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Towards an operational definition of oral frailty: A e-Delphi study

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HIGHLIGHTS

- This study establishes a consensus on an operational definition of oral frailty.
- An international expert panel assessed 55 potential components of oral frailty.
- Oral frailty constitutes mastication, swallowing, oral motor skill, and salivation.
- Based on these findings a revised method for assessing oral frailty is recommended.

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ABSTRACT

Objectives: Building upon our recently developed conceptual definition of oral frailty (the age-related functional decline of orofacial structures), this e-Delphi study aims to develop an operational definition of oral frailty by identifying its components.
Methods: We used a modified e-Delphi study to reach a consensus among international experts on the components of oral frailty. Twelve out of fifteen invited experts in the field of gerodontology participated. Experts responded to three rounds of an online 5-point scale questionnaire of components to be included or excluded from the operational definition of oral frailty. After each round, scores and rationales were shared with all experts, after which they could revise their position. A consensus was reached when at least 70% of the experts agreed on whether or not a component should be included in the operational definition of oral frailty.

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Results: The experts achieved a high level of agreement (80 – 100%) on including eight components of oral frailty and excluding nineteen. The operational definition of oral frailty should include the following components: 1) *difficulty eating hard or tough foods*, 2) *inability to chew all types of foods*, 3) *decreased ability to swallow solid foods*, 4) *decreased ability to swallow liquids*, 5) *overall poor swallowing function*, 6) *impaired tongue movement*, 7) *speech or phonatory disorders,* and 8) *hyposalivation or xerostomia*.
Conclusion: This e-Delphi study provided eight components that make up the operational definition of oral frailty. These components are the foundation for the next stage, which involves developing an oral frailty assessment tool.

1. Introduction

When people age, the risk for oral health problems increases (Chalmers & Ettinger, 2008; Farias et al., 2020; Petersen & Ogawa, 2018). The consequences of oral health problems extend beyond the mouth and have been linked to numerous adverse general health outcomes, especially in older people (de Sire et al., 2022; Hakeem et al., 2020; Hiltunen et al., 2021; Komatsu et al., 2021; Kuo & Lee, 2022; Patel et al., 2021; Watanabe et al., 2020). To better understand the consequences of the aging process on oral health and oral function, the concept of oral frailty has emerged (JapanDentalAssociation, 2019). Yet, a concept like oral frailty remains highly subjective in the absence of a carefully articulated and consented definition (Podsakoff et al., 2016). Therefore, preceding the present study, we analyzed existing definitions of oral frailty in a scoping review and concluded that these definitions were not adequately formulated at a conceptual level. In response, we developed a new definition by synthesizing and conceptualizing the essence of existing ones. We defined oral frailty as the age-related functional decline of orofacial structures (Parisius et al., 2022).

While a conceptual definition is essential in understanding what oral frailty fundamentally is, and how it can be distinguished from other related phenomena (e.g., oral hypofunction), it does not explain which components (i.e., latent characteristics) oral frailty consists of. Therefore, an operational definition is needed to convey the conceptual terms into observable components of oral frailty. Subsequently, to assess oral frailty, these components should be formulated in measurable terms (viz., variables) (Boesjes-Hommes, 1970).

The literature still has ambiguity regarding the operationalization and assessment of oral frailty. The most widely used oral frailty assessment instrument is the one proposed by Tanaka et al. (2018). It consists of six components: the number of natural teeth, chewing ability, articulatory oral motor skills for the "ta" sound, tongue pressure, subjective difficulty in eating tough foods, and subjective difficulty swallowing. A person is considered orally frail when at least three of these six components score below a specified threshold. This instrument was developed in a Japanese cohort. While problems related to oral health in older people are similar on a global scale, nuances may exist in different populations. For example, Schimmel et al. (2022) concluded that although articulatory oral motor skills play an essential role in assessing orofacial function, the thresholds need to be revised for individuals who are non-native speakers of Japanese. Furthermore, although researchers have validated devices for measuring oral functions like tongue movement and bite force in the Japanese population, most of these devices are unavailable outside of Japan, which can impede cross-cultural research and limit the generalizability of findings (Schimmel et al., 2022).

In a recent study conducted in Finland by Hiltunen et al. (2021), oral frailty showed a significant association with Fried's frailty phenotype (i.e., unintentional weight loss, exhaustion, low physical activity, slowness, and physical weakness) (Fried et al., 2001) and a strong relationship with general health, nutrition, and need for help with activities of daily living (ADL). Despite these findings, Hiltunen et al. (2021) also indicated that there is no international consensus on the components of oral frailty. Remarkably, compared to Tanaka et al. (2018), oral frailty is assessed with a different set of components in this study, namely: having a dry mouth, the presence of food residues in the oral cavity, the inability to keep the mouth open during an oral examination, unclear speech, the need for food texture modification (pureed or soft food diet), and the expression of pain during an oral examination. These components are scored dichotomously (yes/no), with the sum reflecting the degree of oral frailty. Furthermore, Hiltunen et al. (2021) point out that, unlike Tanaka et al. (2018), they cannot confirm that the number of remaining teeth determines the severity of oral frailty.

The above indicates that there are divergent views among experts in gerodontology and related fields on the key components of oral frailty, the methods used to assess it, and the thresholds used in those methods. Building on our new conceptual definition of oral frailty, this study aims to establish a consensus among an international panel of experts on the key components of oral frailty to develop an operational definition based on their input.

2. Methods

2.1. Study design

We used a three-round modified e-Delphi (Keeney et al., 2011) (see *Data collection and data analysis*) to reach a consensus on the components of oral frailty among international expert panel members. The modified aspect in this e-Delphi study relates to the first round in which experts were provided with a structured questionnaire rather than the more traditional open-ended questionnaire. In addition, they were given the option to include their own suggestions. A more detailed explanation follows under *Data collection and data analysis*. The letter 'e' in e-Delphi refers to its electronic nature, indicating that the entire study is conducted exclusively online. In addition, we followed an 'all-rounds invitation' approach (Boel et al., 2021). This implies that experts were allowed to participate in the second round irrespective of their participation in the first round. This study was approved by the Academic Centre for Dentistry Amsterdam's ethical commission and registered under file number #2021–6162.

2.2. Expert-panel members

For this study, 15 experts in the field of gerodontology from different regions and countries, were approached. These experts were all part of our networks organized in international societies and associations such as IADR (International Association of Dental Research) and ECG (European College of Gerodontology). An expert was defined as an academic who is actively researching aspects of oral health in older people. After receiving information about the study's aim and procedure, the experts were asked to participate. The number of Delphi participants was set *a priori* at 10 – 15 experts. According to Delbecq & Gustafson Glenview (1976), in cases where the expertise of the panel members is relatively homogeneous, a group size of 10 – 15 is considered adequate for conducting the Delphi process (Delbecq & Gustafson Glenview, 1976; Hsu CCS, 2007; Keeney et al., 2011).

2.3. Data collection and data analysis

Three online questionnaires (viz., round 1 till round 3) were used to investigate which items the experts considered to be components of oral

frailty. Two research team members (RG and FL) pilot-tested the questionnaires before each round. Aspects such as the length of the questionnaire, clarity of wording, content accuracy, response options, structure, and overall clarity were reviewed as well. The questionnaires were distributed using the application Qualtrics version 10.2022 (Qualtrics, Provo, UT). On the questionnaire's welcome page, experts were given information about the current round and instructions for completion. They were given a three-week deadline and received reminders as the deadline approached, as well as one week after. A final reminder and personal message were sent if no response was received. These experts were excluded from participating in that current round, if no action was taken.

Round 1: We identified 17 components of oral frailty in the literature during our scoping review aimed at developing the conceptual definition of oral frailty (Parisius et al., 2022). The experts were asked to rate these 17 components following a structured item assessment (viz., on a 5-point Likert scale ranging from 1. Not at all important to 5. Extremely important), and to provide a rationale for the score. The members of the expert panel were given the opportunity to suggest any missing components of oral frailty.

Round 2: We presented the components of oral frailty on which consensus had been reached and allowed the experts to comment on these. Items that did not reach consensus during round 1 were reiterated in this round. To encourage convergence, anonymized ratings, explanations, and comments from other panel members were included. Lastly, the experts were asked to rate the importance of the open-ended items suggested by their peers of round 1, using the same 5-point Likert scale.

Round 3: The experts received an individual questionnaire to reassess the items on which they diverged from the consensus. The questionnaire included ratings, comments, and descriptive statistical feedback from the previous rounds. In this round, the experts had the opportunity to revise their opinion on these items. In doing so, an attempt was made to achieve the highest possible consensus level.

If 70% or more of the experts gave an item a score of four or higher on the 5-point Likert scale, it was considered a consensus that the item is a component of oral frailty. If 70% or more of the experts rated an item with a score of three or lower on the 5-point Likert scale, it was agreed that the item does not qualify for being considered a component of oral frailty. Any other outcome was considered to be a lack of consensus (Hsu CCS, 2007; Keeney et al., 2011). The data was analyzed using IBM SPSS Statistical Package version 27 (SPSS Inc., Chicago, IL). For each round, expert scores were expressed in frequencies and percentages, which were presented in tables. A flowchart provides an overview of the study (see Fig. 1).

3. Results

3.1. International Delphi expert panel members

Of the 15 experts invited, 13 agreed to participate in this e-Delphi

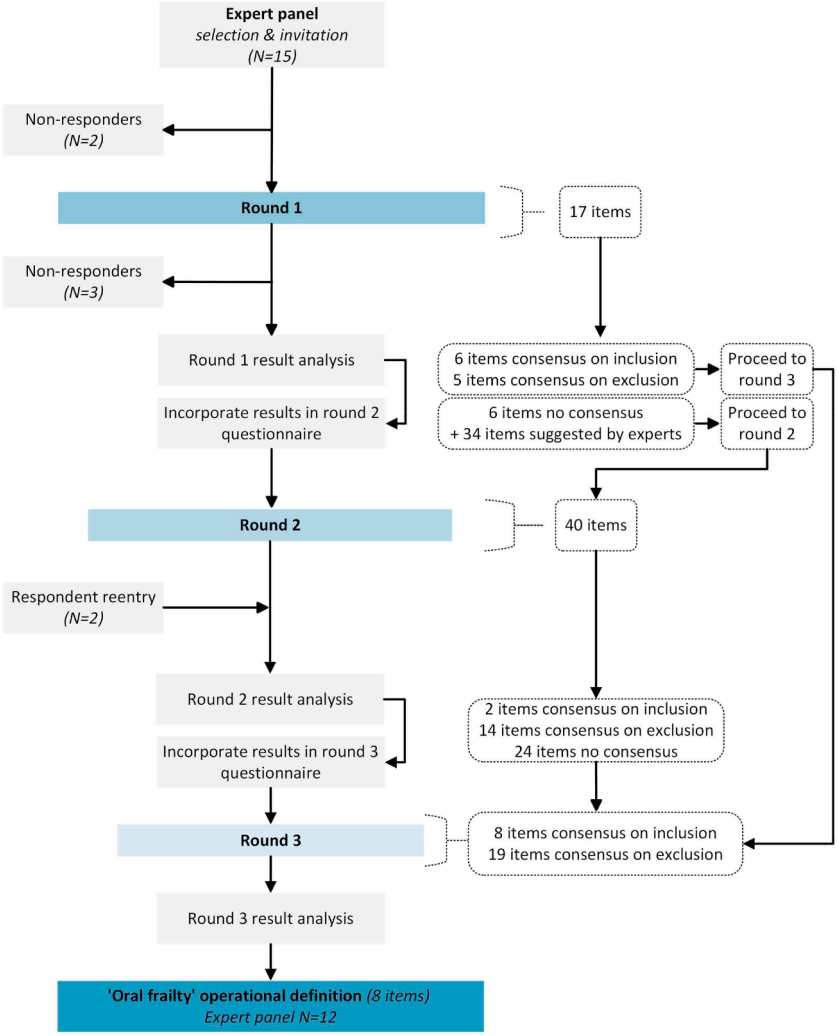

Fig. 1. Flowchart operational definition of oral frailty modified 3-round e-Delphi study.

study, and two experts did not respond to our invitation. In round-1, 10 experts completed the questionnaire, and three did not respond. In round-2 and round-3, 12 experts completed the questionnaire. Seven experts are affiliated with universities in a European country, four in an East Asian country, and one in North America. Of the 12 participating experts, nine hold a professorship, two hold a position as associate professor, and one leads a research team promoting the independence and mental health of older adults. The experts' clinical and/or research area included one or a combination, of the following: gerodontology, prosthodontics, oral medicine, oral neurophysiology, and gerontology. Further details can be found in Table 1.

3.2. Round 1

In the first round, 17 items were presented to the experts. On six of the 17 items, consensus to include was achieved, namely: 1) *difficulty eating hard or tough foods*, 2) *decreased ability to swallow solid foods*, 3) *decreased ability to swallow liquids*, 4) *overall poor swallowing function*, 5) *impaired tongue movement*, and *6) hyposalivation or xerostomia*. On five of the 17 items, more than 70% of the experts scored three or lower, leading to a consensus that these items should be left out of the operational definition of oral frailty. These five items are: 1) *a small number of remaining teeth*, 2) *loss of posterior occlusion*, 3) *age-related oral hygiene decline*, 4) *the decline in smooth and prompt actions of the jaw*, and 5) *a small number of functioning teeth*. No consensus was reached on the remaining six items.

Therefore, these items, including the scores and the comments given by the experts, were reiterated in the second round for reconsideration. Finally, experts suggested 34 possible components of oral frailty for further examination in round two.

3.3. Round 2

In the second round, the expert panel members were presented with 40 items (viz., six items on which no consensus was reached in the first round, and 34 items suggested by the experts). More than 70% of the experts agreed that three of the six previously disagreed items should be excluded. However, no consensus was reached on the remaining three items: 1) *the occurrence of spillage while eating,* 2) *reduced occlusal bite force,* and 3) *articulatory oral motor skill for "ta"*. Furthermore, consensus was reached to include two of the 34 items suggested by the experts: 1) *unable to chew all foods,* and 2) *speech impairment/ phonatory disorders*. The experts agreed to exclude 14 of the 34 items. No consensus was reached on the remaining 24 items. Table 2 displays the exact scores and consensus levels.

3.4. Round 3

During the evaluation of the 51 items in the first two rounds, a consensus was reached on including eight items, while 18 items were agreed to be excluded (Table 2). In the third round, the experts were provided with an individual questionnaire to reassess their position on items where they initially stood outside the consensus. A higher consensus level was achieved for six of the eight items on which experts agreed to be components of oral frailty. Consensus levels for items considered components of oral frailty ranged from 90 to 100% after round three. Experts achieved higher consensus levels on 15 of the 18 items deemed not to be components of oral frailty, with consensus levels ranging from 80 to 100% after round three. Table 2 contains further details.

3.5. The operational definition of oral frailty

According to the majority of the experts in this modified e-Delphi study, the operational definition of oral frailty consists of the following eight components which can be grouped into four categories: 1)

Table 1
Delphi expert panel.

Expert	University	Position	Expertise
Associate Prof. Dr. Limor Avivi-Arber	University of Toronto, Canada	Associate professor in prosthodontics and oral neurophysiology	Prosthodontics and oral neurophysiology
Prof. Dr. Joke Duyck	KU Leuven, Belgium	Professor of Gerodontology and removable Prosthodontics	Gerodontology, prosthodontics
Dr. Hirohiko Hirano	Tokyo Metropolitan Institute for Geriatrics and Gerontology, Japan	Director Department of Dentistry and Oral Surgery and research team leader	Elderly independence promotion
Prof. Dr. Katsuya Iijima	The University of Tokyo, Japan	Professor of Institute for Future Initiatives (IFI), Director of Institute of Gerontology (IOG)	Prevention of sarcopenia-related frailty, multi-disciplinary collaboration, healthy ageing
Prof. Dr. Barbara Janssens	University Gent, Belguim	Professor of gerodontology	Oral health promotion in older adults, mobile dental care, health services research, interprofessional collaboration in oral health.
Prof. Dr. Anastassia Kossioni	National and Kapodistrian University of Athens, Greece	Professor of gerodontology	Gerodontology
Prof. Dr. Chia-Shu Lin	National Yang Ming Chiao Tung University, Taiwan	Professor	Brain Neuroimaging, Behavioral Dentistry, Geriatric Dentistry, Orofacial Pain
Prof. Dr. Gerald McKenna	Queen's University Belfast, Northern Ireland	Chair of Oral Health Services Research and Gerodontology, Centre for Public Health	Gerodontology, Prosthodontics, Restorative Dentistry, Nutrition
Prof. Dr. hc. Frauke Müller	University of Geneva, Switzerland	Professor of Gerodontology and removable Prosthodontics	Gerodontology and removable Prosthodontics
Prof. Dr. Martin Schimmel	University of Bern, Switzerland	Chair of Reconstructive Dentistry and Gerodontology	Prosthodontics, Gerodontology, Implantology, Orofacial Function.
Prof. Dr. Anita Visser	University Medical Center Groningen, University of Groningen, The Netherlands; Radboud University Medical Center, Radboud University Nijmegen The Netherlands	Professor in geriatric dentistry Maxillofacial prosthodontist.	Gerodontology, Maxillo facial prosthodontics.
Associate Prof. Dr. Yutaka Watanabe	Hokkaido University, Japan	Associate Professor of Gerodontology, Department of Oral Health Science, Faculty of Dental Medicine	Epidemiology, geriatrics, and dentistry

Table 2
Final results after 3 rounds: components of oral frailty.

		Source*	Final consensus level	Final result
	COMPONENTS ON WHICH A CONSENSUS IS REACHED			
1	The impaired functional movement of the tongue.	L	100	incl
2	Decreased ability in swallowing solid foods	L	100	incl
3	Oral dryness: hyposalivation and/or xerostomia.	L	100	incl
4	Difficulty in eating hard and/or tough foods.	L	100	incl
5	Unable to chew all types of foods	E	100	incl
6	Speech impairment/phonatory disorders	E	92	incl
7	Decreased ability in swallowing liquids.	L	90	incl
8	Overall poor swallowing function.	L	90	incl
9	Loss of posterior occlusion.	L	100	excl
10	Age-related physical frailty.	L	100	excl
11	Reduced occlusal vertical dimension	E	100	excl
12	Cognitive decline	E	100	excl
13	Lower motivation to keep oral health	E	100	excl
14	Age-related cognitive decline.	L	92	excl
15	Breathing in coordination with chewing and swallowing	E	92	excl
16	The use of complete dentures	E	92	excl
17	Poor fit of dentures	E	92	excl
18	Change in diet	E	92	excl
19	Increase in the number of masticatory cycles	E	92	excl
20	Low eating-related quality of life	E	92	excl
21	Food pocketing in the cheeks	E	92	excl
22	Low number of remaining teeth.	L	90	excl
23	Age-related oral hygiene decline.	L	90	excl
24	Low number of functioning teeth.	L	90	excl
25	Food avoidance behavior	E	83	excl
26	The decline in smooth and prompt actions of the jaw.	L	80	excl
27	The decline in smooth and prompt actions of the lips.	L	80	excl
	COMPONENTS ON WHICH NO CONSENSUS IS REACHED			
28	Adaptive eating behaviors	E	67	excl
29	Wet voice	E	67	excl
30	Unhealthy periodontal condition	E	67	excl
31	Reduced sensibility of the oral mucosa	E	67	excl
32	Altered (deteriorated) quality of saliva	E	67	excl
33	The occurrence of spillage while eating.	L	67	excl
34	Oral diadochokinesis	E	67	excl
35	Lack of facial expression	E	67	excl
36	Physical frailty	E	67	excl
37	Altered (dysgeusia) or lost (ageusia) sense of	E	67	excl
38	Orofacial muscular activity	E	59	excl
39	Choking while eating	E	58	excl
40	Regular aspiration of liquid or solid food	E	58	excl
41	Decreased ability in reducing food into proper size for swallowing	E	58	excl
42	Drooling	E	58	excl
43	Natural mechanical cleaning of the mouth	E	58	excl
44	Weight loss	E	58	excl
45	Articulatory oral motor skill for "ta"	L	58	excl
46	Malnutrition	E	50	excl
47	Sarcopenia	E	50	excl
48	Inability to keep the oral cavity clean	E	50	excl
49	Coughing while eating	E	50	excl
50	Reduced occlusal (bite) force	L	50	excl
51	Maladaptive eating behaviors	E	50	excl

incl = consensus on items to be included in the operational definition; excl = consensus on items to be excluded from the operational definition.
L = Components sourced from literature; E = Components suggested by experts;
* 17 of the components were extracted from literature in our previously conducted scoping review (Parisius et al., 2022), 34 of the components were suggested by the experts.

mastication (*difficulty eating hard or tough foods*, and *inability to chew all types of foods)*; 2) swallowing (*decreased ability to swallow solid foods, decreased ability to swallow liquids*, and *overall poor swallowing function)*; 3) oral motor skill (*impaired tongue movement*, and *speech or phonatory disorders),* and 4) salivation (*hyposalivation or xerostomia*).

4. Discussion

This modified three-round e-Delphi study aimed to reach a consensus on the components that should be included in the operational definition of oral frailty.

4.1. Consensus

In the present study, a total of 51 components were reviewed by field experts, including 17 sourced from literature and 34 newly suggested items brought in by experts in the first round of the e-Delphi study. The experts determined that eight (16%) of the 51 items should be included in the operational definition through consensus. Upon closer examination, the eight items can be grouped into four categories (Fig. 2): mastication (*difficulty eating hard or tough foods* and *inability to chew all types of foods*); swallowing (*decreased ability to swallow solid foods, decreased ability to swallow liquids*, and *overall poor swallowing function*); oral motor skill (*impaired tongue movement*, and *speech or phonatory disorders*); and salivation (*hyposalivation or xerostomia*). Consistent with the conceptual definition of oral frailty, (Parisius et al., 2022) these components reflect the age-related functional decline in orofacial structures and are commonly mentioned in scientific literature as factors associated with the general health decline of older people. This is supported by a recent systematic review by Dibello et al. (2022), who found that factors similar to the eight components identified in this study are associated with adverse health outcomes in older individuals, including mortality, physical frailty, functional disability, reduced quality of life, hospitalization, and falls. The output of the present study will primarily serve to develop an instrument to assess oral frailty, which will help to investigate if and how oral frailty is associated with adverse health outcomes. This knowledge is essential as it opens the possibility of exploring interventions to prevent or reverse the deterioration of orofacial structures and improve oral frailty. However, when an assessment shows that any of these oral functions (mastication, swallowing, oral motor skill, and salivation) are deteriorating, a closer examination is needed to determine the root cause. For example, swallowing problems can have several causes beyond orofacial structures and thus oral frailty (McCarty & Chao, 2021).

Of the 51 items, the experts agreed that 18 items (35%) should not be part of the operational definition of oral frailty. These 18 items can be condensed into four categories: dental status (*the use of complete dentures, poor fit of dentures, reduced occlusal vertical dimension, loss of posterior occlusion, a small number of remaining teeth*, and *a small number of functioning teeth*); diet and eating (*change in diet, food avoidance behavior,*

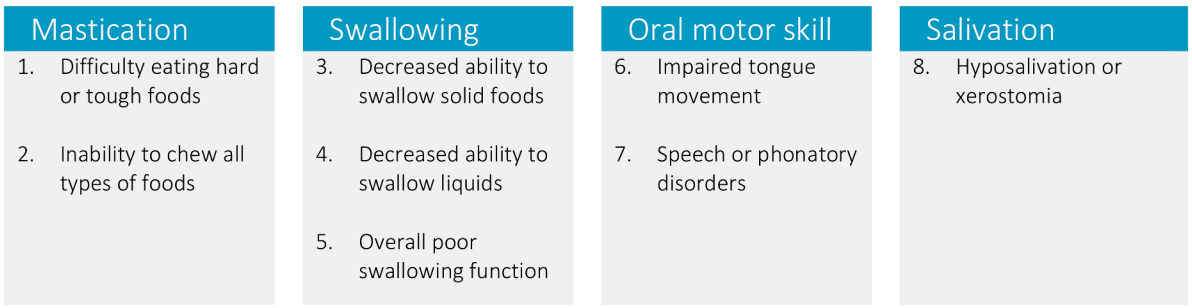

Fig. 2. Categorized components of oral frailty.

low eating-related quality of life, food pocketing in the cheeks, increase in the number of masticatory cycles); age-related factors (*age-related physical frailty, cognitive decline, age-related cognitive decline, lower motivation to keep oral health*, and *age-related oral hygiene decline*); and oral motor skill (*breathing in coordination with chewing and swallowing*, and *the decline in smooth and prompt actions of the jaw*).

The experts had reasons for omitting these items despite them being closely related to the included items. For example, items such as *difficulty in eating hard or tough foods* (included) and *an increase in the number of masticatory cycles* (excluded) can be considered associated with one another, as they both essentially reflect masticatory impairment. The excluded item is worded in a more technical manner, which causes it to lose the essence of the matter, namely the ability to chew hard food. It is further difficult to standardize, as the number of cycles per chewing sequence not only depends on age and dental state but also on the type of bolus chewed. The item that was included (*difficulty in eating hard or tough foods*) is more precisely worded within this context.

Additionally, nine items (viz., the use of complete dentures, poor fit of dentures, change in diet, food avoidance behavior, low eating-related quality of life, age-related physical frailty, cognitive decline, lower motivation to keep oral health, and age-related oral hygiene decline) were excluded as they were considered too general or do not directly reflect the age-related decline of orofacial structures. Therefore, these items do not align with the conceptual definition of oral frailty (Parisius et al., 2022).

In summary, items were omitted due to their lack of relevance to the concept of oral frailty or when having overlap with other items. In instances of overlapping terminology, the item deemed most clear and concise by the experts was retained.

The partial resemblance among some of the eight included items is not an issue at this point. The four categories (mastication, swallowing, oral motor skill, and salivation) along with the eight included items will primarily serve as a guiding framework for developing the oral frailty assessment tool; which our next study will focus on.

4.2. No consenus

The experts did not reach a consensus on 24 of the 51 items (47%). This means that less than 70% of the experts agreed on whether or not these items should be incorporated into the operational definition. Although the absolute majority of the experts (i.e., between 51% and 69%) scored six items (viz., *oral diadochokinesis, regular aspiration of liquid or solid food, decreased ability in reducing food into proper size for swallowing, orofacial muscular activity, articulatory oral motor skill for "ta"*, and *choking while eating*) with a 4 or higher, they were still omitted from the operational definition due to the pre-determined 70% consensus level. This implies that by omitting these items, potentially essential aspects are left out of the operational definition. However, upon closer inspection, it can be concluded that these items are either extensions of or synonymous with items already included. The omission of oral diadochokinesis may surprise some clinicians as it is commonly assessed in clinical practice (e.g., in Japan) (Hara et al., 2013; Iijima et al., 2017; Kugimiya et al., 2020; Sakayori et al., 2016; Satake et al., 2019; Takeuchi et al., 2021; Watanabe et al., 2018; Watanabe et al., 2017). However, in the context of an operational definition, the item oral diadochokinesis would be too narrow in terms of speech and phonation difficulties and tongue movement. Difficulty with speech and tongue movement may also be related to the perceptual processing of intra-oral stimuli. The oral diadochokinesis assessment only focuses on motor aspects. Experts were unable to reach a consensus on this item due to these considerations.

The highest degree of disagreement existed on another six items (viz., coughing while eating, reduced occlusal (bite) force, maladaptive eating behaviors, inability to keep the oral cavity clean, sarcopenia, and malnutrition), with a response distribution in which 50% of the experts scored 4 or higher and 50% scored 3 or lower. This reveals that the view on these items remained inconsistent after three Delphi rounds. This justifies the omission of these six items. However, the great divergence in the experts' opinions on these aspects suggests a need for more research and solid evidence.

The remaining 12 items received a score of 3 or lower from the majority of experts (i.e., between 51% and 69%), meaning that these items are not seen as adequate components of the operational definition of oral frailty. Although a consensus was not reached on these particular items, their exclusion from the operational definition does not undermine the overall assessment of the absolute majority of experts.

Despite their exclusion, however, it is fair to say that further investigation is needed on the excluded items and their association with oral frailty, since research in this emerging field is still in progress.

4.3. Comparison to existing instruments to assess oral frailty

As previously stated, Tanaka et al.'s oral frailty assessment method (Tanaka et al., 2018) is the most commonly used. Our operational definition shares similar components (viz., *unable to chew all foods, difficulty in eating hard and/or tough foods, overall poor swallowing function*) with three components used by Tanaka et al., namely: *chewing ability*, *subjective difficulty in eating tough foods*, and *subjective difficulty in swallowing*. Regarding the other components, Tanaka et al. tend to rely more heavily on technical or clinical measures (viz., tongue pressure and the number of natural teeth), in contrast to our more function-oriented approach. It is worth noting that there exists quite a difference in research aims between this study and the study conducted by Tanaka et al. The aim of the latter was assessing mortality risk, and for this, oral function and oral health measures that are commonly used in Japan were utilized. On the other hand, our objective is to develop an assessment tool designed specifically for the assessment of oral frailty.

Our operational definition only partially aligns with the instrument developed by Hiltunen et al. (2021). While we share similarities in some components, such as experiencing a dry mouth, requiring food texture modification, and having unclear speech, there are notable differences as well. Specifically, our e-Delphi study experts have excluded items equivalent to *the presence of food residues in the oral cavity, the inability to keep the mouth open during an oral examination*, and *the expression of pain*

during an oral examination.

4.4. Study limitations and strengths

A modified e-Delphi design was a practical choice for a study involving participants from different geographical locations worldwide. Electronic surveys allowed experts to participate at their convenient time and from their international location, reducing the logistical challenges and costs associated with in-person meetings. On the other hand, this design also has its downsides regarding open discussions. Although we gave experts outside the consensus a possibility to reconsider their position based on the arguments of fellow experts, the lack of face-to-face interaction and real-time discussion can make it difficult for experts to fully engage with each other's arguments and perspectives. Mainly when experts had contrasting scores, a more open verbal discussion might have led to a higher consensus level. However, when panel members' views differ strongly, the dynamics in a physical group setting could lead to group pressure, resulting in a false consensus (Mullen, 2003). Our modified e-Delphi design has the advantage that group pressure through expert interaction plays only a minor role, if at all.

Despite the international scope of this study, the location of the experts was not representative, as seven of the experts are from Europe, four from East Asia, and one from North America. A broader perspective on the operational definition of oral frailty could have been gathered if experts from the Middle East, South America, Africa, and Australia had also been included. However, average life expectancy varies widely from country to country, and the population of older people with it. The top ten countries with the highest average life expectancy consist of five European and five Asian countries, while African countries are among the bottom ten in this regard (Worldometers.info, 2023). It seems logical that geriatrics may not be a research priority in countries with lower average life expectancy, and a small population of older people makes it difficult to find experts to represent these regions.

In this study, we followed an 'all-rounds invitation' approach (Boel et al., 2021). Two experts who had not participated in the first round were thus allowed to join the second round. This raises concerns about the effect of this approach on the final outcome of this e-Delphi study, considering these two experts did not share their views in the first round. Boel et al. (2021) examined the difference in response rate and final outcome between two approaches to a 3-round e-Delphi study. The first (most common) approach was to invite individuals only if they participated in a previous round (respondents-only), and the second (alternative) approach was to invite individuals for each round, regardless of their participation in the previous round (all-rounds invitation). Results showed no difference between the 'respondents-only' and 'all-rounds' groups in mean (SD) scores, nor in the percentage of critical votes. However, a higher overall response rate was found in the 'all-rounds group' (61%) compared to the 'respondents-only group' (46%). Thus, it can be concluded that the "all-rounds invitation approach" does not affect the final result of the e-Delphi study and is even more favorable in terms of response rate. In this e-Delphi study, the response rate improved from 77% in the first round to 92% in the second and third rounds.

It should be noted that research on this topic is still evolving and that research evidence on oral frailty is limited outside Japan. Therefore, this operational definition is primarily based on expert opinion and may be subject to revision in the future as new evidence emerges. Our operational definition of oral frailty only includes physical components. It is important to note that this definition will be associated with social, and psychological components and background characteristics (e.g. sex, education, income, marital status). To fully understand these associations further studies may be necessary. From a theoretical point of view, it seems that oral frailty is related to other types of frailty (e.g. physical frailty, psychological frailty). However, this has not yet been studied. Before we suggest this in our work, we will conduct a study examining the associations between our oral frailty assessment tool (based on the operational definition presented in the current study) and other types of frailty using well-known and frequently cited assessment tools.

Despite the limitations mentioned above, this operational definition helps to establish a better understanding of the concept of oral frailty by explicitly defining it in terms of observable components. Operational definitions also allow for the objective measurement of concepts and facilitate the replication of studies by other researchers, helping to build a stronger foundation of knowledge in the field. This is particularly important when studying a complex and multidimensional concept such as oral frailty, which may have multiple meanings and interpretations (Parisius et al., 2022). An updated measure of oral frailty may now be indicated, given the nature of the study results. The upcoming study will be dedicated to the development and psychometric evaluation (s.a. reliability, construct validity, and criterion validity) of a novel oral frailty assessment tool. The outcome of this e-Delphi study will lay the groundwork for devising an instrument to measure oral frailty.

5. Conclusion

The findings of this e-Delphi study suggest that oral frailty can be operationally defined by eight components, grouped into four categories namely: 1) mastication (difficulty eating hard or tough foods, and inability to chew all types of foods); 2) swallowing (decreased ability to swallow solid foods, decreased ability to swallow liquids, and overall poor swallowing function); 3) oral motor skill (impaired tongue movement, and speech or phonatory disorders), and 4) salivation (hyposalivation or xerostomia).

Based on the findings of this study, a revised method for assessing oral frailty is recommended using these four categories as the foundation.

CRediT authorship contribution statement

Karl G.H. Parisius: Writing – review & editing, Visualization, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Merel C. Verhoeff:** Writing – review & editing, Visualization, Supervision. **Frank Lobbezoo:** Writing – review & editing, Visualization, Supervision, Methodology, Conceptualization. **Limor Avivi-Arber:** Writing – original draft, Visualization, Investigation. **Joke Duyck:** Writing – review & editing, Visualization, Investigation. **Hirohiko Hirano:** Writing – review & editing, Visualization, Investigation. **Katsuya Iijima:** Writing – review & editing, Visualization, Investigation. **Barbara Janssens:** Writing – review & editing, Visualization, Investigation. **Anastassia Kossioni:** Writing – review & editing, Validation, Investigation. **Chia-Shu Lin:** Writing – review & editing, Visualization, Investigation. **Gerald McKenna:** Writing – review & editing, Visualization, Investigation. **Frauke Müller:** Writing – review & editing, Visualization, Investigation. **Martin Schimmel:** Writing – review & editing, Visualization, Investigation. **Anita Visser:** Writing – review & editing, Visualization, Investigation. **Yutaka Watanabe:** Writing – review & editing, Visualization, Investigation. **Robbert J.J. Gobbens:** Writing – review & editing, Visualization, Supervision, Methodology, Investigation.

Declaration of Competing Interest

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