

## Original Research

**Dependence Levels and Oral Functionality in Older People**

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**Abstract**

It has been suggested that an individual's overall functional capacity gradually declines with age. It has been reported that a decline in oral functionality increases the risk of sarcopenia and frailty, which contributes to the decrease in functional capacity. In Chile, the Preventive



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Medical Examination for Older Adults (EMPAM) is used to assess the functionality of that population; however, this examination does not include an evaluation of oral functionality. To address this gap, the Preventive Dental Examination for Older Adults (EDePAM) was developed to diagnose the most prevalent oral health conditions among older individuals and to provide treatments that maintain and restore oral functionality. To determine whether a correlation exists between the dependency levels assessed by EMPAM and the oral functionality levels evaluated in the EDePAM. This study presents the results of implementing, validating, and assess the economic impact of EDePAM in primary healthcare centers across Cerro Navia, Recoleta, Ñuñoa, and Los Vilos, Chile. Information regarding dependency levels was obtained from EMPAM, while oral hypofunction was assessed through evaluations of masticatory function, occlusal strength, tongue-lip motor function, and swallowing function. The correlation between the two diagnostic assessments was determined using the Kappa index. The study protocol was approved by the Health Service Ethics Committee. The sample consisted of 83 older individuals (66% female; mean age  $71.3 \pm 5.3$  years). According to EMPAM, 83% were classified as non-risk independent, while 17% were categorized as independent at risk or dependent. EDePAM identified that 66.3% of the participants exhibited oral hypofunction. The correlation between the diagnosis of oral hypofunction and the classification of independent at risk/dependent was found to be 37.4%. EMPAM could be enhanced by incorporating an oral health assessment, resulting in a more comprehensive evaluation of the overall health status of older adults and a deeper understanding of their risk of losing independence.

### **Keywords**

Chewing; frailty; geriatric; older people; oral health; sarcopenia

## **1. Introduction**

Population aging has emerged as a primary concern for countries worldwide [1, 2]. In response, Chile has proactively developed strategies aligned with international guidelines, addressing this demographic shift through a Comprehensive Policy on Positive Aging [3] and the creation of the “National Comprehensive Health Plan for Older People, 2020-2030” [4]. The primary challenge is to ensure that individuals age in good health by preventing frailty, avoiding dependency, enhancing functional capacity, and improving subjective quality of life, thereby reducing the gap between life expectancy and healthy life expectancy [4].

In Chile, older adults undergo the Annual Preventive Medical Examination for Older Adults (EMPAM)\* [5], which primarily aims to assess their overall and functional health by classifying individuals according to the Functional Evaluation of Older Adults (EFAM)#. EFAM# serves as a predictor of functional decline in older adults. Functional capacity is one of the most reliable prognostic markers for morbidity, mortality, dependency, health status, life expectancy, and the potential need for institutionalization. Within this context, the decline in oral functionality, primarily due to tooth loss, is strongly associated with aging and linked to various health issues, including malnutrition, cognitive decline, and a reduced ability to perform activities of daily living [5, 6].

The Preventive Dental Examination for Older Adults (EDePAM)<sup>+</sup> was developed to diagnose the most prevalent oral conditions among older individuals and to implement treatments to preserve and restore oral functionality. EDePAM<sup>+</sup> was created through a participatory process that involved experts in areas such as masticatory function, oral mucosal lesions, caries, and periodontal disease. Expert consensus was reached using methodologies like the Delphi method, which is based on expert judgment, to define the best approaches for evaluating each dimension of the examination. Once agreement was achieved, the EDePAM<sup>+</sup> instruments, including a clinical form and an application guide, were created [7]. Both the EDePAM<sup>+</sup> and its application guide underwent validation for appearance, construct validity, reliability, and sensitivity to change. In all validation tests, EDePAM<sup>+</sup> demonstrated its effectiveness as a tool for assessing the disease burden and risk of oral function loss in older adults [8].

Recent studies indicate that deficits in oral functions, such as chewing and swallowing, are risk factors for physical frailty, sarcopenia, cognitive impairment, and a diminished quality of life [9-11], which have also been associated with increased mortality [12]. This decline in oral functionality serves as a crucial indicator of an individual's overall well-being. Therefore, identifying and treating individuals with oral hypofunction is essential, given the far-reaching implications that reduced oral function can have on quality of life and long-term health outcomes [13]. In Chile, older adults suffer from poor oral health, marked by high prevalence of caries, periodontitis, and tooth loss [14, 15], all of which can compromise oral function. This study aimed to determine the consistency between the dependency levels assessed in EMPAM<sup>\*</sup> and the oral functionality levels evaluated in the EDePAM<sup>+</sup>.

## **2. Materials and Methods**

A cross-sectional analysis was conducted on individuals aged  $\geq 60$  years who underwent the EFAM<sup>#</sup> as part of the FONDEF ID22I10101 research project. The study took place in Primary Health Care (PHC) centers located in Cerro Navia (Santiago-Chile), Ñuñoa (Santiago-Chile), Recoleta (Santiago-Chile), and Los Vilos (Coquimbo-Chile) between 2022 and 2024. Clinical records provided data on EMPAM<sup>\*</sup> dependency levels, while oral functionality was evaluated through assessments of masticatory function, occlusal strength, tongue-lip motor function, and swallowing ability, all part of the EDePAM<sup>+</sup> [7].

### **2.1 Determination of Oral Functionality**

Masticatory function is a comprehensive concept encompassing various terms, including masticatory ability and performance [16]. For the subjective evaluation of chewing, the Leake index [17] was utilized, which assesses the patient's perception of difficulty when chewing five types of food (salad, fresh carrot, meat, legumes or vegetables, and uncut apple). A patient experiencing difficulty with at least one food was placed in the "reduced chewing function" category according to the Leake index. Subsequently, the location of occlusal contacts was evaluated using the Eichner index [18]. This index assesses posterior occlusal contact areas at maximum intercuspation, including the premolar and molar regions, with each area counted as one zone, resulting in a total of four occlusal support zones (OSZs) [19]. In category A, patients have 4 OSZs, in category B, 1-3 OSZs, and in category C, no OSZs. Masticatory function is considered normal if the patient has an

Eichner index of A, B, or C without chewing difficulty, and reduced when the Eichner index is B or C along with chewing difficulty.

Occlusal strength is deemed reduced when fewer than 20 natural teeth are present, excluding third molars and teeth with grade 3 mobility [20].

Tongue-lip motor function (oral diadochokinesis) was evaluated by asking patients to repeatedly pronounce the syllables /pa/, /ta/, and /ka/ for five seconds. A rate of less than six syllables per second was considered reduced [20].

Swallowing function was assessed using the repetitive saliva swallowing test, where the patient was instructed to swallow saliva repeatedly for 30 seconds. Fewer than three swallows in 30 seconds was considered indicative of reduced swallowing function [20].

Any participant categorized as “reduced” in at least three of these four oral assessments was assigned an overall score of “oral hypofunction” [20].

## **2.2 Statistical Analysis**

A descriptive analysis of the data was conducted based on sex, age, educational level, EMPAM\* functional assessment, and the components of the oral function assessment. For quantitative variables, the mean  $\pm$  standard deviation was used as a measure of central tendency, while relative frequencies were employed for qualitative variables.

The bivariate analysis was performed using Fisher's exact test. The differences in the frequencies of masticatory function, occlusal function, tongue-lip motor function, swallowing function, and oral hypofunction were analyzed according to sex, age, educational level, and EMPAM\* functional assessment.

The agreement between oral functionality as assessed by EDePAM+ and overall functionality as determined by EMPAM\* (non-risk independent) was evaluated using the Kappa coefficient.

Statistical significance was set at  $p < 0.05$ , with a 95% confidence interval. All analyses were performed using STATA version 16.

## **2.3 Ethics Statement**

The study was explained to all patients. After gaining an understanding, they voluntarily proceeded to sign the informed consent form. The confidentiality of the data was maintained by coding the names of the individuals. The protocol was approved by the Ethics Committee of the Servicio de Salud Metropolitano Norte (049/2022).

## **3. Results**

The sample comprised 83 older individuals, with 66% being women. The mean age was  $71.3 \pm 5.3$  years (median: 72 years; range: 62-85 years). Additionally, 47.6% of the participants had  $\leq 8$  years of formal education. According to the EMPAM\* assessment, 83% were classified as non-risk independent, while 17% were categorized as independent at risk or dependent (Table 1).

**Table 1** Reduction of oral assessments according to sex, age, educational level, functionality determined by EMPAM\*.

| Variable                         |                                 | Frequency (%) | Reduced Masticatory Function |         | Reduced Occlusal Strength |               | Reduced Tongue-Lip Motor Function |               | Reduced Swallowing Function |               |
|----------------------------------|---------------------------------|---------------|------------------------------|---------|---------------------------|---------------|-----------------------------------|---------------|-----------------------------|---------------|
|                                  |                                 |               | Frequency (%)                | p-value | Frequency (%)             | p-value       | Frequency (%)                     | p-value       | Frequency (%)               | p-value       |
| Gender                           | Female                          | 66.27%        | 81.82%                       | 0.2930  | 90.91%                    | 0.5470        | 67.27%                            | 0.5800        | 60.00%                      | 0.2620        |
|                                  | Male                            | 33.73%        | 89.29%                       |         | 89.29%                    |               | 67.86%                            |               | 50.00%                      |               |
| Age                              | <72 years-old                   | 48.19%        | 85.00%                       | 0.5570  | 82.50%                    | <b>0.0220</b> | 60.00%                            | 0.1220        | 58.33%                      | 0.3050        |
|                                  | ≥72 years-old                   | 51.81%        | 83.72%                       |         | 97.67%*                   |               | 74.42%                            |               | 52.50%                      |               |
| Educational level                | ≤8 years                        | 47.56%        | 89.74%                       | 0.2260  | 97.44%                    | 0.0710        | 79.49%*                           | <b>0.0200</b> | 69.23%*                     | <b>0.0310</b> |
|                                  | ≥9 years                        | 52.44%        | 81.40%                       |         | 86.05%                    |               | 55.81%                            |               | 46.51%                      |               |
| Functionality according to EMPAM | Non-risk independent            | 83.13%        | 84.06%                       | 0.6200  | 88.41%                    | 0.2120        | 69.57%                            | 0.2720        | 56.52%                      | 0.6030        |
|                                  | Independet at risk of dependent | 16.87%        | 85.71%                       |         | 100.00%                   |               | 57.14%                            |               | 57.14%                      |               |
| TOTAL                            |                                 |               | 84.34%                       |         | 90.36%                    |               | 67.47%                            |               | 56.63%                      |               |

\*p < 0.05 (Fisher exact's test).

In the context of EDePAM<sup>+</sup>, 66.3% of the participants were identified as having oral hypofunction (Table 2). Specifically, 84.3% exhibited a reduction in masticatory function, 90.4% showed a decrease in occlusal strength, 67.5% had reduced tongue-lip motor function, and 56.6% demonstrated a decline in swallowing function (Table 1).

**Table 2** Oral hypofunction according to sex, age, educational level, functionality determined by EMPAM\*.

| Variable                         |                                  | Oral Hypofunction |               |
|----------------------------------|----------------------------------|-------------------|---------------|
|                                  |                                  | Frequency (%)     | p-value       |
| Gender                           | Female                           | 63.60%            | 0.3240        |
|                                  | Male                             | 71.40%            |               |
| Age                              | <72 years-old                    | 55.0%             | <b>0.0310</b> |
|                                  | ≥72 years-old                    | 76.7%*            |               |
| Educational level                | ≤8 years                         | 82.1%*            | <b>0.0050</b> |
|                                  | ≥9 years                         | 53.50%            |               |
| Functionality according to EMPAM | Non-risk independent             | 66.70%            | 0.5460        |
|                                  | Independent at risk of dependent | 64.30%            |               |
| TOTAL                            |                                  | 66.30%            |               |

\*p < 0.05 (Fisher exact's test).

Among individuals aged ≥72 years, there was a significantly higher frequency of reduced occlusal strength and oral hypofunction ( $p < 0.05$ ). In individuals with ≤8 years of education, oral hypofunction, reduced tongue-lip motor function, and diminished swallowing function were more commonly observed compared to those with >9 years of schooling ( $p < 0.05$ ) (Table 1 and Table 2).

The correlation between the diagnosis of oral hypofunction and independent at risk or dependent was 37.4% (kappa index = -0.0174).

#### 4. Discussion

This study highlights several critical aspects of functionality in older adults, particularly the high prevalence of oral hypofunction, which affects 66.27% of the sample. Aging and lower educational levels were identified as the most significant factors, both of which showed statistically significant associations. Furthermore, the findings reveal a lack of alignment between the functionality levels determined by EMPAM\* and EDePAM<sup>+</sup>, as indicated by a negative kappa index. This means that individuals who are at potential risk of sarcopenia and frailty, and therefore of losing their independence due to oral hypofunction, are classified as non-risk independent in the medical examination. This prevents them from receiving the necessary interventions to restore oral functionality, and consequently reduces the impact of oral hypofunction on their overall health. This discrepancy highlights the complexity of accurately measuring functional capabilities in the older population and underscores the need for comprehensive, multi-dimensional evaluation approaches. Our results highlight the importance of incorporating an oral function assessment into the EMPAM\*.

#### **4.1 Determination of Oral Functionality and Its Impact on General Health**

Oral functionality refers to the ability of the stomatognathic system to perform essential functions, crucial for both oral and overall health. This complex system, composed of interconnected structures, facilitates various physiological and biomechanical processes, including mastication, swallowing, phonation, respiration, and even facial expression. Oral functionality is influenced by multiple factors, all of which must be considered to fully understand its role and implications for general health [21-23].

On the other hand, evaluating oral function is fundamental, especially since the ability to eat and ingest food becomes increasingly important in older adults with sarcopenia, who may enter a cycle of frailty that can ultimately lead to loss of independence. In this context, the concept of oral hypofunction is particularly relevant, as it represents a state where, with appropriate dental treatment, functionality can be restored before oral dysfunction fully manifests [21]. Oral functionality can be assessed through seven clinical signs: poor oral hygiene, oral dryness, reduced occlusal force, diminished tongue-lip motor function, decreased tongue pressure, reduced masticatory function, and impaired swallowing function [21].

Masticatory function involves the proper interaction between the remaining teeth and the masticatory muscles to perform the essential food grinding process, which also stimulates cerebral sensory pathways, potentially preventing cognitive decline and degenerative diseases [16, 19, 22].

Occlusal strength is a critical indicator of the functionality of masticatory muscles and remaining teeth. Reduced occlusal strength, which is common among older adults, can impair masticatory ability, negatively affecting nutrition and potentially contributing to the development of sarcopenia [9, 10, 21, 24]. Tooth loss, especially the loss of posterior teeth, adversely impacts oral health, reducing masticatory capacity, which can diminish the cognitive-sensory feedback loops essential for maintaining optimal brain function [20, 22, 25]. Studies have shown that declines in masticatory function, occlusal strength, and the number of remaining teeth are directly linked to poorer oral function and general health, increasing the risk of systemic diseases and triggering geriatric syndromes [21, 23, 26].

Decreased tongue-lip motor function refers to a reduction in speed and dexterity, resulting from diminished brain function and weakening of the perioral muscles due to systemic diseases and aging. It has been observed that tongue-lip motor function declines as frailty progresses [27].

Impaired swallowing function is characterized by a reduction in the ability to swallow and consume food [28], which can further exacerbate the challenge of obtaining proper nourishment, potentially limiting an individual's ability to effectively intake and digest the necessary nutrients for maintaining overall health and well-being.

#### **4.2 Factors Impacting Oral Functionality**

Oral function is known to be influenced by several factors, including age, sex, and educational level [20, 27]. Evidence suggests that women experience a greater deterioration in oral function than men, particularly as they age. This is reflected in higher rates of edentulism among women (7.1%) than men (2.8%), as well as a lower number of remaining teeth in women, leading to a higher prevalence of denture use. This disparity becomes more pronounced with age [15, 26]. However, in this study, no significant differences were found between men and women.

As individuals age, physiological changes occur that negatively affect chewing ability, mainly due to tooth loss and reduced occlusal and masticatory strength, resulting in oral hypofunction. This condition, characterized by dry mouth, diminished occlusal strength, decreased tongue-lip motor function, and impaired swallowing and chewing, is more common in older adults [21]. In Chile, more than 40% of the population experiences difficulties chewing hard foods [15]. In line with this, our study found a higher prevalence of reduced occlusal strength and oral hypofunction among older people, which mirrors the national situation, where they exhibit a higher prevalence of non-functional dentition (77.5%) and denture use (65.8%) [15].

A low educational level has been directly linked to poorer oral function, as it often correlates with limited access to dental care and oral health education, leading to poor oral hygiene and an increased risk of oral diseases. Individuals with lower educational attainment (<8 years) are at higher risk of not having functional dentition than those with higher educational levels (≥8 years: 56.8% vs. 27.3%). Moreover, people with <8 years of schooling typically have fewer remaining teeth than those with >12 years of education, with a median of only 9 teeth versus 27 teeth, respectively. They also exhibit higher rates of caries and clinical attachment loss [14, 26]. In this study, we observed a higher prevalence of reduced tongue-lip motor function, impaired swallowing function, and oral hypofunction in individuals with ≤8 years of schooling.

#### **4.3 Strengths**

The study's comprehensive approach to evaluating oral functionality is a notable strength. By considering aspects such as masticatory function, occlusal strength, tongue-lip motor function, and swallowing ability, we have provided evidence of the need for a more holistic understanding of older people's overall functionality and the impact of oral function on it. Such knowledge can inform the development of more targeted and effective public health interventions, ultimately enhancing the quality of life for older adults.

#### **4.4 Limitations**

The limitations of this study should be carefully considered when interpreting the findings. The sample size of 83 participants restricts the generalizability of the results, as the sample may not accurately represent the broader population. Moreover, the sample has an overrepresentation of women. Additionally, the cross-sectional design of the study prevents the establishment of causal relationships between the analyzed factors. To address these limitations, future studies should employ larger, more representative samples and utilize longitudinal designs. This would allow for a more thorough exploration of the hypotheses and a deeper understanding of the underlying mechanisms at play.

### **5. Conclusions**

Our findings indicate that the current EMPAM\* framework may be missing critical health indicators that can be identified through oral health evaluations. The lack of correlation between EMPAM\* and EDePAM+ outcomes highlights this gap, suggesting that incorporating an oral health component could significantly enhance the assessment's accuracy. By doing so, EMPAM\* could

provide a more holistic and reliable tool for the early detection of functional decline and dependency risks in older adults, ultimately improving preventive strategies in aging populations.

## Abbreviations

- <sup>+</sup>EDePAM Preventive Dental Examination for Older Adults
- <sup>#</sup>EFAM Functional Evaluation of Older
- <sup>\*</sup>EMPAM Annual Preventive Medical Examination for Older Adults

## Author Contributions

Alicia Morales: Conceptualization, Methodology, Formal Analysis, Writing - original draft, review and editing. Vania Cataldo and Diego Berrios: Writing - original draft; Ana Beatriz and Karen Danke: Methodology, Data Collection. Gisela Jara, Fabiola Werlinger, Mauricio Baeza and Viviana García: Conceptualization, Methodology and Writing - original draft, review and editing. Jorge Gamonal: Conceptualization, Formal Analysis, Writing - review and editing. All authors have read and approved the published version of the manuscript.

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## Competing Interests

The authors have declared that no competing interests exist.

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