nor frailty as the dependent variable
Rihs et al, 2011	None of the frailty criteria nor frailty as the dependent variable - self-perception of oral health stratified by frails and prefrails
Bush et al, 2010	No frailty or frailty's criteria definition
Jensen et al, 2008	No frailty or frailty's criteria definition
Walker & Kiyak, 2007	No frailty or frailty's criteria definition
Semba et al, 2006	None of the frailty criteria nor frailty as the dependent variable
Hashimoto et al, 2006	None of the frailty criteria nor frailty as the dependent variable
Miura et al, 2005	No frailty or frailty's criteria definition
Lee et al, 2004	None of the frailty criteria nor frailty as the dependent variable
Soini et al, 2003	No frailty or frailty's criteria definition. Fatigue was a reason for exclusion.
Tada et al, 2003	Poor frailty's criteria definition (physical activity determined by leisure sports once a week and travel – did not specified what kind of activities, time, intensity...)
Shimazaki et al, 2001	No frailty or frailty's criteria definition
Calabrese et al, 1999	No frailty or frailty's criteria definition
Lester et al, 1998	No frailty or frailty's criteria definition
Osterberg et al, 1996	None of the frailty criteria nor frailty as the dependent variable
Osterberg et al, 1995	None of the frailty criteria nor frailty as the dependent variable
Long & Miller, 1994	No frailty or frailty's criteria definition
Horn et al, 1994	Small sample size
Sullivan et al, 1993	Results not shown

## Apêndice 2

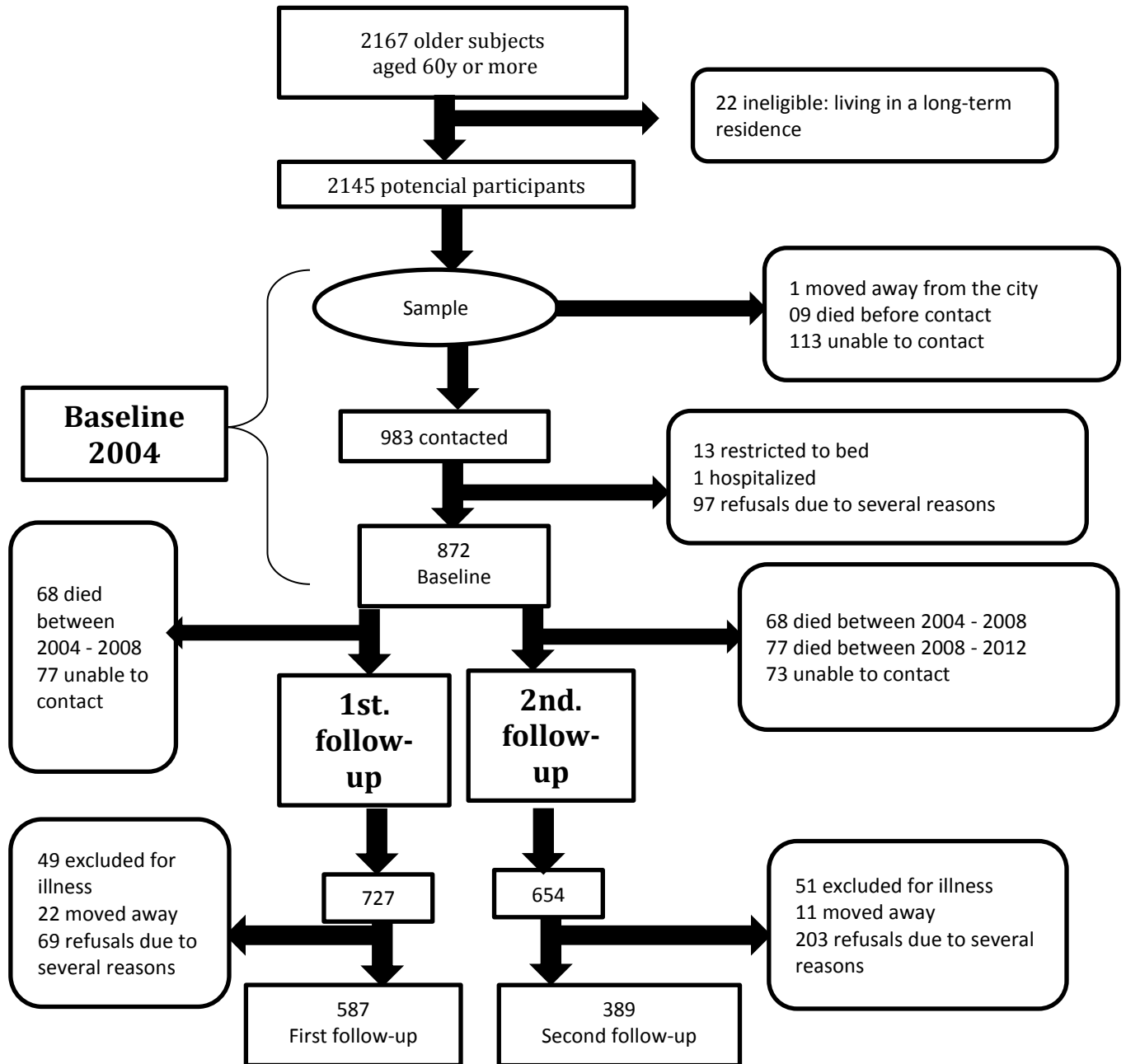


Figure 1: Flow chart of the sample procedure from the baseline to the second follow-up.



**COMITÊ DE ÉTICA EM PESQUISA  
FACULDADE DE ODONTOLOGIA DE PIRACICABA  
UNIVERSIDADE ESTADUAL DE CAMPINAS**



**CERTIFICADO**

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa **"Fatores de risco para a saúde bucal em idosos independentes, com ênfase no estado nutricional e na fragilidade: Estudo de coorte de base populacional"**, protocolo nº 017/2011, dos pesquisadores Luísa Helena do Nascimento Tôrres, Fernando Neves Hugo e Maria da Luz Rosário de Sousa, satisfaz as exigências do Conselho Nacional de Saúde - Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 21/05/2011.

The Ethics Committee in Research of the Piracicaba Dental School - University of Campinas, certify that the project **"Risk factors for oral health among independently living older adults with emphasis on the nutritional status and frailty: A population-based cohort study"**, register number 017/2011, of Luísa Helena do Nascimento Tôrres, Fernando Neves Hugo and Maria da Luz Rosário de Sousa, comply with the recommendations of the National Health Council - Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee on May 21, 2011.

**Profa. Dra. Lívia Maria Andalo Tenuta**  
Secretária  
CEP/FOP/UNICAMP

**Prof. Dr. Jacks Jorge Junior**  
Coordenador  
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.  
Notice: The title of the project appears as provided by the authors, without editing.

## Anexo 2

Frailty, Frailty components and Oral Health: a Systematic Review - Manuscript JAGS-0347-DOH-Mar-14.R1 ↑ ↓ ×

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