J Prosthodont Res. 2022; 66(2): 208–220

OPEN ACCESS JPR Prosthodontic Research

Journal of Prosthodontic Research

Review article

Association of Oral Health and Mini Nutritional Assessment in Older Adults: A Systematic Review with Meta-analyses

Sahar Hussein, Rifat Falak Kantawalla, Stephenie Dickie, Piedad Suarez-Durall, Reyes Enciso *, Roseann Mulligan

Herman Ostrow School of Dentistry of University of Southern California Los Angeles, California, USA

Abstract

Purpose: To evaluate whether poor oral health is associated with a higher risk of malnutrition based on the Mini Nutritional Assessment (MNA) or MNA-SF (short form) in older adults.

Study Selection: For this meta-analysis, cohort and cross-sectional studies with adults 65 years and older, reporting oral health outcomes (i.e. edentulism, number of teeth) and either the MNA or MNA-SF were selected. Four electronic databases were searched (Medline via PubMed, Web of Science, Cochrane Library and EMBASE) through June 2020. Risk of bias was assessed with the checklist by the Agency for Healthcare Research and Quality scale.

Results: A total of 928 abstracts were reviewed with 33 studies, comprising 27,559 participants, aged ≥65 being ultimately included. Meta-analyses showed that the lack of daily oral hygiene (teeth or denture cleaning), chewing problems and being partially/fully edentulous, put older adults at higher risk of malnutrition ($p<0.05$). After adjustment for sociodemographic variables, the included studies reported lack of autonomy for oral care, poor/moderate oral health, no access to the dentist and being edentulous with either no dentures or only one denture were risk factors significantly associated with a higher risk of malnutrition ($p<0.05$).

Conclusion: These findings may imply that once elders become dependent on others for assistance with oral care, have decreased access to oral healthcare, and lack efficient chewing capacity, there is increased risk of malnourishment. Limitations of the study include heterogeneity of oral health variables and the observational nature of the studies. Further studies are needed to validate our findings.

Keywords: Malnutrition, Oral health, Dentures, Occlusion, Edentulous, Mini nutritional assessment (MNA), Meta-analysis

Received 27 August 2020, Accepted 27 April 2021, Available online 15 July 2021

1. Introduction

The proportion of older adults relative to other age groups has continued to grow worldwide, especially in developing countries [1]. This population is at risk of nutritional disorders associated with a reduction in muscle mass and loss of metabolically active components that results in loss of function and worsening health outcomes [2]. Current data suggests there are approximately 3 million malnourished adults in the U.S. alone [3]. Malnutrition can be caused by a variety of factors including difficulty eating, reduced mobility, psychological stress, loss of partner, illiteracy, poverty, and poor access to healthcare, dental care and/or social services [4]. Poor general health and poor oral health are interrelated, especially among older people, primarily because of common disease risk factors, with malnutrition being a significant contributor [5].

Adequate oral health can be defined as: A standard of health of the oral and related tissues that enables an individual to eat, speak and socialize without active disease, discomfort or embarrassment and contributes to general well-being [6]. Elders may suffer a wide range of oral health problems, including but not limited to poor oral hygiene, periodontal diseases, caries, and poorly fitting prosthesis [7]. Tooth loss over the years can lead to complete edentulism in older adults, resulting in variable degrees of oral disability or incapacitation [8]. As a result, a reduction in appetite may occur as a consequence of loss of pleasure in eating, which is considered a risk factor for malnutrition [7-9]. People with impaired mastication may cope by either adapting their food choices or swallowing coarse particles that make for a digestive problem [9]. The first type of behavior can induce imbalance in dietary intake, and the second result in decreased bioavailability of nutrients and gastrointestinal disturbances. In both situations, the impaired dietary or nutrient intake can increase nutrition-induced disease [9].

The Mini Nutritional Assessment (MNA) is the most widely used tool for nutritional screening and assessment due to its ease of use in any care setting [2]. The MNA was developed and validated for use in older adults and incorporates anthropometric assessment, functionality, cognition/depression, dietary assessment and self-perception of health and nutritional status. MNA has been validated in many

DOI: https://doi.org/10.2186/jpr.JPR_D_20_00207
***Corresponding author:** Reyes Enciso, Division of Dental Public Health and Pediatric Dentistry 925 West 34th St, room 4268 Herman Ostrow School of Dentistry of USC Los Angeles, California, 90089-0641 USA.
E-mail address: renciso@usc.edu (R. Enciso).

care settings (independent living, long-term care and acute care). It is a simple, well-validated tool that can be easily administered in 10 to 15 minutes by health professionals (physicians, dietitians, nurses, research assistants) [10], but has been found to be challenging for patients with cognitive impairment and at times inefficient in acute care settings [2]. The MNA in its short form (MNA-SF), can be administered in 4-5 minutes while retaining the accuracy of the original form [2,10-11]. Hence only studies utilizing the MNA or MNA-SF were included in this systematic review.

A recent study of older adults at risk of malnutrition from three emergency rooms found that patients who reported moderately declining oral health had a 14% malnutrition rate, while those reporting poor oral health had a 20% malnutrition rate, a statistically significant difference ($p \leq 0.05$) [3]. The objective of this systematic review and meta-analyses was to determine how poor oral health affects the nutritional status of older adults in order to guide prevention and treatment strategies.

2. Materials and methods

2.1. Design and PICO question

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) [12]. The PICO (Patient, Intervention, Comparison, Outcomes) question was as follows:

- Population: Adults aged ≥ 65 years old.
- Variables of interest: Oral health outcomes.
- Comparison: None.
- Outcomes: MNA or MNA-SF.

2.2. Inclusion and exclusion criteria

Studies were limited to cohorts and cross-sectional studies reporting the association of oral health and nutritional status. Studies including adults <65 years old were excluded as were those not reporting MNA or MNA-SF. Relevant citations were collected for literature reviews, systematic reviews and clinical guidelines. Editorials/commentaries, case series and pilot studies were excluded as were articles unavailable in English.

2.3. Search methods for identification of studies

Four electronic databases were searched (Medline via PubMed, Web of Science, the Cochrane Library and EMBASE) with search strategies described on **Supplement Table 1**. The bibliography sections of all literature reviews, systematic reviews and included studies were scanned for relevant studies.

2.4. Data collection

Three review authors (S.H., R.F.K. and S.D.) scanned the title and abstracts of articles resulting from the search strategy and data were extracted, independently by the same three review authors using a previously prepared data extraction form that included the characteristics of research subjects, interventions, control groups and outcomes. When a clear decision could not be made based on title and abstract only, full text articles were retrieved. Disagreements on inclusion/exclusion were resolved by a fourth author (R.E.). If the study was rejected, the reason for exclusion was recorded. A summary of the included cohort and cross-sectional studies is presented in **Table 1**.

2.5. Assessment of risk of bias in included studies

The included studies were assessed for risk of bias by the Checklist by Agency for Healthcare Research and Quality (AHRQ) scale for cross-sectional studies [13] by three authors (S.H., R.F.K. and S.D.), **Supplement Table 2**.

2.6. Statistical analyses

2.6.1. Meta-analyses

Oral health variables and nutritional status' outcomes were extracted from the included studies by one author and reviewed by a second author. Studies reporting the number of patients presenting with or without a certain oral health variable (i.e. edentulous) and their nutritional status (based on MNA or MNA-SF) as well-nourished (normal), at-risk of malnutrition or malnourished were pooled into a paired meta-analysis. The analyses included only the available data (ignoring missing data). Due to clinical heterogeneity of the participants (hospitalized, community-dwelling), the oral health collection methods (questionnaires/interviews/clinical examination) and the study design (cohort versus cross-sectional), the random-effects model was reported for all meta-analyses when studies were assumed to be identical [14]. One review author (R.E.) calculated estimates of effect as risk ratios with 95% confidence intervals (CI) for the number of patients presenting with or without an oral health variable (i.e. edentulous versus non-edentulous). For number of teeth present (continuous variable), estimates of effect were differences in means with 95% CI. Statistical analyses were conducted with Comprehensive Meta-analysis software version 3 (Biostat, Englewood, NJ, USA) by one of the authors.

2.6.2. Quantitative analyses of included studies

Studies demonstrating a statistically significant association ($p \leq 0.05$) between an oral health variable (i.e. number of teeth, use of dental prosthesis, use of fixed versus removable prosthesis, edentulism) and MNA/MNA-SF categorized as malnourished/at risk versus well-nourished or malnourished versus well-nourished are found in **Table 2** (the unadjusted bivariate associations) and **Table 3** (the adjusted associations). The statistical tests used to report a bivariate association between the oral health variable and MNA/MNA-SF included: Pearson's or Spearman's correlations, Chi-square tests and bivariate odds-ratios for dichotomous variables (yes/no), logistic or linear regression analyses and independent t-tests or Mann-Whitney U-test for continuous variables (i.e. number of teeth). Adjusted analyses for socio-demographic indicators as well as other health variables were reported in **Table 3**.

2.7. Levels of evidence and summary of the review findings

Quality of evidence assessment and summary of the review findings were conducted with the software GRADE profiler© (Grader©), following the Cochrane Collaboration and GRADE Working Group recommendations [15,16], **Supplement Table 4**. In this systematic review the sample size of the meta-analysis was considered as insufficient (small sample size) if less than 400 participants were included in the meta-analysis [17], downgrading the quality of the evidence.

Table 1. Frequency of used luting agent.

Reference, Country, Total Sample size, Study design	Population; Setting and Living conditions	Inclusion criteria	Average Age (mean ± SD) and range;Gender
Boulos *et al.* [26] Lebanon, N=1200 Cross-sectional	Randomly selected community dwelling rural elderly; Interviewed at home.	≥65 years old	75.7 ± 7.1582M/595F
Burks *et al.* [3] USA, N= 252 Cross-sectional	Community-dwelling as well as Assisted Living elderly, admitted to emergency department.	≥65 years old, Non-critically ill, English-speaking	65-74: n=136 ≥75: n=116 124M/128F
Chen *et al.* [27] Taiwan, N=114 Cohort	Patients hospitalized at cardiac and orthopedic units of a tertiary medical center. Majority of them lived with others (86%)	≥65 years old	65-90 yrs 75.2 ± 6.3 50M/64F
Chen *et al.* [28] Taiwan, N=306 Cohort	Randomly selected hospitalized elderly from five medical and surgical units of a tertiary medical center.	≥65 years old	65-89 yrs 71.75± 5.62 143M/163F
Dewake *et al.* [29] Japan, N=53 Cross-sectional	Community-dwelling elders attending an adult daycare center.	≥65 years old Absence of depression or mental disorder	80.4 ± 6.5 17M/36F
Forcano-Sanjuan *et al.* [18] Valencia, Spain N=791 Cross-sectional	Older persons at high risk for hospital readmission. Patients were identified either during discharge process at university hospital or were community-dwelling, identified by a computerized system using a specified set of criteria.	≥65 years old a) Less tan 3 chronic diseases b) absence of > one unplanned Emergency Department visit or hospital admission in the past 12 months.	Mean 79.8 yrs 395M/396F
Feldblum *et al.* [30] Israel, N=259 Cross-sectional	Hospitalized community-dwelling elderly at Internal medicine units Living Alone: 36.7% Living with others: 63.3%	≥65 years old subjects identified as being at nutritional risk	75.2 ±5.8 113M/146F
Gil-Montoya *et al.* [31] Spain, N=2860 Cross-sectional	Community dwelling or institutionalized elderly at geriatric nursing homes, as a part of Spanish National Oral Health Survey of elderly people.	≥65 years old	73.6±6.8 1193M/1667F
Gil-Montoya *et al.* [32] Spain, N=250 Cross-sectional	Institutionalized elderly Four private geriatric centers (nursing homes).	≥65 years old residence for >1 year with or without teeth	82.7 ± 8.2 88 M/162 F
Holst *et al.* [33] Denmark and Sweden, N=233 Cross-sectional	Community dwelling patients hospitalized at three departments of university hospitals.	≥65 years old, admitted for ≥24 hours.	81 ± 7.64 81M/152F
Iizaka *et al.* [34] Japan, N=130 Cross-sectional	Community dwelling elders, participating at a public recurrent school for healthy elderly.	≥65 years old	73.6 ± 6.8 54M/76F
Jürschik *et al.* [35] Spain, N=398 Cross-sectional	Institutionalized older adults selected from multiple institutions (health centers, acute hospitals, social centers, and nursing homes) with different levels of care in the same city.	≥65 years old	72.0 ± 7.0 for men and 77.7 ± 7.5 for women
Kikutani *et al.* [36] Japan, N=716 Cross-sectional	Community dwelling, frail, elderly from 8 community centers in Tokyo, Japan (receiving public long-term care insurance Services).	≥65 years old	83.2 ± 8.6 240M/476F
Kucuk & Kapucu [37] Turkey, N=308 Cross-sectional	Institutionalized elderly individuals Public care institution or private nursing home.	≥65 years old	78.70±7.87 129M/179F
Lamy *et al.* [38] Belgium, N=120 Cross-sectional	Nursing home, assisted living residents receiving long-term care insurance services. Nursing homes in Liège area (Belgium),	≥65 years old	81 ± 8 28M/91F
Lindmark *et al.* [19] Sweden, N=1,156 Retrospective cross-sectional study	Data from the Swedish quality register, Senior Alert, were used. Older adults from all setting/living conditions included. Nursing home (56.6%), Hospital (25.7%).	≥65 years old Those who have had an assessment relating to both their oral health status and their nutritional status using Revised Oral Assessment Guide—(ROAG-J) and Mini Nutritional Assessment—Short Form (MNA-SF), respectively.	82.8 ±7.9 443M/713F

Table 1. (continued)

Lopez-Jornet *et al.* [8] Spain, N=465 Cross-sectional	Non-institutionalized, Community based individuals; individuals under institutionalized living conditions	≥65 years old	75.7 ± 7.8 213 M/252F
Mudge *et al.* [39] Australia, N=134 Cohort study	Community-dwelling, elderly, hospitalized in general medical wards of a large, teaching hospital. Medical wards of the Royal Brisbane and Women's Hospital, Australia.	≥65 years old hospital stay > 2 days, consecutive patients, admitted from the emergency dept. to the study wards	Mean: 80 yrs 66M/68F
Nykänen *et al.* [40] Finland, N=696 Cross-sectional	Randomly selected, community-dwelling subjects in the city of Kuopio.	≥75 years old assessed for nutrition and frailty	81 ± 4.6 213M/483F
Poisson *et al.* [41] France, N=159 Cross-sectional	Hospitalized elderly from both- community and nursing homes Acute care unit of department of Gerontology at a hospital, community-dwelling or in nursing homes	≥65 years old	85.28 ± 5.68 51M/108F
Saarela *et al.* [42] Finland, N=1475 Cross-sectional	A large and representative national survey in in the cities of Helsinki and Espoo, Finland. Assisted living facilities Living at home or in nursing homes	≥65 years old	Mean: 83 yrs 310M/1165F
Saarela *et al.* [43] Finland, N=2188 Cross-sectional	Service housing residents at assisted living facility, those living at own home or in nursing homes.	≥65 years old	Mean: 83 yrs 459M/1729F
Saarela *et al.* [44] Finland, N=343 Cross-sectional	Older people in wards of assisted living facilities in Helsinki. Serviced housing with round the clock-physician, nursing care.	≥65 years old	Mean: 83 yrs 62M/281F
Saarela *et al.* [22] Finland, N=240 Cross-sectional	All long-term care residents (Nursing homes and assisted living facilities) in Helsinki, Finland.	≥65 years old	Mean: 83.9 yrs 1776F/624M
Shiraishi *et al.* [45] Japan, N=108 Retrospective Cohort study	Community dwelling, hospitalized elders, admitted to convalescent wards Rehabilitation Hospital in Japan.	≥65 years old	80.5 ± 6.8 55M/53F
Soini *et al.* [46] Finland, N=3088 Cross-sectional	Private and public nursing home (NH) residents (84%), and residents of long-term care (LT) wards (73%), Helsinki city hospitals.	≥65 years old	Mean age: 83 yrs in NH, 81 yrs in LT. 387M/1649F in NH 263M/789F in LT
Solemdal *et al.* [47] Norway, N=138 Cross-sectional	Community dwelling elderly, hospitalized for acute medical problems at Oslo University Hospital.	age >70 years old home-living, adequate cognition to understand and give written informed consent for procedures.	70-101 yrs 83.2 ± 5.9 39M/99F
Stoffel *et al.* [20] Brazil, N=287 Cross-sectional	Older individuals, 65 to 74y of age, residing in households in the districts or neighborhoods. Examinations and interviews were conducted in residential homes between July and August 2016.	65 to 74 years old individuals with physical, medical, and mental conditions that allowed conducting the study and understanding examinations and interviews performed.	65-74 yrs 69.30±3.52 102M/185F
Subira *et al.* [48] Spain, N=3459 Cross-sectional	Institutionalized and non-institutionalized elders, randomly selected from primary care clinics and institutions.	≥65 years old	65-98 yrs 73.2 ± 6.4 433M/1996F
Syrjala *et al.* [49] Finland, N=157 Cross sectional	Community-dwelling individuals, randomly sampled for Geriatric Multidisciplinary Strategy for Good Care of the Elderly (GeMS) study Home setting	>75 years old dentate subjects, providing MNA information and samples of both stimulated & unstimulated saliva.	>75 yrs 47M/157F
Tsai *et al.* [50] Taiwan, N=2766 Cohort study	Population-based study, based on records of the national household registration. Face-to-face interviews conducted at home	All Taiwanese, ≥65 years old, by the end of 1999	≥65 yrs 1527M/1239F
Wakabayashi *et al.* [21] Japan, N=354 Cross-sectional	Individuals aged ≥ 65 years in need of long-term care Setting: Long-term health care facilities, acute care hospitals, and the community-dwelling aged who were receiving home medical care.	≥ 65 years old with dysphagia or potential dysphagia in need of long-term care (possible dementia or cognitive impairment).	83± 8 118M/236F
Wu *et al.* [51] Hong Kong, N=195 Cross-sectional	Community-dwelling elders, living at private housing estates, or with their families. Evaluated at five NGO run community centers.	Non-institutionalized, ≥65 years old, Communicating in Cantonese/ Mandarin/English	65-94 yrs 75.3±6.7 63M/32 F

Abbreviations: N: total number of patients; SD: Standard deviation; F: female; M: male; yrs; years; NH: Nursing Home; LT: Long-term care.

Table 2. Association between oral health related characteristics and malnutrition based on MNA or MNA-SF. Bivariate analyses - unadjusted model.

ORAL HEALTH OUTCOMES	SIGNIFICANT ASSOCIATION[#] WITH MALNUTRITION (p≤0.05)	NO SIGNIFICANT ASSOCIATION[&] (p>0.05)
Number of teeth present	Fewer teeth were associated with malnutrition Dewake *et al*. [29] (p=0.047), Subira *et al*. [48] (p<0.001), Wu *et al*. [51] (p=0.006)	Gil Montoya *et al*. [32] Lopez Jornet *et al*. [8] Solemdal *et al*. [47] Lindmark *et al*. [19] Syrjala *et al*. [49]
Number of teeth lost	N/A	Stoffel *et al*. [20]
	EDENTULISM AND USE OF PROSTHESIS	
Edentulous (partially or totally) vs. dentate	Edentulism is associated with malnutrition Gil-Montoya *et al*. [31] (p<0.001), Boulos *et al*. [26] (p<0.001)	Lopez Jornet *et al*. [8] Stoffel *et al*. [20]
Edentulous with 0 or 1 complete dentures (CD) vs. edentulous with 2 CD vs. dentate	Edentulous patients wearing none or only 1 complete denture associated with malnutrition vs. edentulous wearing 2 CD vs. dentate Lamy *et al*. [38] (p<0.05), Saarela *et al*. [43] (p=0.014), Saarela *et al*. [44] (p=0.005), Stoffel *et al*. [20] (p=0.046)	N/A
Use of dental prosthesis (partial/complete dentures vs. natural dentition)	Boulos *et al*. [26] (p<0.001)	Dewake *et al*. [29] Forcano-Sanjuan *et al*. [18] Iizaka *et al*. [34] Lindmark *et al*. [19]
Type of dental prosthesis (removable or none vs. fixed)	Use of removable dentures or non-denture wearers were at greater risk of malnutrition than people using fixed-dentures: Tsai *et al*. [50] (p=0.019), Saarela *et al*. [43] (p=0.014)	N/A
Use of removable dentures	N/A	Syrjala *et al*. [49]
Has dental implants	N/A	Lindmark *et al*. [19]
	OCCLUSION	
Number of Occluding Pairs (anterior+posterior or posterior only)	Lower number of occluding tooth pairs associated with malnutrition Gil-Montoya *et al*. [32] (p=0.019 posterior), Wu *et al*. [51] (p=0.003, anterior & posterior)	Poisson *et al*. [41] (posterior only), Solemdal *et al*. [47] (posterior), Syrjala *et al*. [49] (posterior)
Non-functional occlusal support vs. functional	Non-functional occlusal support significantly associated with malnutrition Wakabayashi *et al*. [21] (p=0.004), Kikutani *et al*. [36] (p<0.05)	N/A
	ORAL HEALTH INDEXES	
GOHAI (Geriatric oral health assessment index): Patients with good (57-60), moderate (51-56), or poor (≤50) oral health	Poor/moderate oral health (lower GOHAI<57) associated with malnutrition Chen *et al*. [28] (p<0.0001), Burks *et al*. [3] (p<0.05), Gil-Montoya *et al*. [31] (p<0.001), Wu *et al*. [51] (p=0.007)	Chen *et al*. [27]
OHIP-14 (Scale 0-56, with higher scores indicating poor oral health)	Higher OHIP-14 associated with malnutrition Gil-Montoya *et al*. [32] (p=0.015)	N/A
DFT (decayed, filled teeth)	Higher DFT associated with malnutrition Wu *et al*. [51] (p= 0.011)	N/A
ROAG (Revised oral assessment guide) 8 normal; 9-12 slight/moderate oral problems; 13-24 severe oral problems) or ROAG-J (1: healthy; 2: must be treated by nursing staff; 3: contact the dentist)	Higher ROAG index or ROAG-J associated with malnutrition Shiraishi *et al*. [45] (p<0.001), Lindmark *et al*. [19] (p < .001)	N/A
Dental plaque/Mucosal plaque score/ Deep pocket (≥ 6mm)	N/A	Poisson *et al*. [41] Wu *et al*. [51] Solemdal *et al*. [47]

Table 2. (continued)

ORAL HEALTH CONDITIONS		
Self-assessed chewing problems/difficulty chewing	Chewing problems significantly associated with malnutrition Feldblum *et al*. [30] (p= 0.005), Holst *et al*. [33] (p≤0.005), Jürschik *et al*. [35] (p<0.001), Soini *et al*. [46] (p≤ 0.001,) Boulos *et al*. [26] (p=0.008)	Syrjala *et al*. [49]
Dry mouth/chewing problems	Significantly associated with malnutrition Nykanen *et al*. [40] (p<0.001)	N/A
Low salivary flow/Xerostomia	Significantly associated with malnutrition Soini *et al*. [46] (p ≤ 0.001)	Poisson *et al*. [41] Syrjala *et al*. [49]
Taste disturbance	Significantly associated with malnutrition Holst *et al*. [33] (p<0.005)	N/A
Oral fungal infection/candidiasis	Significantly associated with malnutrition Holst *et al*. [33] (p<0.005), Poisson *et al*. [41] (p<0.01)	N/A
Patients reporting oral health problems/mouth injuries and/or pain in mouth	Significantly associated with malnutrition Jürschik *et al*. [35] (p=0.04), Kucuk & Kapucu [37] (p=0.032), Soini *et al*. [46] (p ≤ 0.001)	N/A
Number of dental and oral problems (bad condition of teeth, problems swallowing, problems chewing and dry mouth)	Significantly associated with malnutrition Saarela *et al*. [22] (p<0.001)	Iizaka *et al*. [34]
ACCESS AND ORAL HYGIENE		
Access to the dentist over 12 months	Patients with no access to the dentist over the past 12 months at higher risk of malnutrition Stoffel *et al*. [20] (p=0.003)	N/A
Participants who had no daily cleaning of teeth and/or dentures	No daily cleaning was significantly associated with malnutrition Jürschik *et al*. [35] (p=0.001), Saarela *et al*. [42] (p<0.01)	N/A

[#] A statistically significant association between the oral health variable and MNA/MNA-SF was defined as: a Chi-square test or Fischer exact test for categorical variables with a p-value ≤ 0.05, a Pearson's or Spearman's correlation test with a p-value ≤ 0.05, a t-test or Mann-Whitney U-test for continuous variables with a p-value ≤ 0.05, a bivariate linear regression analysis with a p-value ≤ 0.05, or an Odds Ratio with a 95% Confidence Interval not including 1.0.

[&] A non-significant association was defined as a Chi-square test, correlation test, t-test, Mann-Whitney U-test or linear regression analysis with a p-value > 0.05 or an Odds Ratio with a 95% Confidence Interval including 1.0.

3. Results

3.1. Results of the search

The initial electronic database search strategy yielded 874 unduplicated references and the hand search strategy yielded 45 additional distinct references. All 919 references were assessed independently by three review authors, and based on the abstracts and titles these were reduced to 191 references that were searched for full-text and analyzed for inclusion independently by the same review authors; 28 manuscripts were relevant for inclusion. An update of the search in February 5th, 2019 resulted in four more relevant included studies [18-21] and one systematic review [7]. The additional systematic review was also reviewed for relevant citations. These additional 4 papers were included in the systematic review and meta-analyses. A second update on June 16th, 2020 resulted in four more studies being found [22-25]. Three of these were excluded as reporting on patients younger than 65 years old with one cross-sectional study included [22] in this systematic review. Main reasons for exclusion are detailed in the PRISMA flowchart (**Fig. 1**). **Table 1** shows a list of all included studies.

3.2. Included studies

3.2.1. Study design.

A total of 33 studies were included in this systematic review [3,8,18-22,26-51]. Twenty eight studies were cross-sectional studies [3,8,18-22,26,29-38,40-44,46-49,51], and five studies were of cohort design [27-28,39,45,50] (**Table 1**).

3.2.2. Population

Total number of participants included in this systematic review was 27,559 with the largest sample size being 3,459 subjects [48] and the smallest one being 53 subjects [29]. All of the studies included patients 65 years or older from both genders with reported ages ranging from 65 to 101 years. Participants in 17 of the studies were solely community dwelling older adults, interviewed at home or in emergency rooms or hospital wards [18,20,26-30,33-34,36,39-40,45,47,49-51]. Seven studies included only institutionalized older adults, living in

Table 3. Multiple logistic regression analyses using nutritional status based on MNA/MNA-SF (well-nourished vs. malnourished/at risk) as a dependent variable. Total GOHAI, autonomy for oral care, access to the dentist and edentulism combined with 0 or 1 prosthesis were found to be statistically significant for malnutrition after adjustment for socio-demographic factors.

ORAL HEALTH OUTCOMES	ADJUSTED ANALYSIS WITH SIGNIFICANT ASSOCIATION WITH MALNUTRITION (p<0.05)	ADJUSTED ANALYSIS WITH NO SIGNIFICANT ASSOCIATION (p>0.05)
Number of remaining teeth	N/A	Wu *et al.* [51]
Edentulous (partially or totally) vs. dentate	N/A	Boulos *et al.* [26]
Number of Occluding Pairs (posterior or anterior+posterior)	N/A	Wu *et al.* [51] Poisson *et al.* [41]
ORAL HEALTH INDEX		
DFT (decayed, filled teeth)	N/A	Wu *et al.* [51]
Shallow pocket (4-5mm)	N/A	Wu *et al.* [51]
Deep pocket (≥6mm)	N/A	Wu et al. [51]
Total GOHAI (Geriatric oral health assessment index); Scale 12-60 with higher scores denoting better oral health	Patients with poor/moderate oral health (lower total GOHAI) at higher risk of malnutrition: Wu *et al.* [51] (p= 0.014[a]; p=0.017[b])	N/A
ORAL HEALTH CONDITIONS		
Salivary hypofunction	N/A	Poisson *et al.* [41]
Oral fungal infection/candidiasis	N/A	Poisson *et al.* [41]
Number of patients reporting oral health problems / mouth injuries and/or pain in mouth	N/A	Boulos *et al.* [26]
ORAL CARE AND ACCESS		
Autonomy for oral care	Patients with no autonomy for oral care were at higher risk of malnutrition: Poisson *et al.* [41] (p=0.004 [c])	N/A
Access to the dentist over 12 months	Patients with no access to the dentist over the past 12 months had 48% higher prevalence ratio of malnutrition: Stoffel *et al.* [20] (p=0.006[d])	N/A
Use of prosthesis by edentulous people	Edentulous individuals with either no dentures or only one denture had 59% higher prevalence ratio of nutritional risk: Stoffel *et al.* [20] (p=0.002[d])	

[a] Wu et al. [51] provided data adjusted for age, systemic disease, gender, education, housing, occupation, periodontal status, total GOHAI score and number of remaining teeth.
[b] Wu et al. [51] provided data adjusted for age, systemic disease, gender, education, housing, occupation, periodontal status, total GOHAI score and number of occluding tooth pairs.
[c] Poisson et al. [41] adjusted for age, gender, dysphagia, salivary hypofunction, candidiasis, posterior occluding pairs (POPs) < 7, self-feeding autonomy.
[d] Stoffel et al. [20] provided a multivariate model adjusted for level of education, marital status, mean age, mean tooth loss, number of comorbidities, number of medicines used per day.

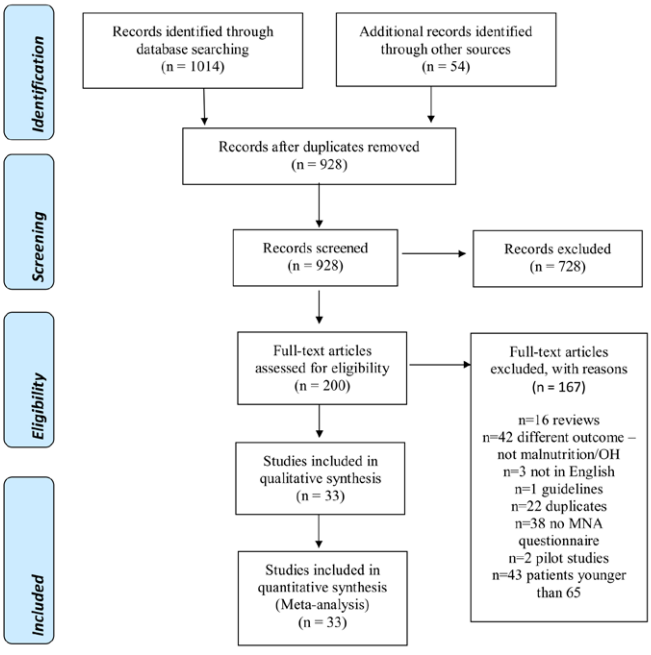

Fig. 1. PRISMA flow diagram.

nursing homes or assisted living facilities [21-22,32,35,37-38,44,46]. Nine studies included both living conditions, community-dwelling and long-term care [3,8,19,21,31,41-43,48].

3.2.3. Nutritional status

The MNA includes 18 items (range of scores, 0-30) consisting of four domains: anthropometric, general, dietary and subjective assessment. An MNA score ≥24 indicates well-nourished, 17-23.5 suggests at-risk for malnutrition and a MNA<17 indicates malnourishment [2]. The total score in MNA-SF version is 14 points, where 12-14 points indicate no risk or well nourished, 8-11 points, a risk of malnutrition and 7 or fewer points, malnutrition [19]. Twenty studies used complete Mini Nutritional Assessment (MNA) and 13 studies used its short form (MNA-SF) [3,18-19,21,29-30,36,40-41,45,47,49-50].

3.2.4. Oral health outcomes

Oral health variables reported in **Tables 2 and 3** are classified into dental status (number of teeth present/absent), edentulism (number of edentulous patients with/without complete dentures), use of prosthesis (use of dental prosthesis, removable vs. fixed pros-

thesis and presence of dental implants), occlusion (number of occluding pairs, functional occlusion), oral care (autonomy and daily cleaning), access to the dentist, oral health conditions and oral health indices including self-assessed chewing difficulty, swallowing difficulty, low salivary flow/xerostomia, painful mouth conditions, mouth injuries, oral fungal infections/candida, and taste disturbances. The following oral health indices were reported by the authors: dental plaque/mucosal plaque score/presence of deep periodontal pocket (≥6mm), Geriatric Oral Health Assessment Index (GOHAI), DFT (decayed, filled teeth), Revised Oral Assessment Guide (ROAG), and Oral Health Impact Profile (OHIP-14).

The GOHAI is a 12-item self-reported index which assesses problems related to food ingestion [31,52]. Participant responses to each item are coded and the total score is used to define patients with good (57-60), moderate (51-56), or poor (≤50) oral health [3]. The Oral Health Impact Profile (OHIP-14) measures people's perception of the social impact of oral disorders on their well-being. on a range from 0 to 56 with higher scores indicating a poorer oral health-related quality of life [53]. The Revised Oral Assessment Guide [ROAG] [54] evaluates oral health by assessing the condition of the voice, lips, oral mucosa, tongue, gums, teeth, saliva, swallowing and any dentures/implants with a total score range of 8 (without oral problems) to 24 (with severe oral problems). The Decayed Missing Filled Teeth [DMFT] or Decayed Filled Teeth [DFT] indexes have been used for over 65 years [55] and are the most common indexes to measure caries experience in dental epidemiology.

3.2.5. Statistical analyses

Though our intention was to perform a meta-analysis for each oral health variable, due to the heterogeneity of the reported oral health variables, the lack of outcomes reported (authors often reported just the p-value not the number of people at-risk/malnourished versus well-nourished), meta-analyses were conducted on six oral health variables (number of edentulous patients, number of people with dental prosthesis (partial or complete), number of patients with chewing problems, mean number of teeth, number of people with poor/moderate oral health (GOHAI<57) and number of people with no daily denture and/or teeth cleaning.

3.3. Risk of bias

The cross-sectional and cohort studies included in this systematic review were assessed for risk of bias using the checklist outlined by the Agency for Healthcare Research and Quality (AHRQ) [13] (**Supplement Table 2**). The AHRQ checklist is composed of nine criteria, which were applied to each included study. Review of **Supplement Table 2** shows a "Yes" response to the "Source of information described" by all thirty-three studies. Two of the studies did not give clear disclosure of the exclusion criteria [36,44] and only 60.6% of the studies reported the time period of data collection. A total of 20 studies were population-based and 13 were not. Out of those 13, seven did not specify if the enrollment of the subjects was consecutive, one was unclear and five studies clearly specified that the subjects were consecutively enrolled. Fully 42.4 % of the studies had an "Unclear" response for the criteria "Assessments for Quality Assurance," meaning that the authors stated "trained" without explanation, while 12.1% had a "No" response (i.e. a single individual was assigned to collect data, but training of this individual was not clearly described, nor was there mention who or how the data was collected). More than a quarter of the studies (27.2%) did not describe patient exclusions from analysis and 18.2% did not control confounding variables. The response rate for collected data was not clear for 9% of the studies, and 21.2% did not state how many patients declined to participate in the study or were excluded and why. The "Missing data in analysis explained" category had "No" responses for 42.8% of the studies reviewed. Overall, 72.7% of the studies reviewed were High Risk of bias, 15.1% were unclear risk of bias and only 12.1% percent were considered "Low Risk of Bias," with a "Yes" for all nine criteria [39,45,47,49].

3.4. Results of the meta-analyses

A meta-analysis was conducted for all the oral health outcomes reported on at least two studies comparing the same groups (at risk/malnourished vs. well-nourished). Of the 33 studies only six meta-analyses could be conducted due to heterogeneity of the reporting of the oral health variables. Some studies reported only p-values but not descriptive statistics of the original outcomes. Partial or fully edentulous patients aged 65 or over had a 9.5% higher chance to be at-risk for malnutrition or malnourishment compared to dentate patients (RR=1.095; 95% CI 1.007 to 1.190; p=0.033; **Fig. 2A**). Older adults with a dental prosthesis (a partial or complete denture or fixed/removable prosthesis) had 3.7% lower chance of being at-risk/malnourished than those without a prosthesis, however this result was not statistically significant (RR=0.963; 95% CI 0.862 to 1.076; p=0.505; **Fig. 2B**). Older adults with chewing problems had nearly twice the risk of malnutrition, with these findings being statistically significant (RR=1.956; 95% CI 1.097 to 3.488; p=0.023; **Fig. 2C**). Older adults with no daily teeth or denture cleaning were at 52.6 % higher risk of malnutrition, again statistically significant results (RR=1.526; 95% CI=1.261 to 1.847; p<0.001; **Fig. 2D**). At-risk or malnourished individuals had on average lost 4 more teeth than those well-nourished, however this difference was not statistically significant (mean difference = - 3.858; 95% CI -7.968 to 0.252; p=0.066; **Fig. 2E**).

3.5. Results of the individual studies

3.5.1. Bivariate analyses.

Table 2 presents the bivariate associations of oral health and nutritional status (MNA or MNA-SF) with a summary of the results presented in **Supplement Table 3**.

3.5.2. Multivariate analyses

Significant multiple logistic regression analyses using nutritional status (well-nourished vs. malnourished/at risk) as a dependent variable were reported by three studies [20,41,51] (**Table 3**). Four oral health variables showed statistical significance after adjusting for socio-demographics and other oral health factors. Patients with poor or moderate oral health, demonstrated by a total GOHAI score< 57, were at higher risk of malnutrition (p=0.014/p=0.017) [51] adjusted for different criteria. Also, patients with no autonomy for oral care were at higher risk of malnutrition (p=0.004) [41]. Stoffel *et al.* [20] showed individuals with no access to the dentist over the past 12 months were at 48% higher prevalence ratio of malnutrition (p=0.006). In the same study [20], edentulous individuals with either none or one denture had a 59% higher prevalence ratio of malnutrition (p=0.002). There were also non statistically significant differences based on MNA/MNA-SF reported on three studies for some oral health outcomes (refer to **Table 3** for an exhaustive list). [26,41,51].

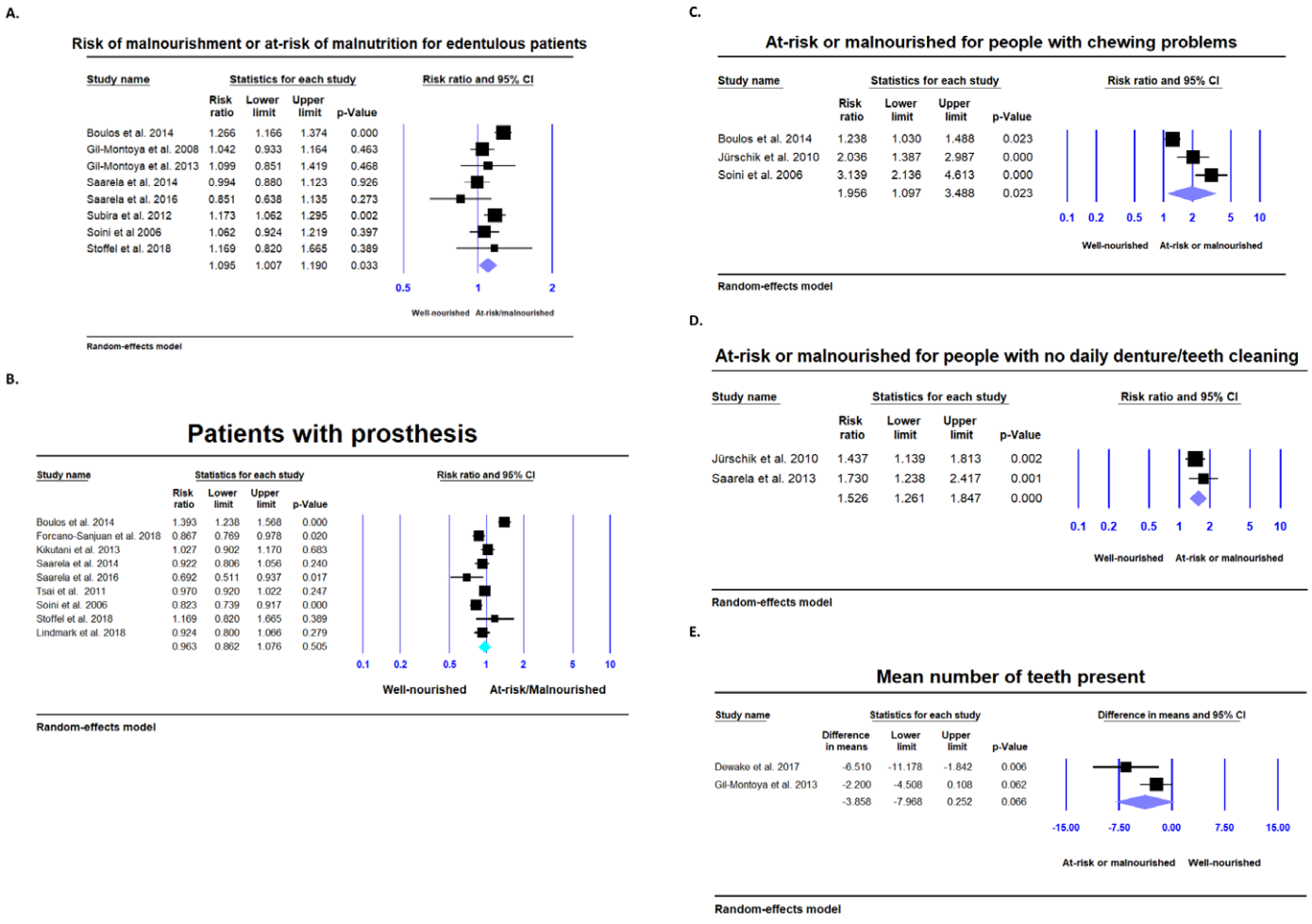

Fig. 2. Meta-analyses. A. Edentulous patients with any type of prosthesis were at a 9.5% significantly higher risk for malnutrition/at-risk of malnutrition (p=0.033); B. Use of prosthesis was not a significant risk for malnutrition or being malnourished (p=0.505); C. Patients with chewing problems were twice at risk of malnutrition or malnourished (p=0.023); D. Patients with no daily teeth or denture cleaning had 52.7% more chances to be at risk of malnutrition or malnourished (p<0.001); E. At-risk or malnourished individuals had on average lost 4 more teeth than those well-nourished (p=0.066).

3.6. Summary of the evidence and quality of the findings (GRADE)

According to GRADE evidence method [15,16], *low evidence* quality grading indicates that "further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate" of the effect. *Very low* evidence quality grading indicates that "we are very uncertain about the estimate" of the effects. The quality of the evidence in this systematic review was *low* or *very low* for all outcomes (**Supplement Table 4**) due to the observational study design (cross-sectional studies and cohorts), the unclear or high risk of bias of the included observational studies, and the small total sample size (<400 participants [17]) of the included studies based on the GRADE evidence method [15-16].

4. Discussion

4.1. Summary of main results

4.1.1. Edentulism and the use of prosthesis

Our meta-analysis showed edentulous patients (with or without prosthesis) were at 9.5% higher risk of malnutrition (p=0.033). Evidence does suggest that edentulous persons lack specific nutrients that could ultimately result in increases of various health disorders [56]. The edentulous, when compared to dentate, frequently report lower intakes of fruits and vegetables due to difficulty chewing foods hard or fibrous in texture, putting them at risk of malnutrition [57]. In one study [20], edentulous with none or only one complete denture(s) were at higher risk for malnutrition than those dentate, after adjustment for socio-demographic factors, access to the dentist, number of comorbidities and daily medications. Although edentulism, with subsequent increase in malnutrition is linked to a declining quality of life, there is hope for edentulous patients, as no statistically significant difference was observed for nutritional risk between dentate and edentulous people with two complete dentures (p>0.05) [38], justifying early and complete prosthetic rehabilitation after total tooth loss.

4.1.2. Use of prosthesis

The meta-analysis (**Fig. 2**) comparing patients with and without different types of prosthesis, showed that the use of prostheses was not significantly associated with malnutrition (p=0.505). According to Lindmark *et al.* [19], having dental implants was similarly not significantly associated with malnutrition (p=0.416). In this review, participants at-risk or malnourished, averaged four more teeth lost than those well-nourished (p=0.066); however, the World Health Organi-

zation considers that individuals are in need of prostheses when one or more teeth are missing with no replacement by a prosthesis [58].

4.1.3. Chewing and occlusion

In our meta-analyses, patients with chewing problems were at nearly twice the risk of malnutrition (p=0.023). In general, persons who have masticatory dysfunction, tend to select food to match their dental status, resulting in an increased consumption of soft and easy-to-eat foods, often resulting in unbalanced poor-quality diets [56,59,60].

Chewing efficiency in the dentate correlated with the number of posterior teeth and occlusal relationships [36], while in another study, the number of premolar-molar *occluding pairs* was a good index of masticatory function. [61]. It is not surprising, then to find a positive association between number of teeth, particularly pairs of occlusal posterior teeth, and the nutritional status of individuals [62]. According to Gil-Montoya *et al*. [32] participants with malnutrition or at-risk had less than eight antagonist pairs of teeth. When considering the effect of occlusal support (functional vs. non-functional) on both mastication and swallowing functions, and its possible impact on nutritional status, Kikutani *et al*. [36] concluded that non-functional occlusal support was significantly associated to malnutrition risk. When comparing older individuals with natural dentition and adequate function to individuals with functionally inadequate occlusion with no dentures, the latter group had a 3.189-fold greater malnutrition risk than the first group (95% CI 1.437 to 7.080) [36]. In comparison, older adults, partially or fully edentulous, but maintaining functional occlusion with dentures in one or both jaws had a 1.704-fold greater malnutrition risk than those with functionally adequate natural dentition [36]. This study emphasizes the importance of early dental treatment and prosthetic rehabilitation in the elderly as a way to protect remaining natural dentition and occlusal function [36].

4.1.4. Salivary flow

Poor oral health, due to a reduction in salivary flow, candidiasis, and related dysphagia [41], can contribute to undernutrition. Soini *et al*. [46], found a positive significant association between salivary hypofunction and malnutrition ($p \leq 0.001$).

4.1.5. Oral health quality of life

In Wu *et al*. [51], the GOHAI score appeared to be a significant indicator of malnutrition in older adults when adjusted for socio-demographics and systemic disease, periodontal status, and the number of remaining teeth, while dental variables (i.e. dental caries, deep pockets, missing teeth, and number of occluding pairs) were not significant risk factors for malnutrition after adjustment.

4.1.6. Lack of daily oral hygiene

Meta-analyses showed that lack of daily oral hygiene (teeth or denture cleaning) placed older adults at 52.7% higher risk of malnutrition (p<0.001). In Saarela *et al*. [42], frail elders in assisted living, and males with lower education and longer institutionalization showed higher incidences of lack of daily oral hygiene, malnourishment and dependence in activities of daily living. This suggests that oral hygiene assistance received by these residents could be inadequate to compensate for loss of independent, daily oral health care. Despite poorer oral health these residents used fewer dental services. Further resources and education should focus on the oral hygiene of frail older assisted living residents.

4.1.7. Autonomy for oral care

Dependency and weak masticatory ability have been described as risk factors for malnutrition [38]. Poisson *et al*. [41] noted that autonomy for oral care (alone versus needed help) was independently associated with undernutrition. They also found a relationship between oral self-care dependency and dysphagia [41].

4.1.8. Access to dental care

Access barriers to oral care over 12 months was significantly associated with higher nutritional risk in the multiple logistic analysis. Stoffel *et al*. [20] argued that the lack of access might be related to the absence of human resources, as well as geographic, financial, and cultural barriers.

4.2. Agreements and disagreements with other reviews

Narrative reviews pertaining to our PICO question were assessed for agreement and/or disagreement with the findings of this systematic review. Gil-Montoya *et al*. [63] concluded that poor oral health is responsible for mastication difficulties, chronic disease destabilization, and impairment of oral health related quality of life with direct effects on the individual's general quality of life and well-being. Deficient mastication has also been related to tooth loss, lack of saliva, masticatory force, and malocclusion issues [64]. This is in agreement with our findings that older adults with chewing problems were at nearly twice the risk of malnutrition (p=0.023).

A systematic review conducted by Toniazzo *et al*. [7], on subjects >60 years of age found that individuals with or at risk of malnutrition had fewer numbers of teeth present in agreement with our review. However, the use of dental prosthesis and/or being edentulous was not associated with the nutritional status (p>0.05); and, those with partials or fully edentulous were at higher risk of malnutrition (p=0.033) with the use of a prosthesis having no effect (p=0.505) [7].

The relationship between food choices, oral health status and the consequences to nutrition was explored by Walls and Steele [65]. The oral health variables of interest were salivary flow and number of teeth, the distribution of these teeth or complete loss of teeth, and the effects on nutrition. The review found that those with a decreased ability to chew food were not choosing nutritious foods such as whole fruits and vegetables or meats. The intake of food high in fiber was significantly decreased, as were micronutrients and vitamin C. The authors concluded that limited nutritional intakes were more likely related to foods choice than the direct mechanical effects of impaired chewing in individuals with compromised oral function [65].

The systematic review conducted by Zelig *et al*. [66] investigated the association between those with missing teeth, those with prosthesis replacing missing teeth and their nutritional status concluding that five of the eight included articles supported positive relationships or associations between missing teeth, teeth replaced with prostheses, and malnutrition risk. Individuals with fewer teeth and poorer occlusion were at an increased risk of malnutrition in agreement with our review.

In a systematic review including seventeen cross-sectional studies, Van Lancker *et al.* [67] concluded that there was tentative evidence to suggest that malnutrition and oral health status were independently associated. This agrees with our review, that patients with poor or moderate oral health, demonstrated by a total GOHAI score< 57, were at higher risk of malnutrition.

4.3. Overall completeness, applicability and heterogeneity

Based on our eligibility criteria (age>65 years, oral health variable, nutritional assessment by MNA), four popular electronic databases (MEDLINE through PubMed, the Cochrane Library, EMBASE and Web of Science) were searched through June 16th, 2020 for relevant studies. Three authors cross-referenced and searched all included studies, literature reviews, and systematic reviews for possible missed references. The results of this study are not applicable to people younger than 65 years old and for certain other patient categories, excluded based on criteria given by our included articles (critical/terminal illness, being on life-support, or parenteral nutrition, poor cognition, refusal to participate).

Though every study used MNA or MNA-SF to measure malnutrition, there was some heterogeneity in terms of oral health variables under consideration. The population type differed, based on whether they were community dwelling or institutionalized, their health status and place of interview/examination e.g. own home, day care center, hospitalization ward or emergency room. The reviewed studies conducted the dental screening using various methods e.g. face to face interviews, questionnaires and clinical exams by nurses/doctors with different levels of training.

4.4. Quality of the evidence and limitations

The overall quality of the evidence according to the GRADE table was *low* for edentulism, use of prosthesis, chewing problems, poor moderate oral health (GOHAI≤57). The quality of the evidence for 'mean number of teeth present' and the variable 'no daily denture or teeth cleaning' was *very low* with only two studies included in the meta-analysis and observational study design (**Supplement Table 4**).

Several limitations should be highlighted in this systematic review. First, only studies including patients aged 65 and over were included. Secondly, primary data collection was undertaken by single or multiple investigators, with different levels of training, utilizing various methods such as oral examinations, questionnaires and personal interviews (**Supplement Table 2**). Most studies included in this systematic review utilized questionaries' with oral health status being self-reported. It is known that self-reported oral health and perceived oral health needs do not correlate with clinical exam findings [54]. Second, there was significant variability regarding the measurements of the oral health variables, with a vast array of oral cavity conditions making up the oral health status data collected. Conditions such as salivary hypofunction or oral lesions may be a consequence of medical conditions and non-modifiable risk factors. All but three studies were high risk/unclear risk of bias.

5. Conclusion

In conclusion, this systematic review with meta-analyses found that edentulism, lack of daily oral hygiene (teeth or denture cleaning) and chewing problems were associated with higher risks of malnutrition based on MNA and MNA-SF assessments. After adjustment for socio-demographic variables, three oral health variables were significantly associated with higher risk of malnutrition in the original studies, lack of autonomy for oral care and access to the dentist, self-reported poor/moderate oral health (measured with the geriatric oral health assessment-GOHAI), and being edentulous with either no dentures or only one denture.

Funding support

No financial support was received by the authors to conduct this research.

Conflicts of interest

The authors declare no conflict of interest.

References

[1] Abdullah B, Wolbring G. Analysis of newspaper coverage of active aging through the lens of the 2002 world health organization active ageing report: A policy framework and the 2010 toronto charter for physical activity: A global call for action. Int J Environ Res Public Health 2013; 10:6799-819. https://doi.org/10.3390/ijerph10126799, PMID:24317386

[2] Cereda E. Mini nutritional assessment. Curr Opin Clin Nutr Metab Care 2012; 15:29-41. https://doi.org/10.1097/mco.0b013e32834d7647, PMID:22037014

[3] Burks CE, Jones CW, Braz VA, Swor RA, Richmond NL, Hwang KS et al. Risk Factors for Malnutrition among Older Adults in the Emergency Department: A Multicenter Study. J Am Geriatr Soc 2017; 65:1741-7. https://doi.org/10.1111/jgs.14862, PMID:28322438

[4] Krishnamoorthy Y, Vijayageetha M, Kumar SG, Rajaa SRT. Prevalence of malnutrition and its associated factors among elderly population in rural Puducherry using mini-nutritional assessment questionnaire. J Fam Med Prim Care 2018; 7:1429-33. https://doi.org/10.4103/jfmpc.jfmpc_22_18, PMID:30613537

[5] Petersen PE, Nörtov B. General and dental health in relation to life-style and social network activity among 67-year-old danes. Scand J Prim Health Care 1989; 7:225-30. https://doi.org/10.3109/02813438909088669, PMID:2626612

[6] Udoye C, Aguwa E. Oral health related knowledge and behaviour among nursing students in a Nigerian tertiary hospital. Internet J Dent Sci 2009; 7:1-8. https://doi.org/10.1002/pip

[7] Toniazzo MPM, Amorim P de SAP, Muniz FWMGF, Weidlich P. Relationship of nutritional status and oral health in elderly: Systematic review with meta-analysis. Clin Nutr 2018; 37:824-30. https://doi.org/10.1016/j.clnu.2017.03.014, PMID:28392164

[8] Lopez-Jornet P, Saura-Perez M, Llevat-Espinosa N. Effect of oral health dental state and risk of malnutrition in elderly people. Geriatr Gerontol Int 2013;13:43-9. https://doi.org/10.1111/j.1447-0594.2012.00853.x, PMID:22530802

[9] N'Gom PI, Woda A. Influence of impaired mastication on nutrition. J Prosthet Dent 2002; 87:667-73. https://doi.org/10.1067/mpr.2002.123229, PMID:12131890

[10] Vellas B, Villars H, Abellan G. Overview of the MNA® - Its History and Challenge. J Nut Heal Aging 2006;10:456-63. https://doi.org/10.1021/la204855j, PMID:17183418

[11] Kaiser MJ, Bauer JM, Ramsch C, Uter W, Guigoz Y, Cederholm TTD et al. Validation of the Mini Nutritional Assessment short-form (MNA-SF): a practical tool for identification of nutritional status. J Nutr Heal Aging 2009; 13:782-8. https://doi.org/10.1007/s12603-009-0214-7, PMID:19812868

[12] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009; 6:e1000097. https://doi.org/10.1371/journal.pmed.1000097, PMID:19621072

[13] Rostom A, Dube C, Cranney A. Agency for Healthcare Research and Quality evidence reports summaries. University of Ottawa Evidence-based Practice Center. Ottawa, Canada: University of Ottawa 2004

[14] Borenstein M, Hedges L V, Higgins JPT, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. Res Synth Methods 2010; 1:97-111. https://doi.org/10.1002/jrsm.12, PMID:26061376

[15] Higgins J, Green S (editors). Cochrane Handbook for Systematic Reviews of Interventions 2011; Version 5.1.0 [updated March 2011]. https://doi.org/10.1002/9780470712184

[16] Guyat G, Oxman A, Vist G. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 2008; 336:924-6. https://doi.org/10.1136/bmj.39489.470347.ad, PMID:18436948

[17] Schwingshackl L, Knüppel S, Schwedhelm C, Hoffmann G MB, Stelmach-Mardas M, Dietrich S et al. Perspective: NutriGrade: A Scoring System to Assess and Judge the Meta-Evidence of Randomized Controlled Trials and Cohort Studies in Nutrition Research. Adv Nutr An Int Rev J 2017; 8:789-90. https://doi.org/10.3945/an.116.013052, PMID:28140319

[18] Forcano-Sanjuan S, Soriano-Melchor E, Valdivieso-Martinez B. Nutritional screening in a case management program for community-living older individuals at high risk of hospital admission. Eur Geriatr Med 2018; 9:691-6. https://doi.org/10.1007/s41999-018-0083-x, PMID:34654222

[19] Lindmark U, Jansson H, Lannering C, Johansson L. Oral health matters for the nutritional status of older persons—A population-based study. J Clin Nurs 2018; 27:1143-52. https://doi.org/10.1111/jocn.14146, PMID:29076209

[20] Stoffel LMB, Muniz FWMG, Colussi PRG. Nutritional assessment and associated factors in the elderly: A population-based cross-sectional study. Nutrition 2018; 55-56:104-10. https://doi.org/10.1016/j.nut.2018.03.053, PMID:29980089

[21] Wakabayashi H, Matsushima M, Ichikawa H. Occlusal Support, Dysphagia, Malnutrition, and Activities of Daily Living in Aged Individuals Needing Long-Term Care: A Path Analysis. J Nutr Heal Aging 2018; 22:53-8. https://doi.org/10.1007/s12603-017-0897-0, PMID:29300422

[22] Saarela RKT, Savikko NM, Soini H. Burden of Oral Symptoms and Health-Related Quality of Life in Long-Term Care Settings in Helsinki, Finland. J Nutr Heal Aging 2019; 23:1021-5. https://doi.org/10.1007/s12603-019-1268-9, PMID:31781733

[23] Su Y, Yuki M, Hirayama K. Denture wearing and malnutrition risk among community-dwelling older adults. Nutrients 2020; 12:1-12. https://doi.org/10.3390/nu12010151, PMID:31948104

[24] Azizi A, Sanaie S, Fattahi S. Dental health status of community-dwelling older adults and its relation to their nutritional status in northwest of Iran. Healthy Aging Res. 2019. https://doi.org/10.35248/har.2019.8.10

[25] Kiesswetter E, Hengeveld LM, Keijser BJ. Oral health determinants of incident malnutrition in community-dwelling older adults. J Dent 2019; 85:73-80. https://doi.org/10.1016/j.jdent.2019.05.017, PMID:31085349

[26] Boulos C, Salameh P, Barberger-Gateau P. Factors associated with poor nutritional status among community dwelling Lebanese elderly subjects living in rural areas: Results of the AMEL study. J Nutr Heal Aging 2014; 18:487-94. https://doi.org/10.1007/s12603-014-0463-y, PMID:24886735

[27] Chen CC-H, Bai Y-Y, Huang G-H, Tang ST. Revisiting the concept of malnutrition in older people. J Clin Nurs 2007; 16:2015-26. https://doi.org/10.1111/j.1365-2702.2006.01867.x, PMID:17419795

[28] Chen CC-H, Tang ST, Wang C, Huang G-H. Trajectory and determinants of nutritional health in older patients during and six-month post-hospitalisation. J Clin Nurs 2009; 18:3299-3307. https://doi.org/10.1111/j.1365-2702.2009.02932.x, PMID:19735335

[29] Dewake N, Hamasaki T, Sakai R. Relationships among sense of coherence, oral health status, nutritional status and care need level of older adults according to path analysis. Geriatr Gerontol Int 2017; 17:2083-88. https://doi.org/10.1111/ggi.13025, PMID:28345311

[30] Feldblum I, German L, Castel H. Characteristics of undernourished older medical patients and the identification of predictors for undernutrition status. Nutr J 2007; 6. https://doi.org/10.1186/1475-2891-6-37, PMID:17980023

[31] Gil-Montoya JA, Subira C, Ramon JM, Gonzalez-Moles MA. Oral health-related quality of life and nutritional status. J Public Health Dent 2008; 68:88-93. https://doi.org/10.1111/j.1752-7325.2007.00082.x, PMID:18248335

[32] Gil-Montoya JA, Ponce G, Sánchez Lara I, Barrios R, LLodra JC, Bravo M. Association of the oral health impact profile with malnutrition risk in Spanish elders. Arch Gerontol Geriatr 2013; 57:398-402. https://doi.org/10.1016/j.archger.2013.05.002, PMID:23763956

[33] Holst M, Yifter-Lindgren E, Surowiak M. Nutritional screening and risk factors in elderly hospitalized patients: association to clinical outcome? Scand J Caring Sci 2013; 27:953-61. https://doi.org/10.1111/scs.12010, PMID:23181396

[34] Iizaka S, Tadaka E, Sanada H. Comprehensive assessment of nutritional status and associated factors in the healthy, community-dwelling elderly. Geriatr Gerontol Int 2008; 8:24-31. https://doi.org/10.1111/j.1447-0594.2008.00443.x, PMID:18713186

[35] Jürschik P, Torres J, Solá R. High rates of malnutrition in older adults receiving different levels of health care in Lleida, Catalonia: An assessment of contributory factors. J Nutr Elder 2010; 29:410-22. https://doi.org/10.1080/01639366.2010.521043, PMID:21104512

[36] Kikutani T, Yoshida M, Enoki H. Relationship between nutrition status and dental occlusion in community-dwelling frail elderly people. Geriatr Gerontol Int 2013; 13:50-54. https://doi.org/10.1111/j.1447-0594.2012.00855.x, PMID:22489562

[37] Kucuk EO, Kapucu S. Malnutrition in Elderly Staying in Nursing Homes. KONURALP TIP Derg 2017; 9:222-7. https://doi.org/10.18521/ktd.318404

[38] Lamy M, Mojon P, Kalykakis G. Oral status and nutrition in the institutionalized elderly. J Dent 1999; 27:443-8. https://doi.org/10.1016/s0300-5712(99)00002-0, PMID:10399411

[39] Mudge AM, Ross LJ, Young AM. Helping understand nutritional gaps in the elderly (HUNGER): A prospective study of patient factors associated with inadequate nutritional intake in older medical inpatients. Clin Nutr 2011; 30:320-5. https://doi.org/10.1016/j.clnu.2010.12.007, PMID:21262553

[40] Nykänen I, Lönnroos E, Kautiainen H. Nutritional screening in a population-based cohort of community-dwelling older people. Eur J Public Health 2013; 23:405-9. https://doi.org/10.1093/eurpub/cks026, PMID:22539629

[41] Poisson P, Laffond T, Campos S. Relationships between oral health, dysphagia and undernutrition in hospitalised elderly patients. Gerodontology 2016; 33:161-168. https://doi.org/10.1111/ger.12123, PMID:24612262

[42] Saarela RKT, Soini H, Muurinen S. Oral hygiene and associated factors among frail older assisted living residents. Spec Care Dent 2013; 33:56-61. https://doi.org/10.1111/j.1754-4505.2012.00314.x, PMID:23451925

[43] Saarela RKT, Soini H, Hiltunen K. Dentition status, malnutrition and mortality among older service housing residents. J Nutr Heal Aging 2014; 18:34-8. https://doi.org/10.1007/s12603-013-0358-3, PMID:24402386

[44] Saarela RKT, Lindroos E, Soini H. Dentition, nutritional status and adequacy of dietary intake among older residents in assisted living facilities. Gerodontology 2016; 33:225-32. https://doi.org/10.1111/ger.12144, PMID:25163661

[45] Shiraishi A, Yoshimura Y, Wakabayashi H, Tsuji Y. Poor oral status is associated with rehabilitation outcome in older people. Geriatr Gerontol Int 2017; 17:598-604. https://doi.org/10.1111/ggi.12763, PMID:27150279

[46] Soini H, Muurinen S, Routasal P. Oral and nutritional status - Is the MNA (R) a useful tool for dental clinics. J Nutr Heal AGING 2006; 10:495-99. PMID:17183421

[47] Solemdal K, Sandvik L, Moinichen-Berstad C. Association between oral health and body cell mass in hospitalised elderly. Gerodontology 2012; 29:e1038-e44. https://doi.org/10.1111/j.1741-2358.2011.00607.x, PMID:22187971

[48] Subira C, Ramon JM, Almerich JM. Oral health issues of Spanish adults aged 65 and over. Int Dent J 2001; 51:228-34. https://doi.org/10.1002/j.1875-595x.2001.tb00871.x, PMID:11561883

[49] Syrjala A-MH, Pussinen PI, Komulainen K. Salivary flow rate and risk of malnutrition - a study among dentate, community-dwelling older people. Gerodontology 2013; 30:270-5. https://doi.org/10.1111/j.1741-2358.2012.00679.x, PMID:22582846

[50] Tsai AC, Chang T-L. Association of dental prosthetic condition with food consumption and the risk of malnutrition and follow-up 4-year mortality risk in elderly Taiwanese. J Nutr Heal AGING 2011; 15:265-70. https://doi.org/10.1007/s12603-010-0299-z, PMID:21437557

[51] Wu LL, Cheung KY, Lam PYP, Gao XL. Oral health indicators for risk of malnutrition in elders. J Nutr Heal Aging 2018; 22:254-61. https://doi.org/10.1007/s12603-017-0887-2, PMID:29380853

[52] Wong S, Graham A, Green D, Hirani SP, Forbes A. Nutritional supplement usage in patients admitted to a spinal cord injury center. J Spinal Cord Med 2013; 36:645-51. https://doi.org/10.1179/2045772313y.0000000105, PMID:24090376

[53] Slade G. Derivation and validation of a short-form oral health impact profile. Community Dent Oral Epidemiol 1997; 25:284-90. https://doi.org/10.1111/j.1600-0528.1997.tb00941.x, PMID:9332805

[54] Andersson P, Westergren A, Karlsson S. Oral health and nutritional status in a group of geriatric rehabilitation patients. Scand J Caring Sci 2002; 16:311-8. https://doi.org/10.1046/j.1471-6712.2002.00086.x, PMID:12191044

[55] Broadbent JM, Thomson WM. For debate: problems with the DMF index pertinent to dental caries data analysis. Community Dent Oral Epidemiol 2005; 33:400-9. https://doi.org/10.1111/j.1600-0528.2005.00259.x, PMID:16262607

[56] De Marchi RJ, Hugo FN, Hilgert JB, Padilha DMP. Association between oral health status and nutritional status in south Brazilian independent-living older people. NUTRITION 2008; 24:546-53. https://doi.org/10.1016/j.nut.2008.01.054, PMID:18455655

[57] Österberg T, Tsuga K, Rothenberg E. Masticatory ability in 80-year-old subjects and its relation to intake of energy, nutrients and food items. Gerodontology 2002; 19:95-101. https://doi.org/10.1111/j.1741-2358.2002.00095.x, PMID:12542218

[58] WHO Oral Health Surveys. Basic Methods. (1997) 4th edition. Geneva

[59] Moynihan P, Bradbury J. Compromised dental function and nutrition. Nutrition 2001; 17:177-8. https://doi.org/10.1016/s0899-9007(00)00562-1, PMID:11240353

[60] Nowjack-Raymer RE, Sheiham A. Association of edentulism and diet and nutrition in US adults. J Dent Res 2003; 82:123-6. https://doi.org/10.1177/154405910308200209, PMID:12562885.

[61] Chai J, Chu FCS, Chow TW, Shum NC, Hui WWH. Influence of dental status on nutritional status of geriatric patients in a convalescent and rehabilitation hospital. Int J Prosthodont 2006;19:244-9. PMID:16752619

[62] Sahyoun NR, Lin CL, Krall E. Nutritional status of the older adult is associated with dentition status. J Am Diet Assoc 2003; 103:61-6. https://doi.org/10.1053/jada.2003.50003, PMID:12525795

[63] Gil-Montoya JA, de Mello ALF, Barrios R. Oral health in the elderly patient and its impact on general well-being: A nonsystematic review. Clin Interv Aging 2015; 10:461-7. https://doi.org/10.2147/cia.s54630, PMID:25709420

[64] Sheiham A, Steele JG, Marcenes W. The relationship among dental status, nutrient intake, and nutritional status in older people. J Dent Res 2001; 80:408-13. https://doi.org/10.1177/00220345010800020201, PMID:11332523

[65] Walls AWG, Steele JG. The relationship between oral health and nutrition in older people. Mech Ageing Dev 2004; 125:853-57. https://doi.org/10.1016/j.mad.2004.07.011, PMID:15563930

[66] Zelig R, Touger-Decker R, Chung M, Byham-Gray L. Associations Between Tooth Loss, With or Without Dental Prostheses, and Malnutrition Risk in Older Adults A Systematic Review. Top Clin Nutr 2016; 31:232-47. https://doi.org/10.1097/tin.0000000000000077

[67] Van Lancker A, Verhaeghe S, Van Hecke A. The association between malnutrition and oral health status in elderly in long-term care facilities: A systematic review. Int J Nurs Stud 2012; 49:1568-81. https://doi.org/10.1016/j.ijnurstu.2012.04.001, PMID:22542267