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Meta-analyses

Relationship of nutritional status and oral health in elderly: Systematic review with meta-analysis

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SUMMARY

This systematic review aimed to compare the nutritional status and oral health in older adults individuals. Three databases (Medline-Pubmed, Scopus and EMBASE) were searched up to October 28th 2016 for studies that performed the Subjective Global Assessment (SGA) or the Mini Nutritional Assessment (MNA) and an oral examination performed by a dental professional, either dental hygienist or a dentist. Both observational and interventional studies were screened for eligibility. Meta-analyses were performed comparing the malnourished/at risk of malnutrition and the normal nutrition subjects with three oral health parameters (edentulism, use of prosthesis and mean number of present teeth). Twenty-six studies were included in the systematic review, of which 23 were cross-sectional. It was showed that well-nourished subjects had a significantly higher number of pairs of teeth/Functional Teeth Units (FTU) in comparison to individuals with risk of malnutrition or malnutrition. The meta-analyses showed no statistically significant association between edentulism and use of prosthesis, as the pooled Relative Risk were, respectively, 1.072 (95% CI 0.957−1.200, p = 0.230) and 0.874 (95% CI 0.710 −1.075, p = 0.202). On the other hand, the pooled Standard Mean Difference of mean number of present teeth were −0.141 (95% CI −0.278 to −0.005, p = 0.042) in subjects with at risk of malnutrition/ malnourished. FTU and mean number of teeth present were significantly associated with nutritional status. Furthermore, more longitudinal studies in this field are needed.

1. Introduction

The elderly population is particularly vulnerable to dietary restrictions, as it tends to have less natural teeth and, possibly, present major nutritional issues [1]. Nutrition and health in general are among the main concerns for the elderly [2]. The most important nutritional disorder seen in the elderly population is malnutrition, which is associated with increased mortality and susceptibility to infections and impaired quality of life [3].

Poor oral hygiene, caries, periodontal disease, and defective or poorly fitting dentures are some of the common problems in this population [4]. The distribution and the number of the teeth influence the comfort and ease of mastication, as well as the presence of dental prostheses [5,6]. Tooth loss may induce the inappropriate selection of food and food texture of the adaptation for the dental condition. As a result, it can reduce the appetite, as consequence for the loss of pleasure in eating, which also estimated as a risk factor for malnutrition [7–9].

Poor masticatory function and oral health are known as risk factors for malnutrition [10]. Many studies describe the relationship between tooth loss and elderly nutritional status, that show that the edentulism can have negative effects on chewing, nutrition and dental health, suggesting that loss of partial teeth and tooth loss are predictors of nutritional status [1,7–15].

This systematic review aimed to evaluate and compare the oral health status older adults with normal nutrition, at risk of malnutrition and malnourished individuals.

2. Methodology

This systematic review presented the focused question: “Is the malnutrition or the risk of malnutrition, determined by the MNA or SGA, related with oral health status in older adults subjects?”

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2.1. Search strategy

Three databases, MEDLINE-Pubmed, Scopus, and EMBASE, were searched. In MEDLINE, the following search strategy was performed:

#1 Periodontal disease[MeSH Terms] OR Periodontal disease [Text Word] OR [Text Word] OR Oral hygiene[MeSH Terms] OR Oral hygiene[Text Word] OR Dental plaque[MeSH Terms] OR Oral health[MeSH Terms] OR Oral health[Text word] OR DMF Index[MeSH Terms] OR tooth loss[Text Word] OR dental caries[MeSH Terms] OR Dental caries[Text Word] OR Root caries[Text Word] OR Dental prosthesis[MeSH Terms] OR Dental prosthesis[Text Word] OR Dental decay[Text word]
#2 Nutritional Status[MeSH Terms] OR Subjective global assessment[Title/Abstract] OR Mini nutritional assessment [Title/Abstract] OR Nutritional Status[Title/Abstract] OR Malnutrition[MeSH Terms] OR Malnutrition[Title/Abstract] OR Nutritional assessment[Text word] OR Nutritional assessment[MeSH Term]
#3 #1 AND #2

Adaptation of this search strategies were performed on both Scopus and EMBASE databases, and the literature was searched up to October 28th 2016. All the following aspects needed to be fulfilled for inclusion:

- Subjects with at least 60 years old;
- Studies that performed a nutritional evaluation, such as MNA or its short-form or SGA;
- The studies had to perform an oral examination by a dental professional, either dentist or a dental hygienist.
- The study should include any of the following oral outcomes: tooth loss, number of present teeth, of edentulous, of subjects using prosthesis, Decayed, Missing or Filled Index (DMF), functional teeth units (FTU), caries, any dental plaque index, any gingival index, probing depth or clinical attachment level.

Both observational and interventional studies were screened for eligibility. Only the baseline data of the interventional studies that fulfilled the prior criteria was screened. In this systematic review it was included elderly with at least 60 years of age. This criterion was based on the World Health Organization (WHO) categorization for both underdeveloped ($\geq$60 years old) and developed ($\geq$65 years old) countries [16], since we did not limit the country of the study. We imposed no restrictions regarding language or date of publication. Studies with one of the following characteristics were excluded:

- Case reports, *in vitro* studies, experimental animal, letters to the editor, and systematic or narrative reviews;
- Self-reported oral health outcomes;

The references of every selected study and related systematic reviews were also screened for eligibility [17,18]. Studies were screened independently by two researchers (MPT and FWMGM), using the criteria previously described. Studies selected for detailed analysis by the two investigators had an agreement (kappa) of 0.87. Only when a consensus was not possible, a third researcher (PSA) was involved.

2.2. Data extraction

Two researchers independently performed the data extraction (MPT and PSA), using a Word spreadsheet specifically developed for this study. Data extracted included author, country, number of subjects included, number of subjects at risk of malnutrition/malnourished, number of subjects well-nourished, type of study, follow-up, age, sex, oral outcomes, nutritional scale, number of edentulous, number of teeth present, FTU, occluding pairs, denture use, mean DMFT, MNA/SGA classification.

The authors were contacted by email to get access to additional data in order to be included in the qualitative or quantitative analysis.

2.3. Quality assessment

Two researchers (PSA and FWMGM) independently assessed the risk of bias within the studies, and used the Agency for Healthcare Research and Quality (AHRQ) scale for cross-sectional studies [19] and by the Newcastle-Ottawa quality assessment scale for the case-control and cohort studies [20] as recommended by a systematic review previously published [21]. The AHRQ scale is composed of eleven items. To every item, it was assigned a “yes”, “no” or “unclear” answer to low risk, high risk or unclear risk of bias, respectively. The item “Clarify what follow-up, if any, was expected” was classified as not applicable to all studies. The Newcastle-Ottawa scale assigns a score of zero to nine stars to each article, whereby a greater number of stars indicate a higher-quality study [22].

2.4. Statistical analysis

We executed meta-analyses by comparing the malnourished/at risk of malnutrition and the normal nutrition individuals in relation to edentulism, use of prosthesis and mean number of present teeth. We combined malnourished (MNA < 17) and at risk of malnutrition (MNA from 17 to 24) in the same category in order to allow a proper statistical analysis, since the number of malnourished individuals was very low in the included studies.

The meta-analyses of present teeth in both malnourished/at risk of malnutrition and the normal nutrition subjects were performed using the standard mean difference (SMD). Regarding the number of edentulous and the use of prosthesis, the relative risk (RR) for malnutrition/be at risk of malnutrition was assessed to both oral condition.

Institutionalization was the variable considered for the subgroup analysis. Two studies included both noninstitutionalized and institutionalized individuals, however, their data could not be extracted for each environmental facility category. Considering that the sample was composed mainly by noninstitutionalized older adults (approximately 90% of the sample), both studies were classified for the noninstitutionalized subgroup [23,24]. Heterogeneity was assessed by the Q test and quantified with the I^2 statistic. The Egger's and Begg's tests were used to assess publication bias. When high heterogeneity was detected (I^2 > 40%), sources of effect modification of the pooled SMD and the RR were investigated using linear meta-regression [22]. Only age was included in the meta-regression.

The heterogeneity parameter (tau [2]) was calculated using the method of moment and p-values were estimated with MonteCarlo simulation from 1000 permutations. The tau [2] express the standard deviation of the true between-groups variance. Meta-analyses and meta-regression were conducted using Stata13.1 software [25,26].

3. Results

3.1. Study selection

Twenty-six studies were included in the systematic review and the main reasons for exclusion are showed in Fig. 1. Twenty-three

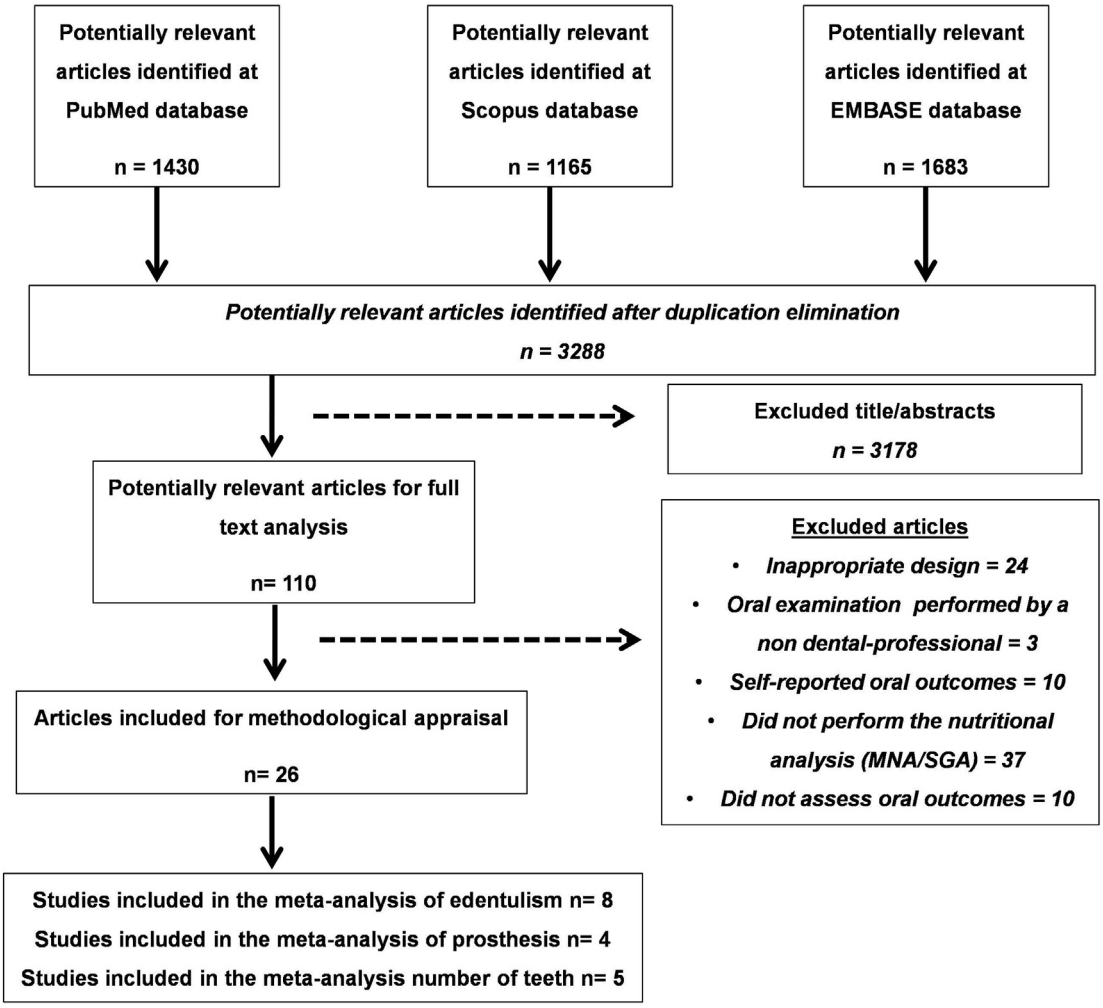

Fig. 1. Flowchart of the study selection.

cross-sectionals [7,9,10,14,15,23,24,27–42] one case-control [43], one cohort [44] and one clinical trial [45] were included in this study. Regarding the clinical trial, the baseline data was considered for analysis. Overall, 13.257 participants were included in all 26 studies selected in this systematic review and Table S1 describes them.

3.2. Nutritional assessment

Regarding the nutritional diagnosis, 18 studies used complete MNA [7,9,10,14,15,23,24,28,29,32,34–36,38,40,42,43,45] and 7 applied MNA-SF [30,31,33,37,39,41,44]. One of the studies [27] performed the MNA-SF for whole sample and the complete assessment was performed when the short form of the instrument resulted in a score of malnourished/at risk of malnutrition.

3.3. Oral status

Table 1 summarizes the qualitative analyses regarding oral health and nutritional status.

3.4. Risk of bias

The case-control [43] and the cohort [44] studies were ranked by the New-Castle Ottawa scale. The case-control study received four out of nine stars and they were referred to the following criteria: case definition, representativeness of the cases, definitions of controls, and comparability of cases and controls. The cohort study received eight out nine stars. Figure 2 shows the risk of bias for the cross-sectional studies and the baseline data of the clinical trial by means of the AHRQ scale.

From the 10 criteria evaluated, the answers "Yes" ranged from two to seven. Only ten studies received six to seven "Yes" answers [9,10,23,29,31,34,35,39–41]. All studies provided sufficient data of the source information. However, none of the included studies stated if the examiner were blinded to the nutritional status. Only three studies described any assessment for quality assurance purpose, such as examiner reproducibility [23,24,35].

3.5. Meta-analysis

The studies that assessed the nutritional status using MNA and provided sufficient data describing the oral condition were included in the meta-analysis. Three separated meta-analyses were conducted in order to account for different oral parameters evaluated in the studies. The meta-analysis for edentulism was performed with eight studies [15,23,24,28,32,35,38,42], the use of prosthesis was composed with 4 studies [32,33,35,36] and mean number of present teeth included 5 studies [10,15,32,35,42].

The pooled RR for edentulism was 1.072 (95% CI 0.9657–1.200), showing that the risk for edentulism was not significantly different

Table 1
Descriptive analyses of the studies included in the systematic review, regarding oral health outcomes and nutritional status.

Oral health outcomes	References	Results
Remaining teeth (19 studies)	[10,14,24,31,32]	Significantly fewer teeth in individuals with malnutrition or at risk of malnutrition.
	[15,28,34,35,39,42,44,45]	No statically significant difference between groups.
	[7,9,23,33,38,41]	Did not analyze this parameter.
Use of dental prosthesis (16 studies)	[28,29,32,34,35,39,44]	No statically significant difference between groups.
	[7,9,14,15,30,37,41,43,45]	Did not analyze this parameter.
Edentulous individuals (12 studies)	[23]	Significantly higher number of edentulous in individuals with at least risk of malnutrition.
	[28,34,35,45]	No statically significant difference between groups.
	[9,31,36,43]	Did not analyze this parameter.
	[15,24,42]	Presented only the percentage of individuals with malnutrition.
Edentulous wearing dental prosthesis (2 studies)	[7,10]	Edentulous without prosthesis or with prosthesis in only one arch were more likely to be at risk of malnutrition.
Functional Teeth Units or Occluding Pairs (11 studies)	[14,27,29,33,35,36,39,42]	Significantly more FTU or occluding pairs in individuals with normal malnutrition.
	[15]	No statically significant difference between groups.
	[37,41]	Did not analyze this parameter.
DMFT (5 studies)	[40]	Individuals with malnutrition presented higher DMFT scores than normal nutrition individuals.
	[23,24,29,37]	Did not analyze this parameter.
Dental Plaque and other periodontal disease parameter (6 studies)	[9,30,37]	No statically significant difference between groups considering dental plaque.
	[35]	No statically significant difference between groups considering periodontitis (probing depth >6 mm).
	[24,41]	Did not analyze this parameter.

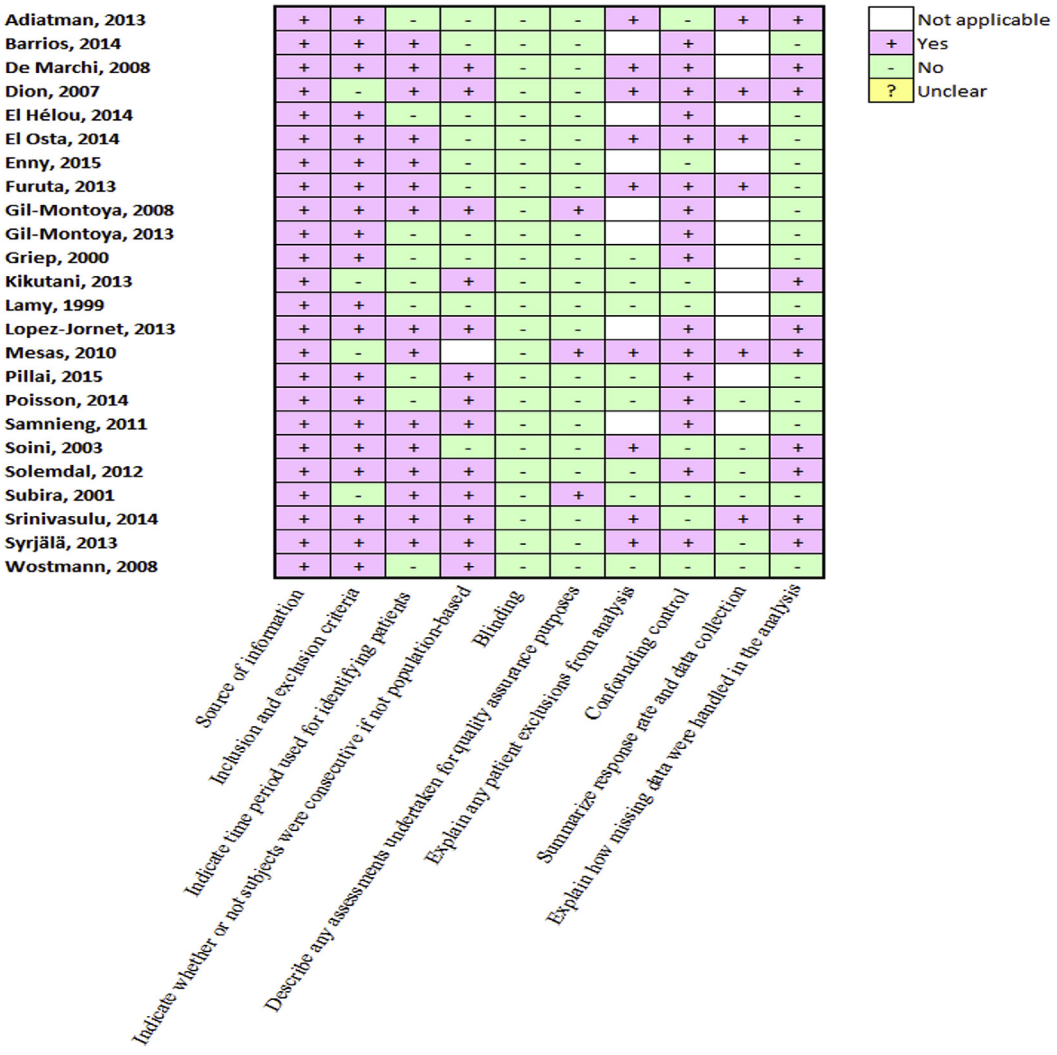

Fig. 2. Results of the evaluation of the risk of bias in the cross-sectional studies.

between groups, even when institutionalization was considered favoring the normal nutritional individuals (Fig. 3A). No publication bias was detected in both tests for this analysis (p = 0.711and p = 0.839 for Begg's and Egg's tests, respectively) (Fig. S1). A moderate risk of bias was detected (I^2 = 50%, p-value = 0.051). The meta-regression adjusted for age did not explain heterogeneity (coefficient −0.0072; p = 0.513).

Regarding the prosthesis use, the pooled RR was 0.874 (95% CI 0.710–1.075), demonstrating no significant difference between malnourished/at risk of malnutrition and normal nutrition individuals in relation to prosthesis use (Fig. 3B). Subgroup analysis did not change the overall results. Furthermore, no publication bias was showed in both test for this analysis (p = 0.089 and p = 0.072 for Begg's and Egg's tests, respectively). To better view the publication bias data, see the Funnelplot (Fig. S2). A high heterogeneity was found (I^2 = 78%, p = 0.003). Again, the meta-regression adjusted for age did not explain heterogeneity (coefficient −0.010; p = 0.351).

The meta-analysis of mean number of present teeth showed that the subjects with malnourished/at risk of malnutrition demonstrated had significantly fewer teeth (SMD of −0.141; 95% CI −0.278 to −0.00502) (Fig. 3C) in comparison with individuals with normal nutrition. The subgroup analysis revealed that studies with noninstitutionalized individuals accounted for this difference (SMD −0.18; 95% CI −0.32 to −0.04). There was no risk of bias, according to the Begg's and Egg's tests (p = 0.806 and p = 0.474, respectively) (Fig. S3). A low heterogeneity showed for this analysis (I^2 = 9.7%, p = 0.351), and no meta-regression was performed.

4. Discussion

This study aimed to systematically review if there is an association between malnutrition or the risk of malnutrition, assessed by MNA or SGA, and the oral health status in elderly. It was demonstrated that individuals with malnutrition/at risk of malnutrition had less number of present teeth and that the use of prosthesis and to be edentulous had no association with the nutritional status.

MNA is the first method for the elderly nutritional assessment patients to be chosen, since it was built especially for this population [46]. The MNA is divided into 2 stages, a short one, which is a screening tool [47]. The complete form is assessed when malnutrition is diagnosed previously [46].

The association between poor oral health outcomes and malnourished individuals may be evidenced, mainly, for the number of present teeth, as demonstrated in qualitative [10,14,24,31,32] and quantitative analysis. Malnourished individuals presented 0.14 less teeth on average when compared to the well-nourished. Although this result is statistically significant, the interpretation of this finding should be evaluated cautiously, because its clinical significance may not be relevant.

Number of remaining teeth is an important outcome for buccal status particularly in older adults since it represents the long-life exposure to the cumulative effect of caries and periodontitis [5,48]. Some studies observed that the number of food items that elderly were able to eat were significantly associated with number of present teeth, leading to limited choice of foods and a consequent reduction of the intake of fruits, vegetables and fibers, providing an increased risk of malnutrition [1,8,14,49].

The number of FTU is a reliable indicator of chewing and determines chewing ability [50]. This systematic review included several studies that reported the data of occluding pairs and FTUs, but a quantitative approach was not possible to be performed. The literature shows that individuals without posterior occluding pairs were twice more likely to be malnourished [35]. Additionally, there is a significant association between a lower number of

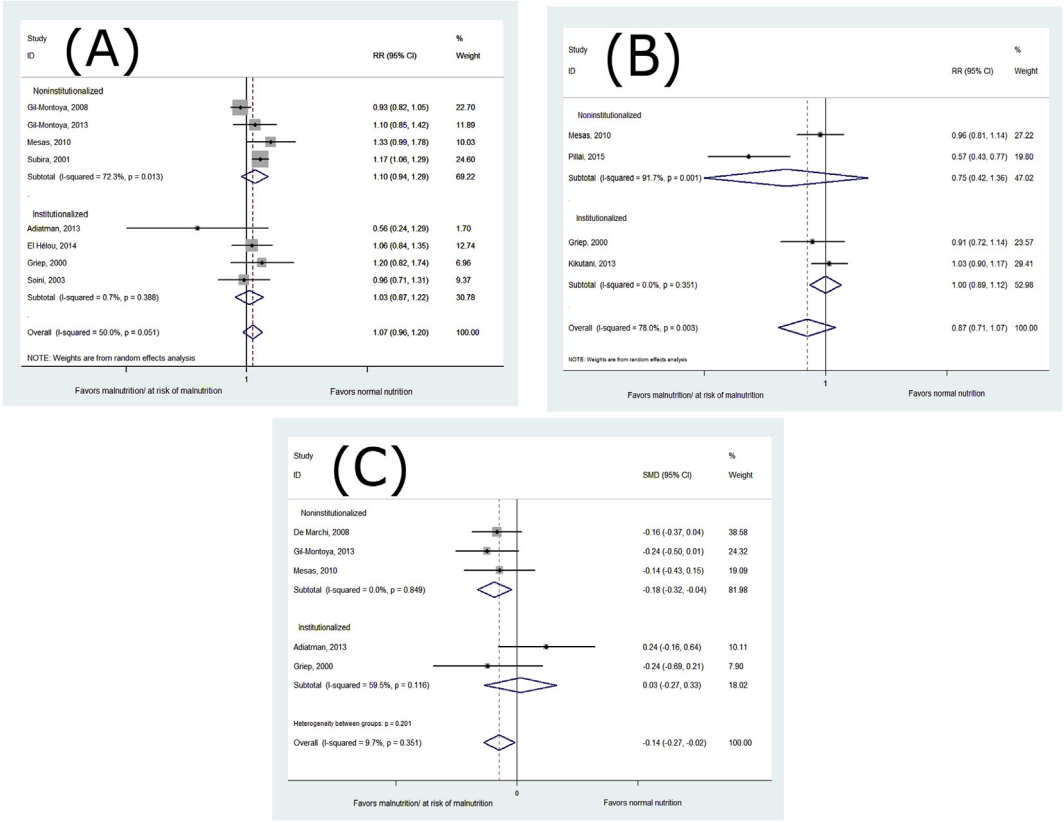

Fig. 3. Florest plot for the edentulism (A), number of prosthesis (B), and mean number of teeth present (C).

posterior occluding pairs and reduction in the nutrients intake [14,15,27,33,36]. El Osta et al. [29] observed that elderly with less <4 FTU have deficient masticatory functions and avoid to eat hard food, such as vegetables and meat, which would explain the increased risk of malnutrition of these individuals.

Regarding the use of prosthesis, most of the studies were not able to show a significant difference between malnourished and well-nourished individuals [28,29,32,34,35,39] although subjects using denture demonstrated chewing ability and bite force reduced to only 20% [17,51] in comparison to fully dentate individuals. The quantitative analysis from this study also showed no relationship between the use of prosthesis and the elderly nutritional status. However, the relation between prosthesis use and nutritional status is highly influenced by edentulism. Besides that, edentulous with at a maximum of only one complete denture are more prone to eat foods with pastry consistency in daily routine, presenting lower scores of MNA compared to individuals who present healthy dietary preferences [7,49]. This suggests that edentulous individuals that use a complete pair of prosthesis have a better nutritional status [10] compared to edentulous using only one complete denture, indicating that wearing complete pair of dentures may be an advantage against malnutrition [7].

Regarding the studies evaluating the relationship between edentulism and nutritional status, only one showed a higher risk of malnutrition in fully edentulous patients [23]. The meta-analysis performed in this study did not find a statistically significant association between edentulism and nutritional status. Population-based studies found a correlation with edentulism and nutrients consumption and multiples nutritional deficiencies [11,52,53]. The edentulism reduce the chewing ability, leading to changes in the eating habits and selection of easily chewed foods. Those foods may not contain all the nutrients to a well balanced diet.

Institutionalization is a risk factor for malnutrition in older adults and the present meta-analysis considered this fact when showed the subgroup analysis [54,55]. It was demonstrated that oral health status in institutionalized individuals contributes less to malnutrition than in noninstitutionalized older adults. This fact can be explained mainly be the characteristics inherent to institutionalized individuals that are *per se* related to nutritional deficiencies and malnutrition, such as severe chronic diseases and polypharmacy, advanced age, functional dependence, immobility and dysphagia [56]. In this scenario, poor oral health has little contribution to malnutrition.

The biological plausibility addressing oral health and nutritional status is driven by the cumulative effect of oral disease throughout the life cycle [1,57]. In this direction, caries and periodontal diseases lead to tooth loss and impaired masticatory function. Higher numbers of individuals presenting tooth loss, wearing dental prosthesis, and edentulous are most commonly among elderly people [58]. Although the opposite direction should not be neglected, tooth loss and its consequences impose dietary restriction in the elderly with repercussion in their nutritional status.

Some limitations must be highlighted in this systematic review. Only studies that performed an oral examination by a dental professional were included in this systematic review, excluding other important outcomes to the nutritional status, such as salivary flow and specifics test to assess chewing capacity. There is a high variability in the selected studies, suggesting major differences among them, such as follow-up, risk of bias, and different oral health indicators. These characteristics may influence the results and partially explain the discrepant results found in this study. It is not possible to exclude the possibility that the oral health outcomes assessed in this systematic review are, in fact, sub-rogated ones. Additionally, the findings of this study should be taken cautiously, as most of the included studies were cross-sectional and this study design did not include temporality between the associations.

More studies are necessary to clarify the issues raised by this study. These studies should use a standardized methodology with longer follow-up, searching for a direct association between the clinical oral indicators and the nutritional status. Oral health should be assessed by means of clinical parameters, avoiding self-reported evaluation.

5. Conclusions

It was concluded that the mean number of teeth present was associated with nutritional status. However, the clinical effect of this association may not be relevant. On the other hand, edentulism and use of prosthesis was not associated with nutritional status. Nevertheless, it is necessary to be cautious in interpreting the results because these studies have major methodological limitations.

Conflict of interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.clnu.2017.03.014.

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