






# Oral function and nutritional status in non-acute hospitalised elders

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## Funding information

Open access funding provided by Universite de Geneve

## Abstract

**Introduction:** Malnutrition and risk of malnutrition continues to be a common finding in elders, yet its association with oral function in hospitalised patients remains unclear.

**Material and methods:** Patients aged 70 years or over who had been hospitalised for non-acute rehabilitation were recruited. Nutritional risk was screened using the Mini-Nutritional Assessment Short Form (MNA-SF) and Nutritional Risk Screening (NRS) scores. Malnutrition was assessed according to the Global Leadership Initiative on Malnutrition (GLIM) criteria. All participants underwent the oral hypofunction test battery, evaluating oral hygiene, oral dryness, occlusal force, tongue-lip motor function, tongue pressure, masticatory and swallowing function. Statistical analyses comprised Mann-Whitney or Kruskal-Wallis tests. Bivariate associations between categorical variables were tested using the Pearson chi-square test; for continuous variables, the Spearman correlation was calculated. A *P*-value < .05 was considered statistically significant.

**Results:** Sixty patients aged a mean  $82.5 \pm 7.0$  years participated. Some 88.3% were diagnosed with oral hypofunction, and this was more common in older patients (*P* = .020). Analysing the 7 oral hypofunction tests as an interval variable (NiOF) revealed additional correlations with number of teeth ( $\rho = 0.477$ ) as well as the nutritional risk, evaluated by the MNA-SF ( $\rho = -0.284$ ) and NRS ( $\rho = 0.317$ ) scores. NiOF scores were higher among denture wearers (*P* = .003). GLIM did not confirm the correlation with NiOF. Biomarkers such as serum albumin and CRP were not associated with the NiOF score.

**Conclusion:** In this sample, the association between oral function and nutritional state is more obvious in nutritional risk scores than in the malnutrition diagnosis by GLIM.

## KEYWORDS

ageing, GLIM, malnutrition, MNA-SF, nutrition, older adults, oral function, oral hypofunction

## 1 | INTRODUCTION

Malnutrition is defined as a deficiency, excess or imbalance of a wide range of nutrients, resulting in measurable adverse effects on body composition, function and clinical outcomes.<sup>1</sup> Malnutrition is highly prevalent among old persons, and being “at nutritional risk” is even more frequent.<sup>2-5</sup> A recent systematic review and meta-analysis reported a pooled prevalence for malnutrition of 28.0% for hospitalised, 17.5% for residential care and 8.5% among community dwelling elders.<sup>6</sup> Higher prevalence rates were reported in adults aged >80 year, in women and in patients with one or multiple comorbidities.<sup>6</sup> Hence, a particular risk of malnutrition exists for persons who are either hospitalised or live in institutions.

Although malnutrition is a global concern associated with incremental morbidity, mortality and cost for health care,<sup>7</sup> there has been a fundamental lack of consensus on diagnostic criteria for application in clinical settings. Recently, the Global Leadership Initiative on Malnutrition (GLIM), which involves experts in clinical nutrition from all over the world, established a global consensus for diagnosing and assessing malnutrition in adults.<sup>8</sup> They suggested a two-step process, starting with screening for malnutrition, then assessment for diagnosis and, finally, grading the severity of malnutrition. Tools to screen for nutritional risk include the Mini-Nutritional Assessment Short Form (MNA-SF)<sup>9</sup> and Nutrition Risk Screening (NRS-2002).<sup>10</sup>

In 2018, the Japanese Society of Gerodontology published a position paper aiming to standardise the examination of oral disorders related to age.<sup>11</sup> They defined “oral hypofunction” as being located at the third level of the four stages of oral function: (1) decreased oral health literacy; (2) small problems in the mouth; (3) deterioration of oral function; and (4) oral disorders. The different stages are defined according to the seven clinical parameters of oral hygiene, oral dryness, occlusal force, tongue-lip motor function, tongue pressure, chewing function and swallowing function. Oral hypofunction is defined as a state when 3 or more of these signs are present. In a study of oral frailty was found to be a potential risk factor for physical frailty, sarcopenia and subsequent requirement for long-term care.<sup>12</sup>

Promoting oral health and timely treatment of impaired oral function may be effective in preventing adverse health outcomes such as malnutrition. Prevention of oral hypofunction may even be an important part of healthy ageing. It has been reported that nutritional status and oral function influence each other in a vicious cycle.<sup>13</sup> Neurological disorders induce poor masticatory efficiency, frequently associated with lower BMI and serum albumin concentrations.<sup>14</sup> Following tooth loss, the comminution and preparation of a food bolus may be impaired, which in turn increases the risk of aspiration into the airways.<sup>15</sup> The loss of masticatory efficiency may change food selection towards decreased consumption of vegetables, fruits, proteins, minerals and vitamins,<sup>16</sup> with this remaining unnoticed by the patient.<sup>17</sup> Although there have been many reports on the relationship between oral health and nutritional state, most have been limited to self-reported nutritional intake or have examined the association between the dental state and/or the presence of a removable prostheses, limiting the analysis to purely anatomical

criteria. Only recently have studies investigated oral functional parameters and food choice.<sup>18,19</sup> Nutritional intake in non-acute hospitalised elders is largely monitored by the institution, and nutritional supplements are prescribed where indicated. Hence, it seems particularly interesting to investigate the association between oral function and malnutrition in a functionally impaired population with limited food choice. Greater dependency was reported as an important risk for malnutrition.<sup>4</sup>

This study investigated the association between a poor oral functional status in non-acute hospitalised elders and their nutritional status. The hypothesis was that there is an association between the nutritional risk defined by MNA-SF and NRS scores, and with malnutrition confirmed by the GLIM criteria.

## 2 | MATERIAL AND METHODS

Approval from the local ethical committee (CCER) for research on humans was obtained (#2019-01338). Patients were recruited in the department of rehabilitation and long-term care of the University Hospital of Geneva (HUG).

The inclusion criteria were the following: age of 70 years or over; ability to follow simple instructions and understand the French language; willingness to participate in the study; and signed informed consent. Patients were excluded if they had conditions affecting oral intake such as tube feeding, poorly-controlled diabetes, gastrointestinal symptoms (such as nausea, vomiting, diarrhoea and constipation) or antimicrobial treatment during the month prior to the examination.

### 2.1 | Protocol

After screening and obtaining informed consent, participants' characteristics were extracted from the medical records and noted on the clinical record form. The findings of the MNA-SF, the NRS-2002 and the body mass index (BMI) were also retrieved from the medical records, as was the inflammatory state, measured by plasma levels of C-reactive protein and plasma albumin. The fat-free mass index (FFMI) was assessed by electric bioimpedance (BIA) using four electrodes placed on the dorsal surface of the right wrist, hand, ankle and foot.<sup>20</sup> An AC current (800 mA; 50 kHz) is applied through the BIA device (Nutriguard®, DataInput), and the device records the resistance and reactance. The fat-free mass is calculated according to the Geneva formula,<sup>21</sup> developed and validated against dual-energy X-ray absorptiometry for older people in the Geneva area.<sup>22</sup> The fat-free mass divided by height squared ( $m^2$ ) calculates the FFMI. If any of the information was not available in the medical chart, the dietician conducted the nutritional assessments, evaluated the FFMI (SA) and asked the medical staff to take blood samples for the biomarkers. The dietician also inquired about recent food intake and whether there was any specific prescribed diet (normal, mixed and mashed).

Assessments of oral function were mostly conducted in one visit; they were divided into two sessions a few days apart, when participants expressed fatigue or discomfort during the examinations. A comprehensive oral examination was conducted in the patients' room by two investigators (MO and YI), who examined the dental status and measured clinical signs/symptoms indicating oral hypofunction according to the oral hypofunction test battery, as described by Minakuchi et al in 2018.<sup>11</sup>

## 2.2 | Oral hypofunction

The oral hypofunction test battery comprised the following tests (Table 1). The findings of the seven following mentioned measurements are summed to give the "number of impaired oral functions" (NiOF). The score ranges from 0 (healthy oral function) to 7 (highest number of impaired oral functions). When three or more of the seven criteria are fulfilled, the patient is diagnosed with "oral hypofunction."

### 2.2.1 | Oral hygiene

The number of microorganisms on the tongue dorsum is measured by rubbing a cotton swab on the central area of the tongue dorsum using a bacterial counter (PHC Co., Ltd). When the total number of microorganisms is  $\geq 3.162 \times 10^6$  (CFU/mL), the "poor oral hygiene" criterion is fulfilled.<sup>23</sup>

### 2.2.2 | Oral dryness

The wetness of the mucosa is measured with an oral moisture checker Mucus which is positioned on the in the central area of the tongue dorsum (Life Co., Ltd.). The measurement is repeated thrice, and the median of the three readings is adopted for analysis. When the measured oral dryness score is below 27.0, it is classified as "oral dryness."<sup>24</sup>

TABLE 1 Oral hypofunction test battery<sup>11</sup>

Oral function	Outcome	Measuring devices	Threshold
Oral hygiene	Number of bacteria	Bacterial counter (PHC Co., Ltd.)	$\geq 3.162 \times 10^6$ CFU/mL
Oral dryness	Mucosal wetness on tongue dorsum	Oral moisture checker (Mucus, Life Co., Ltd.)	<27.0
Occlusal force	Occlusal force of the whole dentition	Pressure indicating film (Dental Prescale II, GC Corporation)	<500 N
Tongue-lip motor function	Measure the motor speed and dexterity as oral diadochokinesis	Automatic counter (Kenkokun Handy, Takei Scientific Instruments Co., Ltd.)	<6 times per second
Tongue pressure	Maximum tongue pressure	Tongue pressure measuring instrument (JMS TPM-01, JMS Co., Ltd.)	<30 kPa
Masticatory function	Measure the glucose concentration obtained from chewed gummy jelly	Masticatory ability testing system (Glucosensor GS-II, GC Corporation)	<100 mg/dL
Swallowing function	Self-administered questionnaire	10-item Eating Assessment Tool [EAT-10]	score of EAT-10 $\geq 3$

### 2.2.3 | Occlusal force measurement

Occlusal force is measured by clenching for 3 seconds in habitual occlusion using a thin indicator sheet covering the entire dentition (Dental Prescale II, GC Corporation). The analysis of the cumulative occlusal forces is calculated electronically. When the occlusal force is lower than 500 N, it is determined to be "poor occlusal force."<sup>25</sup>

### 2.2.4 | Tongue-lip motor function

Tongue-lip motor function is evaluated by the motor speed and dexterity as oral diadochokinesis. Here, the score represents the number of times the participant is able to repeat each of the syllables /pa/, /ta/ and /ka/ in 5 seconds using an automatic counter (Kenkokun Handy, Takei Scientific Instruments Co., Ltd.). When the number of any of /pa/, /ta/ or /ka/ produced per second is less than six, it was classified as "poor tongue-lip motor function."<sup>26</sup>

### 2.2.5 | Tongue pressure

Maximum tongue pressure is assessed by means of the JMS tongue pressure measuring instrument (TPM-01, JMS Co., Ltd.). Here, the patient is asked to compress the balloon of the device between tongue and anterior palate using the maximum voluntary force of the tongue. When the maximum tongue pressure is less than 30 kPa, it is considered to be "impaired tongue pressure."<sup>27</sup>

### 2.2.6 | Masticatory function

Masticatory function is assessed by the glucose concentration obtained from a chewing gummy jelly. The patient is asked to chew 2 g of gummy jelly for 20 seconds. From the retrieved specimen, the amount of eluted glucose is then measured using a masticatory ability measurement device (Glucosensor GS-II,

GC Corporation). When the glucose concentration is lower than 100 mg/dL, the patient is diagnosed with "poor masticatory function."<sup>28</sup>

### 2.2.7 | Swallowing function

A self-administered questionnaire, the 10-item Eating Assessment Tool (EAT-10, Nestlé), is used to determine swallowing function. When the score of EAT-10 is three or higher, the patient is considered to have a "poor swallowing function."<sup>29</sup>

## 2.3 | Nutritional status

The MNA-SF<sup>9</sup> and NRS-2002<sup>10</sup> were used for screening the risk of malnutrition. For the MNA-SF, 12-14 points are considered "normal nutritional status"; scores between 8 and 11 represent a "risk of malnutrition," whereas scores of 7 or below represent "malnutrition." For the NRS-2002, scores range from 0 to 3 for mild, moderate or severe for impaired nutritional state and severity of disease respectively. For persons aged over 70 years, 1 was added to the total score.<sup>30</sup> Since all participants in the present study were aged over 70 years, the scores ranged from 0 to 7. Scores  $\geq 3$  were considered to represent people who were "at risk" for malnutrition.

The GLIM considers both (a) phenotypic ( $>5\%$  weight loss within the previous 6 months or  $>10\%$  weight loss in more than 6 months, BMI  $< 22$  kg/m<sup>2</sup> if age  $>70$  years, FFMI  $<17$  kg/m<sup>2</sup> in men and  $<15$  kg/m<sup>2</sup> in women) and (b) aetiologic criteria (reduced food intake and level of inflammation with CRP  $>10$  mg/L). Participants were classified as malnourished when at least 1 phenotypic criterion and 1 aetiologic criterion were met. The severity of the malnutrition is based on the phenotypic criteria in a stage 1 "moderate malnutrition" and stage 2 "severe malnutrition." The criteria are detailed in Cederholm et al.<sup>8</sup>

## 2.4 | Statistical analysis

The sample size was calculated using the program G\*Power 3.1.9.2 (Institute of Experimental Psychology, Heinrich Heine University)<sup>31</sup> based on an association between oral function and nutritional state<sup>32</sup> using the calculated effect size  $d = 0.50$  (medium size effect). The calculated sample size was  $n = 54$ , but, to account for possible drop-outs, the sample size was set at 60.

Continuous variables were submitted to a normality test (Kolmogorov-Smirnov) with  $P < .05$  except for age. Bivariate correlations were evaluated with the Spearman Rho coefficient. Differences between groups were tested using non-parametric Mann-Whitney or Kruskal-Wallis tests.  $P$ -values  $< .05$  were considered statistically significant.

## 3 | RESULTS

### 3.1 | Demographic characteristics of the patient sample

A total of 249 patients were screened by (RS) as fitting the inclusion and exclusion criteria; 236 of those were selected, and 66 (28%) gave consent to participate in the study. Six patients did not complete the entire assessment, for fatigue or being discharged from the hospital before it took place. Finally, 60 patients completed the entire assessment between October 2019 and July 2020 and were included into the present analysis (Figure 1).

The patient characteristics are summarised in Table 2. Their age ranged between 70 and 96 years old with a median age of 82 (IQR 11.0). Five per cent of the participants were living in a nursing home, and the remainder were living independently. Around 50% had been hospitalised for falls, fractures or weakness. The participants were suffering from up to 5 different diseases and were prescribed up to 14 medications per day.

### 3.2 | Dental status

Fourteen per cent of the participants were edentulous, 36% had fewer than 20 teeth, and 51% had more than that. Only 5% had received implants, while 65% did not wear dentures. Only 3 participants needed help with their oral hygiene.

### 3.3 | Nutritional status

The median BMI of the participants was 23.8 (IQR 8.0), with a minimum at 16.1 and a maximum at 55.4. Twelve patients (20%) had lost at least 5% of their weight in the last 6 months; in 10 further patients (17%), the loss was more than 10% of their initial weight. The participants' mean FFMI was 17.4 (SD 2.6; Table 3).

Nutritional supplements had been provided to 40% of patients, and diet counselling had been organised for 55% of the sample. Thirteen of the participants (22%) were on a mixed diet, which means that their food is chopped up in a blender to facilitate chewing and swallowing.

### 3.4 | Diagnosis of nutritional risk

The MNA-SF median value of this sample was 10.0 (IQR 4.0), ranging from 2.5 to 14.0, the maximum score. According to the MNA-SF, 30 participants (50%) were at nutritional risk, while another 18% had malnutrition.

The NRS had a median score of 2.0 (IQR 2.0). Almost half (48%) were at nutritional risk (NRS  $\geq 3$ ) and thereby should have a nutritional care plan set up.

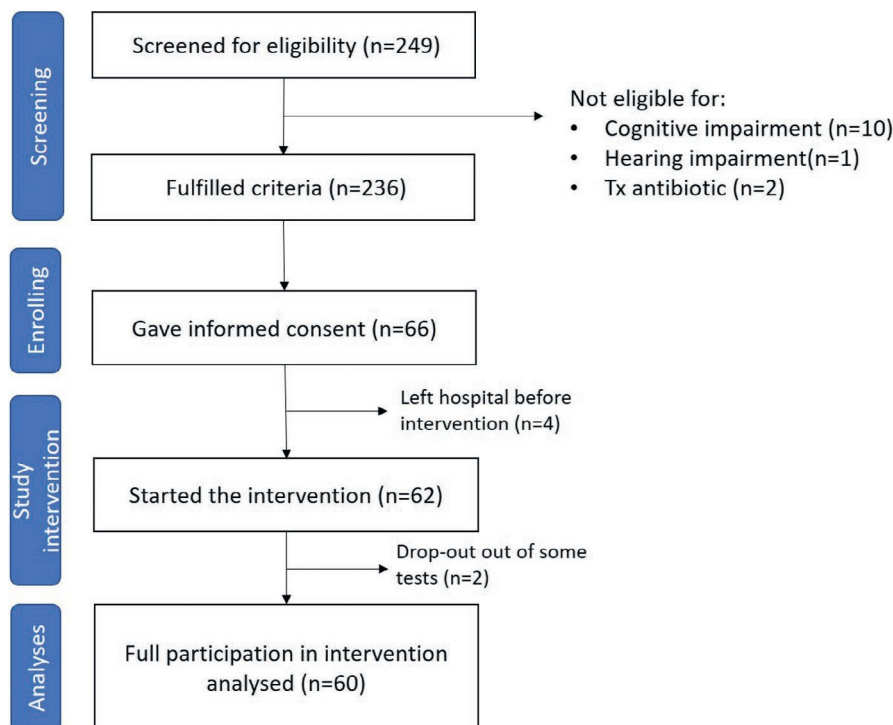


FIGURE 1 Flow chart for patient participation from screening to analysis

TABLE 2 Summary data on patient characteristics

Gender % (n)	
Male	36.7 (22)
Female	63.3 (38)
Age in years, median (IQR)	82 (11.0)
Higher education % (n)	53.0 (32)
The reason for hospitalisation, % (n)	
Waiting for LTC placement	25.0 (15)
Fracture	31.7 (19)
Physical rehabilitation due to weakness	13.3 (8)
Poor physical condition	5.0 (3)
Heart disease	6.7 (4)
Lower back pain	5.0 (3)
Cognitive impairment	1.7 (1)
Other	11.7 (7)
Number of diagnosed diseases, median (IQR)	2 (2.0)
Number of medication/d, median (IQR)	6 (3.0)
Dental state % (n)	
Edentulous	13.3 (8)
Less than 20 natural teeth	38.3 (23)
More than 20 natural teeth	48.3 (29)
Oral Hypofunction % (n)	88.3 (50)
NiOF median (IQR)	4.5 (3.0)

### 3.5 | Diagnosis of malnutrition

According to the GLIM criteria, 32 patients (53%) were nutritionally healthy, 11 (18%) were diagnosed a moderate malnutrition of stage 1

and 17 (28%) a severe malnutrition of stage 2 (Table 3). The participants' mean FFMI was 17.4 (SD 2.6).

### 3.6 | Biomarkers

The level of serum albumin and CRP is listed in Table 3. For albumin, 24% the participants presented a level <3.5 mg/dL; and 52% had a CRP level below 10 mg/dL.

Neither albumin nor CRP were associated with the oral hypofunction diagnosis, or with the NiOF.

### 3.7 | Oral Hypofunction and Number of impaired Oral Functions (NiOF)

Fifty-three patients (88%) were diagnosed with oral hypofunction (NiOF  $\geq 3$ ). For this diagnosis, there was no correlation with any of the variables except for being older ( $P = .020$ ). The rate of positive and negative diagnoses per test oral function is displayed in Figure 2.

When considering the NiOF as an interval variable from 0 to 7, its median was 4.5 (IQR 3.0; Table 2). Half of the scores were 4 or below, whereas the other half was 5 or higher (Table 4). NiOF correlated with age ( $\rho = 0.304$ ) and the number of teeth ( $\rho = -0.477$ ). NiOF further correlated with the nutritional risk as evaluated by MNA-SF ( $\rho = -0.284$ ), and NRS ( $\rho = 0.317$ ) scores. When analysing MNA-SF as 3 categories (scores 0-7, 8-11, 12-14) and NRS as 2 categories (0-2, 3-7), there was a tendency, but no significant difference. NiOF was also not significantly different for GLIM considered as yes/no diagnosis, or when taking into consideration the stages 1 and 2.

This latter was true when taking into consideration the entire sample or only those patients who were pre-screened at nutritional risk by MNA-SF and NRS combined, as well as MNA-SF or NRS individually. MNA-SF screened 41 patients positive (MNA sf lower than 12), of which 26 were confirmed by GLIM. NRS screened 29 participants with a risk for malnutrition, and this diagnosis was confirmed for 25 patients by GLIM.

**TABLE 3** Summary data on patients' nutritional risk and malnutrition state

FFMI, median (IQR)	17.4 (2.7)
BMI, median (IQR)	23.8 (8.0)
BMI <18.5, n (%)	4 (6.7)
Weight loss n (%)	
At least 5% of their weight	12 (20.4)
More than to 10% of their initial weight	10 (16.7)
MNA-SF, median (IQR)	10 (4.0)
Malnutrition n (%)	11 (18.3)
Risk of malnutrition n (%)	30 (50.0)
NRS median (IQR)	2.0 (2.0)
NRS n (%)	
NRS ≥ 3	29 (48.3)
GLIM n (%)	
No malnutrition	32 (53.3)
Moderate malnutrition	11 (18.3)
Severe malnutrition	17 (28.3)
CRP (mg/L), median (IQR)	9.6 (25.9)
CRP <10 mg/L, n (%)	31 (51.7)
Albumin mg/dL, median (IQR)	36.0 (6.0)
Albumin <3.5 mg/dL, n (%)	14 (23.7)

Abbreviations: BMI, body mass index; FFMI, fat-free mass index; GLIM, Global Leadership Initiative on Malnutrition; MNA-SF, Mini-Nutritional Assessment Short Form; NRS, Nutritional Risk Screening.

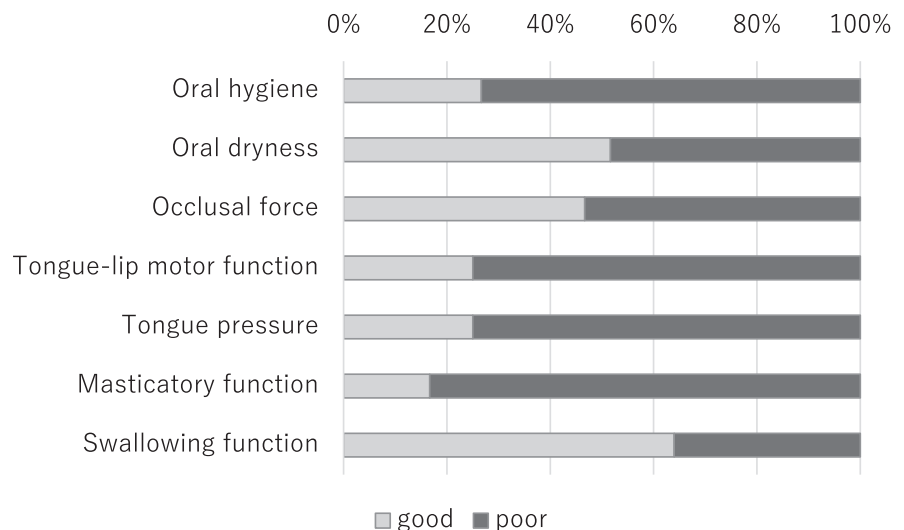
NiOF was not significantly different between men and women, or by education level. It was similar for those who had been offered diet counselling vs those who did not. Similarly, participants receiving nutritional supplement and weight loss presented similar NiOF scores. However, higher NiOF scores were observed among denture wearers ( $P < .003$ ; [Figure 3](#)) and those eating a mixed diet ( $P < .001$ ).

## 4 | DISCUSSION

The present study assessed in 60 non-acute hospitalised patients aged 70 years or over the risk and the diagnosis of malnutrition and studied their association with oral function. The results indicated that a large percentage of the study participants were diagnosed with oral hypofunction and that the number of impaired oral functions correlated with the nutritional risk, as evaluated by MNA-SF and NRS. However, GLIM and biomarkers such as albumin and CRP were not associated with the NiOF.

When interpreting the findings, it should be born in mind that only 1 in 5 patients agreed to participate. This may be related to the patients' morbidity and fatigue, their busy rehabilitation schedule or simply a lack of interest, as there was no immediate reward for the patient other than helping science and a free dental examination. Accordingly, the current study should be considered to be a pilot study, and confirmation of the findings in a larger study is needed.

The concept of oral hypofunction takes into consideration a large variety of functions of the stomatognathic system. Traditionally, anatomical features like the number of natural teeth present, the number of occluding pairs of teeth or even wearing removable dentures were part of an oral examination and considered relevant for evaluating oral function and health. Previous authors have mentioned the importance of including functional parameter to an oral examination, as function seems more relevant to the well-being of the patient than just the presence of teeth.<sup>18</sup> Although the concept of oral hypofunction fully aligns with this philosophy, it has its shortcomings, when a cut-off value of 3 or more of the 7 tests is applied.



**FIGURE 2** Rate of positive and negative diagnoses per oral function

According to this cut-off, there was a very high prevalence of oral hypofunction (88.3%) in this study. Hence, the binary analysis may fall short of depicting the severity of the impairment. In our sample, 50% of participants scored 0 to 4 impaired functions, whereas the other 50% scored 5, 6 or 7 (Table 4). Consequently, a cut-off value of 5 or more may be more discriminative and add sensitivity to the test. The sample in this study consisted of patients who were hospitalised for rehabilitation or long-term care. Although only 5% of the participants was living permanently in a long-term care facility, the number of chronic diseases and the considerable intake of medications, and the fact of that they are hospitalised distinguished them from "healthy ageing" elders. Given the high prevalence of oral hypofunction in this study, a "correction factor" for the cut-off value would be adequate, as it is done for the NRS for patients aged over 70 years.<sup>30</sup> In the present study, we bypassed the potentially too low cut-off by analysing the NiOF as an interval variable. This allowed us confirming correlations with age and dental state and to furthermore identify correlations with the participant's nutritional risk as evaluated by MNA-SF and NRS. It is important to bear in mind that NiOF is the number of the 7 tests, that scored positive, but it does not take into consideration the severity of each individual impairment. A more differentiated diagnosis of oral function would be possible, when the

individual assessments would be analysed as continuous variables, rather than using a cut-off.

The dental state, as in number of teeth and the presence of removable prostheses, proved also related to the NiOF. Tooth loss affects most oral functions, in particular when related to mastication and swallowing.<sup>33</sup> Occlusal support is needed for triggering the swallowing reflex, and tooth loss has been associated with a higher prevalence of dysphagia.<sup>15</sup> The smaller total occlusal surface reduces the likelihood that food is being comminuted between an upper and a lower tooth, resulting in a lower chewing efficiency. Furthermore, the chewing muscles tend to atrophy, when underused along with tooth loss, which further limits the chewing performance and bite force.<sup>34,35</sup> Removable dentures add functional limits to the masticatory performance, especially when poorly fitting. Furthermore, chewing force creates pressure on the mucosa-born parts which may cause pain and dislodge the denture with wide mouth opening. Hence, the correlation of NiOF and dental state seems logical and well documented.

Both oral hypofunction and the NiOF indicated a correlation with age. Physiological ageing includes the gradual impairment of all motor functions, in particular when left untrained, and the oral sphere is not spared from this process. Consequently, all 7 domains of the oral hypofunction score are likely to deteriorate with age, which can be statistically confirmed by the findings from this study.

This study aimed to investigate the weight of oral functional impairment on the patient's nutritional status. As the MNA-SF and the NRS scores for the risk of malnutrition revealed a significant correlation with NiOF, the corresponding hypothesis can be confirmed for NiOF, but not for oral hypofunction. As discussed before, NiOF brings into light more differentiated information from the oral hypofunction test battery than just a binary analysis.

The hypothesis cannot be confirmed for the association of NiOF or the oral hypofunction and the diagnosis of malnutrition as evaluated by phenotypical and aetiologic criteria, as used in the GLIM index introduced in 2019 by Cederholm et al.<sup>8</sup> How could this

TABLE 4 Distribution of the number of impaired oral functions (NiOF)

NiOF	% patient
1	1.7
2	10.0
3	18.3
4	20.0
5	25.0
6	23.3
7	1.7

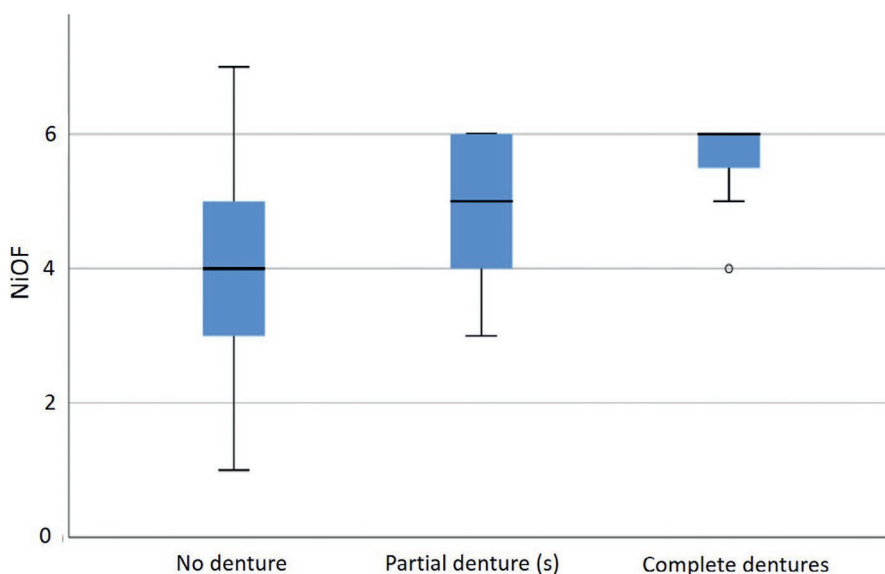


FIGURE 3 NiOFs in patients without denture, with 1 or 2 partial dentures or upper and lower complete dentures

difference be explained? Several of the investigated parameters used in MNA-SF and GLIM are identical (weight loss, BMI and reduced food intake). Differences occur with the MNA-SF evaluating motricity, acute disease, stress and neuropsychological problems, whereas GLIM includes body composition and inflammation. The latter may be less relevant to oral functions than reduced motricity, which has a direct effect on the masticatory performance and swallowing disorders.<sup>5</sup> Likewise for cognitive impairment and inflammation, both have a well-established detrimental effect on oral health.<sup>36</sup> Hence, the association between the nutritional state and NiOF comes into view more clearly when using MNA-SF scores than GLIM.

Body composition, as used in GLIM, may have also been more influenced than the neuro-muscular control, evaluated in MNA-SF, by the nutritional care plan and food supplements, administered in 40% of the study participants and the 55% who received nutritional counselling respectively. These interventions, as well as the limited food choice within the institution, might have also normalised the levels of serum albumin. Kyle and collaborators<sup>3</sup> stated in a multi-centre study that serum albumin and BMI underestimated the prevalence of malnutrition and that the body composition might be a more sensitive marker. More recently, Evans and co-workers<sup>37</sup> questioned the use of biomarkers for nutritional assessments and linked serum albumin levels rather to inflammatory state than malnutrition.

Future research might want to refine the oral hypofunction test battery and the corresponding analysis, as the recommended binary cut-off seems to fall short in evincing all facets of oral functional impairment, especially in frail elders. Further research should also investigate the effect of treating oral hypofunction on the nutritional state. However, for a large-scale population-wide oral hypofunction screening, simpler test methods, which may be administered by auxiliary health professionals or the patient's family, might be useful.

## 5 | CONCLUSION

A correlation between oral function and nutritional state seems more obvious when using screening tools like MNA-SF and NRS scores, rather than assessment tools including body composition (GLIM). Further research is needed to refine the oral hypofunction analysis, verify a causal relationship and investigate the effect of a treatment to rehabilitate oral function.

## ACKNOWLEDGEMENTS

The authors express their gratitude to the participants of the study, and the staff of the Loëx Hospital for their help in running the experiments. Open Access Funding provided by Universite de Geneve.

## CONFLICT OF INTEREST

The authors declare no conflict of interest. Funding of the salary of Yoshiki Imamura and Midori Ohta for 1.5 months was received from the GC Corporation. Otherwise, the study was entirely run with institutional funds of the University of Geneva.

## AUTHOR CONTRIBUTION

Midori Ohta involved in conception of study, acquisition of data, data entry, interpretation of results and drafting manuscript. Yoshiki Imamura involved in acquisition of data and finalising manuscript. Najla Chebib involved in conception of study, acquisition of data, interpretation of results and drafting manuscript. Regina Maria Schulte-Eickhoff involved in patient screening and acquisition of data. Sandrine Allain served as study nurse and involved in acquisition of nutritional data. Laurence Genthon Graf, Christophe Graf and Takayuki Ueda involved in conception of study, interpretation of results and finalising manuscript. Frauke Müller served as senior author and involved in conception of study, interpretation of results, draft and final version of manuscript.

## DATA AVAILABILITY STATEMENT

Data available on request from the authors.

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**How to cite this article:** Ohta M, Imamura Y, Chebib N, et al. Oral function and nutritional status in non-acute hospitalised elders. *Gerodontology*. 2022;39:74–82. doi:[10.1111/ger.12612](https://doi.org/10.1111/ger.12612)