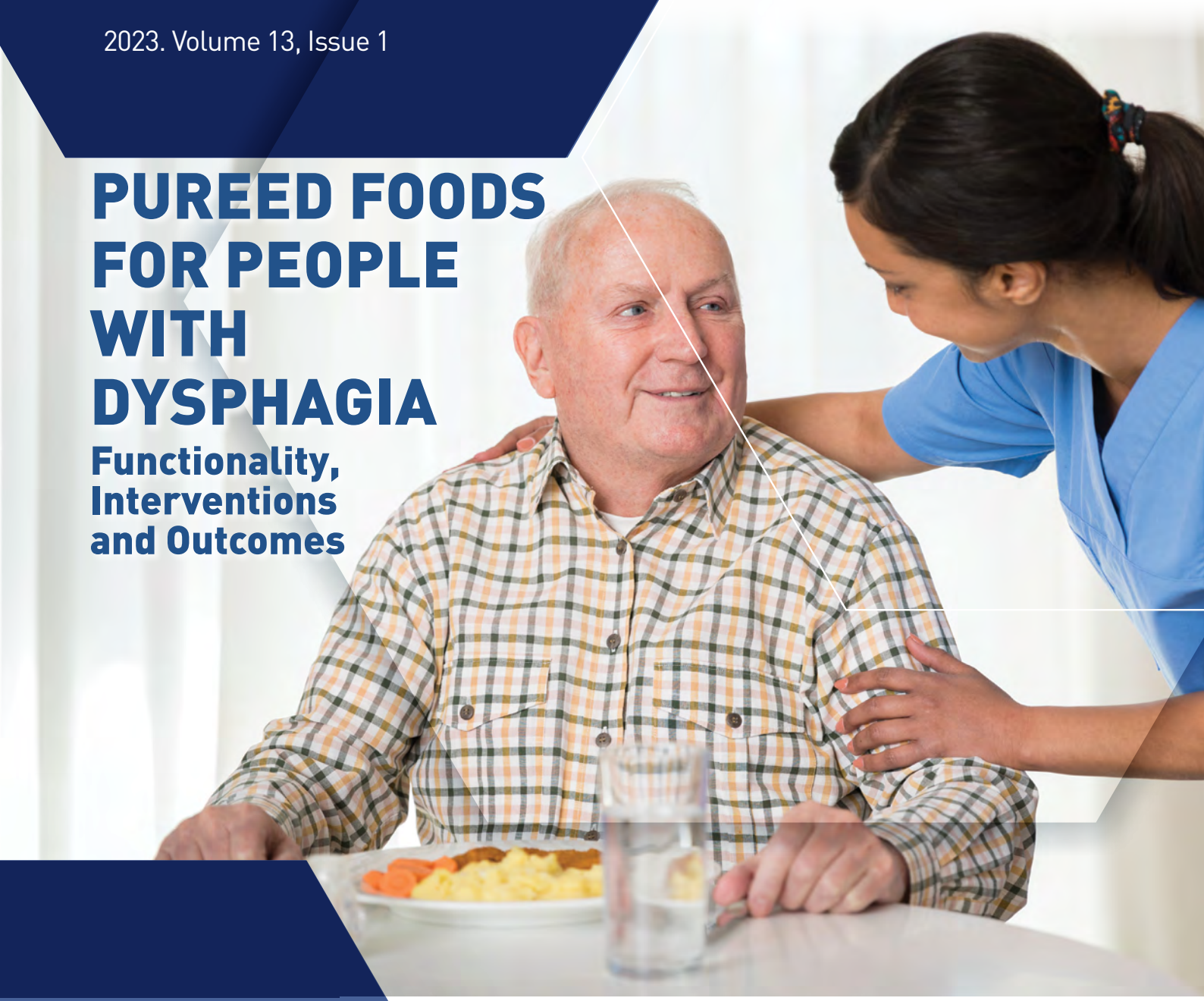
CLINICAL NUTRITION HIGHLIGHTS

Science supporting better nutrition

2023. Volume 13, Issue 1

PUREED FOODS FOR PEOPLE WITH DYSPHAGIA

Functionality, Interventions and Outcomes



Nestlé Nutrition Institute

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PUREED FOODS FOR PEOPLE WITH DYSPHAGIA: Functionality, Interventions and Outcomes

2023. Volume 13, Issue 1

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Prologue by the Editor-in-Chief

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PROLOGUE: WHAT DO WE KNOW ABOUT PUREED FOODS AS AN INTERVENTION FOR DYSPHAGIA?

Prof. Catriona Steele, PhD, CCC-SLP, S-LP(C), Reg. CASLPO, ASHA Fellow. Canada Research Chair in Swallowing and Food Oral Processing.

Dysphagia (swallowing impairment) is thought to affect as many as 8% of the world's population and is a particular concern in the elderly[1]. Texture modification is the most common intervention for people with dysphagia[2, 3], resulting in widespread use of texture modified diets, particularly in residential care settings[4-10]. Texture modification is certainly not a new idea. In fact, if you dig back through the dysphagia literature, you will find evidence showing that we have been modifying food and liquid consistencies since the very beginning of our practice. Indeed, an article by Coster and Schwartz in the 3rd issue of the Dysphagia journal in 1987 (its first year of publication) focused on this topic, and proposed the concepts of feeding competence and the swallow-safe bolus[11]. Feeding competence was described as "the ability to be able to swallow a variety of food textures and liquid consistencies without difficulty", and the person's ability to form a "swallow-safe" bolus from foods with a variety of physical characteristics. A "swallow-safe" bolus was defined as a bolus with physical aspects that enable "unimpeded passage through the food pathway without aspiration, choking, or retention in the pharynx".

Just 3 years later, in 1990, we can find the first published description of an institutional diet plan designed to reduce the risk of aspiration[12]. The article describes foods that were allowed or disallowed in diets for patients considered to be at aspiration risk, and emphasizes concepts of ease in chewing, ease in swallowing and bolus cohesion: "Foods selected for the aspiration risk reduction diet were chosen because studies have demonstrated that, in general, substances that are easy to chew (pureed consistency) are not always easy to swallow... For patients with decreased laryngeal elevation, a weak or uncoordinated swallow, or with poor oral muscular control or reduced oral sensation, semisolid consistencies that form a cohesive bolus and can be swallowed as a single bolus were chosen.... The aspiration risk reduction diet omits mixed dishes with large pieces of meat, such as stew, goulash, chow mein, and stroganoff. To reduce the risk of small pieces of food entering the airway and increasing the chance of respiratory compromise, foods that fall or break apart... also are not part of the menu. Sticky foods such as white bread, plain mashed potatoes, and peanut butter also tend to cause problems with this population due to the effort they require in movement."

In the years that have passed since those early publications, the predominant focus of research exploring diet texture as an intervention for dysphagia has been on liquids rather than foods. Systematic reviews from 2015 and later highlight this imbalance in the literature. For example, in a systematic review which I led for the International Dysphagia Diet Standardisation Initiative, we wrote "If the literature on thickened liquids is sparse, this is even more apparent when reviewing the literature regarding texture-modified foods and swallowing.... The identified literature discussed only a small number and variety of solid foods. With the exception of longer duration and higher amplitude masseter surface electromyography signals when ingesting solid foods with increasing thickness or hardness, the findings of the identified studies do not clearly point to measurable differences in either oral processing or swallowing parameters across the particular solid foods tested[13].

In 2021, Nestlé Health Science approached me to discuss the scientific evidence supporting and exploring

pureed foods as an intervention for people with dysphagia, and specifically dysphagia that impacted their ability to eat regular foods. As we discussed what we knew about this topic, we became rapidly aware of the paucity of literature addressing important clinical questions regarding pureed foods. Despite their widespread use, we were unaware of clinical trial evidence demonstrating safety and efficacy with pureed foods. On the other hand, we were aware of studies showing inadequate nutrition amongst individuals receiving pureed diets. And, perhaps most troubling, we recognized that clinicians lack access to validated assessments for evaluating whether or not a person requires pureed food.

Faced with this apparent gap in knowledge, we decided to solicit expert evidence-based summaries of current knowledge regarding dysphagia for solid foods; the clinical evaluation of oral function including chewing and foods oral processing; the implementation of texture modified diets including pureed foods in residential care settings; and the use of commercially prepared pureed foods. The resulting contributions from an international group of authors with expertise in speech-language pathology, dentistry and clinical nutrition are compiled in this special issue. These articles not only summarize current knowledge but collectively identify gaps in knowledge that represent priority areas for research in the coming years. We hope this will serve as a useful contribution both for clinicians and researchers, and will help to catalyze new research to address the needs of people with dysphagia who require diet texture modification.

REFERENCES

1. *Cichero JA, Steele C, Duivestein J, Clave P, Chen J, Kayashita J, et al. The Need for International Terminology and Definitions for Texture-Modified Foods and Thickened Liquids Used in Dysphagia Management: Foundations of a Global Initiative. Curr Phys Med Rehabil Rep. 2013;1:280-91.*
2. *Robbins J, Nicosia M, Hind JA, Gill GD, Blanco R, Logemann J. Defining Physical Properties of Fluids for Dysphagia Evaluation and Treatment. SIG 13 Perspectives on Swallowing and Swallowing Disorders (Dysphagia). 2002;11(2):16-9.*
3. *Garcia JM, Chambers Et, Molander M. Thickened liquids: practice patterns of speech-language pathologists. Am J Speech Lang Pathol 2005;14(1):4-13.*
4. *Wu X, Yousif L, Miles A, Braakhuis A. Exploring Meal Provision and Mealtime Challenges for Aged Care Residents Consuming Texture-Modified Diets: A Mixed Methods Study. Geriatrics (Basel). 2022;7(3).*
5. *Wu XS, Miles A, Braakhuis A. Nutritional Intake and Meal Composition of Patients Consuming Texture Modified Diets and Thickened Fluids: A Systematic Review and Meta-Analysis. Healthcare (Basel). 2020;8(4).*
6. *Wu XS, Miles A, Braakhuis AJ. Texture-Modified Diets, Nutritional Status and Mealtime Satisfaction: A Systematic Review. Healthcare (Basel). 2021;9(6).*
7. *Keller HH, Carrier N, Slaughter SE, Lengyel C, Steele CM, Duizer L, et al. Prevalence and Determinants of Poor Food Intake of Residents Living in Long-Term Care. J Am Med Dir Assoc. 2017;18(11):941-7.*
8. *Vucea V, Keller HH, Morrison JM, Duizer LM, Duncan AM, Carrier N, et al. Modified Texture Food Use is Associated with Malnutrition in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. J Nutr Health Aging. 2018;22(8):916-22.*
9. *Vucea V, Keller HH, Morrison JM, Duncan AM, Duizer LM, Lengyel CO, et al. Intake and Factors Associated with Consumption of Pureed Food in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. J Nutr Gerontol Geriatr. 2018;37(2):59-81.*
10. *Ballesteros-Pomar MD, Cherubini A, Keller H, Lam P, Rolland Y, Simmons SF. Texture-Modified Diet for Improving the Management of Oropharyngeal Dysphagia in Nursing Home Residents: An Expert Review. J Nutr Health Aging. 2020;24(6):576-81.*
11. *Coster ST, Schwarz WH. Rheology and the swallow-safe bolus. Dysphagia. 1987;1(3):113-8.*
12. *Curran J, Groher ME. Development and dissemination of an aspiration risk reduction diet. Dysphagia. 1990;5(1):6-12.*
13. *Steele CM, Alsanei WA, Ayanikalath S, Barbon CE, Chen J, Cichero JA, et al. The influence of food texture and liquid consistency modification on swallowing physiology and function: a systematic review. Dysphagia. 2015;30(1):2-26.*

AN OVERVIEW OF SWALLOWING AND DYSPHAGIA WITH SOLID FOODS

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Dysphagia is a term used to describe impairment in the act of swallowing, i.e., moving food or liquid through the mouth and pharynx to the oesophagus and eventually the stomach. There is no clear consensus on the definition of dysphagia, with some people adopting a definition based on patient-reported symptoms whereas others adopt definitions based on different types of clinical assessment. Dysphagia is classified under digestive symptoms and signs in the International Classification of Diseases (ICD-10, code R13), although it is rarely coded as a primary diagnosis and is more commonly recognised as a feature or comorbidity in a wide variety of other health conditions and injury processes[1]. Dysphagia is thought to affect up to 8% of the world's population, particularly people of advanced age or with a neurological disease[1, 2].

Dysphagia is sometimes further labelled by the region of the body or the phase of swallowing where impairment is experienced or noticed (oral, pharyngeal or oesophageal) or by the products that are most difficult to swallow (liquids, solid foods). Oropharyngeal dysphagia (OD) most commonly involves dysfunction in two key functions, namely airway protection and bolus clearance, also referred to as swallowing safety and efficiency[1]. As a rule, difficulties with airway protection (i.e., penetration-aspiration) occur more commonly with thin liquids, which flow fast and can easily slip into the airway through gaps in the defence mechanism of laryngeal vestibule closure, much like water can slip through cracks or holes in a dike. Conversely, difficulties with bolus clearance, resulting in residue remaining in the pharynx after a swallow, are more common with thicker liquids[3-5]. Standard protocols for swallow screening and clinical assessment typically begin with and focus heavily on swallowing safety with thin liquids. Thickened liquids are the most common intervention recommended to limit penetration-aspiration[6, 7].

Much less is known or taught regarding the oral phase of swallowing and difficulties swallowing solid foods. In this regard, we know that food is broken down by mastication and that the tongue and cheek muscles coordinate to position and maintain solid boluses on the occlusal surface of the molar teeth during mastication[8-11]. As food boluses are broken down, particles are mixed with saliva and carried into the upper region of the pharynx on the dorsal surface of the tongue, which cycles in and out of the oral cavity with each chewing cycle. The generally accepted premise is that oral processing serves to reduce foods with a variety of initial consistencies to a uniform swallow-ready consistency that is presumed to be similar in its properties to the soft-and-bite-sized or minced-and-moist levels on the International Dysphagia Diet Standardisation Initiative (IDDSI) Framework. Once such foods have been transported to the pharynx for swallowing, there are thought to be very few differences in the ensuing swallowing process that are attributable to bolus consistency. However, standard stimuli for use in videofluoroscopic swallowing assessments are limited to liquids, ranging from thin to paste consistency. The radiographic assessment of swallowing with foods typically involves the smearing of barium paste onto cookies, crackers or bread, the off-label mixing of barium powders and suspensions with various food products (e.g. fruit cocktail, minced vegetables), and occasionally the use of barium pills or barium-powder-filled gelatin capsules[12].

Despite the prominent role of dentition and mastication in the oral phase of swallowing, dentists are not typically involved in swallowing assessment, except in Japan. Rather, the most common professions involved

in swallowing assessment in North America, Europe and Australia are speech-language pathologists, dieticians, occupational therapists, phoniatricians, otolaryngologists and gastroenterologists. For these professionals, limited curriculum is devoted to chewing and oral processing beyond the fact that chewing should occur in a rotary rather than a purely vertical ("munching") fashion[13, 14]. The assessment of oral function may involve the testing of lingual strength[15-17], and/or the use of tools like the Test of Mastication and Swallowing of Solids (TOMASS) to evaluate the number of chews and the duration of chewing required to process and swallow a standard cracker[18-20]. However, beyond this, the evaluation of the oral phase of swallowing is largely subjective and non-standardised.

Clinicians who are charged with evaluating swallowing and recommending suitable diet textures for people with reported or presumed dysphagia may be influenced by evidence that there are age-related reductions in the strength and bulk of the tongue and oral musculature (referred to by some authors as sarcopenia)[21-24]. They may also be influenced by the presence of dental prostheses or observations of missing, broken or decayed teeth. In specific populations, such as those who have undergone radiation for head and neck cancer, reported or observed difficulties with xerostomia and saliva production may also be associated with reported difficulties in managing solid food[25]. When the assessment yields the impression that a patient has difficulty in the oral phase of swallowing with solid foods, it is common practice to recommend texture-modified foods (TMFs) that have been pre-processed to reduce hardness or particle size and perhaps mixed with sauces or other binding agents to create moist, cohesive boluses. The recently introduced IDDSI Framework outlines several degrees of food texture modification, addressing hardness, particle size, cohesiveness and adhesiveness, from regular foods to "easy-to-chew" foods, to "soft and bite-sized", "minced-and-moist", "pureed" and "liquidised" foods [26, 27].

In this narrative review, we will critically appraise selected key articles regarding the prevalence of oral phase dysphagia involving difficulty swallowing regular solid foods, the effectiveness of diet texture modification to address this issue, and evidence of negative outcomes associated with the use of TMFs. Where possible, we will comment separately on the use of pureed foods versus lesser degrees of texture modification.

What is the Prevalence of Oral Phase Dysphagia for Solid Foods?

The literature contains no information regarding the specific prevalence of oral phase dysphagia or of difficulty swallowing solid foods. This enormous information gap may be attributed to different definitions of and diagnostic criteria for dysphagia, and the prevailing focus on aspiration as a primary concern in the assessment of dysphagia. However, we can draw some inferences regarding the possible prevalence of difficulties with oral phase functions from other sources.

One such source of information lies in the reported use of TMFs in diets for older adults living in residential care settings. Different methods have been used to determine the prevalence of TMF use, including surveys, interviews, observational studies and audits. The results of four such studies are shown in Table 1. One recent observational study, the Making the Most of Mealtimes (M3) project[28-30] , sought to understand predictors of nutritional status in seniors residing in long-term care (LTC) facilities in Canada. Data were collected for 640 nursing home residents, i.e., 20 residents from each of 32 nursing homes from 4 provinces, purposively selected to be representative of rural/urban, public/private and small/large facilities. Modified-food textures spanning the range from IDDSI Level 6 (soft & bite-sized) to Level 3 (liquidised) were reported to be prescribed for 47.1% (i.e. 301) of the 639 residents in the final sample, with 71 of these residents receiving pureed foods. The project included a screening test for dysphagia, which involved observation for signs of penetration-aspiration on teaspoons of applesauce and a 3-oz continuous water drinking task[31]. Three days of meal observation were also completed, and any signs of coughing or choking were documented. Overall, 78 participants (12%) were seen to display signs of swallowing difficulty on the applesauce boluses during the swallow screen, while 19 (3%) were noted to have choking episodes during meals. A second observational study was conducted in 10 residential aged care facilities in Auckland, New Zealand[32] and reported overall that 23% of the residents were receiving texture-modified foods or liquids. In 2018, Streicher and colleagues (33) reported findings from the Nutrition Day survey exercise, conducted across 926 different nursing home units in 19 countries. Texture-

modified diet use was broken down between patients identified as having dysphagia (42%) and those not identified as having dysphagia (8%). A second recent large-scale project surveyed aged care facilities related to the implementation of IDDSI Framework in Australia (34). Survey responses representing 1,282 facilities and 90,938 residents suggested that ≤59% of residents were receiving TMFs, with pureed foods being prescribed for ≤7% of residents.

Table 1. Observational studies and audits

AUTHOR	STUDY DETAILS	FREQUENCY OF TEXTURE MODIFIED DIET USE
Vucea et al. [29]	Observational study of a sample of 639 residents from 32 nursing homes across Canada	47.1% receiving texture modified foods ; 11% receiving pureed foods
Miles et al. [32]	Observational study of 10 residential aged care facilities in Auckland, New Zealand.	23% of residents were receiving texture-modified food and/or liquid.
Streicher et al. [33]	Nutrition Day survey of 926 nursing home units in 19 countries.	42% of those identified with dysphagia receiving texture modified foods ; 8% among those not identified with dysphagia
Cichero et al. [34]	Survey of 1,282 aged-care facilities (90,938 residents) across Australia	59% receiving texture modified foods ; 7% receiving pureed foods

Efficacy of Texture-Modified Foods for Dysphagia

Over the past decade, several systematic reviews have explored issues related to the provision of TMFs for people with dysphagia. In 2013, Andersen and colleagues[35] reported the results of a Danish review intended to produce evidence-based guidelines regarding diet textures used in the management of dysphagia in adults. This included the appraisal of evidence regarding three food textures (normal, soft and pureed) and four liquid consistencies (normal, chocolate milk, syrup and jelly), and addressed four research questions related to the use of these products to limit aspiration, prevent aspiration pneumonia, improve nutritional and fluid intake and achieve better nutritional outcomes. The review found evidence to support the use of thickened fluids to reduce aspiration but mixed evidence regarding the impact of texture modification in combination with individual counselling for preventing pneumonia. With respect to nutritional outcomes, the review found mixed evidence regarding the benefits of using nutritionally-enriched thickened fluids and texture modification for improving nutritional and fluid intake and nutritional status. None of the studies reviewed addressed the safety or nutritional outcomes of pureed foods in comparison to lesser degrees of food texture modification. A subsequent update to this review[36] found no additional literature since 2010 regarding the effects of using TMFs to facilitate safe and efficient oral intake in people with OD compared to a normal diet.

On behalf of IDDSI, Steele and colleagues[37] explored prior literature regarding the impact of liquid consistency and food texture on swallowing behaviours. Of 36 articles meeting the inclusion criteria for review, the majority described differences in swallowing across liquid consistencies: 15 using barium stimuli in videofluoroscopy and 16 using non-radiographic methods. Pureed or extremely thick liquid products such as applesauce, chocolate pudding, chicken spread, peanut butter, yogurt, cheese spread and barium paste were included in 19 of the studies exploring liquids. It is important to note that the pureed products in these studies were the thickest consistencies studied, and comparisons were made to thinner liquids rather than exploring the impact of pureed compared to solid foods. Swallowing behaviours across different food textures were reported in 18 of the studies reviewed. In these studies, the stimuli included chewing gums with different hardness; custom-prepared gels using agar, k-carrageenan, gelatin, Gellan gum, psyllium seed gum and/or locust bean gum; biscuits or cookies; breakfast

cereals; bread; spaghetti; banana; peanuts; raw carrots; apples; rice gruel; cooked rice; rice crackers; gummy candies; cheese; corned beef and Konjac jelly. Overall, the review found evidence supporting the impression that thicker and harder food items require greater effort in oral processing and swallowing. With specific regard to chewing, the evidence showed faster rates, longer cycle durations and an increased number of chewing cycles for harder foods. Around the same time, a review and white paper conducted on behalf of the European Society for Swallowing Disorders[38] explored the role of liquid viscosity in swallowing physiology and outcomes in patients with oropharyngeal dysphagia, but did not specifically address questions related to the safety and efficacy of using pureed foods compared to other food textures.

More recently, Wu and colleagues[39, 40] conducted two related systematic reviews looking at nutritional status, meal composition and mealtime satisfaction outcomes of patients receiving texture-modified diets. As a rule, TMF consumers reported poor satisfaction and had compromised nutritional status. None of the studies reviewed explored differences in chewing, oral processing or swallowing physiology between different degrees of solid food texture modification.

One recent study of interest comes from Korea[41] and specifically compared measures of swallowing safety and efficiency in adults with neurogenic dysphagia between two texture-modified rice products (a rice gruel and a rice porridge) and two bulgogi products (a bulgogi mousse compared to ground bulgogi). Unfortunately, it is difficult to map the texture descriptions of these products to IDDSI Framework. The rice gruel was observed to transit faster through the oropharynx and to require fewer swallows to clear than the rice porridge, and the bulgogi mousse required a greater number of swallows to clear than the ground bulgogi. There were no differences observed in penetration-aspiration or residue, leading the authors to conclude that the novel rice gruel and bulgogi mousse products were safe and effective for use in patients with dysphagia.

Negative Sequelae of Using Texture-Modified Foods

The Korean article discussed in the previous paragraph[41] was limited to a comparison of swallowing physiology across stimuli within a single videofluoroscopy exam. However, it is also important to understand the available evidence regarding longer-term consumption of TMFs and more specifically to ask whether there is any evidence of negative outcomes.

Perhaps the most cited research in this respect is the randomised control trial known as Protocol 201, led by Drs Logemann and Robbins from 1998 to 2008. This project focused primarily on the immediate and longer-term effectiveness of thickened liquids for limiting aspiration and preventing pneumonia in adults with medical diagnoses of Alzheimer's Disease and/or Parkinson's Disease and videofluoroscopically-confirmed dysphagia involving aspiration on thin liquids. In the first phase of the study, which compared three interventions in each participant within a single videofluoroscopy, an extremely thick liquid consistency (labelled honey-thick in the original article) was found to be better at limiting aspiration than mildly thick liquids (labelled nectar-thick in the original article) or use of a chin-down position when swallowing thin liquids[42]. However, and importantly so, 49% of the 711 participants in the study continued to aspirate in all 3 interventions, suggesting that the long-term use of extremely thick liquids would not be likely to eliminate aspiration in these individuals. Among the 256 participants who were subsequently randomised to consume thickened liquids over a 3-month time-frame, those who were assigned to the extremely-thick liquids presented almost twice the incidence of pneumonia than those assigned to mildly-thick liquids[43]. It is important to acknowledge that the data available from the Protocol 201 study do not include information regarding the food textures that were prescribed in participants' diets. Nevertheless, given that extremely thick liquids are now recognised as having the same textural and rheological characteristics as pureed foods in IDDSI Framework, it is worth recognizing that this diet consistency was associated with an increased risk of adverse events in the Protocol 201 project. One obvious issue to highlight here is the fact that the project's design involved the provision of

extremely thick liquids to a randomly-selected proportion of the study participants, of whom approximately 2/3 were already known to aspirate this consistency.

Several recent animal studies have explored the comparative safety of aspirating liquids of different consistencies via the direct delivery of thickened liquids to the lungs of rabbits or rodents, with repeated infusions over extended study periods[44-47]. Collectively, these studies point to the fact that greater lung damage occurs with (experimentally intentional) aspiration of thicker consistencies compared to thinner consistencies, for example, thickened water compared to regular water. Thus, it would seem prudent to make sure that extremely thick liquids or pureed foods are not associated with aspiration in patients with dysphagia prior to prescribing their inclusion in diets.

One further negative outcome that may require careful consideration when prescribing TMFs for people with dysphagia is the presence of pharyngeal residue after the swallow. Here, once again, there is very little evidence in the published literature to provide guidance, although the evidence that is available suggests that there is an increased risk of pharyngeal residue with extremely thick (and perhaps sticky) liquids compared to thinner consistencies[4]. Whether extremely thick liquids are likely to result in greater pharyngeal residue than moderately or mildly thick liquids, and whether starch-thickened liquids contribute to greater pharyngeal residue than xanthan gum-thickened liquids remains unclear at this time and is confounded by the influence of bolus volume across the available studies[3,5]. One interesting bolus property that may have particular relevance based on this literature is stickiness. Whether there are differences in pharyngeal residue across stimuli with different degrees of stickiness/adhesiveness in IDDSI Level 4 (extremely thick liquids/pureed foods) remains an important question for future research.

Conclusion

The literature covered in this narrative review highlights several issues that contribute to a lack of clarity regarding the impact of food texture modification on oral processing swallowing. Among these is the lack of clear, consistent and well-defined terminology to describe food texture, particularly for studies performed prior to the introduction of IDDSI Framework. However, one related but perhaps more difficult challenge is the fact that most research in this area has explored outcomes of dietary modifications that include both the use of thickened fluids and the concurrent modification of food texture, rather than examining the impact of modifying food texture in isolation. Where swallowing outcomes have been measured, they focus almost exclusively on penetration-aspiration and respiratory outcomes. While a few studies have explored differences in pharyngeal residue across varying degrees of liquid thickening, there is a paucity of clinical studies comparing oral processing and chewing outcomes for pureed foods compared to different degrees of food texture modification. What little information can be gleaned from the literature depends on inferences drawn from studies involving extremely thick liquids which, as per IDDSI Framework, have similar textural and rheological characteristics to pureed foods.

Conflicts of interest

CMS has received fees as a speaker and for teaching, training and research activities from Nestlé Health Science, and serves as a member of the board of directors for IDDSI, the International Dysphagia Diet Standardisation Initiative.

REFERENCES

1. *Clave P, Shaker R. Dysphagia: current reality and scope of the problem. Nat Rev Gastroenterol Hepatol. 2015;12(5):259-70.*
2. *Cichero JA, Steele C, Duivestein J, Clave P, Chen J, Kayashita J, et al. The Need for International Terminology and Definitions for Texture-Modified Foods and Thickened Liquids Used in Dysphagia Management: Foundations of a Global Initiative. Curr Phys Med Rehabil Rep. 2013;1:280-91.*
3. *Vilardell N, Rofes L, Arreola V, Speyer R, Clave P. A Comparative Study Between Modified Starch and Xanthan Gum Thickeners in Post-Stroke Oropharyngeal Dysphagia. Dysphagia. 2016;31(2):169-79.*
4. *Hind J, Divyak E, Zielinski J, Taylor A, Hartman M, Gangnon R, et al. Comparison of standardized bariums with varying rheological parameters on swallowing kinematics in males. J Rehabil Res Dev. 2012;49(9):1399-404.*
5. *Steele CM, Peladeau-Pigeon M, Barbon CAE, Guida BT, Namasivayam-MacDonald AM, Nascimento WV, et al. Reference Values for Healthy Swallowing Across the Range From Thin to Extremely Thick Liquids. J Speech Lang Hear Res. 2019;62(5):1338-63.*
6. *Robbins J, Nicosia M, Hind JA, Gill GD, Blanco R, Logemann J. Defining Physical Properties of Fluids for Dysphagia Evaluation and Treatment. SIG 13 Perspectives on Swallowing and Swallowing Disorders (Dysphagia). 2002;11(2):16-9.*
7. *Garcia JM, Chambers Et, Molander M. Thickened liquids: practice patterns of speech-language pathologists. Am J Speech Lang Pathol 2005;14(1):4-13.*
8. *Hiiemae K. Mechanismss of food reduction, transport and deglutition: How the texture of food affects feeding behaviour. J Texture Stud. 2004;35:171-200.*
9. *Hiiemae K, Heath MR, Heath G, Kazazoglu E, Murray J, Sapper D, et al. Natural bites, food consistency and feeding behaviour in man. ArchOral Biol. 1996;41(2):175-89.*
10. *Hiiemae KM, Palmer JB. Food Transport and Bolus Formation during Complete Feeding Sequences on Foods of Different Initial Consistency. Dysphagia. 1999;14(1):31-42.*
11. *Palmer JB, Hiiemae KM, Liu J. Tongue-jaw linkages in human feeding: a preliminary videofluorographic study. Archives of Oral Biology 1997;42:429-41.*
12. *Steele CM, Martin-Harris B, Gosa MM, Edwards Allen S. Diagnosis and Management of Swallowing Physiology: Standardized Contrast, the MBSImP™, & the IDDSI Framework. . Applied Radiology. 2021.*
13. *Arvedson JC, Brodsky L. Pediatric swallowing and feeding: Assessment and management. 2nd Edition ed. Albany, NY: Singular Publishing; 2002.*
14. *Arvedson JC, Lefton-Greif M. Anatomy, physiology and development of feeding. Seminars in Speech & Language. 1996;17:261-8.*
15. *Adams V, Mathisen B, Baines S, Lazarus C, Callister R. A systematic review and meta-analysis of measurements of tongue and hand strength and endurance using the Iowa Oral Performance Instrument (IOPI). Dysphagia. 2013;28(3):350-69.*
16. *Robbins J, Gangnon RE, Theis SM, Kays SA, Hewitt AL, Hind JA. The effects of lingual exercise on swallowing in older adults. J Am Geriatr Soc. 2005;53(9):1483-9.*
17. *Minakuchi S, Tsuga K, Ikebe K, Ueda T, Tamura F, Nagao K, et al. Oral hypofunction in the older population: Position paper of the Japanese Society of Gerodontology in 2016. Gerodontology. 2018;35(4):317-24.*
18. *Huckabee ML, McIntosh T, Fuller L, Curry M, Thomas P, Walshe M, et al. The Test of Masticating and Swallowing Solids (TOMASS): reliability, validity and international normative data. Int J Lang Commun Disord. 2018;53(1):144-56.*
19. *Lamvik-Gozdzikowska K, Guiu Hernandez E, Apperley O, McIntosh T, Huckabee ML. Quantitative assessment of oral phase efficiency: validation of the Test of Masticating and Swallowing Solids (TOMASS). Int J Lang Commun Disord. 2019.*
20. *Frank U, van den Engel-Hoek L, Nogueira D, Schindler A, Adams S, Curry M, et al. International standardisation of the test of masticating and swallowing solids in children. J Oral Rehabil. 2019;46(2):161-9.*
21. *Sakai K, Nakayama E, Rogus-Pulia N, Takehisa T, Takehisa Y, Urayama KY, et al. Submental Muscle Activity and Its Role in Diagnosing Sarcopenic Dysphagia. Clin Interv Aging. 2020;15:1991-9.*
22. *Sakai K, Nakayama E, Tohara H, Kodama K, Takehisa T, Takehisa Y, et al. Relationship between tongue strength, lip strength, and nutrition-related sarcopenia in older rehabilitation inpatients: a cross-sectional study. Clin Interv Aging. 2017;12:1207-14.*
23. *Onuki W, Magara J, Tsujimura T, Ito K, Sakai H, Kulvanich S, et al. Survey of oral hypofunction in older outpatients at a dental hospital. J Oral Rehabil. 2021;48(10):1173-82.*
24. *Wakabayashi H. Presbyphagia and Sarcopenic Dysphagia: Association between Aging, Sarcopenia, and Deglutition Disorders. J Frailty Aging. 2014;3(2):97-103.*

25. Rogus-Pulia NM, Gangnon R, Kind A, Connor NP, Asthana S. A Pilot Study of Perceived Mouth Dryness, Perceived Swallowing Effort, and Saliva Substitute Effects in Healthy Adults Across the Age Range. Dysphagia. 2018;33(2):200-5.
26. Cichero JAY, Lam P, Steele CM, Hanson B, Chen J, Dantas RO, et al. Development of International Terminology and Definitions for Texture-Modified Foods and Thickened Fluids Used in Dysphagia Management: The IDDSI Framework. Dysphagia. 2017;32(2):293-314.
27. Cichero JAY, Lam PTL, Chen J, Dantas RO, Duivestein J, Hanson B, et al. Release of updated International Dysphagia Diet Standardisation Initiative Framework (IDDSI 2.0). J Texture Stud. 2019.
28. Keller HH, Carrier N, Slaughter SE, Lengyel C, Steele CM, Duizer L, et al. Prevalence and Determinants of Poor Food Intake of Residents Living in Long-Term Care. J Am Med Dir Assoc. 2017;18(11):941-7.
29. Vucea V, Keller HH, Morrison JM, Duizer LM, Duncan AM, Carrier N, et al. Modified Texture Food Use is Associated with Malnutrition in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. J Nutr Health Aging. 2018;22(8):916-22.
30. Vucea V, Keller HH, Morrison JM, Duncan AM, Duizer LM, Lengyel CO, et al. Intake and Factors Associated with Consumption of Pureed Food in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. J Nutr Gerontol Geriatr. 2018;37(2):59-81.
31. Namasivayam-MacDonald AM, Morrison JM, Steele CM, Keller H. How Swallow Pressures and Dysphagia Affect Malnutrition and Mealtime Outcomes in Long-Term Care. Dysphagia. 2017;32(6):785-96.
32. Miles A, Liang V, Sekula J, Broadmore S, Owen P, Braakhuis AJ. Texture-modified diets in aged care facilities: Nutrition, swallow safety and mealtime experience. Australas J Ageing. 2020;39(1):31-9.
33. Streicher M, Wirth R, Schindler K, Sieber CC, Hiesmayr M, Volkert D. Dysphagia in Nursing Homes-Results From the NutritionDay Project. J Am Med Dir Assoc. 2018;19(2):141-7 e2.
34. Cichero JAY, editor Dysphagia Diets in Australia: IDDSI Standardised terminology keeping people safe. Japanese Society for Dysphagia Research; 2021; Nagoya, Japan.
35. Andersen UT, Beck AM, Kjaersgaard A, Hansen T, Poulsen I. Systematic review and evidence based recommendations on texture modified foods and thickened fluids for adults (>=18 years) with oropharyngeal dysphagia. e-SPEN Journal. 2013;8(4):e127-e34.
36. Beck AM, Kjaersgaard A, Hansen T, Poulsen I. Systematic review and evidence based recommendations on texture modified foods and thickened liquids for adults (above 17 years) with oropharyngeal dysphagia - An updated clinical guideline. Clin Nutr. 2018;37(6 Pt A):1980-91.
37. Steele CM, Alsanei WA, Ayanikalath S, Barbon CE, Chen J, Cichero JA, et al. The influence of food texture and liquid consistency modification on swallowing physiology and function: a systematic review. Dysphagia. 2015;30(1):2-26.
38. Newman R, Vilardell N, Clave P, Speyer R. Effect of Bolus Viscosity on the Safety and Efficacy of Swallowing and the Kinematics of the Swallow Response in Patients with Oropharyngeal Dysphagia: White Paper by the European Society for Swallowing Disorders (ESSD). Dysphagia. 2016;31(2):232.
39. Wu XS, Miles A, Braakhuis A. Nutritional Intake and Meal Composition of Patients Consuming Texture Modified Diets and Thickened Fluids: A Systematic Review and Meta-Analysis. Healthcare (Basel). 2020;8(4).
40. Wu XS, Miles A, Braakhuis AJ. Texture-Modified Diets, Nutritional Status and Mealtime Satisfaction: A Systematic Review. Healthcare (Basel). 2021;9(6).
41. Kwak, S., Chu YJ, Choi KT, Chang MC. Safety and Efficacy of Specially Designed Texture-Modified Foods for Patients with Dysphagia Due to Brain Disorders: A Prospective Study. Healthcare. 2021(9):728.
42. Logemann JA, Gensler G, Robbins J, Lindbald AS, Brandt D, Hind JA, et al. A randomized study of three interventions for aspiration of thin liquids in patients with dementia or Parkinson's disease. . Journal of Speech Language & Hearing Research. 2008;51(1):173-83.
43. Robbins J, Gensler G, Hind J, et al. Comparison of 2 interventions for liquid aspiration on pneumonia incidence: A randomized trial. Annals of Internal Medicine. 2008;148(7):509-18.
44. Siddiqui MT, Litts JK, Cheney DM, Kuhn MA, Nativ-Zeltzer N, Belafsky PC. The effect of aspirated barium sulfate, iodixanol, and diatrizoic acid on survival and lung injury in a lagomorph model. Laryngoscope. 2017;127(5):E148-E52.
45. Ueha R, Nativ-Zeltzer N, Sato T, Goto T, Yamauchi A, Belafsky PC, et al. The effects of barium concentration levels on the pulmonary inflammatory response in a rat model of aspiration. Eur Arch Otorhinolaryngol. 2020;277(1):189-96.

46. *Nativ-Zeltzer N, Ueha R, Nachalon Y, Ma B, Pastenkos G, Swackhamer C, et al. Inflammatory Effects of Thickened Water on the Lungs in a Murine Model of Recurrent Aspiration. Laryngoscope. 2021;131(6):1223-8.*

47. *Nativ-Zeltzer N, Kuhn MA, Imai DM, Traslavina RP, Domer AS, Litts JK, et al. The effects of aspirated thickened water on survival and pulmonary injury in a rabbit model. Laryngoscope. 2018;128(2):327-31.*

AN OVERVIEW OF THE SCREENING AND EVALUATION OF ORAL FUNCTION IN OLDER ADULTS

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Oropharyngeal dysphagia is a term used to describe difficulty in swallowing and transporting food or liquid from the mouth to the oesophagus. A reported 8% of the world's population suffers from dysphagia[1]. Although dysphagia may occur at any age, the reported prevalence increases above the age of 65 years to 30%-40%[1]. Dysphagia has been recognised as a geriatric syndrome[2], and its prevalence is thought to exceed 50% in elderly adults living in nursing homes and residential care facilities[3, 4]. These individuals have increased morbidity and are also prone to weight loss, dehydration and malnutrition[5, 6].

Chewing difficulties are another prominent concern in the elderly, for which reason recognition as a geriatric syndrome has been proposed based on co-occurrence with sarcopenia and other elements of frailty[7]. Both chewing difficulties and dysphagia are components of poor oral health or 'oral hypofunction' in the elderly[8,9]. Oral health comprises mastication, swallowing and speaking functions and is a fundamental part of physical health, quality of life and general well-being. Oral hypofunction is associated with declines in systemic health and, more specifically, reduced nutrient intake and malnutrition[10, 11]. Therefore, it is important to develop methods to screen oral function among older adults and address oral health concerns that represent risks of dysphagia and malnutrition.

Studies have linked malnutrition, sarcopenia and frailty to a variety of different components of poor oral function, including a small number of remaining functional teeth[12], hard and soft tissue resorption[13], oral pain[14], impaired chewing ability[15], impaired masticatory performance[16], reduced bite force[17], xerostomia or reduced salivary flow[18], reduced tongue strength[19], impaired oral motor skills[20] and impaired swallowing[21]. Experts have advocated that the regular twice-yearly examination of oral function can help to identify risk for oral hypofunction and promote improved quality of life[22]; however, there is a lack of international consensus on methods for evaluating oral function. In 2016, the Japanese Society of Gerodontology released a position paper proposing that the identification of oral hypofunction should involve a detailed examination of seven oral health conditions: dentition status, masticatory function, occlusal force, oral hygiene and moisture, tongue pressure, oral motor skill and swallowing function[23]. They proposed that oral hypofunction should be identified if three or more signs and symptoms meet the cut-off criteria. However, the proposed cut-off values are not necessarily aligned with the different screening tools available globally for evaluating oral function. This variation in testing protocols and cut-off scores makes it difficult to compare results across studies. Therefore, in this narrative review, we will describe the elements and tools used to screen for oral hypofunction in older adults.

Screening of Overall Oral Health Status

The Geriatric Oral Health Assessment Index (GOHAI)[24] and Oral Health Assessment Tool (OHAT)[25] are commonly used tools to measure oral health and oral health-related quality of life (OHQOL) in the elderly population. The GOHAI is a self-report questionnaire that comprises twelve questions about physical function (eating, swallowing and speaking), psychological function (worry about oral health)

and pain (discomfort while eating). Responses are provided on a 5-point Likert scale (1 - always, 2 - often, 3 - sometimes, 4 - rarely, 5 - never). A high cumulative total score (57-60) indicates good oral health, whereas scores under 50 represent compromised oral health. The OHAT consists of eight items (oral hygiene, natural teeth, saliva, tongue, lips, gingiva, dentures and dental pain) scored by a clinician, caregiver or researcher. The scores are categorical (0 - healthy, 1 - oral changes, 2 - unhealthy), and scores of 1 or 2 in any item indicate the need for referral to a dental professional.

Screening of Dentition

Tooth loss impairs masticatory performance and chewing efficiency, leading to difficulties with bolus formation. Edentulousness is a common finding in older age, with a wide variation between countries. The prevalence of edentulousness in people aged 65–74 years in upper/middle-income countries is high (35%), whereas the mean number of remaining natural teeth is lower than 20 in most countries, particularly in people over 75 years of age. The rate of edentulousness in people over 65 years in Europe ranges from 7% to 45% [26, 27]. Tooth loss in the elderly is associated with an increased risk of dysphagia and poor health[28] and with malnutrition[29]. The World Health Organization (WHO) stated that at least 20 teeth are necessary for older adults to maintain proper function[30]. However, both the number and also the functional arrangement of natural and artificial teeth are relevant for masticatory function. A dental prosthesis serves as a first-line treatment to replace missing teeth. Older adults wearing complete dentures report greater difficulty with chewing than those with removable partial dentures, while those with removable partial dentures report greater difficulty than those with fixed partial dentures[31, 32]. The Eichner index (EI) is a method for evaluating functional dentition, independent of the type(s) of prosthesis present, based on the number of occlusal contacts between natural or restored pre-molar and molar teeth[33]. Tooth loss is categorised into three groups: individuals in Group A have four occlusal contact support zones (full support); individuals in Group B have one to three occlusal contact support zones; and individuals in group C have no occlusal contact support zones across their remaining teeth. Groups A and C. It has been found that increasing occlusal support (i.e., group A >group B) in older adults resulted in better chewing function by increasing bite force and shortening chewing duration[34]. Another study reported that individuals in Eichner Group C with no occlusal support also had a lower prognostic nutritional index (PNI)[35]. The Eichner classification is a reliable tool for capturing dental function based on the number of functional occlusal units present.

Screening of Masticatory Performance

Masticatory performance and efficiency are two related constructs, and both of them are important in evaluating oral function and focusing on comminution, i.e., the ability to break food down into smaller pieces. Masticatory performance is defined as 'a measure of the comminution of food attainable under standardized testing conditions', while masticatory efficiency is defined as 'the effort required to achieve a standard degree of comminution of food'[36]. Masticatory performance is measured based on a person's ability to fragment standard test foods or their self-report responses to questions regarding chewing food. By contrast, masticatory efficiency is measured by counting the number of chewing cycles required to reduce the original test food particle to half size[37]. Individuals with impaired masticatory function are at risk of choking due to inadequate particle size reduction.

Several different approaches have been used to study comminution in food science literature. One method is to measure the size of food particles expectorated after chewing, most commonly by determining whether dried particles pass through sieves. A comminution test can use either a single sieve or multiple sieves. In the single sieve method, the weight percentage of chewed food passing through a sieve with a fixed aperture is calculated after several chewing cycles. In the multiple sieve method, the average particle size after a given number of chewing cycles is calculated, or the d50, i.e., median particle size represented by the aperture of the sieve through which 50% of the sample has passed[38]. Smaller particle sizes signify better comminution and better masticatory function.

A more recent method for evaluating masticatory function involves evaluating food mixing ability using colour-changing wax or chewing gum[39]. Two-coloured chewing gums such as ViviDent Fruit Swing or Hue-Check Gum can be used [40]. Alternatively, two sticks of differ-

ent-coloured chewing gum can be stacked and given to the patient or research participant. The test has the person chew the gum normally for a pre-determined number of chewing cycles and then expectorate the chewed bolus from the mouth. Subsequently, a 5-graded scale is used to assess the colour mixture and bolus form[41] in combination with an optoelectronic assessment to measure the variance of hue (VOH)[39]. Better masticatory function translates into a strong colour mixture and a low VOH. The colour mixing ability method is better than the comminution method for differentiating between subjects with intact versus impaired masticatory function[42].

Another option for evaluating masticatory function is based on the premise that the chewing process releases chemical components of the bolus into the mouth, where they are mixed with saliva. Tests involving the chewing of gummy jelly candies have been developed on this basis[43, 44]. Here, a gummy jelly is chewed for a specified number of chewing cycles and expectorated into a collection device with saliva. The collection device retains particles on a sieve while allowing the saliva to drain through into a jar, and a probe is used to measure the glucose content of the saliva specimen[45]. A clinical evaluation of chewing can also be conducted using the Test of Mastication and Swallowing of Solids (TOMASS)[46]. The TOMASS requires the subject to ingest a standard cracker 'as rapidly and as comfortably as possible'. Similar crackers sourced around the world have been used to develop preliminary reference measures. The test produces four measures: number of bites, masticatory cycles per bite, swallows per bite and total time taken per cracker. The TOMASS is reliable and valid compared to instrumental metrics of the number and duration of chewing cycles[46, 47]. Individuals with dysphagia have reportedly presented a significantly higher number of masticatory cycles, swallows and total time per cracker [47].

Screening of Occlusal/Biting Force

One explanation for reduced masticatory performance and impaired comminution ability may be reduced bite force. Bite force may be influenced by the subject's anatomical and physiological characteristics, such as age, gender, dental status, type of dental prosthesis and facial morphology[48]. Bite force is frequently reduced in older adults due to muscular atrophy[49]. Weak occlusal force is associated with longer chewing cycles and swallowing of coarser, less comminuted food.

Maximum voluntary bite force (MBF) can be measured with a pressure-sensitive sheet or a plate housing a force transducer[50]. Examples of such devices include:

- The GM10 occlusal force meter was developed by Nagano Keiki, Japan, and consists of a bite plate of vinyl material and a hydraulic pressure gauge. The bite force is calculated in Newtons (N) and the value is displayed digitally. For measurement, the subjects are instructed to bite the sensor part (at the first molar region) as hard as possible 3-5 times, and an average value is calculated. The accuracy, repeatability and validity of the GM10 occlusal force meter in measuring MBF have been previously published[51].
- The Dental Prescale system (Dental Prescale, Fuji Film Co., Tokyo, Japan) consists of a horseshoe-shaped bite sheet and a computerised system for scanning. Each sheet contains two pressure-sensitive foils with colouration according to intensity[52].
- The T-Scan system (Tekscan, Inc., South Boston, MA) consists of an ultra-thin sensor sheet in the shape of a dental arch[53]. One advantage of this system is the ultra-thin, low-profile sensors, conducive to recording in a close-to-natural position, thus making it comfortable for the subject[54].

Attention must be paid to recording technique, device location along the dental arch, device dimension, and unilateral versus bilateral measurement, all of which can influence the value of MBF measures[55]. Previous studies have demonstrated associations between low MBF and increased dysphagia risk in older adults[56] and also between low MBF, malnutrition and frailty[17].

Screening of Salivary Function and Oral Moisture

Saliva plays a crucial role in oral function by facilitating mastication, bolus formation, and swallowing. Older adults frequently suffer from dry mouth[57]. Salivary production can be evaluated objectively using tests of stimulated saliva weight or volume (after chewing gum or paraffin wax for a specified time period and expectorating oral contents for measurement) or by collecting unstimulated saliva in a

collection cup over a given time frame[58]. The Saxon Test is a simple screening method to measure saliva secretion, in which the subject is instructed to chew on a sterile gauze sponge for 2 minutes[59]. The amount of saliva produced is determined by measuring the increase in gauze weight after chewing. The reliability of the Saxon Test has been confirmed, with an average score of <2.00 g after 2 minutes indicative of hyposalivation[60].

An alternative approach to screening for issues with salivary flow is to measure moisture levels inside the mouth. The modified Schirmer Test is one such test[61], using filter paper test strips, calibrated in 1-mm intervals and impregnated with blue dye at the 0-mm wick end, which are placed sublingually on the floor of the patient/participant's mouth. When exposed to moisture, the dye travels up the length of the strip and the distance of blue dye travelled can be read at a designated interval of one minute. Devices for measuring oral moisture levels are also available. One such device, the Oral Moisture Checker (Mucus, Life Co., Ltd, Japan), has been reported to be useful for screening for dry mouth and is easy to use with elderly patients. First, the subject is asked to rinse their mouth with 100 ml of water to create a common starting condition. The device probe is then placed on the dorsum of the tongue at a pressure of about 200 g cm2, described as just enough pressure to notice the neck of the sensor beginning to bend. The device estimates oral mucosal moisture at rest within 2 seconds, causing minimal discomfort. Values <27% (in weight percent water content) at the tongue location are considered to signify dry mouth[62]. Yamada and colleagues found significantly lower oral moisture measures in adults with hyposalivation than those with typical saliva production, with the results confirmed by stimulated salivary flow tests. Similar results were subsequently reported by Fukushima et al.[63].

Screening of Tongue Pressure Generation Capacity

The tongue helps to swallow and process food by producing propulsive forces to transport the bolus through the oropharynx. The measurement of maximum isometric tongue pressure (or tongue strength) is commonly used in swallowing assessments. Various devices have been developed for measuring lingual strength. However, the most accessible device available in clinical practice involves an air-filled bulb placed in the mouth on top of the tongue. The patient/participant is instructed to squeeze the bulb against the hard palate using their tongue, and the resulting change in pressure is measured in a hand-held device to which the bulb is connected. Two examples of this type of device include the Iowa Oral Performance Instrument (IOPI Medical LLC, Carnation, WA, USA) and the Japanese JMS tongue pressure measuring device (TPM-01, JMS Co., Ltd.)[64]. Maximum isometric pressure (MIP) is measured as the greatest pressure in kilopascals (kPa) across 3 task repetitions. Pressures can also be measured during regular effort saliva swallows (RESS) or effortful saliva swallows (ESS)[65]. Although measurement values are similar across the IOPI and the JMS devices[64,66], the thresholds for classifying a person with tongue weakness may be device-specific. Several studies concur that tongue strength declines gradually with ageing[67-69]. Reduced tongue strength has been identified as a target for intervention in adults with dysphagia[70-72] and is associated with longer meal durations and reduced dietary intake in older adults in residential care facilities[73].

Screening of Oral Motor Function

The oral motor system is concerned with mastication, swallowing, speech production and denture retention[74]. Any issues with muscle tone, strength and the initiation and coordination of movement may impact these functions. The specific structures and muscles of interest are those receiving motor innervation from cranial nerves V (trigeminal), VII (facial), IX (glossopharyngeal), X (vagus), XI (spinal accessory) and XII (hypoglossal), i.e., the lips, jaw, cheeks, soft palate, tongue, pharynx, neck and larynx, as well as components of the respiratory system that are needed for speech and swallowing. Sensory function supported by the trigeminal, facial, glossopharyngeal and vagus nerves is also commonly included in orofacial evaluations as part of comprehensive speech and swallowing assessments. Age-related decline in oral motor function is reportedly associated with a higher risk of dysphagia[75]. Therefore, it is important to assess the oral motor system as part of the evaluation of oral function. The oral mechanism examination generally involves the evaluation of muscle symmetry, tone, strength and elements of rate, endurance and pre-

cision in sustained use and rapid alternating movement tasks (diadochokinesis)[76]. Reference values are available to aid the interpretation of maximum performance tasks[77]. One common component of oral motor function evaluation, which has specifically been included in the Japanese Society of Gerodontology-recommended oral function tests, are diadochokinetic speech tasks, in which the patient/participant is asked to pronounce the syllables "pa-pa-pa", "ta-ta-ta" or "ka-ka-ka" sequentially for five seconds as fast as possible, and the number of repetitions per second is calculated[62]. This task may also be made more challenging from a coordination perspective by alternating between the three syllables (i.e., "pa-ta-ka-pa-ta-ka"). According to a recent review, reported mean values for "pa-pa-pa" repetition in healthy adults aged 70 and older range from 4.23 to 6.7 syllables per second[77]. Slightly lower average values are reported for the "ta", "ka", and "pa-ta-ka" tasks. Several studies suggest that diadochokinetic rates decline with advancing age and frailty[19]. The Japanese Society of Gerodontology position paper proposes that a diadochokinetic rate of <6.0 syllables per second may indicate tongue-lip motor hypofunction, warranting further assessment.

Screening of Swallowing Function

The Japanese Society of Gerodontology position paper concludes its guidance regarding the evaluation of oral function by recommending a standard screen for dysphagia (swallowing impairment). It should be noted that the gold standard comprehensive swallowing assessment involves either a radiographic (videofluoroscopy) or fiberoptic endoscopic evaluation of swallowing. There is some debate in the field regarding both the diagnostic criteria for dysphagia and swallow screening methods. The Japanese position paper explicitly suggests the Eating Assessment Tool (EAT-10), a questionnaire used to identify patient-reported symptoms of swallowing difficulty[78]. The EAT-10 comprises ten questions rated on a scale of 0-4 (no problem to severe problem), resulting in cumulative scores ranging from 0 to 40 points. EAT-10 total scores of 3 or greater are considered to indicate a need to refer the patient for comprehensive assessment[78]; higher scores have also been reported in individuals with more severe dysphagia, with an increased risk of aspiration in those with scores >15 [79]. The EAT-10 has been published by the Nestlé Nutrition Institute and is available in several languages.

Other commonly used procedures for swallow screening involve clinician observation for signs and symptoms of swallowing difficulty on water swallow tests[80, 81]. It should be noted that most of these tests focus on signs suggesting possible penetration or aspiration of material into the airway, such as coughing, throat clearing or wet voice quality. As a rule, swallow screening protocols do not include observations of mastication, oral processing or swallowing with thicker consistencies or solid food textures. For additional discussion regarding methods for evaluating swallowing and choking risks with solid foods, please refer to the article by Steele in this issue.

Conclusion

The literature covered in this narrative review highlights the various indices, instruments and questionnaires available for screening of oral function, including overall oral health status, dentition, masticatory performance, occlusal/biting force, oral moisture and salivary function, tongue pressure, oral motor skills and swallowing function. Further research is needed to validate the cut-offs proposed for differentiating healthy oral function from oral hypofunction in older adults and to confirm the sensitivity and specificity of these measures for identifying risk for dysphagia, malnutrition and other sequelae.

Conflicts of interest

CMS has received fees as a speaker and for teaching, training and research activities from Nestlé Health Science, and serves as a member of the board of directors for IDDSI, the International Dysphagia Diet Standardisation Initiative.

REFERENCES

1. *Wirth R, Dziewas R, Beck AM, Clavé P, Hamdy S, Heppner HJ, et al. Oropharyngeal dysphagia in older persons–from pathophysiology to adequate intervention: a review and summary of an international expert meeting. Clinical interventions in aging. 2016;11:189.*
2. *Baijens LW, Clave P, Cras P, Ekberg O, Forster A, Kolb GF, et al. European Society for Swallowing Disorders - European Union Geriatric Medicine Society white paper: oropharyngeal dysphagia as a geriatric syndrome. Clin Interv Aging. 2016;11:1403-28.*
3. *Clave P, Rofes L, Carrion S, Ortega O, Cabre M, Serra-Prat M, et al. Pathophysiology, relevance and natural history of oropharyngeal dysphagia among older people. Nestle Nutrition Institute workshop series. 2012;72:57-66.*
4. *Steele CM, Greenwood C, Ens I, Robertson C, Seidman-Carlson R. Mealtime difficulties in a home for the aged: not just dysphagia. Dysphagia 1997;12(1):43-50.*
5. *Clave P, Shaker R. Dysphagia: current reality and scope of the problem. Nat Rev Gastroenterol Hepatol. 2015;12(5):259-70.*
6. *Keller HH, Carrier N, Slaughter SE, Lengyel C, Steele CM, Duizer L, et al. Prevalence and determinants of poor food intake of residents living in long-term care. Journal of the american Medical Directors association. 2017;18(11):941-7.*
7. *Woo J, Tong C, Yu R. Chewing difficulty should be included as a geriatric syndrome. Nutrients. 2018;10(12):1997-2011.*
8. *Minakuchi S, Tsuga K, Ikebe K, Ueda T, Tamura F, Nagao K, et al. Oral hypofunction in the older population: Position paper of the Japanese Society of Gerodontology in 2016. Gerodontology. 2018;35(4):317-24.*
9. *Yoon MN, Ickert C, Slaughter SE, Lengyel C, Carrier N, Keller H. Oral health status of long-term care residents in Canada: Results of a national cross-sectional study. Gerodontology. 2018;35(4):359-64.*
10. *Iwasaki M, Hirano H, Ohara Y, Motokawa K. The association of oral function with dietary intake and nutritional status among older adults: Latest evidence from epidemiological studies. Jpn Dent Sci Rev. 2021;57:128-37.*
11. *Mann T, Heuberger R, Wong H. The association between chewing and swallowing difficulties and nutritional status in older adults. Aust Dent J. 2013;58(2):200-6.*
12. *Hakeem FF, Bernabé E, Sabbah W. Association between oral health and frailty: A systematic review of longitudinal studies. Gerodontology. 2019;36(3):205-15.*
13. *Hasegawa Y, Sakuramoto A, Sugita H, Hasegawa K, Horii N, Sawada T, et al. Relationship between oral environment and frailty among older adults dwelling in a rural Japanese community: a cross-sectional observational study. BMC Oral Health. 2019;19(1):1-6.*
14. *Bakker MH, Vissink A, Spoorenberg SL, Wynia K, Visser A. Self-reported oral health problems and the ability to organize dental care of community-dwelling elderly aged≥ 75 years. BMC Oral Health. 2020;20(1):1-9.*
15. *Iwasaki M, Motokawa K, Watanabe Y, Shirobe M, Inagaki H, Edahiro A, et al. Association between oral frailty and nutritional status among community-dwelling older adults: the Takashimadaira study. The journal of nutrition, health & aging. 2020;24(9):1003-10.*
16. *Horibe Y, Ueda T, Watanabe Y, Motokawa K, Edahiro A, Hirano H, et al. A 2-year longitudinal study of the relationship between masticatory function and progression to frailty or pre-frailty among community-dwelling Japanese aged 65 and older. Journal of Oral Rehabilitation. 2018;45(11):864-70.*
17. *Iwasaki M, Yoshihara A, Sato N, Sato M, Minagawa K, Shimada M, et al. A 5-year longitudinal study of association of maximum bite force with development of frailty in community-dwelling older adults. Journal of oral rehabilitation. 2018;45(1):17-24.*
18. *Friedlander AH, Friedlander IK, Gallas M, Velasco E. Late-life depression: its oral health significance. International dental journal. 2003;53(1):41-50.*
19. *Watanabe Y, Hirano H, Arai H, Morishita S, Ohara Y, Edahiro A, et al. Relationship between frailty and oral function in community-dwelling elderly adults. Journal of the American Geriatrics Society. 2017;65(1):66-76.*
20. *Matsuo K, Kito N, Ogawa K, Izumi A, Kishima M, Itoda M, et al. Improvement of oral hypofunction by a comprehensive oral and physical exercise programme including textured lunch gatherings. Journal of Oral Rehabilitation. 2021;48(4):411-21.*
21. *Clave P, Arreola V, Romea M, Medina L, Palomera E, Serra-Prat M. Accuracy of the volume-viscosity swallow test for clinical screening of oropharyngeal dysphagia and aspiration. Clin Nutr. 2008;27(6):806-15.*
22. *Hatanaka Y, Furuya J, Sato Y, Taue R, Uchida Y, Shichita T, et al. Regular Oral Health Management Improved Oral Function of Outpatients with Oral Hypofunction in Dental Hospital: A Longitudinal Study. International Journal of Environmental Research and Public Health. 2022;19(4):2154.*

23. Minakuchi S, Tsuga K, Ikebe K, Ueda T, Tamura F, Nagao K, et al. Oral hypofunction in the older population: Position paper of the Japanese Society of Gerodontology in 2016. Gerodontology. 2018;35(4):317-24.
24. Atchison KA, Dolan TA. Development of the geriatric oral health assessment index. Journal of dental education. 1990;54(11):680-7.
25. Chalmers J, King P, Spencer A, Wright F, Carter K. The oral health assessment tool—validity and reliability. Australian dental journal. 2005;50(3):191-9.
26. Petersen PE, Kandelman D, Arpin S, Ogawa H. Global oral health of older people--call for public health action. Community Dent Health. 2010;27(4 Suppl 2):257-67.
27. Kossioni AE. Current status and trends in oral health in community dwelling older adults: a global perspective. Oral Health Prev Dent. 2013;11(4):331-40.
28. Holm-Pedersen P, Schultz-Larsen K, Christiansen N, Avlund K. Tooth loss and subsequent disability and mortality in old age. Journal of the American Geriatrics Society. 2008;56(3):429-35.
29. Kossioni AE. The Association of Poor Oral Health Parameters with Malnutrition in Older Adults: A Review Considering the Potential Implications for Cognitive Impairment. Nutrients. 2018;10(11).
30. Petersen PE, Yamamoto T. Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. Community dentistry and oral epidemiology. 2005;33(2):81-92.
31. Limpuangthip N, Tumrasvin W, Sakultae C. Masticatory index for patients wearing dental prosthesis as alternative to conventional masticatory ability measures. PloS one. 2022;17(1):e0263048.
32. Lee J-H, Kim DH, Park Y-G, Lee SY. Chewing Discomfort According to Dental Prosthesis Type in 12,802 Adults: A Cross-Sectional Study. International Journal of Environmental Research and Public Health. 2021;18(1):71.
33. Ikebe K, Matsuda K-i, Murai S, Maeda Y, Nokubi T. Validation of the Eichner index in relation to occlusal force and masticatory performance. International Journal of Prosthodontics. 2010;23(6).
34. Huang Y-F, Liu S-P, Muo C-H, Chang C-T. The impact of occluding pairs on the chewing patterns among the elderly. Journal of Dentistry. 2021;104:103511.
35. Abe A, Kurita K, Hayashi H, Ishihama T, Ueda A. Correlation between prognostic nutritional index and occlusal status in gastric cancer. Oral Diseases. 2020;26(2):465-72.
36. Ferro KJ, Morgano SM, Driscoll CF, Freilich MA, Guckes AD, Knoernschild KL, et al. The glossary of prosthodontic terms. 2017.
37. Bates J, Stafford G, Harrison A. Masticatory function—a review of the literature: III. Masticatory performance and efficiency. Journal of oral rehabilitation. 1976;3(1):57-67.
38. van der Bilt A, van der Glas HW, Mowlana F, Heath MR. A comparison between sieving and optical scanning for the determination of particle size distributions obtained by mastication in man. Arch Oral Biol. 1993;38(2):159-62.
39. Buser R, Ziltener V, Samietz S, Fontolliet M, Nef T, Schimmel M. Validation of a purpose-built chewing gum and smartphone application to evaluate chewing efficiency. Journal of oral rehabilitation. 2018;45(11):845-53.
40. Arakawa I, Abou-Ayash S, Genton L, Tsuga K, Leles CR, Schimmel M. Reliability and comparability of methods for assessing oral function: Chewing, tongue pressure and lip force. Journal of oral rehabilitation. 2020;47(7):862-71.
41. Liedberg B, Ekberg O, Owall B. Chewing and the dimension of the pharyngoesophageal segment. Dysphagia 1991;6(4):214-8.
42. Speksnijder CM, Abbink JH, van der Glas HW, Janssen NG, van der Bilt A. Mixing ability test compared with a comminution test in persons with normal and compromised masticatory performance. Eur J Oral Sci. 2009;117(5):580-6.
43. Murakami K, Hori K, Yoneda H, Sato N, Suwanarpa K, Sta. Maria MT, et al. Compatibility of two types of gummy jelly tests for detecting decreased masticatory function. Gerodontology. 2022;39(1):10-6.
44. Nokubi T, Yoshimuta Y, Nokubi F, Yasui S, Kusunoki C, Ono T, et al. Validity and reliability of a visual scoring method for masticatory ability using test gummy jelly. Gerodontology. 2013;30(1):76-82.
45. Kobayashi Y, Shiga H, Arakawa I, Yokoyama M. The effectiveness of measuring glucose extraction for estimating masticatory performance. Prosthodontic research & practice. 2006;5(2):104-8.
46. Huckabee ML, McIntosh T, Fuller L, Curry M, Thomas P, Walshe M, et al. The Test of Masticating and Swallowing Solids (TOMASS): reliability, validity and international normative data. International Journal of Language & Communication Disorders. 2018;53(1):144-56.
47. Todaro F, Pizzorni N, Scarponi L, Ronzoni C, Huckabee ML, Schindler A. The Test of Masticating and Swallowing Solids

(TOMASS): Reliability and validity in patients with dysphagia. Int J Lang Commun Disord. 2021;56(3):558-66.

48. Palinkas M, Nassar MSP, Cecílio FA, Siéssere S, Semprini M, Machado-de-Sousa JP, et al. Age and gender influence on maximal bite force and masticatory muscles thickness. Archives of oral biology. 2010;55(10):797-802.
49. Ahn KY, Kim ST. The change of maximum bite force after botulinum toxin type a injection for treating masseteric hypertrophy. Plastic and reconstructive surgery. 2007;120(6):1662-6.
50. van der Bilt A. Assessment of mastication with implications for oral rehabilitation: a review. J Oral Rehabil. 2011;38(10):754-80.
51. Serra C, Manns A. Bite force measurements with hard and soft bite surfaces. Journal of Oral Rehabilitation. 2013;40(8):563-8.
52. Shinogaya T, Bakke M, Thomsen C, Vilmann A, Matsumoto M. Bite force and occlusal load in healthy young subjects--a methodological study. The European journal of prosthodontics and restorative dentistry. 2000;8(1):11-5.
53. Maness WL, Golden RF, Benjamin MH, Podoloff RM. Pressure and contact sensor system for measuring dental occlusion. Google Patents; 1989.
54. Verma TP, Kumathalli KI, Jain V, Kumar R. Bite force recording devices-a review. Journal of clinical and diagnostic research: JCDR. 2017;11(9):ZE01.
55. Koc D, Dogan A, Bek B. Bite force and influential factors on bite force measurements: a literature review. Eur J Dent. 2010;4(2):223-32.
56. Ono T, Kumakura I, Arimoto M, Hori K, Dong J, Iwata H, et al. Influence of bite force and tongue pressure on oro-pharyngeal residue in the elderly. Gerodontology. 2007;24(3):143-50.
57. Närhi T. Prevalence of subjective feelings of dry mouth in the elderly. Journal of dental research. 1994;73(1):20-5.
58. Takano T, Kugimiya Y, Morita K, Tazawa S, Ueda T, Sakurai K. Intra-and inter-investigator reliabilities of oral moisture measured using an oral moisture-checking device. Journal of oral rehabilitation. 2020;47(4):480-4.
59. Kohler PF, Winter ME. A quantitative test for xerostomia. The Saxon test, an oral equivalent of the Schirmer test. Arthritis Rheum. 1985;28(10):1128-32.
60. Ono Minagi H, Yamanaka Y, Sakai T. Evaluation of the Saxon test for patients with hyposalivation without Sjögren's syndrome. Journal of Oral Rehabilitation. 2020;47(12):1550-6.
61. Chen A, Wai Y, Lee L, Lake S, Woo S-B. Using the modified Schirmer test to measure mouth dryness: a preliminary study. The Journal of the American Dental Association. 2005;136(2):164-70.
62. Yamada A, Kanazawa M, Komagamine Y, Minakuchi S. Association between tongue and lip functions and masticatory performance in young dentate adults. Journal of oral rehabilitation. 2015;42(11):833-9.
63. Fukushima Y, Yoda T, Kokabu S, Araki R, Murata T, Kitagawa Y, et al. Evaluation of an oral moisture-checking device for screening dry mouth. Open Journal of Stomatology. 2013;3(08):440.
64. Utanohara Y, Hayashi R, Yoshikawa M, Yoshida M, Tsuga K, Akagawa Y. Standard values of maximum tongue pressure taken using newly developed disposable tongue pressure measurement device. Dysphagia. 2008;23(3):286-90.
65. Steele CM. Optimal approaches for measuring tongue-pressure functional reserve. Journal of Aging Research. 2013;2013.
66. Yoshikawa M, Yoshida M, Tsuga K, Akagawa Y, Groher ME. Comparison of three types of tongue pressure measurement devices. Dysphagia. 2011;26(3):232-7.
67. Nicosia MA, Hind JA, Roecker EB, Carnes M, Doyle J, Dengel GA, et al. Age effects on the temporal evolution of isometric and swallowing pressure. Journals of Gerontology Series A-Biological Sciences & Medical Sciences 2000;55(11):M634-40.
68. Fei T, Polacco RC, Hori SE, Molfenter SM, Peladeau-Pigeon M, Tsang C, et al. Age-related Differences in Tongue-Palate Pressures for Strength and Swallowing Tasks. Dysphagia. 2013.
69. Vanderwegen J, Guns C, Van Nuffelen G, Elen R, De Bodt M. The influence of age, sex, bulb position, visual feedback, and the order of testing on maximum anterior and posterior tongue strength and endurance in healthy belgian adults. Dysphagia. 2013;28(2):159-66.
70. Robbins J, Kays SA, Gangnon RE, Hind JA, Hewitt AL, Gentry LR, et al. The effects of lingual exercise in stroke patients with dysphagia. Arch Phys Med Rehabil. 2007;88(2):150-8.
71. Yeates EM, Molfenter SM, Steele CM. Improvements in tongue strength and pressure-generation precision following a tongue-pressure training protocol in older individuals with dysphagia: three case reports. Clin Interv Aging. 2008;3(4):735-47.
72. Rogus-Pulia N, Rusche N, Hind JA, Zielinski J, Gangnon R,

Safdar N, et al. Effects of Device-Facilitated Isometric Progressive Resistance Oropharyngeal Therapy on Swallowing and Health-Related Outcomes in Older Adults with Dysphagia. J Am Geriatr Soc. 2016;64(2):417-24.

73. *Namasivayam AM, Steele CM, Keller H. The effect of tongue strength on meal consumption in long term care. Clinical Nutrition. 2016;35(5):1078-83.*

74. *Baum B, Bodner L. Aging and oral motor function: evidence for altered performance among older persons. Journal of dental research. 1983;62(1):2-6.*

75. *Rech R, Baumgarten A, Colvara B, Brochier C, de Goulart B, Hugo F, et al. Association between oropharyngeal dysphagia, oral functionality, and oral sensorimotor alteration. Oral diseases. 2018;24(4):664-72.*

76. *McAllister S, Kruger S, Doeltgen S, Tyler-Boltrek E. Implications of variability in clinical bedside swallowing assessment practices by speech language pathologists. Dysphagia. 2016;31(5):650-62.*

77. *Kent RD, Kim Y, Chen L-m. Oral and Laryngeal Diadochokinesis Across the Life Span: A Scoping Review of Methods, Reference Data, and Clinical Applications. Journal of Speech, Language, and Hearing Research. 2022;65(2):574-623.*

78. *Belafsky PC, Mouadeb DA, Rees CJ, Pryor JC, Postma GN, Allen J, et al. Validity and reliability of the Eating Assessment Tool (EAT-10). Ann Otol Rhinol Laryngol. 2008;117(12):919-24.*

79. *Cheney DM, Siddiqui MT, Litts JK, Kuhn MA, Belafsky PC. The Ability of the 10-Item Eating Assessment Tool (EAT-10) to Predict Aspiration Risk in Persons With Dysphagia. Ann Otol Rhinol Laryngol. 2015;124(5):351-4.*

80. *Martino R, Silver F, Teasell R, Bayley M, Nicholson G, Streiner DL, et al. The Toronto Bedside Swallowing Screening Test (TOR-BSST): development and validation of a dysphagia screening tool for patients with stroke. Stroke. 2009;40(2):555-61.*

81. *Suiter DM, Sloggy J, Leder SB. Validation of the Yale Swallow Protocol: a prospective double-blinded videofluoroscopic study. Dysphagia. 2014;29(2):199-203.*

CURRENT PRACTICES AND CHALLENGES WITH THE PRODUCTION OF PUREED FOODS

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The number of people suffering from dysphagia is on the rise, and the likelihood of developing dysphagia increases with age alongside increasing comorbidities[1–3]. As a symptom of many diseases and disorders, it is not surprising that studies find the prevalence of dysphagia to be higher in people with greater health-related disabilities. The prevalence of dysphagia is higher in institutional settings compared with hospitals or community settings and is more likely in patients discharged to a nursing home after hospitalisation than in those who are able to return home independently[4–7].

There has been a growing trend towards developing texture-modified diets (TMDs) as a dietary intervention to address dysphagia and chewing difficulties, with over one third of institutionalised residents requiring TMDs[8–10]. The goal of using TMDs is to ensure safe and/or efficient oral intake. TMDs are categorised based on their textural characteristics, including hardness, adhesiveness, cohesiveness, firmness, fracturability, springiness, viscosity and yield stress[11]. Different levels of TMDs are often achieved by softening, chopping, mincing, mashing and blending. Among all TMDs, the puree category has been studied the most extensively over the last decade. Pureed food must be free of lumps and is designed to require no chewing effort. Considering the common use of pureed food for institutional residents, this paper will summarise the evidence to date concerning pureed food production.

1. Standardisation of pureed food

A lack of standardised puree meal production puts institutionalised people at risk[12,13]. Based on our systematic review, it is difficult to establish how compliant food service operations were in producing pureed diets given an absence of consistent descriptions and of limited studies assessing meal textures[12]. The first international framework for TMDs and thickened fluids was published by the International Dysphagia Diet Standardisation Initiative (IDDSI) in 2015, which categorises TMDs into four continuous levels (level 6 - soft & bite-sized, level 5 - minced & moist, level 4 - pureed and level 3 - liquidised)[11]. Prior to publication of IDDSI Framework, several countries developed and implemented national standardisations of terminologies and descriptions for puree (Table 1). Other terminologies, such as blended, mashed and homogenised, have been used to describe pureed diets in previous studies[12].

Table 1. Common terminologies and descriptions used for pureed diet published by different countries.

COUNTRY	TERMINOLOGY	DESCRIPTION
IDDSI [11]	**Pureed**	This diet should have no lumps and not be sticky. The liquid must not separate from the solid. Foods can fall off a spoon in a single spoonful when tilted and continue to hold shape on a plate. Foods do not require chewing.
USA [14]	**Level 1 – Dysphagia pureed**	The diet consists of foods that are pureed, homogenous and cohesive. Foods should be "pudding-like". Foods that require bolus formation, controlled manipulation and chewing are not allowed.
UK [15]	**Texture C – Thick puree dysphagia diet**	This diet should be smooth throughout with no "bits", and the bolus should remain cohesive in the mouth. Foods should be able to hold their shape, moist and not sticky in the mouth. There is no loose fluid that has separated off. Require no chewing.
Australia/ New Zealand [16]	**Texture C – Smooth Puree**	This diet consists of smooth and lump-free foods but may have a grainy quality. It should have a consistency similar to commercial pudding. Foods should be moist and cohesive enough to hold their shape on a spoon.
Japan [17]	**Level 2 – Gelatine jelly (mixer meal with gelatine)**	This diet includes blender, mixer, pureed or paste foods. The foods should not be sticky and can be scooped up with a spoon. Subcode 2-1 refers to smooth and homogeneous particles, and 2-2 refers to heterogeneous particles, including soft particles.

IDDSI = International Dysphagia Diet Standardisation Initiative

Producing pureed food can be difficult due to texture and consistency requirements, particularly with foods containing high fibre and water content (such as meat and leafy vegetables). It is important to assess the textural parameters affecting food oral processing and swallowing[18]. Food technology industries and food scientists have explored the rheological and textural components of pureed foods using objective instrumental techniques. Several empirical methods are frequently used to measure pureed food consistency, including the line spread test, the Bostwick consistometer method and IDDSI testing methods. Fundamental testing methods can obtain a comprehensive textural analysis, identifying the viscoelasticity, extensional flow, slipperiness and mechanical properties of pureed foods[19,20]. Common food science guidelines for measuring puree textures focus on food viscosity before ingestion. While saliva plays an important role in oral cavity activity, there is insufficient evidence investigating the viscosity, solubility and stability properties of pureed foods after they have been introduced into the mouth[21].

Rigorous rheological testing is only feasible for industry and large commercial kitchens, but not in institutional settings at the bedside or point of meal service delivery. IDDSI introduced accessible and low-cost testing methods for all levels of TMDs which can be carried out in institutional food services. The Fork Drip Test and Spoon Tilt Test are recommended to assess the cohesiveness and adhesiveness of pureed foods. Pureed food should be able to hold its shape on the spoon and sit in a mound/pile on the fork. To pass these tests, a small amount of puree food may flow through the spaces between the tines of the fork without continuously dripping, and it must also easily slide off a spoon with very little food remaining[22]. Despite these easy-to-use IDDSI testing methods, testing pureed food before serving is not a routine practice[11,23,24]. Health professionals, food service staff, patients and caregivers often use visual inspection to evaluate appropriateness, and few studies have evaluated the application of IDDSI testing in institutional food services[11,24,25]. A promising photographic tool-atlas developed by Spanish researchers

provides a visualised demonstration of TMDs, which can be used as a food testing reference for caregivers, clinical and food service staff[26]. More research is required to identify feasible and accurate measurements for clinical, food service and industry stakeholders.

2. Challenges related to standardisation

The adoption of IDDSI terminology facilitates consistent communication for everyone involved in dysphagia management. While IDDSI universal dysphagia diet framework was launched in 2015, and has been widely endorsed globally, it is still in the process of being implemented in many healthcare settings. Our previous work and other early studies have explored implementation and have reported favourable attitudes towards IDDSI[23,27–29]. However, they have also uncovered implementation challenges. Institutional facilities differ in terms of operational structure and organisational culture and implementation plans need be tailored based on needs analyses. Limited empirical evidence is available to establish the most effective implementation strategies for institutional settings, although multidisciplinary support has been advocated[23,30,31]. One disadvantage of institutional settings with regard to hospitals is that dieticians and speech-language therapists are not always available, making collaboration with the food service and caregivers more difficult[23,32]. An investment in additional human resources and a dedicated project leader appears to be valuable in the initial implementation phase[23].

In an institutional environment, staff often use different terminologies, resulting in miscommunication and incorrect delivery[10,33,34]. Our recent work found that pureed diets had the best compliance with IDDSI standards compared with the Minced & Moist and Soft & Bite-sized levels, yet only half of the institutional pureed meals audited were IDDSI-compliant[23]. The most common examples of non-compliance involved stickiness, lumps in soup and offering cake/biscuits without modifications[23]. Staff were often familiar with pureed diets due to frequent use in institutions, although the descriptions were not fully understood[23]. It has been reported that distinguishing between pureed and minced and moist consistencies during meal service is challenging, particularly with commercial products[23]. Furthermore, staff reported uncertainty about suitable desserts, fruits and mid-meal options.

A lack of dysphagia training has been reported by clinical and food service staff[33,35]. Personnel involved in food production and feeding require proper education regarding IDDSI Framework. For example, food service staff should learn the requirements of each level of TMDs, labelling and how to test compliance with IDDSI criteria. Meanwhile, clinical staff require a theoretical exploration of the framework and a deeper understanding of dysphagia management, feeding techniques, clinical signs and an ability to identify inappropriate food. By incorporating practical demonstrations, such as hands-on testing practice and meal preparation training, staff can be more actively engaged and more effectively educated[30]. Based on the challenges identified, we conducted an institution-tailored implementation, and pureed food compliance improved significantly by 42% six months into the intervention[35]. Additionally, staff had a significantly higher knowledge level of IDDSI after the intervention in terms of IDDSI Framework, testing methods and the identification of pureed food appropriateness[35].

The targeted intervention yielded promising results in enhancing staff understanding of IDDSI and providing more IDDSI-compliant pureed foods, although pureed diets still failed to fully adhere to IDDSI standards[35]. Using a comprehensive IDDSI implementation including tailored strategies can be effective and sustainable. Continuous monitoring and reflection are imperative and have been lacking in previous institutional-driven implementation[23].

3. Challenges related to nutrition

People with dysphagia are more likely to experience weight loss, malnutrition and nutrient deficiencies[12]. Our systematic review indicated that institutional residents consuming TMDs are evidently more susceptible to malnutrition, particularly those requiring a pureed diet[36]. With regard to food textures, residents requiring pureed diets had the lowest nutritional status score[10]. Pureed diets typically contain fewer nutrients due to the higher level of texture and consistency modification, such as the need to add water to reach the appropriate texture[25,37]. Several studies have shown that institutional pureed menus are significantly low in nutrients, particularly in energy, protein, carbohydrates, fat and fibre[12]. The blending and typical

thermal processing used in kitchens cause considerable nutrient loss, including vitamins and fibre[20,37]. Accordingly, oral nutritional supplements and meal fortification are commonly used to add extra nutrients for residents requiring pureed diets[12]. In our recently published observational study, 41% of institutional residents requiring pureed diets were prescribed oral nutritional supplements[9]. Consistent with the literature, our study found that 63% of the residents were able to complete all the daily oral nutritional supplements offered, which contributed to a significantly higher total energy and protein intake[38,39]. Offering oral nutritional supplements on a regular basis encourages adherence, although it may influence meal consumption as a result of satiety and mouth-drying, particularly dairy-based ONS containing whey or casein protein[40,41]. Further research is needed to examine long-term compliance and sensory influence on intake for pureed diet consumers[9,42].

Before oral nutritional supplements are implemented, dieticians should be consulted for advice on whether food-first strategies, such as offering small and frequent meals or nutrient-dense foods, can be feasible. The food-first approach has positive effects on nutritionally vulnerable older adults and can be used in combination with other dietary approaches[12]. A range of ingredients has been used in pureed food fortification, including vitamin powder, rice-based infant cereals, high-fibre cereals, whey protein powder and rapeseed oil[39,43–45]. In our systematic review, we concluded that studies that have implemented fortified pureed diets reported significant improvement in energy, protein and micronutrient intake, and therefore more residents were able to meet their nutritional recommendations[12,39,43,45]. Purchasing pre-fortified foods is a more common approach in institutions rather than incorporating fortification into freshly made foods[46,47]. It should be noted that some ingredients used in the fortification process have thickening effects and would consequently alter the texture and consistency of pureed foods[44]. Future studies should consider exploring whether fortified pureed foods still comply with IDDSI standards.

The reduced nutritional content of pureed diets requires a larger portion of food to achieve an individual's nutrition requirement, although in our recent work we found that only 59% of residents were able to finish their pureed meals[46]. Although enhanced nutrition intake with a reduction in food consumption has been reported with the use of enzyme infusion, the relationship between meal consumption and nutrition intake is inconclusive because there are few intervention studies[48]. Offering small amounts of food with a higher nutrition density is critical for people with small appetites.

Some promising cutting-edge technologies, such as non-thermal technologies and three-dimensional (3D) printing, have been applied in the production of pureed foods. In contrast to the conventional modification methods involving a dilution process, non-thermal technologies can preserve modified foods with greater nutritional density, aesthetic appeal and flavour of the meat[49]. These technologies may support greater mealtime consumption. An instrumental sensory analysis, nutritional profile, swallowing assessment and consumer test should be incorporated to determine the suitability and acceptability of novel pureed food.

4. Challenges related to palatability

Adequate nutritional consumption is multifactorial in institutionalised adults, related not only to food quality but also to physical and cognitive barriers to self-feeding and motivation to eat. Institutionalised older adults are at a higher risk of developing cognitive impairment, which can lead to a decreased sense of smell and taste perception[50,51]. Pureed diets are not only nutritionally inferior, but often have an unattractive meal presentation, resulting in reduced appetite and a loss of interest in eating. In this regard, palatability is an essential component contributing to the quality of pureed diets, which is strongly related to residents' acceptance and compliance. In a qualitative study exploring residents' sensory perception of pureed food, residents were unsatisfied with the quality and the consistency of pureed diets, particularly the appearance, taste and presentation of the foods[52]. Similar findings were observed from our recent consumer test study (under review), in which we surveyed healthcare professionals and healthy older adults and found that the appearance of pureed foods was the least accepted sensory aspect. The provision of flavourful and attractive pureed diets can compensate for the loss of sensory perception and incapacity to distinguish the food[53]. Aesthetic appeal can be improved by adjusting flavour, texture and consistency, adding colourful garnish and reshaping appearance.

Shaped/moulded pureed meals have a significantly better appearance and consequently give rise to greater mealtime satisfaction, suggesting that visually appealing pureed diets may stimulate oral intake (Figure 1)[48]. Flavour and texture liking are positively related to the appearance of TMDs[54]. Additionally, pureed food palatability is affected by ingredient contents, processing technique and thickeners[55,56]. In order to produce in-house shaped pureed foods, food services often add ingredients with a thickening function, such as commercial starch-based or gum-based thickeners, commercial enzyme gellant or natural starchy ingredients (bread, flour, cereals). Thickeners vary in terms of stability (over time, with temperature and depending on what they are added to) as well as in terms of consistency, colour and taste. Thickeners should therefore be carefully selected to reduce any adverse impact on safety or mealtime enjoyment. Inappropriate amounts of thickeners can lead to a sticky texture that is unsuitable for a pureed diet[57,58]. Dieticians and speech-language therapists should be consulted when staff are unsure about product compliance.

Another challenge for food services is to maintain the shape of moulded purees. Frozen moulded purees are sensitive to temperature change and may lose the defined outline and their texture may be altered after re-heating[11]. It is crucial for food service operations to heat up purees to the optimal temperature and retest them against IDDSI Level 4 Audit Tool at serving temperature (www.iddsi.org). While there is a lack of robust evidence suggesting positive feedback from institutional residents, improved intake was found in institutions using shaped pureed diets[45,58–60]. We confirmed this conclusion with a meta-analysis which demonstrated that both energy and protein intake were better with shaped TMDs[12]. Compared to puree foods shaped with thickeners, 3D printing provides a more promising appearance without affecting the texture or taste of pureed foods[61]. However, the feasibility of implementing 3D printed pureed diet in institutional settings requires further exploration and clinical assessments.

Figure 1. Moulded pureed meals (left) compared to typical pureed meals (right) served in institutional settings.

5. Institutional menu planning

Menu cycles in most institutional settings range from three to six weeks[62]. Several studies have reported that the nutrients offered by pureed menus were typically lower than regular menus and failed to meet the recommended serving sizes[46,62,63]. Menu quality varies across institutions depending on their size, operation style, staff availability and dietician involvement[32,62]. Poor nutritional quality and non-compliant textures coincide with a lack of standardised pureed diet recipes and inconsistent portion sizes[62]. Based on our TMD menu audit results, high-fibre foods such as whole grains, raw fruits and vegetables are usually missing from pureed menus due to food texture restrictions. Adding pureed fruit or fibre supplements to porridge and pureed lentils to soups can increase the fibre content[64]. Food service managers should clearly document the ingredient ratios and cooking methods for all foods. Portioning can be improved by using standard scoops and moulds[35].

Additionally, the number of food choices and variety of pureed diets can be limited, particularly during mid-meals[33,65]. Menu choices have been identified as a predictor of pureed meal consumption[66]. Sweet-tasting mid-meals and desserts are preferred by institutional older adults with dysphagia and low appetite[55,67]. Foods such as ice cream, fruit yoghurt, custard and whipped cream are high in energy and protein and should be available to residents with poor oral intake, especially those who tend to skip meals. Our recent study concurs with Keller and Duizer's findings, which indicated a lack of variety when commercial products were used[52]. Using a mixture of commercial products and freshly made purees and different condiment combinations can reduce the boredom of repetitive foods. Pureed menus should incorporate naturally pureed textured foods, which are more acceptable, such as pudding, mousse, porridge and mashed potatoes.

We also found that the majority of pureed meals were plated meal service while regular meals were served from a bulk-tray service. Moreover, second helpings were not offered to anyone who finished their meals. Offering nutrient-rich snacks and second helpings to residents is crucial to enable adequate consumption from planned menus. Residents from different cultural backgrounds tend to be less compliant with unfamiliar institutional foods[68]. Therefore, culturally diverse pureed foods should be offered on menus, based on the demographics of institutional residents. An interview study conducted with dietary staff reported that chefs have little involvement in pureed recipe development depending on their experience and organisation characteristics[25]. Developing culinary courses targeting pureed meals for special diets can be helpful for institutional chefs. Longer menu cycles and more food choices per meal may improve residents' satisfaction and reduce the risk of malnutrition[69]. Food waste monitoring and resident satisfaction surveys can effectively identify residents' preferences. To be cost-efficient, institutions often prepare food in large quantities. In our evaluation of institutional pureed choices, the cost of commercial ready-made purees was reported to be higher than producing in-house, although they offer standardised consistency and save staff cooking time[23]. Therefore, institutions need to weigh the advantages and price differences based on the amount of production required and staff availability.

Institutional food services frequently use a mix of ready-made commercial products and freshly prepared foods made in-house. Furthermore, menu planning costs should factor in food purchases, food wastage, staff labour and possible hospitalisation costs. Dieticians should routinely review the nutrition profile of food products and assess the overall nutrients provided by menus with a view to ensuring that they offer adequate nutrition and variety. Pureed foods are known to be indistinguishable or unrecognisable, and thus the staff involved in food preparation and serving should be familiar with the food content and be able to explain it to residents. Inaccuracies in delivery can be minimised using IDDSI colour-coded food labels[45].

6. Meal service

In a previous study, nurses reported that mealtime observation was their usual screening approach for dysphagia, whereas less than half of nursing homes had a clinical protocol implemented for screening and assessment[70]. Several studies have observed that pureed diets are often offered to residents with dementia to minimise choking risk without speech-language therapist assess-

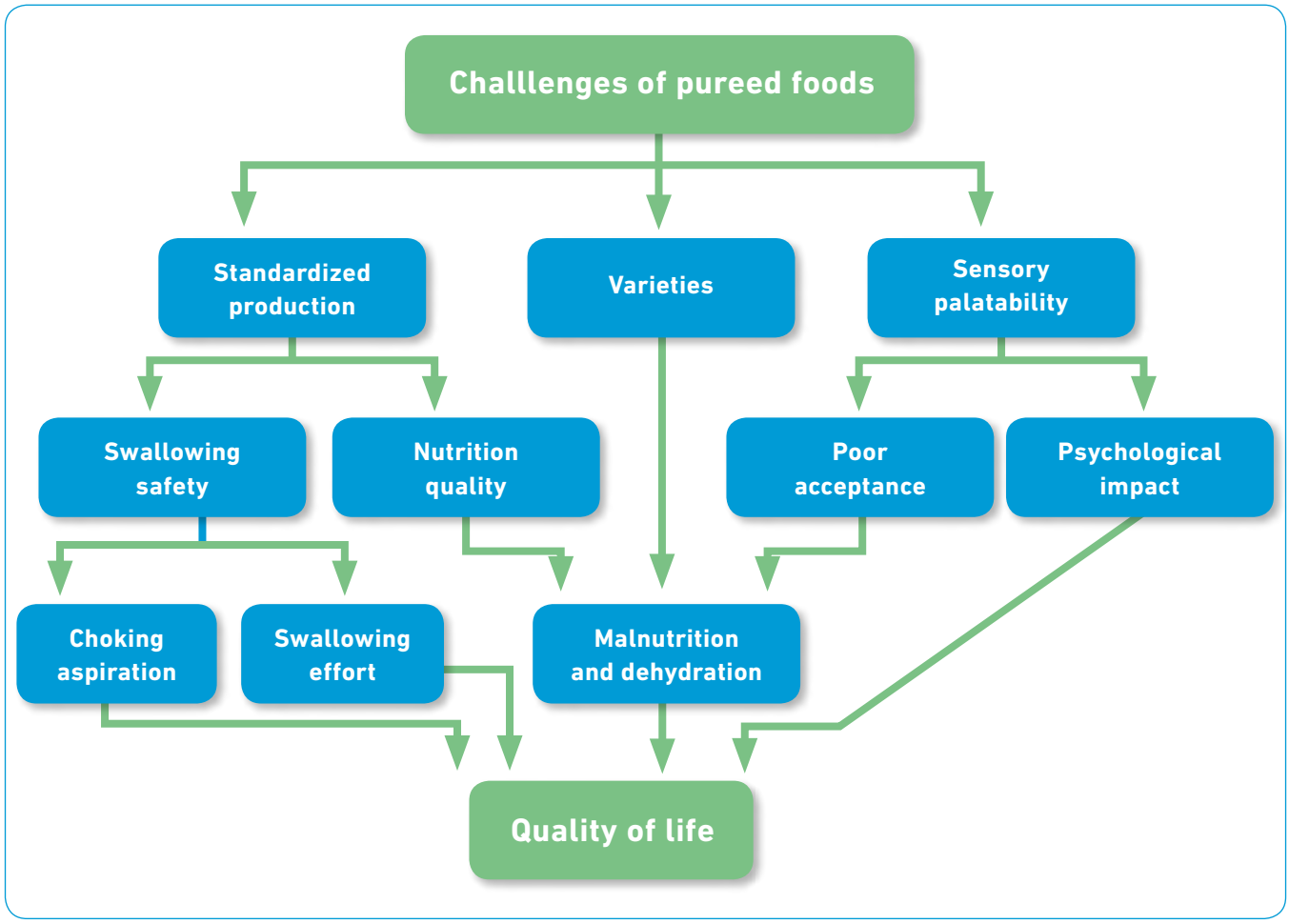
ment[71,72]. Pureed diets may be being overused in institutional settings without comprehensive assessment due to the limited access or funding for speech-language therapists[73]. Speech-language therapists have a wide range of interventions available to them beyond texture modification. Pureed food should not replace other levels of TMDs for residents who require less food modification and all texture modification should be a last resort for the maintenance of quality of life. Long-term consumption of pureed food is associated with low self-esteem, a feeling of embarrassment, refusal to eat and reduced quality of life[74,75]. Institutions need to recognise the role of speech-language therapists and dieticians.

The need for supervision and feeding assistance is exceptionally high among residents receiving pureed diets[46,76]. Pureed meals are often stirred together during feeding when the facility is understaffed, as demonstrated by previous study results and our own regular observations during institution mealtimes[52,77]. This further impairs a resident's capacity to distinguish the food on their plate with further reduction in mealtime enjoyment. Using safe feeding strategies can enhance residents' dining experience and improve patient safety. Staff should encourage social interaction and additional time for slower eaters[78]. Close observation and resident-centred strategies can positively influence patient long-term satisfaction and quality of life without compromising safety[68]. For residents requiring mealtime assistance, staff may consider planning designated mealtime schedules following speech-language therapist recommendations. Offering optimal self-feeding utensils and dinnerware, such as lipped plates and spoons, can motivate independence in eating and in making residents feel more empowered and experience pleasure[78,79]. Future studies should explore interventions that can improve residents' mealtime enjoyment and the efficiency of mealtime assistance.

Conclusions

We have highlighted several challenges involved in producing nutritious, palatable and IDDSI-compliant pureed foods (Figure 2). Variations in pureed food processing can significantly impact nutritional quality, nutrient composition, texture and consistency. As a result of insufficient nutrients offered by pureed menus, coupled with poor acceptance, older institutional adults are at high risk of malnutrition. To overcome this barrier, greater attention must be paid to nutrition quality, standardised production and sensory acceptance when in the production of pureed foods. The majority of the institutions used a combination of in-house-made and commercial products to prepare pureed diets. Fortified pureed foods and moulding have been proven to be effective strategies for improving nutrition intake. Furthermore, commercial thickeners, ready-made purees and new processing technologies are promising in improving quality of life through enhanced presentation and consistent texture, although the impact on oral intake and nutritional status requires further consolidated research. The provision of a pureed diet in institutional settings requires multidisciplinary input and a tailored implementation approach. Dysphagia clinicians such as speech-language therapists and dieticians may consider working together to develop a guideline on pureed diet prescription for clinical staff, particularly for facilities with limited resources and access. In the meantime, dieticians must support menu development and keep institutions conversant with commercial products to maximise nutrition and palatability.

Figure 2. Current challenges with the production of pureed food.



REFERENCES

1. *Leder SB, Suiter DM. An epidemiologic study on aging and dysphagia in the acute care hospitalized population: 2000-2007. Gerontology. 2009;55(6):714–8.*
2. *Bhattacharyya N. The prevalence of dysphagia among adults in the United States. Otolaryngol - Head Neck Surg (United States). 2014;151(5):765–9.*
3. *Serra-Prat M, Hinojosa G, Lõpez D, Juan M, Fabré E, Voss DS, et al. Prevalence of oropharyngeal dysphagia and impaired safety and efficacy of swallow in independently living older persons. Journal of the American Geriatrics Society. 2011.*
4. *Lin LC, Wu SC, Chen HS, Wang TG, Chen MY. Prevalence of impaired swallowing in institutionalized older people in Taiwan. J Am Geriatr Soc. 2002;50(6):1118–23.*
5. *Baijens LWJ, Clavé P, Cras P, Ekberg O, Forster A, Kolb GF, et al. European society for swallowing disorders - European union geriatric medicine society white paper: Oropharyngeal dysphagia as a geriatric syndrome. Clin Interv Aging. 2016;11:1403–28.*
6. *Namasivayam AM, Steele CM. Malnutrition and Dysphagia in Long-Term Care: A Systematic Review. J Nutr Gerontol Geriatr [Internet]. 2015;34(1):1–21. Available from: http://dx.doi.org/10.1080/21551197.2014.1002656*
7. *Carrión S, Cabré M, Monteis R, Roca M, Palomera E, Serra-Prat M, et al. Oropharyngeal dysphagia is a prevalent risk factor for malnutrition in a cohort of older patients admitted with an acute disease to a general hospital. Clin Nutr. 2015;*
8. *Pauly L, Stehle P, Volkert D. Nutritional situation of elderly nursing home residents. Z Gerontol Geriatr. 2007 Feb;40(1):3–12.*
9. *Wu XS, Yousif L, Miles A, Braakhuis A. A Comparison of Dietary Intake and Nutritional Status between Aged Care Residents Consuming Texture-Modified Diets with and without Oral Nutritional Supplements. Nutrients [Internet]. 2022 Feb 5;14(3):669. Available from: https://www.mdpi.com/2072-6643/14/3/669*
10. *Vucea V, Keller HH, Morrison JM, Duizer LM, Duncan AM, Steele CM. Prevalence and Characteristics Associated with Modified Texture Food Use in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. Can J Diet Pract Res [Internet]. 2019;80(3):104–10. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med16&NEWS=N&AN=30724101*
11. *Cichero JAY, Lam P, Steele CM, Hanson B, Chen J, Dantas RO, et al. Development of International Terminology and Definitions for Texture-Modified Foods and Thickened Fluids Used in Dysphagia Management: The IDDSI Framework. Dysphagia. 2017;32(2):293–314.*
12. *Wu XS, Miles A, Braakhuis A. Nutritional Intake and Meal Composition of Patients Consuming Texture Modified Diets and Thickened Fluids: A Systematic Review and Meta-Analysis. Healthcare. 2020;8(4):579.*
13. *Cichero JAY, Steele C, Duivestein J, Clavé P, Chen J, Kayashita J, et al. The Need for International Terminology and Definitions for Texture-Modified Foods and Thickened Liquids Used in Dysphagia Management: Foundations of a Global Initiative. Curr Phys Med Rehabil Reports. 2013;1(4):280–91.*
14. *National Dysphagia Diet Task Force., editor. National Dysphagia Diet: Standardization for Optimal Care. In: Journal of the American Dietetic Association. [Chicago, Ill.]: Elsevier Science Publishers; 2004. p. 1182.*
15. *British Dietetic Association. National Descriptors for Texture Modification in Adults. 2011.*
16. *Australia DA of, Limited TS pathology A of A. Texture-modified foods and thickened fluids as used for individuals with dysphagia Australian standardised labels and definitions. Nutr Diet. 2007;64(s2):53–76.*
17. *The Dysphagia Diet Committee of the Japanese Society of Dysphagia Rehabilitation. The Japanese Dysphagia diet 2013. Japanese J Dysphagia Rehabil. 2013;17:225–67.*
18. *Hadde EK, Chen J, E.K. H, Chen J. AO - Hadde Jianshe; ORCID: http://orcid.org/0000-0002-7000-1469 EK. O http://orcid. org/000.-0002-0642-7035 AO-C. Texture and texture assessment of thickened fluids and texture-modified food for dysphagia management. J Texture Stud [Internet]. 2021;52(1):4–15. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emexc&NEWS=N&AN=633363604*
19. *Giura L, Urtasun L, Belarra A, Ansorena D, Astiasarán I. Exploring tools for designing dysphagia-friendly foods: A review. Foods. 2021;10(6):1–16.*
20. *Raheem D, Carrascosa C, Ramos F, Saraiva A, Raposo A. Texture-modified food for dysphagic patients: A comprehensive review. Int J Environ Res Public Health. 2021;18(10).*
21. *Sukkar SG, Maggi N, Travalca Cupillo B, Ruggiero C. Optimizing Texture Modified Foods for Oro-pharyngeal Dysphagia: A Difficult but Possible Target? Front Nutr. 2018;5(August):1–10.*
22. *Martineau C. International Dysphagia Diet Standardisa-*

tion Initiative: IDDSI Framework Testing Methods [Internet]. Medecine des Maladies Metaboliques. 2019. Available from: http://iddsi.org/framework/ (accessed

23. Wu XS, Braakhuis AJ, Miles A. An Evaluation of Texture-Modified Diets Compliant with the International Dysphagia Diet Standardization Initiative in Aged-Care Facilities Using the Consolidated Framework for Implementation Research. Dysphagia. 2022;
24. Côté C, Giroux A, Villeneuve-Rhéaume A, Gagnon C, Germain I. Is iddsi an evidence-based framework? A relevant question for the frail older population. Geriatr [Internet]. 2020;5(4):1–16. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85094675303&doi=10.3390%2Fgeriatrics5040082&partnerID=40&md5=b48ca1b305c7c69aa1333dc5072cc83d
25. Ilhamto N, Anciado K, Keller HH, Duizer LM. In-House Pureed Food Production in Long-Term Care: Perspectives of Dietary Staff and Implications for Improvement. J Nutr Gerontol Geriatr [Internet]. 2014;33(3):210–28. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med10&NEWS=N&AN=25105716
26. Ruiz Brunner MLM, Cieri ME, Rodríguez Marco MP, Cuestas E. The photographic atlas of Spanish food consistency: a new tool for the treatment of dysphagia. Rev Esp Enferm Dig [Internet]. 2019;111(11):858–61. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85074874342&doi=10.17235%2Freed.2019.6305%2F2019&partnerID=40&md5=51341f2db2c00344b4e2b2e08c2a087c
27. Su M, Zheng G, Chen Y, Xie H, Han W, Yang Q, et al. Clinical applications of IDDSI framework for texture recommendation for dysphagia patients. J Texture Stud. 2018;49(1):2–10.
28. Hopper M, Roberts S, Wenke R, Hopper Z, Bromiley L, Whillans C, et al. Improving Accuracy of Texture-Modified Diets and Thickened Fluids Provision in the Hospital: Evidence in Action. Dysphagia [Internet]. 2021;(0123456789):1–13. Available from: https://doi.org/10.1007/s00455-021-10294-4
29. Rule D. Implementation Strategies for the International Dysphagia Diet Standardization Initiative (IDDSI) [doctoral thesis]. University of Cincinnati; 2019.
30. Rule DW, Kelchner L, Mulkern A, Couch S, Silbert N, Weldeen K, et al. Implementation Strategies for the International Dysphagia Diet Standardisation Initiative (IDDSI), Part I: Quantitative Analysis of IDDSI Performance Among Varied Participants. Am J Speech-Language Pathol [Internet]. 2020 Aug;29(3):1514–28. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emexb&NEWS=N&AN=632016813
31. Lam P, Stanschus S, Zaman R, Cichero JAY. Implementation of the International Dysphagia Diet Standardisation Initiative (IDDSI) Framework: The Kempen Pilot. Br J Neurosci Nurs. 2017;13(2):S18–26.
32. Burger C, Kiesswetter E, Alber R, Pfannes U, Arens-Azevedo U, Volkert D, et al. Texture modified diet in German nursing homes: Availability, best practices and association with nursing home characteristics. BMC Geriatr [Internet]. 2019;19(1):284. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med16&NEWS=N&AN=31646961
33. Hill C, Clapham RP, Buccheri A, Field M, Shee AW. Assessing adherence and exploring barriers to provision of prescribed texture modifications for dysphagia in a residential aged care facility in rural Australia. Int J Speech Lang Pathol [Internet]. 2021;0(0):1–10. Available from: https://doi.org/10.1080/17549507.2021.1953144
34. Rosenvinge SK, Starke ID. Improving care for patients with dysphagia. Age Ageing. 2005;34(6):587–93.
35. Wu XS, Miles A, Braakhuis AJ. The Effectiveness of International Dysphagia Diet Standardization Initiative – Tailored Interventions on Staff Knowledge and Texture-Modified Diet Compliance in Aged Care Facilities : A Pre-Post Study. Curr Dev Nutr [Internet]. 2022;6(4):nzac021. Available from: https://doi.org/10.1093/cdn/nzac032
36. Wu XS, Miles A, Braakhuis AJ. Texture-modified diets, nutritional status and mealtime satisfaction: a systematic review. Healthc. 2021;9(6):1–19.
37. Durant M. A comparison of Energy Provision by Diet Order in a Long-Term Care Facility. Can J Aging / La Rev Can du Vieil. 2008;27(2):225–227.
38. Wright L, Cotter D, Hickson M, Frost G. Comparison of energy and protein intakes of older people consuming a texture modified diet with a normal hospital diet. J Hum Nutr Diet [Internet]. 2005;18(3):213–9. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=15882384
39. Welch PK, Dowson M, Endres JM. The effect of nutrient supplements on high risk long term care residents receiving pureed diets. J Nutr Elder [Internet]. 1991;10(3):49–62. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=-

JS&PAGE=reference&D=med3&NEWS=N&AN=2072250

40. Withers CA, Lewis MJ, Gosney MA, Methven L. Potential sources of mouth drying in beverages fortified with dairy proteins: A comparison of casein- and whey-rich ingredients. J Dairy Sci [Internet]. 2014;97(3):1233–47. Available from: http://dx.doi.org/10.3168/jds.2013-7273
41. Methven L, Rahelu K, Economou N, Kinneavy L, Ladbrooke-Davis L, Kennedy OB, et al. The effect of consumption volume on profile and liking of oral nutritional supplements of varied sweetness: Sequential profiling and boredom tests. Food Qual Prefer. 2010 Dec 1;21(8):948–55.
42. Todorovic V. Evidence-based strategies for the use of oral nutritional supplements. Br J Community Nursingo. 2005;10(4):158–64.
43. Adolphe JL, Whiting SJ, Dahl WJ. Vitamin fortification of pureed foods for long-term care residents. Can J Diet Pract Res [Internet]. 2009;70(3):143–50. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19709470
44. Kennewell S, Kokkinakos M. Thick, cheap and easy: Fortifying texture-modified meals with infant cereal. Nutr Diet [Internet]. 2007;64(2):112–5. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-34249800372&doi=10.1111%2Fj.1747-0080.2007.00101.x&partnerID=40&md5=4db1088d58535fb6543c996a460fb762
45. Ott A, Senger M, Lotzbeyer T, Gefeller O, Sieber CC, Volkert D, et al. Effects of a Texture-Modified, Enriched, and Reshaped Diet on Dietary Intake and Body Weight of Nursing Home Residents with Chewing and/or Swallowing Problems: An Enable Study. J Nutr Gerontol Geriatr [Internet]. 2019;38(4):361–76. Available from: https://doi.org/10.1080/21551197.2019.1628158
46. Miles A, Liang V, Sekula J, Broadmore S, Owen P, Braakhuis AJ. Texture-modified diets in aged care facilities: Nutrition, swallow safety and mealtime experience. Australas J Ageing [Internet]. 2019;39(1):31–9. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85062948488&doi=10.1111%2Fajag.12640&partnerID=40&md5=57285e5419d86e2cd14456771b13a61b
47. Cave DP, Abbey KL, Capra SM. Can foodservices in aged care homes deliver sustainable food fortification strategies? A review. Int J Food Sci Nutr [Internet]. 2020;71(3):267–75. Available from: https://doi.org/10.1080/09637486.2019.1658722
48. Higashiguchi T. Novel diet for patients with impaired mastication evaluated by consumption rate, nutrition intake, and questionnaire. Nutrition [Internet]. 2013;29(6):858–64. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed14&NEWS=N&AN=52466973
49. Sungsinchai S, Niamnuy C, Wattanapan P, Charoenchaitrakool M, Devahastin S. Texture Modification Technologies and Their Opportunities for the Production of Dysphagia Foods: A Review. Compr Rev Food Sci Food Saf [Internet]. 2019;18(6):1898–912. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emexc&NEWS=N&AN=634033714
50. González-Colaço Harmand M, Meillon C, Rullier L, Avila-Funes J-A, Bergua V, Dartigues J-F, et al. Cognitive decline after entering a nursing home: a 22-year follow-up study of institutionalized and noninstitutionalized elderly people. J Am Med Dir Assoc [Internet]. 2014 Jul 1;15(7):504–8. Available from: https://doi.org/10.1016/j.jamda.2014.02.006
51. Correia C, Lopez KJ, Wroblewski KE, Huisingh-Scheetz M, Kern DW, Chen RC, et al. Global Sensory Impairment among Older Adults in the United States. J Am Geriatr Soc. 2016;64(2):306–13.
52. Keller H, Duizer LM. What do consumers think of pureed food? Making the most of the indistinguishable food. J Nutr Gerontol Geriatr [Internet]. 2014;33(3):139–59. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=emed15&NEWS=N&AN=603674847
53. Schiffman SS, Graham BG. Taste and smell perception affect appetite and immunity in the elderly. Eur J Clin Nutr. 2000 Jun;54 Suppl 3:S54-63.
54. Ettinger L, Keller HH, Duizer LM. Characterizing Commercial Pureed Foods: Sensory, Nutritional, and Textural Analysis. J Nutr Gerontol Geriatr. 2014;33(3):179–97.
55. Okkels SL, Saxosen M, Bügel S, Olsen A, Klausen TW, Beck AM. Acceptance of texture-modified in-between-meals among old adults with dysphagia. Clin Nutr ESPEN [Internet]. 2018;25(2018):126–32. Available from: https://doi.org/10.1016/j.clnesp.2018.03.119
56. Rothenberg E, Wendin K. Texture modification of food for elderly people [Internet]. Vol. 2, Modifying Food Texture: Volume 2: Sensory Analysis, Consumer Requirements and Preferences. Elsevier Ltd.; 2015. 163–185 p. Available from: http://dx.doi.org/10.1016/B978-1-78242-334-8.00007-9

57. *Stahlman LB, Garcia JM, Hakel M, Chambers IV E. Comparison ratings of pureed versus molded fruits: Preliminary results. Dysphagia. 2000;15(1):2–5.*

58. *Pu D, Choi YY, Chan KMK, Poon MMW. Modifying puree meals in residential aged care facilities: A multi-centre feasibility and acceptability study. Geriatr. 2021;6(4):1–12.*

59. *Torrence SE. Pureed diets in a long-term care setting: Does use of pre-shaped pureed foods increase consumption? Northen Illinois University; 2011.*

60. *Cassens D, Johnson E, Keelan S. Enhancing taste, texture, appearance, and presentation of pureed food improved resident quality of life and weight status. Nutr Rev [Internet]. 1996;54(1 Pt 2):S51-4. Available from: http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medc&NEWS=N&AN=8919682*

61. *Strother H, Moss R, McSweeney MB. Comparison of 3D printed and molded carrots produced with gelatin, guar gum and xanthan gum. J Texture Stud. 2020;51(6):852–60.*

62. *Vucea V, Keller HH, Morrison JM, Duncan AM, Duizer LM, Carrier N, et al. Nutritional quality of regular and pureed menus in Canadian long term care homes: an analysis of the Making the Most of Mealtimes (M3) project. BMC Nutr [Internet]. 2017;3(1):80. Available from: https://doi.org/10.1186/s40795-017-0198-3*

63. *Chisholm A, Jensen J, Field P. Eating environment in the aged-care residential setting in New Zealand: Promoters and barriers to achieving optimum nutrition. Observations of the foodservice, menu and meals. Nutr Diet. 2011;68(2):161–6.*

64. *Ghani H, Motowylo B, Olsen M, Hartl R, Naidoo S, Cammer A. Fibre Content & Fibre Fortification of Menu Items Served to Sherbrooke Community Centre Residents on Texture Modified Diets. Univ Saskatchewan Undergrad Res J. 2020;6(3).*

65. *Wang D, Everett B, Brunero S, Northall T, Villarosa AR, Salamonson Y. Perspectives of residents and staff regarding food choice in residential aged care: A qualitative study. J Clin Nurs. 2020;29(3–4):626–37.*

66. *Razalli NH, Cheah CF, Mohammad NMA, Abdul Manaf Z. Plate waste study among hospitalised patients receiving texture-modified diet. Nutr Res Pract. 2021;15(5):655.*

67. *Miles A, Dennison K, Amer Oad M, Shasha L, Royal M. Consumer Satisfaction of Texture Modified Meals Served in Residential Aged-Care Facilities. Int J Food Sci Nutr Res. 2019 Jun 14;1(1.1005).*

68. *Reimer HD, Keller HH. Mealtimes in nursing homes: striving for person-centered care. J Nutr Elder. 2009 Oct;28(4):327–47.*

69. *Carrier N, Ouellet D, West GE. Nursing home food services linked with risk of malnutrition. Can J Diet Pract Res. 2007;68(1):14–20.*

70. *Engh MCN, Speyer R. Management of Dysphagia in Nursing Homes : A National Survey. Dysphagia [Internet]. 2021;(0123456789). Available from: https://doi.org/10.1007/s00455-021-10275-7*

71. *Cichero JAY. Evaluating chewing function: Expanding the dysphagia field using food oral processing and the IDDSI framework. J Texture Stud. 2020;51(1):56–66.*

72. *Painter V, Le Couteur DG, Waite LM. Texture-modified food and fluids in dementia and residential aged care facilities. Clinical Interventions in Aging. 2017.*

73. *Bennett MK, Ward E, Scarinci N, Waite M. Perspectives on Mealtime Management in Residential Aged Care: Insights From a Cross- Disciplinary Investigation. J Nutr Gerontol Geriatr. 2014;33(4):325–39.*

74. *Swan K, Speyer R, Heijnen BJ, Wagg B, Cordier R. Living with oropharyngeal dysphagia: effects of bolus modification on health-related quality of life—a systematic review. Quality of Life Research. 2015.*

75. *O'Keeffe ST. Use of modified diets to prevent aspiration in oropharyngeal dysphagia: Is current practice justified? BMC Geriatr. 2018;18(1):1–11.*

76. *Vucea V, Keller HH, Morrison JM, Duncan AM, Duizer LM, Lengyel CO, et al. Intake and Factors Associated with Consumption of Pureed Food in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. J Nutr Gerontol Geriatr [Internet]. 2018;37(2):59–81. Available from: https://doi.org/10.1080/21551197.2018.1470056*

77. *Austbø Holteng LB, Frøiland CT, Corbett A, Testad I. Care staff perspective on use of texture modified food in care home residents with dysphagia and dementia. Ann Palliat Med. 2017;6(4):310–8.*

78. *Carrier N, West GE, Ouellet D. Dining experience, foodservices and staffing are associated with quality of life in elderly nursing home residents. J Nutr Heal Aging. 2009;13(6):565–70.*

79. *Milte R, Ratcliffe J, Chen G, Miller M, Crotty M. Taste, choice and timing: Investigating resident and carer preferences for meals in aged care homes. Nurs Heal Sci. 2018;20(1):116–24.*

SENSORY, NUTRITIONAL AND TEXTURAL ANALYSIS OF COMMERCIAL PUREED FOODS AND ASSOCIATED COSTS

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Chewing and swallowing problems limit the ability to eat foods with their normal texture and thus increase the risk of malnutrition. Both of these problems are widespread, particularly among the elderly. Estimates obtained from the Nutrition Day project data show a prevalence of dysphagia among care home residents of more than 13%, although figures vary widely from one country to another[1]. The most common dietary strategy for chewing and/or swallowing problems is the use of mashed or pureed foods. Of all meals served in care homes, between 26% and 67% are texture-modified diets (TMDs)[1,2].

Technology has evolved in recent decades and there are commercial products are now available on the market with complete nutritional value and a suitable texture for swallowing. These TMDs are designed to compensate for functional limitations in chewing and/or swallowing and thus help to ensure an adequate dietary intake. As these products are easy to prepare and serve, introducing them in hospital kitchens and care homes brings great advantages[3].

Evidence-based indications for texture-modified diets

Texture-modified foods are designed to compensate for functional limitations in chewing and/or swallowing. Texture modification can also slow bolus transit through the mouth and pharynx, which improves swallowing safety by reducing the frequency of aspiration in people with oropharyngeal dysphagia. It is important to remember that aspiration pneumonia in patients with oropharyngeal dysphagia has a high mortality rate; however, our group found that adaptation of the diet in patients with dysphagia was associated with a reduction in mortality in patients hospitalised for aspiration pneumonia (6% vs 31.3%, p <0.0001)[4].

The clinical guidelines of the European Society for Clinical Nutrition and Metabolism (ESPEN) establish that older people with malnutrition, or at risk of malnutrition and with signs of oropharyngeal dysphagia and/or chewing problems should be offered enriched and texture-modified foods as a compensatory strategy to improve dietary intake[5]. Due to the lack of quality clinical studies in these situations, this recommendation was made as good clinical practice, but it obtained a strong consensus of 100% of the guideline reviewers. Data from a systematic review served as the basis for Beck et al[6] to also establish a recommendation based on good clinical practice in favour of the use of texture-modified foods in oropharyngeal dysphagia. Along the same lines, a consensus of expert opinions and evidence-based recommendations for best practices in the nutritional management of oropharyngeal dysphagia have also supported the recommendation of texture-modified foods[7].

Potential risks and benefits of texture-modified diets

It has long been known that home-made pureed diets do not consistently provide sufficient levels of protein to ensure adequate intake in elderly individuals with

chewing and swallowing problems[8]. These traditionally prepared diets can have low nutritional value and, in particular, tend to be low in energy and protein. Continued use of such diets can lead to nutritional deficiencies and compromise the patient's nutritional status. The diets of 83% of patients receiving home-made TMDs do not meet the necessary nutritional requirements, leading to nutritional deficiency[3].(Figure 1)

Figure 1. Risks and benefits of texture-modified diets

TRADITIONAL PUREED FOODS	ADAPTED BASIC NUTRITION

• Variable nutritional value
  • Loss of micronutrients: vitamins and minerals
  • Difficylty with pureeing proteins
  • Insufficient amounts
	• Nutritional value adequate, exact and constant

• Variable texture	• Texture smooth and homogeneous
• Presence of fish bones, small bones, etc.	
• Repetitive taste	• Variety of flavours
• Time consuming to prepare	• Easy and quick to prepare
• High degree of handling	• Little handling
• Food contamination	• Microbiological safety
• Repetitive with many foods excluded	• Rotation with home-made dishes, mixture or replacement

Although research in this field has traditionally been limited, a systematic review recently established that the consumption of pureed diets was associated with lower intake, particularly of energy and calcium, but that intake can be optimised through the enrichment of these diets[9]. Along these lines, in a subsequent systematic review, the same authors[10] found that when the nutritional intervention was carried out with enriched TMDs, compared to the traditional alternative, nutritional status improved, both in terms of weight and muscle strength assessed by dynamometry[11], and in nutritional risk scales, such as the MNA-SF[12]. Increased satisfaction with food was also found when TMDs were personalised or moulds were used to improve appearance[10].

The quality of the TMD is also an important factor in acceptance by patients with dysphagia. Our group designed an assessment tool to objectively determine the adequacy of the foods included in a hospital's TMD menus. The "Objective Evaluation Tool for Texture-Modified Foods" (OET-TMF) consists of seven items that assess the nutritional quality of the food (energy and protein intake), presence of allergens, texture and viscosity, cooking, type of storage, shelf life and patient acceptance. The total score ranges from 0 to 64 and is divided into four categories: high quality; good quality; medium quality; and poor quality. The study of four different commercial TMFs contributed to the validation of the tool. All the products assessed scored between high and good in terms of quality. There was a trend ($p = 0.077$) for a correlation towards higher consumption when the overall quality of the product was higher. The product that scored the highest with the tool was the best accepted; the product with the lowest score had the highest rejection rate[13]. Whether or not a product is accepted by the patient therefore depends on its quality, so it is essential that the quality of commercial TMDs be assessed. This is an important area for improvement, as we know that there is great variability between the different options in terms of their nutritional, sensory and texture characteristics[14].

Working to improve the evidence base: the ABADIA study

Few studies have described the nutritional differences between in-home and commercially prepared TMDs. We conducted a study (known as the ABADIA study) to determine not only the nutritional properties, but also the resources and costs associated with the preparation of TMDs[15]. This was an observational, prospective, descriptive study looking at the preparation of three types of pureed diets: 1) in-home TMD (hTMD); 2) concentrated nutrient-dense commercial food products (cTMD); and 3) cTMD-Mix prepared using the MixxPro® automatic food mixer to produce blended meals (cTMD-Mix). The study was carried out in the routine clinical practice context, one arm in hospitals and the other in nursing homes, and included patients aged 65 or over who were receiving TMD at the start of the study, with stable clinical status and estimated survival >1 month (50 patients in hospitals and 62 in residences). The patients were monitored for 15 days. The mean age of the patients included was 87.3 (standard deviation-SD-8.3 years) and 66.4% were women. The most common reasons for being prescribed a pureed diet were neurological diseases (35.5%) and swallowing problems (38.2%). According to the Mini Nutritional Assessment (MNA)[16], 50% of the patients were suffering from malnutrition and 47.3% were at risk of malnutrition. According to the EAT-10 questionnaire[17], 84.8% of the patients were at risk of dysphagia, and according to the SNAQ questionnaire[18,19], 33% had poor appetite.

The primary objective of the study was to identify the use of resources associated with the preparation of TMDs. To the best of our knowledge, this is the first study conducted in geriatric nursing homes to evaluate the use of resources and costs of TMD production for patients with dysphagia or mastication difficulties using natural and commercial foods. The time required to prepare each portion was much lower with the commercial TMDs: 11.2 (SD 3.89) min (hTMD), 1.7 (SD 0.28) min (cTMD) and 1.6 (SD 0.00) min (cTMD-Mix) (Figure 2). Although raw material costs were lower for hTMD compared to cTMD and cTMD-Mix, considering the resources needed to prepare the diets, the cost per portion and the cost per 100 g served were lower for the commercial diets than for in-home diets. The total cost per portion (human resources, ingredients and energy consumption) amounted to €2.33 (SD 0.63), €2.01 (SD 0.39), and €2.00 (SD 0.33) for hTMD, cTMD and cTMD-Mix, respectively. The average cost per 100 Kcal was €2.80 (SD 1.32) [hTMD], €0.62 (SD 0.18) [cTMD] and €0.58 (SD 0.13) [cTMD-Mix]. In the nursing home using hTMD, the main cost component was associated with human resources, while in the centres using cTMD and cTMD-Mix, the cost was related to raw material (Figure 3).

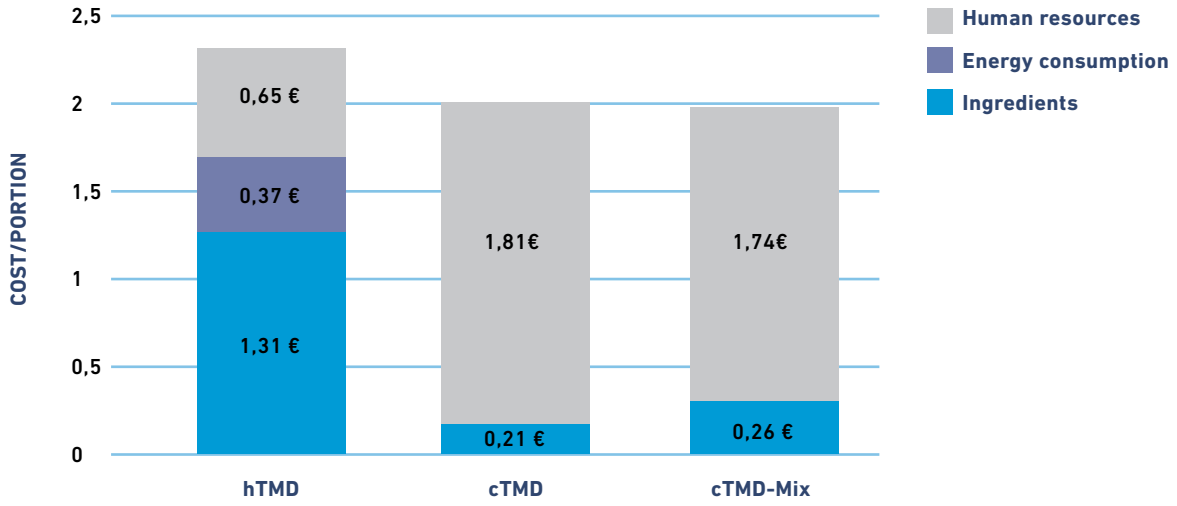
Figure 2. Use of resources in the ABADIA study.

	Mean time/portion preparation.	Mean cost/portion.	Mean cost/100kcal.
h-TMD	11.3 minutes	€2.33 [SD 0.63]	€2.80 [SD 1.32]
c-TMD	1.7 minutes	€2.01 [SD 0.39]	€0.62 [SD 0.18]
c-TMD-Mix	1.6 minutes	€2.00 [SD 0.33]	€0.58 [SD 0.13]

SD: standard deviation.

h-TMD= in-home texture modified diet; c-TMD= concentrated nutrient-dense commercial TMD; cTMD-Mix=cTMD-Mix prepared using the MixxPro® automatic food mixer to produce blended meals

Figure 3. Breakdown of cost per portion.

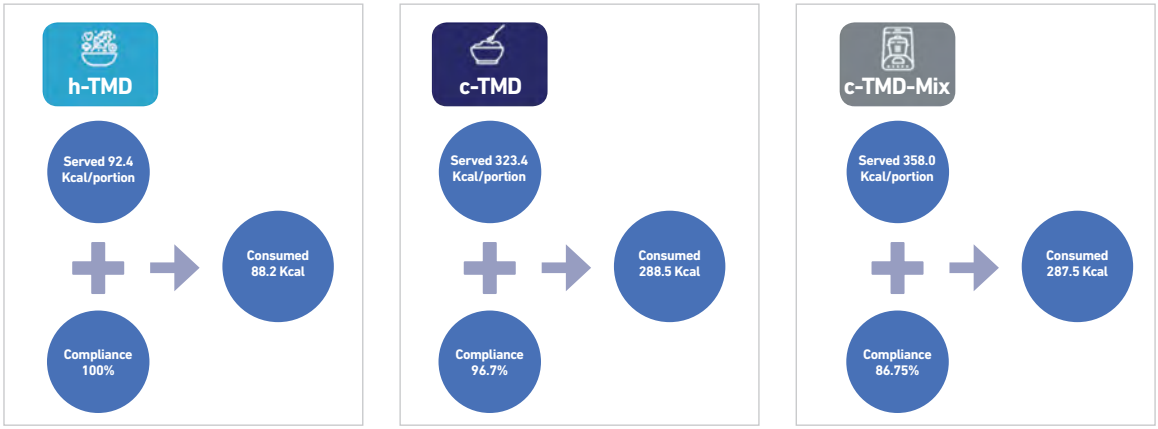


hTMD, in-home TMD; cTMD, commercial TMD hand blended; cTMD-Mix, commercial TMD automatically blended.

The secondary objectives of the study included describing participants' degree of satisfaction and compliance with each type of pureed diet studied and describing the nutritional characteristics and the safety of each type of pureed diet. More than 80% of the participants considered that the diet had acceptable to very good sensory characteristics, as well as a homogeneous texture. Poor appetite was the main determining factor in rating how the diet tasted: 75% of patients with a good appetite thought it tasted good or very good compared to only 48% of those with a poor appetite, and a better appetite was associated with greater compliance[20].

Overall, compliance with the diet was good, as the proportion of food eaten was above 80% [hTMD: 95.5% (SD 10.7); cTMD: 89.2% (SD 15.9); cTMD-Mix: 80.3% (SD 21.4)]. Regarding compliance and the mean amount served per portion, the total amount ingested per portion was around 30% higher in homes serving commercial meals: patients receiving hTMD, cTMD, and cTMD-Mix ingested a daily mean of 197.7 g (SD 21.6), 284.6 g (SD 49.6) and 281.9 g (SD 73.4), respectively. Similarly, considering the calories served, the calories consumed per portion were 88.2 [IQR 72.2-122.3] (hTMD), 288.5 [IQR 253.5-325.1] (cTMD) and 287.5 [IQR 276.2-298.8] (cTMD-Mix). Our results show that although compliance was higher in the nursing home with hTMD, the final kilocalories ingested were much higher in patients with cTMD or cTMD-Mix than in patients receiving hTMD. (Figure 4)

Figure 4. Energy consumed in the ABADIA study.



h-TMD= in-home texture modified diet; c-TMD= concentrated nutrient-dense commercial TMD; cTMD-Mix=cTMD-Mix prepared using the MixxPro® automatic food mixer to produce blended meals

Regarding food safety, during diet preparation the food needs to reach a temperature above 65ºC and not be exposed to temperatures between 15ºC and 45ºC to guarantee microbiological safety[3]. The three types of diet studied presented a good safety profile. In all cases, microbiologically safe temperatures (>65°C) were reached during preparation, and the presence of microorganisms was not detected in the analysis. The mean temperature of meals after blending was 80.6ºC (SD 1.6) (hTMD), 88.2ºC (SD 1.02) (cTMD) and 85.0ºC (SD 0.0) (cTMD-Mix), while at the time of serving to patients it was 54.3ºC (SD 1.22) (hTMD), 58.7ºC (SD 0.31) (cTMD) and 75.0ºC (SD 0.0) (cTMD-Mix). It should be noted that only the cTMD-Mix remained above 65°C until the time of serving. In relation to swallowing safety, median swallowing-related adverse events (cough during intake or fractional swallowing) reported per intake were minimal: h-TMD 0.9 (IQR 0.1–1.0), c-TMD 0.3 (IQR0.0–0.7) and c-TMD-Mix 0.1(IQR0.0-0.1). No serious adverse event (choking) was detected.

From the results of the ABADIA study, we can state that commercial TMDs, both prepared manually and using an automatic food mixer, lead to a reduction in both preparation time and resource consumption compared to in-home alternatives. Patient satisfaction and adherence to the diets were both good in all cases, although patients receiving commercial TMDs had a higher energy intake. Poor appetite was the main factor determining how patients rated the taste of the diet and a better appetite was associated with greater compliance. This suggests that the low intake sometimes associated with pureed diets may have more to do with the particular characteristics of these patients.

Application to clinical practice in nursing homes for the elderly

Resident-centred personalised care planning should include the management or care of malnutrition and dysphagia, both highly prevalent conditions in this context. Nutritional care must be given high priority in residential care homes and a number of fundamental aspects need to be taken into account: 1) meeting nutritional requirements personalised for the residents' characteristics; 2) adapting the texture of foods and fluids to facilitate safe swallowing and maximise intake; 3) prioritising residents' quality of life and carefully assessing the need for dietary restrictions.

An expert working group identified the main challenges in the management of dysphagia in nursing homes and made recommendations for achieving optimal nutritional care in this situation[7]. One of the unmet needs detected concerned improving the quality of therapeutic diets. In the absence of strong evidence of TMDs promoting safety and benefiting long-term outcomes, it was the collective opinion of the committee that, when managed and developed appropriately and accepted by the consumer, TMDs can be beneficial for residents in nursing homes. Based on the authors' opinion, adherence to nutritionally enhanced TMDs may have a direct beneficial effect in preventing unintentional weight loss and dehydration and in improving skin health, wound healing and quality of life of nursing home residents. These nutritionally enhanced TMDs may also have a positive impact on functional outcomes, such as improved mobility and independence when combined with other interventions (e.g. mobility interventions or other forms of exercise). Recommendations for the improvement and consistency of nutritional quality and improved adherence to TMDs for residents with swallowing difficulties are given in the document[7]. One of the most important ones is the need to consider TMDs as therapeutic diets, necessary in people with dysphagia to improve nutritional status, promote hydration and minimise the risk of aspiration.

Following this recommendation, the TMDs we use in people with dysphagia must guarantee sufficient nutritional quality to meet nutritional requirements, be prepared with a consistent texture that ensures safety and undoubtedly have sensory qualities that promote patient satisfaction and consequently adherence to the diet. Texture-modified diets based on nutrient-dense commercial food products are an inexpensive, quick-to-prepare and safe alternative to prepare high-calorie diets for patients with dysphagia and/or chewing disorders and they have been shown to have good nutritional properties, combined with low adverse events on swallowing function and excellent patient satisfaction and compliance.

Application to clinical practice in the community for the elderly

If we have scant scientific evidence to support what happens in patients with dysphagia in nursing homes, then there are even fewer studies that report upon and guide the use of texture-modified diets in patients with dysphagia or chewing disorders who are living in the community. However, common sense tells us that modifying the diet to avoid complications from impaired swallowing safety remains paramount. Commercial texture-modified diets have several relevant advantages in this context. They ensure a texture that limits the risk of aspiration choking. In addition, they facilitate the task of preparing the diet for caregivers and family members and ensure that the nutritional composition is correct. Texture-modified diets formulated using nutrient-dense commercial food products are an inexpensive, quick-to-prepare and interesting alternative to facilitate the feeding of older adults in the community with dysphagia or chewing difficulties.

Conflicts of interest

MDBP has received fees as a speaker and for teaching and training activities from Nestlé Health Science, Fresenius Kabi, Nutricia Danone, Vegenat Healthcare, Persan Farma, Lilly, Novo Nordisk and Adventia Farma.

REFERENCES

1. Streicher M, Wirth R, Schindler K, Sieber CC, Hiesmayr M, Volkert D. Dysphagia in Nursing Homes-Results From the NutritionDay Project. J Am Med Dir Assoc [Internet]. 2018 Feb 1 [cited 2022 Mar 11];19(2):141-147.e2. Available from: https://pubmed.ncbi.nlm.nih.gov/29030310/
2. Painter V, le Couteur DG, Waite LM. Texture-modified food and fluids in dementia and residential aged care facilities. Clin Interv Aging [Internet]. 2017 Aug 2 [cited 2022 Mar 20];12:1193–203. Available from: https://pubmed.ncbi.nlm.nih.gov/28814845/
3. Velasco C, García-Peris P. [Texture-modified foods; from grounding or dehydration to current products]. Nutricion hospitalaria [Internet]. 2014 [cited 2022 Mar 11];29(3):465–9. Available from: https://pubmed.ncbi.nlm.nih.gov/24558986/
4. Rodriguez Garcia S, Calleja Fernández A, Llorente García J, Pérez Panizo M, Estrada Álvarez F, García Martínez S, et al. Predictors of mortality in aspiration pneumoniae. Revista Clínica Española [Internet]. 2012 [cited 2022 Apr 2];212 EspecialCongreso:246–246. Available from: www.elsevier.es/rce
5. Volkert D, Beck AM, Cederholm T, Cruz-Jentoft A, Goisser S, Hooper L, et al. ESPEN guideline on clinical nutrition and hydration in geriatrics. Clin Nutr [Internet]. 2019 Feb 1 [cited 2022 Mar 11];38(1):10–47. Available from: https://pubmed.ncbi.nlm.nih.gov/30005900/
6. Beck AM, Kjaersgaard A, Hansen T, Poulsen I. Systematic review and evidence based recommendations on texture modified foods and thickened liquids for adults (above 17 years) with oropharyngeal dysphagia - An updated clinical guideline. Clin Nutr [Internet]. 2018 Dec 1 [cited 2022 Mar 11];37(6 Pt A):1980–91. Available from: https://pubmed.ncbi.nlm.nih.gov/28939270/
7. Ballesteros-Pomar MD, Cherubini A, Keller H, Lam P, Rolland Y, Simmons SF. Texture-Modified Diet for Improving the Management of Oropharyngeal Dysphagia in Nursing Home Residents: An Expert Review. J Nutr Health Aging [Internet]. 2020 Jun 1 [cited 2022 Mar 11];24(6):576–81. Available from: https://pubmed.ncbi.nlm.nih.gov/32510109/
8. Dahl WJ, Whiting SJ, Tyler RT. Protein content of pureed diets: implications for planning. Canadian journal of dietetic practice and research : a publication of Dietitians of Canada = Revue canadienne de la pratique et de la recherche en dietetique : une publication des Dietetistes du Canada [Internet]. 2007 Jun [cited 2022 Mar 11];68(2):99–102. Available from: https://pubmed.ncbi.nlm.nih.gov/17553196/
9. Wu XS, Miles A, Braakhuis A. Nutritional Intake and Meal Composition of Patients Consuming Texture Modified Diets and Thickened Fluids: A Systematic Review and Meta-Analysis. Healthcare (Basel) [Internet]. 2020 Dec 1 [cited 2022 Mar 11];8(4). Available from: https://pubmed.ncbi.nlm.nih.gov/33371326/
10. Wu XS, Miles A, Braakhuis AJ. Texture-Modified Diets, Nutritional Status and Mealtime Satisfaction: A Systematic Review. Healthcare (Basel) [Internet]. 2021 Jun 1 [cited 2022 Mar 11];9(6). Available from: https://pubmed.ncbi.nlm.nih.gov/34073835/
11. Reyes-Torres CA, Castillo-Martínez L, Reyes-Guerrero R, Ramos-Vázquez AG, Zavala-Solares M, Cassis-Nosthas L, et al. Design and implementation of modified-texture diet in older adults with oropharyngeal dysphagia: a randomized controlled trial. European Journal of Clinical Nutrition 2019 73:7 [Internet]. 2019 Jan 14 [cited 2022 Mar 20];73(7):989–96. Available from: https://www.nature.com/articles/s41430-019-0389-x
12. Shimizu A, Momosaki R, Kayashita J, Fujishima I. Impact of Multiple Texture-Modified Diets on Oral Intake and Nutritional Status in Older Patients with Pneumonia: A Retrospective Cohort Study. Dysphagia 2019 35:4 [Internet]. 2019 Sep 18 [cited 2022 Mar 20];35(4):574–82. Available from: https://link.springer.com/article/10.1007/s00455-019-10063-4
13. Calleja-Fernández A, Pintor-de-la-Maza B, Vidal-Casariego A, Cano-Rodríguez I, Ballesteros-Pomar MD. Objective Evaluation Tool for Texture-Modified Food (OET-TMF): Development of the Tool and Validation. Dysphagia [Internet]. 2016 Jun 1 [cited 2022 Mar 11];31(3):360–6. Available from: https://pubmed.ncbi.nlm.nih.gov/26796742/
14. Ettinger L, Keller HH, Duizer LM. Characterizing commercial pureed foods: sensory, nutritional, and textural analysis. J Nutr Gerontol Geriatr [Internet]. 2014 [cited 2022 Apr 2];33(3):179–97. Available from: https://pubmed.ncbi.nlm.nih.gov/25105714/
15. Ballesteros-Pomar MD, Pérez-Martín J, Mendiola MJ, García-García JM, Parrado-Cuesta S, Caracuel ÁM, et al. Cost, microbiological, and nutritional properties of pureed food production in nursing homes. The ABADIA

Study. Nutricion hospitalaria [Internet]. 2021 [cited 2022 Mar 11];38(3):470–7. Available from: https://pubmed.ncbi.nlm.nih.gov/33775099/

16. *Mini Nutritional Assessment (MNA) [Internet]. [cited 2022 Apr 2]. Available from: https://www.mna-elderly.com/*
17. *Peláez RB, Sarto B, Segurola H, Romagosa A, Puiggrós C, Vázquez C, et al. [Translation and validation of the Spanish version of the EAT-10 (Eating Assessment Tool-10) for the screening of dysphagia]. Nutricion hospitalaria [Internet]. 2012 [cited 2022 Apr 2];27(6):2048–54. Available from: https://pubmed.ncbi.nlm.nih.gov/23588456/*
18. *Rolland Y, Perrin A, Gardette V, Filhol N, Vellas B. Screening older people at risk of malnutrition or malnourished using the Simplified Nutritional Appetite Questionnaire (SNAQ): a comparison with the Mini-Nutritional Assessment (MNA) tool. J Am Med Dir Assoc [Internet]. 2012 [cited 2022 Apr 2];13(1):31–4. Available from: https://pubmed.ncbi.nlm.nih.gov/21700503/*
19. *Wilson MMG, Thomas DR, Rubenstein LZ, Chibnall JT, Anderson S, Baxi A, et al. Appetite assessment: simple appetite questionnaire predicts weight loss in community-dwelling adults and nursing home residents. Am J Clin Nutr [Internet]. 2005 [cited 2022 Apr 2];82(5):1074–81. Available from: https://pubmed.ncbi.nlm.nih.gov/16280441/*
20. *Ballesteros Pomar M, Chazin. V, Pérez J, Parrado S, Caracuel A, GarcésB, et al. Alimentación básica adaptada y Mixxpro: aceptabilidad de la dieta para la disfagia. Estudio ABADIA. Nutrición Hospitalaria. 2019;34 (Supl 1):12.*

EPILOGUE: SUMMARY AND RECOMMENDATIONS REGARDING THE USE OF PUREED FOODS IN PEOPLE WITH DYSPHAGIA TO SOLID FOODS

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In the prologue to this special issue, I identified the following issues regarding the use of pureed foods in diets for people with dysphagia:

1) a paucity of literature addressing important clinical questions regarding pureed foods;
2) despite widespread use, a lack of clinical trial evidence demonstrating safety and efficacy (or adverse outcomes) with pureed foods;
3) some evidence pointing to inadequate nutrition in individuals receiving pureed diets;
4) a lack of access to validated clinical assessments for evaluating whether or not a person requires pureed food.

The four chapters contributed by invited experts help to shape our understanding of these issues and provide several important insights. First, it is clear that there is consensus across several systematic reviews and clinical guidelines (including those of ESPEN, the European Society for Clinical Nutrition and Metabolism) that texture-modified foods should be considered as a strategy for improving dietary intake in older people who present the combination of suspected oropharyngeal dysphagia (including chewing problems) and malnutrition or risk of malnutrition[1]. However, there are three key qualifications regarding this guidance:

a) nutritional enrichment of pureed foods is desirable to address converging evidence across multiple observational studies showing that;
b) pureed food should not replace lesser degrees of texture modification for individuals who have the oral processing skills required to handle more complex food textures; and
c) we need to recognize that long-term consumption of pureed food is associated with low self-esteem, feelings of embarrassment, refusal to eat and reduced quality of life[2,3]. Therefore, when modified foods are recommended, a reassessment should be planned to monitor acceptance, tolerance and nutritional adequacy and to identify opportunities for resuming the intake of a wider variety of food textures in a patient's diet.

These conclusions shine some light on the need for valid clinical assessment methods to identify the need for texture-modified foods in a judicious way, and the training of appropriate health care professionals to provide those assessments. The articles in this special issue highlight the fact that minimal training in evaluating swallowing, chewing and oral processing skills is provided across a variety of relevant health care disciplines and point to a need for the development of interprofessional skills. Additionally, one clear priority is the need to develop valid measurement tools that take functional dentition, masticatory performance and efficiency, salivary function, lingual strength and swallowing function into consideration. The assumption that pureed foods are needed in individuals with dentures or edentulism without careful evaluation of oral processing function is not supported.

Currently, our literature appears to contain no information about the specific prevalence of oral phase dysphagia or of difficulty swallowing solid foods. However, it is clear from observational studies, including the Nutrition Day project, that texture-modified foods are widely used in residential care settings, comprising 26%-67% of the meals provided in care homes[4,5], with pureed foods being prescribed for 7%-11% of residents overall[6-8] and in higher proportions for adults thought to have dysphagia.

Against this backdrop of the pervasive use of texture-modified foods, to our knowledge, there have been no trials exploring the safety, efficiency or nutritional outcomes of pureed foods in comparison to lesser degrees of diet texture modification[9-13]. It is abundantly clear, however, that pureed foods can have adverse outcomes, and the latter fall into two main categories. First, there is converging evidence across studies that institutional residents consuming TMDs are at increased risk for malnutrition, particularly those requiring pureed diet[13, 14]. Several studies have shown that institutional pureed menus are significantly low in nutrients, particularly in energy, protein, carbohydrates, fat and fibre[12, 15-17]. Second, and although we can probably take some comfort and reassurance from the fact that adverse respiratory events are not widely reported as an outcome of pureed diet prescription in residential care settings, there are circumstance in which aspiration of a pureed or extremely thick consistency appears to constitute a greater risk of pulmonary compromise[18-22]. The key word here is "aspiration" of pureed foods. Pureed foods (or their liquid form of extremely thick drinks) are intended to minimise the risk of aspiration. When that is not the case, the literature suggests that they can actually lead to worse respiratory consequences than the aspiration of thinner consistencies, presumably because they are harder to expel from the respiratory system. This realization enforces the need for pureed food prescription to be based on a valid assessment rather than the well-meaning presumption that they will be safe.

However, these concerns are offset by promising results from studies involving nutritionally-enhanced pureed foods that show better nutritional outcomes and greater acceptance and consumption of pureed foods with better nutritional quality. The ABADIA study[23] described in the chapter by Dr Ballesteros-Pomar, further demonstrates that commercially pre-prepared nutritionally-enhanced texture-modified foods can be cost-effective, based on savings in production time, human resources and cost per calorie. The chapter by Wu and colleagues further illustrates the importance of using standardized terminology and texture measurement methods, such as those developed by IDDSI, to ensure consistency in texture-modified food production.

We hope that the information compiled in this special issue serves not only to synthesise what is known about the indications for and use of pureed foods in older adults with dysphagia and nutritional risk, but also to highlight priorities for future research. There is much work to be done!

Conflicts of interest

CMS has received fees as a speaker and for teaching, training and research activities from Nestlé Health Science, and serves as a member of the Board of Directors of IDDSI, the International Dysphagia Diet Standardisation Initiative.

REFERENCES

1. *Volkert D, Beck AM, Cederholm T, Cruz-Jentoft A, Goisser S, Hooper L, et al. ESPEN guideline on clinical nutrition and hydration in geriatrics. Clin Nutr. 2019;38(1):10-47.*
2. *Swan K, Speyer R, Heijnen BJ, Wagg B, Cordier R. Living with oropharyngeal dysphagia: effects of bolus modification on health-related quality of life--a systematic review. Qual Life Res. 2015;24(10):2447-56.*
3. *O'Keeffe ST. Use of modified diets to prevent aspiration in oropharyngeal dysphagia: is current practice justified? BMC Geriatr. 2018;18(1):167.*
4. *Streicher M, Wirth R, Schindler K, Sieber CC, Hiesmayr M, Volkert D. Dysphagia in Nursing Homes-Results From the NutritionDay Project. J Am Med Dir Assoc. 2018;19(2):141-7 e2.*
5. *Painter V, Le Couteur DG, Waite LM. Texture-modified food and fluids in dementia and residential aged care facilities. Clin Interv Aging. 2017;12:1193-203.*
6. *Cichero JAY, editor Dysphagia Diets in Australia: IDDSI Standardised terminology keeping people safe. Japanese Society for Dysphagia Research; 2021; Nagoya, Japan.*
7. *Vucea V, Keller HH, Morrison JM, Duizer LM, Duncan AM, Carrier N, et al. Modified Texture Food Use is Associated with Malnutrition in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. J Nutr Health Aging. 2018;22(8):916-22.*
8. *Vucea V, Keller HH, Morrison JM, Duncan AM, Duizer LM, Lengyel CO, et al. Intake and Factors Associated with Consumption of Pureed Food in Long Term Care: An Analysis of Making the Most of Mealtimes (M3) Project. J Nutr Gerontol Geriatr. 2018;37(2):59-81.*
9. *Beck AM, Kjaersgaard A, Hansen T, Poulsen I. Systematic review and evidence based recommendations on texture modified foods and thickened liquids for adults (above 17 years) with oropharyngeal dysphagia - An updated clinical guideline. Clin Nutr. 2018;37(6 Pt A):1980-91.*
10. *Steele CM, Alsanei WA, Ayanikalath S, Barbon CE, Chen J, Cichero JA, et al. The influence of food texture and liquid consistency modification on swallowing physiology and function: a systematic review. Dysphagia. 2015;30(1):2-26.*
11. *Newman R, Vilardell N, Clave P, Speyer R. Effect of Bolus Viscosity on the Safety and Efficacy of Swallowing and the Kinematics of the Swallow Response in Patients with Oropharyngeal Dysphagia: White Paper by the European Society for Swallowing Disorders (ESSD). Dysphagia. 2016;31(2):232-49.*
12. *Wu XS, Miles A, Braakhuis A. Nutritional Intake and Meal Composition of Patients Consuming Texture Modified Diets and Thickened Fluids: A Systematic Review and Meta-Analysis. Healthcare (Basel). 2020;8(4).*
13. *Wu XS, Miles A, Braakhuis AJ. Texture-Modified Diets, Nutritional Status and Mealtime Satisfaction: A Systematic Review. Healthcare (Basel). 2021;9(6).*
14. *Keller H, Vucea V, Slaughter SE, Jager-Wittenaar H, Lengyel C, Ottery FD, et al. Prevalence of Malnutrition or Risk in Residents in Long Term Care: Comparison of Four Tools. J Nutr Gerontol Geriatr. 2019:1-16.*
15. *Ilhamto N, Keller HH, Duizer LM. The effect of varying ingredient composition on the sensory and nutritional properties of a pureed meat and vegetable. J Nutr Gerontol Geriatr. 2014;33(3):229-48.*
16. *Durant M. A comparison of energy provision by diet order in a long-term care facility. Can J Aging. 2008;27(2):225-7.*
17. *Velasco C, Garcia-Peris P. [Texture-modified foods; from grounding or dehydration to current products]. Nutr Hosp. 2014;29(3):465-9.*
18. *Robbins J, Gensler G, Hind J, et al. Comparison of 2 interventions for liquid aspiration on pneumonia incidence: A randomized trial. Annals of Internal Medicine. 2008;148(7):509-18.*
19. *Nativ-Zeltzer N, Kuhn MA, Imai DM, Traslavina RP, Domer AS, Litts JK, et al. The effects of aspirated thickened water on survival and pulmonary injury in a rabbit model. Laryngoscope. 2018;128(2):327-31.*
20. *Nativ-Zeltzer N, Ueha R, Nachalon Y, Ma B, Pastenkos G, Swackhamer C, et al. Inflammatory Effects of Thickened Water on the Lungs in a Murine Model of Recurrent Aspiration. Laryngoscope. 2021;131(6):1223-8.*
21. *Ueha R, Nativ-Zeltzer N, Sato T, Goto T, Nito T, Belafsky PC, et al. Acute inflammatory response to contrast agent aspiration and its mechanisms in the rat lung. Laryngoscope. 2019;129(7):1533-8.*
22. *Ueha R, Nativ-Zeltzer N, Sato T, Goto T, Nito T, Tsunoda K, et al. Chronic inflammatory response in the rat lung to commonly used contrast agents for videofluoroscopy. Laryngoscope Investig Otolaryngol. 2019;4(3):335-40.*
23. *Ballesteros Pomar MD, Perez-Martin J, Mendiola MJ, Garcia-Garcia JM, Parrado-Cuesta S, Caracuel AM, et al. Cost, microbiological, and nutritional properties of pureed food production in nursing homes. The ABADIA Study. Nutr Hosp. 2021;38(3):470-7.*