Aging Clinical and Experimental Research
https://doi.org/10.1007/s40520-022-02258-x

REVIEW ARTICLE

Frequency and associated factors for swallowing impairment in community-dwelling older persons: a systematic review and meta-analysis

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Received: 29 June 2022 / Accepted: 13 September 2022

Abstract

Introduction Swallowing impairment (SI) is an underdiagnosed dysfunction frequently seen as an expected condition of aging. However, SI can lead to health complications and considerable social impact.

Methods The objective of this systematic review with meta-analysis was to evaluate the frequency and associated factors with SI in community-dwelling older persons. Searches were performed in 13 electronic databases including MEDLINE and EMBASE (from inception to September 18, 2021). Data extraction and methodological quality assessment of included studies were performed by two independent reviewers. Meta-analysis of proportions with 95% confidence interval (CI) and prediction interval (PI) was used to pool estimates. Subgroup analysis by Country and Assessment Method was performed. General meta-analysis was used to pool measures of association between potential risk factors and SI occurrence (odds ratio [OR] or prevalence ratio [PR]).

Results The worldwide estimated frequency of SI in community-dwelling older persons was 20.35% (95%CI 16.61–24.68%, 95%PI 4.79–56.45, I^2 99%, $n = 33{,}291$). This estimation varied across assessment methods and by country. The main factors associated with SI were a dry mouth (OR 8.1, 95%CI 4.9–13.4), oral diadochokinesis (OR 5.3, 95%CI 1.0–27.3), ≥ 80 years old (OR 4.9, 95%CI 2.6–9.2), genetic factor (SNPrs17601696) (OR 4.8, 95%CI 2.7–8.3), and partial dependence (OR 4.3, 95%CI 2.0–9.3). And the main factors associated with SI estimated by PR were dry mouth sensation (PR 4.1, 95%CI 2.6–6.5), oral sensorimotor alteration (PR 2.6, 95%CI 1.4–4.9), osteoporosis (PR 2.51, 95%CI 1.2–5.3), and heart diseases (PR 2.31, 95%CI 1.1–5.0).

Conclusion One in five older adults worldwide are expected to experience SI and factors associated with this underdiagnosed dysfunction included biological and physiological changes related to aging, physical and psychological conditions, and poor oral health. Early assessment is paramount for the prevention of future clinical complications and should be a high priority in health care practices.

Keywords Deglutition · Deglutition disorders · Aged · Oral health · Systematic review

Introduction

The world demographic profile is changing with noticeable aging of the population. Several dysfunctions that compromise the quality of life of older adults and may aggravate their clinical conditions have been underdiagnosed by healthcare providers [1]. One of these relevant and late-recognized dysfunctions and secondary signs to clinical disorders is dysphagia, functional impairments characterized by any difficulty in conducting food from the oral cavity to the stomach [2].

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Published online: 07 October 2022

Swallowing impairment (SI), particularly, is frequently underdiagnosed but has potential for health complications and a significant social impact [2]. The belief that it is an expected condition of aging, along with potentially neglected associated factors, leads to a belated identification of the condition and treatment, especially in the community-dwelling older adults [3]. The deficit in swallowing capacity is related to neurological alterations, even in the early stages of the disease [3], and to structural deficits of the oral cavity, such as tooth loss [4]. Besides respiratory complications, the difficulties in swallowing may later lead to nutritional deficiencies due to the limited variety of the diet [5]. It has also been associated with changes in social and emotional aspects since, in many cultural contexts, mealtimes are usually an opportunity for human and social interaction and pleasure [2].

A diverse array of diagnostic methods of dysphagia is available, including the objective evaluation with imaging, clinical assessments, and subjective scales. These methods differ in accuracy, difficulty of implementation, and costs [6]. Epidemiologic estimates of the disease frequency may vary depending on the diagnostic methods being used as well as the characteristics of the population being studied and the study design. To further support clinical practice and research efforts related to dysphagia, we conducted a systematic review of the current literature. The objective of this systematic review with meta-analysis was to evaluate the frequency of SI and its associated factors in community-dwelling older persons. Understanding the distribution and associated factors is a first step to better understanding the impact of this condition in older adults.

Materials and methods

Protocol and registration

This review followed the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) [7], and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) [8]. The study protocol is registered in the International Prospective Register of Systematic Reviews (PROSPERO: CRD42020153738).

Eligibility criteria

Articles that investigated the presence of SI in community-dwelling older adults (≥ 60 years) as outcome were considered included in this review. Observational descriptive and analytical studies (cross-sectional or cohort studies [if prevalence reported at baseline]) were included. Self-entitled case–control studies that did not select the cases and control patients based on the presence/absence of the outcome (SI) were evaluated as cohort studies, and only the baseline assessment was extracted. Real case–control studies were excluded.

There was no language restriction. Different diagnosis methods were considered to include in the review: objective instrumental (videofluoroscopy and flexible endoscopic evaluation of swallowing), clinical assessment (clinical evaluation with different consistencies, water, or saliva), screening instruments, or self-reported. To avoid overestimating the frequency of SI, samples of older people with tracheostomy or undergoing rehabilitation through home care were excluded. In addition, studies that did not include a clear criterion for SI definition and only reported on swallowing performance (muscle strength, electrical activity, or pharyngolaryngeal volumetric measurements) were excluded.

Literature search

The searches were performed in the electronic databases MEDLINE (accessed via PubMed), EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, Web of Science, Virtual Health Library (VHL) Regional Portal (including registers from the databases LILACS, CUMED, IBECS, BINACIS, LIPECS, BBO—Dentistry, BDENF—Nursing), and SciELO (from inception to September 18, 2021). The Cochrane Database of Systematic Reviews and the Centre for Reviews and Dissemination were reviewed for similar systematic reviews. The reference lists of previous systematic reviews and included studies were used as additional sources. Also, the first ten pages of results from Google Scholar were manually searched.

The search strategy combined terms to characterize the population of interest (community-dwelling older persons) and the condition of interest (SI), including the indexed terms for 'aged', 'independent living', 'healthy aging'; 'deglutition disorders', 'dysphagia', and variations of these. To enhance the comprehensiveness of the search, words related to exposures and study design were not included in the search strategy. The search terms were adapted to each database requirements. The complete search strategy is presented in Supplementary Table 1.

Study selection

Searched results were aggregated and duplicates were removed in the Endnote X9 (Thompson Reuters, Philadelphia, Pennsylvania) reference management software. Two reviewers (RSR and KWS) independently screened the citation and abstracts of studies identified in the initial searches to determine eligibility. For the potentially eligible and uncertain citations, full-text versions were retrieved and independently reviewed by the two reviewers.

Disagreements in the selection process were resolved by a third-party blind and independent reviewer (JBH).

Data extraction

One reviewer (RSR) used a form developed a priori to extract the following data: first author and year of publication, journal abbreviation, country of origin, continent, study design, research design, sample size, sampling, sex, mean and standard deviation or minimum and maximum age, socioeconomic (or proxy) level, SI assessment methods used, and SI frequency by assessment method. For association measurements, potentially associated factors were only considered when an adjusted multivariable analysis was presented. Even when the study design was cross-sectional, many studies presented odds ratios (OR) instead of prevalence ratios (PR). Both measurements were extracted and were analyzed separately. The descriptive measures extracted were standardized across studies when possible. Two reviewers (KWS and MAZM) independently checked all the extracted data.

Methodological quality assessment

Methodological quality was assessed for each included study by two independent reviewers (RSR and KWS), using the "JBI Critical Appraisal Checklist for studies reporting prevalence data", a specific tool for observational study design (Joanna Briggs Institute) [9]. The checklist consists of nine questions with the possibility of answering yes, no, unclear, or not applicable.

Statistical analysis

The frequency of older persons with SI was pooled by meta-analysis of proportions [10]. To estimate a general frequency only one frequency estimate was considered for each study, following a standard criterion considering the quality of the method used (in the order: instrumental, clinical, screening instrument, and self-reported). Additionally, supplementary analysis including all estimates for each assessment method was performed individually.

The meta-analyses of single proportions were conducted using the random intercept logistic regression model with logit transformation and were performed following the random-effects model due to the high heterogeneity across studies. Results were presented as a percentage of older people with SI with a 95% confidence interval (95%CI), as well as with the 95% prediction interval (95%PI). The PI reflects the variation of effects over different settings, including the values to be expected in future patients in different settings [11], and is considered a more conservative way to incorporate uncertainty into analyses in which true heterogeneity is expected, the case of meta-analysis of prevalence estimates [12]. Statistical heterogeneity between studies was also assessed by the I^2 inconsistency test, in which values above 25% and 50% were considered indicative of moderate and high heterogeneity, respectively. High heterogeneity was investigated using subgroup analysis considering the assessment method of SI and country of sample origin.

Association measurements were pooled by general meta-analysis. The results were presented as OR or PR with 95%CI according to the effect measure described in each study. The p value ≤ 0.05 was considered statistically significant. All analyses were performed using Meta [13] and Metafor [14] R Packages in the RStudio (version 1.4.1106), an integrated development environment using the R statistical software (version 4.1.0) (The R-project for statistical computing) [15].

Results

The systematic literature search returned 2,865 studies, which was reduced to 1,720 after duplicates' removal. Titles and abstracts were read and 96.1% of the papers were excluded for not meeting inclusion criteria. In total, 67 studies underwent full-text review, 41 were included in the qualitative analysis and global meta-analysis (Fig. 1) [3, 4, 16–54]. Nineteen studies investigated possible associated factors with SI [4, 16–27, 43, 46, 48, 51, 53, 54], seventeen presented analyses regardless of sex [4, 16–21, 23, 25–27] and two presented stratified for females and males [16, 22]. The effect measure in sixteen studies was OR [16–26, 43, 46, 51, 53, 54], and in three studies was PR [4, 22, 48].

Descriptive characteristics of the included studies are presented in Table 1. English was the predominant publication language; only three were published in other languages (Portuguese [21], Korean [29], and Spanish [52]. Most studies are from the last decade, with only four published before 2010 [18, 19, 30, 31]. Most of the studies were conducted in Japan (34.1%) [16, 23, 24, 26, 27, 30, 36–39, 43, 49, 51, 53, 54] followed by the United States of America (21.9%) [3, 19, 28, 31–35, 42]. By continent, most studies (58.5%) were from Asia [16, 17, 22–24, 26, 27, 29, 30, 36–39, 43–47, 49–51, 53, 54].

Table 2 summarizes the diagnostic assessment methods used in the included studies. Thirty-four used only one method to estimate SI frequency: three used objective instrumental assessments [4, 33, 34], seven water and saliva test [22–24, 37, 39, 43], seventeen a screening instrument [18–20, 25, 29, 30, 36, 40, 41, 45–47, 49–51, 54], and seven self-perception [3, 16, 21, 26, 38, 42, 48]. Seven studies presented the estimated frequency of SI by more than one assessment method: one presented by all subtypes [17],

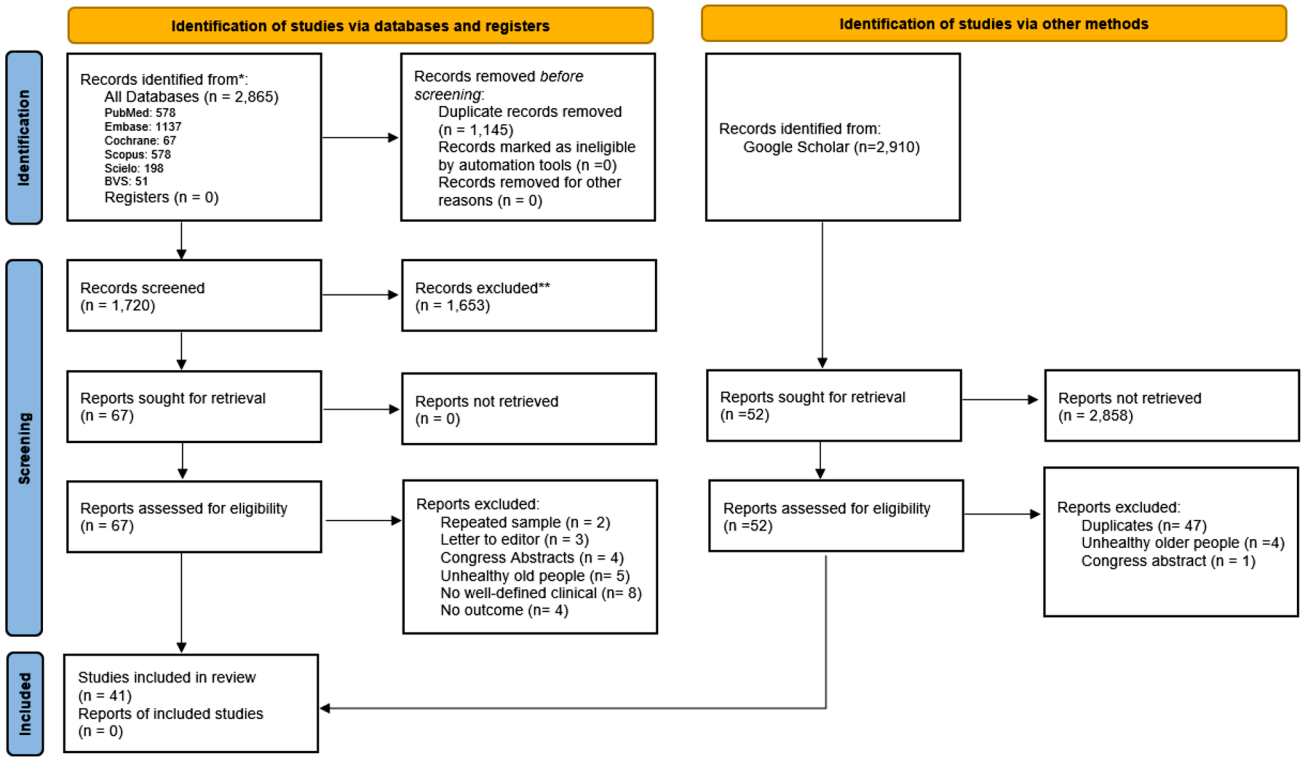

Fig. 1 PRISMA 2020 flow diagram of article selection process

two by objective assessment, water test, and a screening instrument [28, 37], and four presented by water test and a screening instrument [27, 32, 44, 53]. The lowest estimated frequency of SI was found by Zhang H. et al. 2020 [44], 5.5% assessed by Eating Assessment Tool (EAT-10), followed by Mulheren et al. 2018 [28], 6.4%, assessed by videofluoroscopy and Penetration/Aspiration Scale in the USA. The highest frequency of SI (63.7%) was estimated by Bahat et al. 2019 [25], that used the EAT-10 screening instrument in Turkey, followed by Hida et al. 2020 [39] that used the 30-mL Water Swallow (50.4%).

The methodological quality assessment is shown in Table 3. Most studies not presented an adequate sample size [17–19, 23–29, 31, 33–35, 37, 39–42, 49, 50, 54], using a convenience sampling method [3, 4, 16–20, 26–29, 31–35, 37, 39, 40, 49–54], and the condition was not measured in a standard and reliable way [3, 17–19, 28–37, 39–42, 47, 48, 50, 52, 54]. In addition, most studies did not control the effect measures for possible confounding factors in their analyses [3, 17–19, 21, 23–25, 30, 34, 36, 39, 40, 42, 44, 45, 49, 50, 52].

General frequency

The global meta-analysis showed a worldwide pooled frequency of SI in community-dwelling older persons of 20.35% (95%CI 16.61–24.68%, 95%PI 4.79–56.45, I^2 99%, $k=41$ studies, $n=33{,}291$ individuals—Fig. 2). Even though high heterogeneity between studies was identified, the estimated 95%CI using the random-effects model (that incorporates heterogeneity in the variance estimation) shows a variation of only 5% to 6% around the estimated frequency. The results have shown high heterogeneity and potential differences across countries, with higher estimates from Turkey (63.71%, 95%CI 60.87–66.45%, $k=1$, $n=1{,}138$—Fig. 2) and lower from China (10.52%, 95%CI 4.25–23.75%, I^2 100%, $k=2$, $n=5{,}154$—Fig. 2).

Frequency by assessment method

Some included studies showed frequency data by more than one assessment method. Six studies [4, 17, 26, 31–33] showed data for objective measures, thirteen for water test or saliva [17, 22–24, 26–28, 32, 35, 37, 39, 43, 44, 53], twenty-five for screening questionnaires [17–20, 25, 27–32, 35, 36, 40, 41, 44–47, 49–54], and nine for single-item self-report [3, 16, 17, 21, 26, 31, 38, 42, 48]. The pooled effect for each assessment method is shown in Fig. 3.

The estimated frequency with objective methods of SI assessment was 26.14% (95%CI 15.34–40.88%, 95%PI 3.27–78.73, $I^2=89.9\%$, $k=6$, $n=551$—Fig. 3A). All heterogeneity was explained by removing the study of Mulheren

Table 1 Descriptive characteristics of the analyzed studies

Study	Journal abbreviation	Country	Continent	E or C study	Research design	Sampling type	n (F/M/GD*)	Age mean (±sd) Age mean (min – max)	Education level
Rech et al. (2018) [4]	Oral Dis	Brazil	America	E	CS	C	142 (76/66)	73.5 (±8.9)	Up to elementary: (59–41.6%); Up to High: (52–36.6%); Up to Higher: (31–21.8%)
Mann et al. (2013) [3]	Australian Dental Journal	USA	America	E	CS	C	1065 (697/368)	75.5 (±8.4)	< high school and none listed:197 (18%); high school: 423 (40%); College: 323(30%); Postgraduate or higher 69(6%); Missing 53(5%)
Inui et al. 2017 [16]	Clin Interv Aging	Japan	Asia	E	CS	C	356 (238/118)	69.5 (60.0–79.0)	–
Chen et al. (2012) [17]	JNR	Taiwan	Asia	C	CS	C	216 (156/60)	74.2 (±6.3)	Iliterate: 57(26.4%); elementary school: 87(40.3%); high school: 24(11.1%); high school: 24(11.1%); college: 16(7.4%); above college: 8(3.7%)
Raginis-Zborowska et al. (2015) [18]	Exp Gerontol	England	Europe	E	CS	E	555 (430/125)	81.4 (±5.3)	–
Roy et al. (2007) [19]	Ann Otol Rhinol Laryngol	USA	America	C	CS	C	117 (78/39)	76.0 (±18.5)	< high school: 14(12.0); high school: 48(41%), associate's degree: 18(15.4%), bachelor's degree: 19(16.2%), master's degree: 18 (15.4%)
Byeon et al. (2016) [20]	JPTS	Korea	Asia	C	CS	C	325 (217/108)	73.1 (±8.3)	–
Mourão et al. (2016) [21]	Audiol Commun Res	Brazil	America	E	CS	P	507 (351/156)	71.9 (±5.2)	–
Yang et al. (2014) [22]	JAGS	Korea	Asia	E	CS	P	415 (220/195)	74.0 (65.0–95.0)	–
Okamoto et al. (2012) [23]	J Am Geriatr Soc	Japan	Asia	E	CS	C	3663 (1881–1782)	72.0 (±8.0)	–
Cha et al. (2019) [24]	Dysphagia	Korea	Asia	E	CS	P	236 (122/114)	76.6 (±5.8)	–
Bahat et al. (2019) [25]	J Nutr Health Aging	Turkey	Europe	E	CS	P	1138 (790/348)	74.1 (±7.3)	–
Nishida et al. (2020a) [26]	Gerodontology	Japan	Asia	E	CS	C	3475 (1920/1555)	75.8 (±6.8)	–
Nishida et al. (2020b) [27]	J Nutr Health Aging	Japan	Asia	C	CS	C	202 (167/35)	78.2 (±6.3)	–
Mulheren et al. (2018) [28]	Dyspagia	USA	America	C	CS	C	32 (16/16)	76.2 (±6.9)	–
Park et al. (2015) [29]	J Korean Soc Food Sci Nutr	Korea	Asia	E	CS	C	419 (303/116)	74.5 (±4.7)	–
Kawashima et al. (2004) [30]	Dysphagia	Japan	Asia	E	CS	E	1,313 (738/575)	74.1 (±6.9)	–
Chen et al. (2009) [31]	Dysphagia	USA	America	C	CS	C	169 (NR)	75.0 (±6.0)	
González-Fernández et al. (2014) [32]	J Am Geriatr Soc	USA	America	E	CS	C	47 (47/0)	86.3 (85.0–94.0)	–

Table 1 (continued)

Study	Journal abbreviation	Country	Continent	E or C study	Research design	Sampling type	n (F/M/GD*)	Age mean (±sd) Age mean (min – max)	Education level
Garand et al. (2019) [33]	Ann Otol Rhinol Laryngol	USA	America	C	CS	C	55 (38/17)	68.7 (±8.0)	–
Butler et al. (2011) [34]	J Gerontol A Biol Sci Med Sci	USA	America	C	CS	C	73 (35/38)	77.3 (±7.3)	–
Molfenter et al. (2018) [35]	JSLHR	USA	America	E	CS	C	44 (23/21)	76.9 (±7.1)	–
Igarashi et al. (2019) [36]	Plos one	Japan	Asia	E	CS	P	510 (283/227)	75.0 (±7.2)	–
Takeuchi et al. (2017) [37]	J Oral Rehabil	Japan	Asia	E	CS	C	176 (127/49)	84.3 (±7.7)	–
Mikami et al. (2019) [38]	Geriatr. Gerontol	Japan	Asia	E	CS	P	785 (441/344)	77.0 (±4.6)	12.7(±2.5) years of study
Hida et al. (2021) [39]	Aging Clin Exp Res	Japan	Asia	C	CS	C	139 (99/44)	76.9 (±4.7)	–
Jardine et al. 2021 [40]	Dysphagia	New Zealand	Oceania	C	CS	C	1020 (622/396/2)	75.2 (±6.2)	–
Holland G et al. 2011[41]	ISDE	England	Europe	E	CS	P	634 (485/149)	81.0 (±5.0)	–
Namasivayam-MacDonald et al. (2020) [42]	Geriatric Nursin	USA	America	E	CS	C	895 (719/176)	82.8 (±7.8)	–
Shimazaki et al. (2020) [42] [43]	Oral Health Prev Dent	Japan	Asia	E	CS	P	4676 (2408/2268)	(75–80)	–
Zhang et al. (2020) [44]	J Nutr Health Aging	China	Asia	E	CS	C	3361 (1740/1621)	72.6 (±6.10)	Illiterate 941 (28.0%); Primary school 1440 (42.8%); Middle school or above 958 (28.5%)
Zhang et al. (2021) [45]	Dysphagia	China	Asia	E	CS	C	1793 (NR)	75.2 (±0.47)	–
Chaleekrua et al. (2021) [46]	J Prim Care Community Health	Thailand	Asia	E	CS	P	874 (577/295)	69.7 (±6.79)	–
Liu et al. (2021) [47]	J. Pers. Med	Taiwan	Asia	E	CS	P	1000 (785/215)	60-≥85	Less than primary school 145 (14.5%); Primary school 354 (35.4%); Junior or senior high school 334 (33.4%); University or above 167 (16.7%)
Mello et al. (2021) [48]	Dysphagia	Brazil	America	E	CS	P	1447 (912/535)	60-≥80	None 196(13.7%); 1–7 years of study 779(54.3%); 8 or more years of study 459(32.0%)
Nishida et al. (2021) [49]	Nutrients	Japan	Asia	C	CS	C	320 (268/52)	77.3 (±6.6)	–
Sella-Weiss et al. (2021) [50]	Clinical Nutrition ESPEN	Israel	Asia	C	CS	C	180 (107/74)	75.9 (±8.0):female 75.9 (±7.8):male	–
Takeuchi et al. (2021) [51]	Aging Clin Exp Res	Japan	Asia	C	CS	C	188 (NR)	74.0 (70.0–79.0)	–
Fernández-Rosati et al. (2018) [52]	Rev Med Chile	Chile	America	C	CS	C	80 (51/29)	75 (±14)	–

Table 1 (continued)

Study	Journal abbreviation	Country	Continent	E or C study	Research design	Sampling type	n (F/M/GD*)	Age mean (±sd) Age mean (min – max)	Education level
Yamabe et al. (2019) [53]	Acta Med. Nagasaki	Japan	Asia	E	CS	C	304 (239/65)	79.9 (± 7.2)	–
Ogino et al. (2021) [54]	Clin. Med	Japan	Asia	C	CC	C	242 (153/89)	78 (71–84)	–

E epidemiologic study, *C* clinical study, *CS* cross-sectional study, *CC* case–control study, *P* probabilistic; convenience, *F* female, *M* male, *GD* gender diverse, *NR* not registered, *sd* standard deviation, *min* minimum, *max* maximum

et al. 2018 [28] and Chen et al. 2012 [17], and the frequency estimated becomes 38.22% (95%CI 33.00–43.71, 95%PI 27.29–50.48, I^2 0%, $k=4$, $n=314$). Pooled frequency of SI from water tests was 14.60% (95%CI 10.30–20.28%; 95%PI 3.52–44.48, $I^2=98.0\%$, $k=13$, $n=13{,}361$—Fig. 3B).

SI frequency assessed by screening instruments was estimated as 19.52% (95%CI 15.01–25.00%, 95%PI 4.54–55.30, I^2 99.0%, $k=24$, $n=14{,}700$—Fig. 3C). Self-reported frequency of SI was 17.67% (95%CI 12.95–23.65%, 95%PI 5.34–44.95, $I^2=97.0\%$, $k=8$, $n=8{,}131$—Fig. 3D).

Factors associated with swallowing impairment

Across studies, forty-three different factors were analyzed as potentially associated with SI using OR as the effect measure. Thirty factors considered both sexes and thirteen stratified by sex as male and female. Meta-analysis was performed for the factors repeated in more than one study, namely age (continuous) [17, 23–25], diabetes mellitus (presence) [23], sex (female) [23–25], and number of drugs (continuous) [25, 53]. Their estimated pooled effect was grouped with the effect measures of the other factors in Fig. 4A. A significant association was observed for 24 factors, including dry mouth (OR 8.1, 95%CI 4.9–13.4), oral diadochokinesis "ka" (OR 5.3, 95%CI 1.0–27.3), age "≥ 80 years old" (OR 4.9, 95%CI 2.6–9.2), the specific genetic factor "SNP rs17601696" (OR 4.75, 95%CI 2.72–8.31); "partial dependence" (OR 4.29, 95%CI 1.99–9.25); age "75–84 years old" (OR 3.25, 95%CI 1.46–7.22); and "major depressive disorder" (OR 3.05, 95%CI 1.16–8.02) (Fig. 4A). Considering only factors stratified by sex, only "oral dryness" was associated with SI in women (OR 1.80, 95%CI 1.05–3.07) and in men (OR 3.68, 95%CI 1.57–8.64).

Three studies that used PR as the effect measure, investigated forty-two factors, considering both sexes in the analysis [4, 21, 48]. Thirteen factors showed significant association with SI, including: "multimorbidity" (PR 30.0, 95%CI 4.10–219.75), "female sex" (PR 2.60, 95%CI 1.58–4.29), "oral sensorimotor alteration" (PR 2.58, 95%CI 1.36–4.89), "osteoporosis" (PR 2.51, 95%CI 1.18–5.34) and "dry mouth" (PR 2.46, 95%CI 1.53–3.96) (Fig. 4B).

Discussion

This systematic review was conducted to identify, quantify, and summarize a worldwide frequency of SI in the community-dwelling older persons and describe the factors associated with SI investigated in the literature. The estimated frequency of SI worldwide was 20.35% (95%CI 16.61–24.68%; 95%PI 4.79–56.45), including more than 30 thousand individuals in the analysis. The frequency estimates were heterogeneous across and within countries. Some variation was

Table 2 Descriptive characteristics of frequency estimated by the studies and type of assessment

Study	Self-reported *n* (%)	Screening *n* (%)	Water test or saliva *n* (%)	Clinical + Objective—instrumental *n* (%)
Rech et al. (2018) [4]	–	–	–	The clinical evaluation of swallowing is divided into the initial investigation with the indirect swallowing test and the direct deglutition test assessing the three food consistencies (pasty, liquid, and solid) (Caslpo, 2014): 142 (37.5%)
Mann et al. (2013)[3]	Swallowing difficulty self-reported: 175 (16.43%)	–	–	–
Inui et al. (2017)[16]	"Do you sometimes choke on drinks/food such as tea and soup?": 109 (20.5%)	–	–	–
Chen et al. (2012)[17]	The participants were asked whether they had a problem with swallowing: 41 (19.2%)	Swallow Questionnaire: 21 (10.5%)	90-ml Water Swallowing Test: 19 (11.2%)	Two or more of the following present: (1) self-report of swallow difficulty, (2) swallow impairment score of 92, and (3) swallowing rate of $\leq$4.22 ml. s^{-1} or choking: 23 (9.5%)
Raginis-Zborowska et al. (2015) [18]	–	Sydney Swallow Questionnaire (SSQ): 59 (11.3%)	–	–
Roy et al. (2007)[19]	–	M.D. Anderson Dysphagia Inventory (MDADI): 38 (32.5%)	–	–
Byeon et al. (2016) [20]	–	A modified dysphagia risk assessment for the community-dwelling elderly (DRACE): 171 (52.6%)	–	–
Mourão et al. (2016) [21]	Swallowing disorder reported: verified through five questions with dichotomous answers (yes/no) for the presence or absence of difficulties in the last 12 months: 182 (35.9%) (least one affirmative)	–	–	–
Yang et al. (2014) [22]	–	–	Standardized Swallowing Assessment (SSA): 139 (33.5%)	–
Okamoto et al. (2012) [23]	–	–	30-mL Water Swallow Test: 554 (15.1%)	–
Cha et al. (2019) [24]	–	–	Standardized Swallowing Assessment (SSA): 54 (22.9%)	–
Bahat et al. (2019) [25]	–	Eating Assessment Tool (EAT-10): 725 (63.70%)	–	–
Nishida et al. (2020a) [26]	Frailty checklist—Item: "Have you choked on tea or soup recently?" 431 (12.4%)	–	–	–

Table 2 (continued)

Study	Self-reported *n* (%)	Screening *n* (%)	Water test or saliva *n* (%)	Clinical + Objective—instrumental *n* (%)
Nishida et al. (2020b) [27]	–	Eating Assessment Tool (EAT-10): 54 (26.7%)	100-mL Water Swallow Test: 16 (7.9%)	
Mulheren et al. (2018) [28]	–	Dysphagia Handicap Index (DHI): 9 (29.0%)	Swallow Screen Protocol: 6 (18.8%) (minimum two failures)	Videofluoroscopy (VFSS) + Penetration/ Aspiration Scale (PAS): 2 (6.4%) (score of 3)
Park et al. (2015) [29]	–	Modified dysphagia risk assessment scale: 195 (46.50%)	–	–
Kawashima et al. (2004) [30]	–	Dysphagia screening questionnaire: 182 (13.8%)	–	–
Chen et al. (2009) [31]	‘‘Do you have difficulties with swallowing?’’ 16 (13.3%)	M.D. Anderson Dysphagia Inventory (MDADI): 17 (15.9%)	–	–
González-Fernández et al. (2014) [32]	–	Swallowing function questionnaire: 10 (21.3%)	Swallow Screen Protocol: 10 (21.3%) (minimum two failures)	–
Garand et al. (2019) [33]	–	–	–	Videofluoroscopy (VFSS) + Penetration/Aspiration Scale (PAS): 23 (42.0%) (score of 3)
Butler et al. (2011) [34]	–	–	–	Flexible endoscopic evaluation of swallowing (FEES) + Penetration/ Aspiration Scale (PAS): 28 (38.4%) (score of 3)
Molfenter et al. (2018) [35]	–	Eating Assessment Tool (EAT-10): 5 (11.4%)	30-mL Water Swallow: 9 (20.4%)	Videofluoroscopy (VFSS) + Penetration/Aspiration Scale (PAS): 16 (36.4%) (score of 3)
Igarashi et al. (2019) [36]	–	Eating Assessment Tool (EAT-10): 128 (25.1%)	–	–
Takeuchi et al. (2017) [37]	–	–	30-mL Water Swallow Test: 43 (24.4%)	–
Mikami et al. (2019) [38]	“Do you ever experience choking or coughing when drinking tea or soup?”: 185 (23.6%)	–	–	–
Hida et al. (2021) [39]	–	–	30-mL Water Swallow: 70 (50.4%)	–
Jardine et al. (2021) [40]	–	Eating Assessment Tool (EAT-10): 225 (22.1%)	–	–
Holland et al. (2011) [41]	–	Sydney oropharyngeal Dysphagia questionnaire (SSQ): 72 (11.4%)	–	–
Namasivayam-MacDonald et al. (2020) [42]	“Any problems with chewing or swallowing while eating in the past month?” 182 (20.3%)	–	–	–
Shimazaki et al. (2020) [43]	–	–	Repetitive saliva swallowing test (RSST): 181 (3.87%)	–

Table 2 (continued)

Study	Self-reported *n* (%)	Screening *n* (%)	Water test or saliva *n* (%)	Clinical + Objective—instrumental *n* (%)
Zhang et al. (2020) [44]	–	Eating Assessment Tool (EAT-10): 185 (5.5%)	30-mL Water Swallow: 415 (12.9%)	–
Zhang et al. (2021) [45]	–	Ohkuma questionnaire: 344 (19.2%)	–	–
Chaleekrua et al. (2021) [46]	–	Eating Assessment Tool (EAT-10): 100 (11.4%)	–	–
Liu et al. (2021) [47]	–	Eating Assessment Tool (EAT-10): 151 (23.9%)	–	–
Mello et al. (2021) [48]	"Do you have swallowing difficulties?" 117 (8.1%)	-	–	–
Nishida et al. (2021) [49]	–	Eating Assessment Tool (EAT-10): 38 (11.9%)	–	–
Sella-Weiss et al. (2021) [50]		Hebrew 10-Item Eating Assessment Tool (H-EAT-10): 33 (18.3%)	–	–
Takeuchi et al. (2021) [51]	–	Eating Assessment Tool (EAT-10): 21 (11.2%)	–	–
Fernández-Rosati et al. (2018) [52]	–	Eating Assessment Tool (EAT-10): 16 (18.2%)	–	–
Yamabe et al. (2019) [53]	–	Eating Assessment Tool (EAT-10): impossible to determine	100-mL Water Swallow Test: 35 (11.5%)	
Ogino et al. (2021) [54]	–	Eating Assessment Tool (EAT-10): 46 (19%)	–	–

Table 3 Risk of bias assessment in Observational Studies whit Joanna Briggs Institute Critical Appraisal Checklist

Study	1	2	3	4	5	6	7	8	9
Rech et al. (2018) [4]	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mann et al. (2013) [3]	Y	Y	Y	Y	Y	Y	N	Y	Y
Inui et al. (2017) [16]	Y	Y	Y	Y	Y	N	Y	Y	Y
Chen et al. (2012) [17]	Y	Y	N	Y	Y	Y	N	Y	Y
Raginis-Zborowska et al. (2015) [18]	Y	Y	N	Y	Y	Y	N	Y	Y
Roy et al. (2007) [19]	Y	Y	N	Y	Y	Y	N	Y	Y
Byeon et al. (2016) [20]	Y	Y	Y	Y	Y	Y	Y	Y	Y
Mourão et al. (2016) [21]	Y	Y	Y	Y	Y	N	Y	Y	Y
Yang et al. (2014) [22]	Y	Y	Y	Y	Y	Y	Y	Y	Y
Okamoto et al. (2012) [23]	Y	Y	N	Y	Y	Y	Y	Y	Y
Cha et al. (2019) [24]	Y	Y	N	Y	Y	Y	Y	Y	Y
Bahat et al. (2019) [25]	Y	Y	N	Y	Y	Y	Y	Y	Y
Nishida et al. (2020a) [26]	Y	Y	N	N	Y	Y	Y	Y	Y
Nishida et al. (2020b) [27]	Y	Y	N	N	Y	Y	Y	Y	Y
Mulheren et al. (2018) [28]	N	N	N	Y	Y	Y	N	Y	Y
Park et al. (2015) [29]	Y	Y	N	N	Y	Y	N	Y	Y
Kawashima et al. (2004) [30]	Y	Y	Y	Y	Y	Y	N	Y	Y
Chen et al. (2009) [31]	Y	Y	N	Y	Y	Y	N	Y	Y
González-Fernández et al. (2014) [32]	Y	Y	Y	Y	Y	Y	N	Y	Y
Garand et al. (2019) [33]	Y	Y	N	Y	Y	Y	N	Y	Y
Butler et al. (2011)[34]	N	U	N	Y	Y	Y	N	Y	Y
Molfenter et al. (2018) [35]	Y	Y	N	Y	Y	Y	N	Y	Y
Igarashi et al. (2019) [36]	Y	Y	Y	Y	Y	Y	N	Y	Y
Takeuchi et al. (2017) [37]	Y	Y	N	Y	Y	Y	N	Y	Y
Mikami et al. (2019) [38]	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hida et al. (2021) [39]	Y	Y	N	Y	Y	N	N	Y	Y
Jardine et al. (2021) [40]	Y	Y	N	N	Y	Y	N	Y	Y
Holland et al. (2011) [41]	Y	Y	N	Y	Y	Y	N	Y	Y
Namasivayam-MacDonald et al. (2020) [42]	Y	Y	N	Y	Y	Y	N	Y	Y
Shimazaki et al. (2020) [43]	Y	Y	Y	Y	Y	N	Y	Y	Y
Zhang et al. (2020) [44]	Y	Y	Y	Y	Y	Y	Y	Y	Y
Zhang et al. (2021) [45]	Y	Y	Y	Y	N	Y	Y	Y	Y
Chaleekrua et al. (2021) [46]	Y	Y	Y	Y	N	Y	Y	Y	Y
Liu et al. (2021) [47]	Y	Y	Y	Y	N	Y	N	Y	Y
Mello et al. (2021) [48]	Y	Y	Y	Y	Y	Y	N	Y	Y
Nishida et al. (2021) [49]	Y	Y	N	N	Y	Y	Y	Y	Y
Sella-Weiss et al. (2021) [50]	Y	Y	N	N	Y	Y	N	Y	Y
Takeuchi et al. (2021) [51]	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fernández-Rosati et al. (2018) [52]	Y	Y	Y	N	N	Y	N	Y	Y
Yamabe et al. (2019) [53]	Y	Y	Y	N	Y	Y	Y	Y	Y
Ogino et al. (2021) [54]	Y	N	N	N	Y	Y	N	Y	Y

1. Was the sample frame appropriate to address the target population?
2. Were study participants sampled in an appropriate way?
3. Was the sample size adequate?
4. Were the study subjects and the setting described in detail?
5. Was the data analysis conducted with sufficient coverage of the identified sample?
6. Were valid methods used for the identification of the condition?
7. Was the condition measured in a standard, reliable way for all participants?
8. Was there appropriate statistical analysis?
9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

Results: *Y* yes, *N* no, *U* unclear, *NA* not applicable

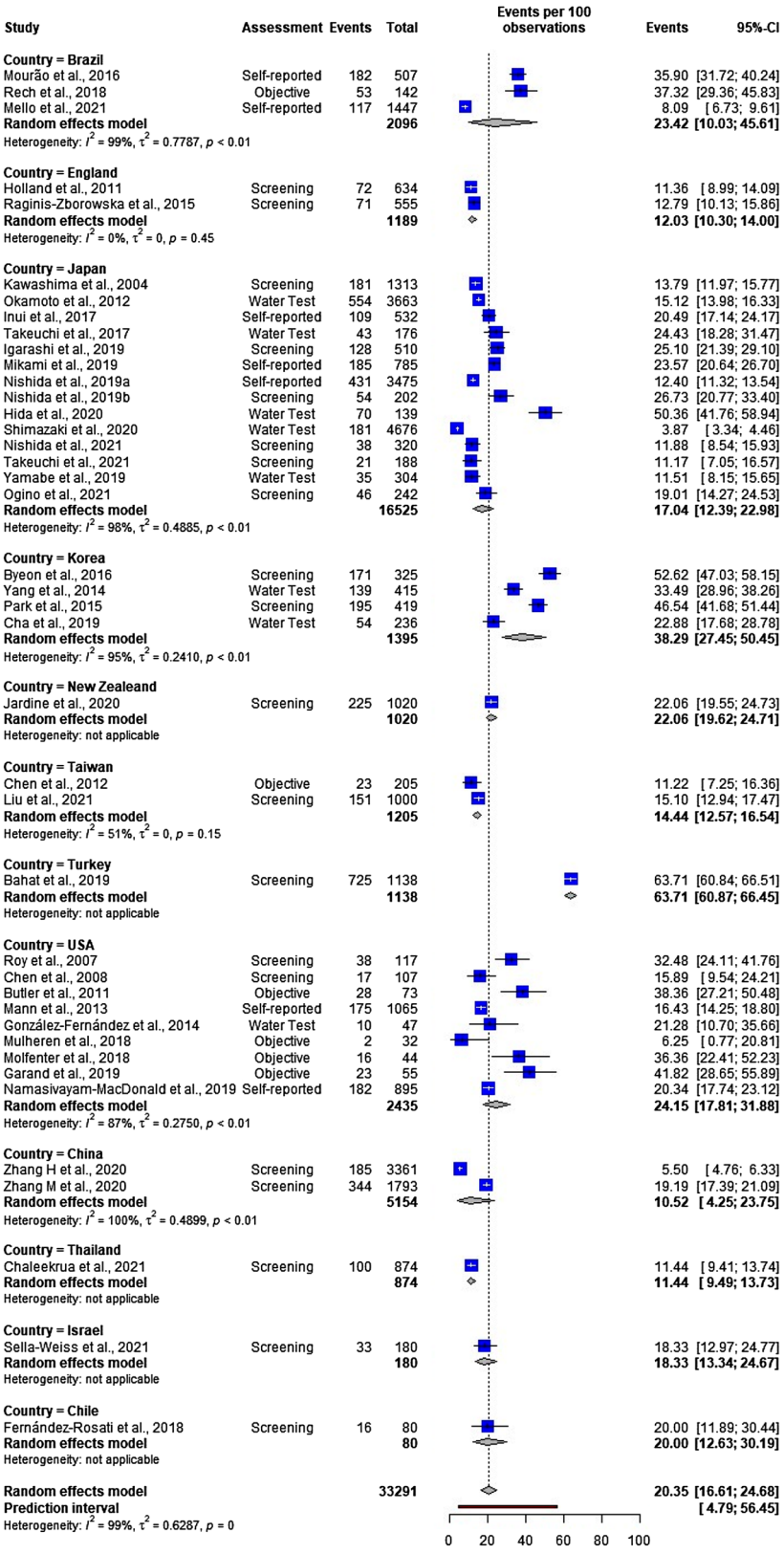

Fig. 2 Global meta-analysis of the frequency of oropharyngeal dysphagia by country

perceived across assessment methods, and the water test and screening instruments seems to underestimate the SI frequency in relation to the objective assessment.

Currently, there is no standardized instrument for screening and diagnosis in dysphagia, so it varies between different locations, publics, and health professionals [55]. We

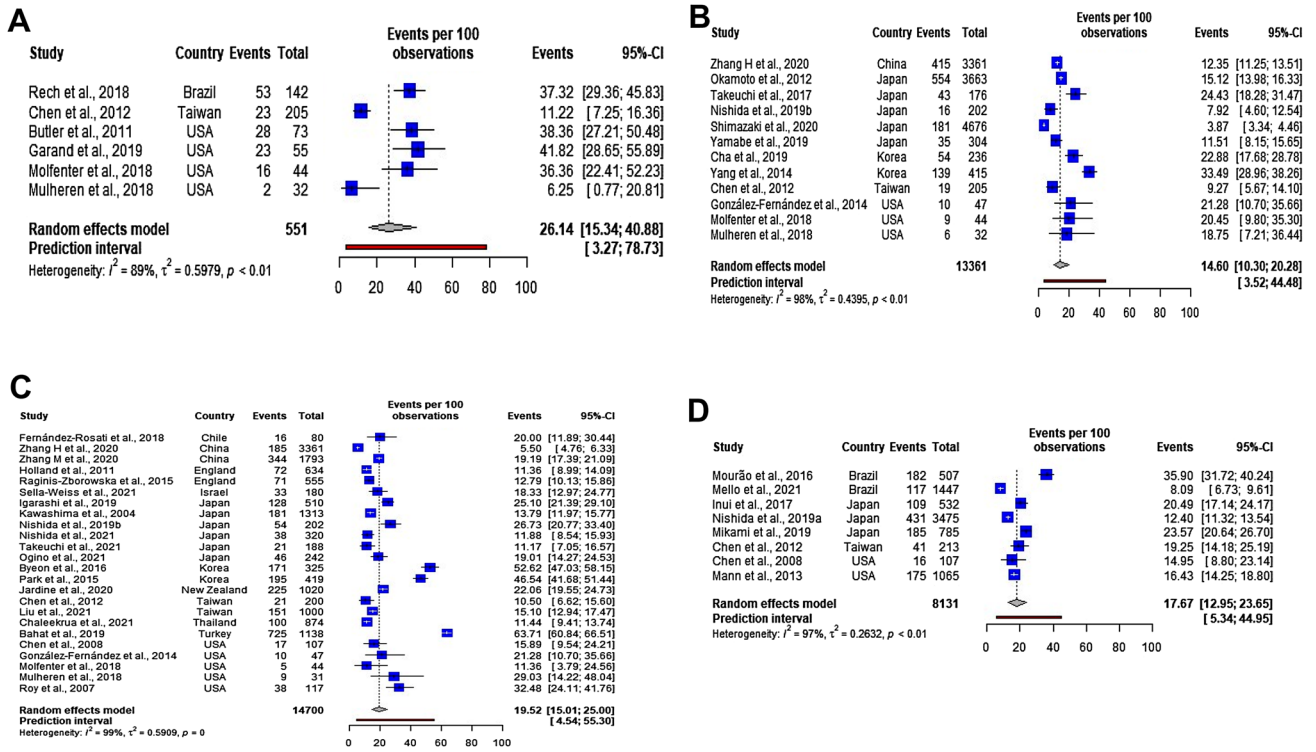

Fig. 3 Meta-analysis of the frequency of oropharyngeal dysphagia for each assessment method. Meta-analysis' subgroups of the frequency of oropharyngeal dysphagia by objective method 3A. Meta-analysis' subgroups of the frequency of oropharyngeal dysphagia by water test 3B. Meta-analysis' subgroups of the frequency of self-reported oropharyngeal dysphagia 3C. Meta-analysis' subgroups of the frequency of oropharyngeal dysphagia by screening instruments 3D

identified many diagnostic methods available to establish the presence of SI, which showed influence on the frequency estimates. The objective assessment showed the higher frequency of SI while the water test and screening instruments showed the lower, with a difference of 11.5% and 8.5%, respectively. Self-reported SI estimative was closer to the objective assessment, with a difference of 6.6%. Though the patients' perception may be a indicative of risk of having the condition, it cannot be considered a diagnosis [48]. Also, the literature reports that older people rarely spontaneously complain about swallowing, even though it is a frequent symptom in this population [56–58].

The lack of standardization may be a reflex of the fragility of the available methods. Previous systematic reviews showed that most bedside swallow examinations lack the sensitivity and none specific screening protocol provides an adequate predictive value [59], and that the strategies with the greatest reliability were the clinical examinations which evaluated different food consistencies [60]. Also, screening instruments, such as EAT-10, may present problems with intercultural validation [61]. Even the objective instrumental diagnoses, considered as the gold-standard, have insufficient evidence on the validity and reliability of its results [62], which may be influenced by the professionals who make it, the protocol it uses, and the measures it considers.

The SI emerges as a public health problem, deserving more effort to enhance the individuals' care and community geriatrics health trough comprehensive and effective public health policies and financial investment [59]. Prevention and early detection of dysphagia are important issues to be considered in an aging society. Swallowing may be subject to impairment due to old age, which is directly associated with the development of SI [63]. Some authors have already titled SI as a geriatric syndrome [5, 64], representing a challenge that goes beyond the clinical speech-language view.

Although this study makes it possible to present a worldwide estimate of SI, it is clear from its sub-analyses the importance of investigating the factors associated not only with the physiological aspects of aging but also with the socioeconomic factors from each country. Studies that have investigated SI in the community-dwelling are recent and concentrated in some countries, specially Japan [16, 23, 24, 26, 27, 30, 36–39, 43, 49, 51, 53, 54] and the United States [3, 19, 28, 31–35, 42], being worthy of further investigation by researchers, clinicians, and government representatives of low- and middle-income countries [65].

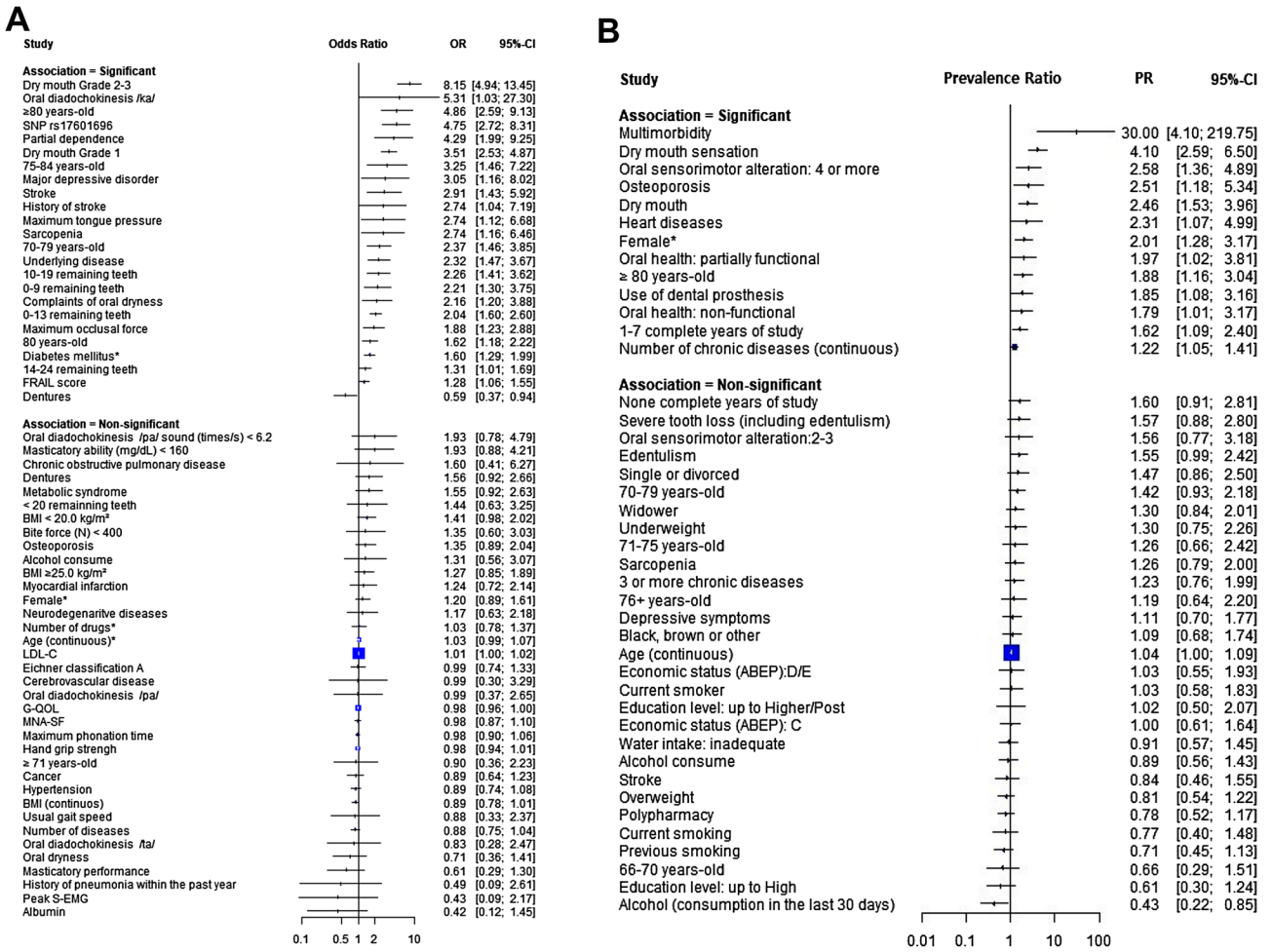

Fig. 4 Meta-analysis of odds ratio factors associated with oropharyngeal dysphagia estimates for both sexes (4A). Prevalence ratio estimates for both sexes (4B)

The literature showed several factors associated with SI in community-dwelling older persons: biological and physiological changes related to aging (loss of muscle mass and function, decreased tissue elasticity, sensory impairment, and reduced compensatory capacity of the brain), secondary diagnosis and treatments (number of chronic diseases, neurological diseases, and medication use), oral health conditions (tooth loss and xerostomia), and psychological status (depressive disorder) [4, 16, 20, 23–25]. These findings highlight the importance of multidisciplinary care of the aging population, including nutritional support, exercise activities, oral health care, coordination between medical specialties to prevent and control chronic non-communicable diseases and provide adequate medication management to increase the safety of the swallowing process [1–6].

Socioeconomic factors are known to impact health outcomes of individuals and populations [66–69]. Even though, only two included studies investigated the impact of education levels or economic status on SI, with no significant association identified [4, 48]. There is empirical evidence that individuals with lower educational levels and lower health literacy have worse health in comparison to more educated peers [69, 70]. A higher prevalence of SI was reported on nursing home residents with lower education level [71], which showed association with lower health literacy [72, 73], a factor needing consideration by speech therapists in patients' care [74, 75].

Despite the broad search conducted, only few of the studies identified were population-based and designed to measure the prevalence of SI, with a representative sample [41, 43, 46–48]. This limited our analysis, as we could not estimate the actual prevalence of SI. Other limitations of our study are due the different types of studies and populations included, without representation from many countries, low methodological quality of the studies and heterogeneity in the analyses. It is noteworthy that studies with variable sample sizes were included, and all analyzes showed high inconsistency (I^2), a characteristic that is expected in this

type of meta-analyses [12]. For this reason, prediction intervals were estimated for the analyses. The prediction range reflects the variation in treatment effects in different contexts, including the variation in expected effects in future. It is based on the estimation of the standard deviation of the variation between studies, not being much influenced by the sample size [11, 12]. The PI for all analyses was considerably wide, reflecting an important variation around the estimated global frequency to be expected in future studies in different settings [10].

In conclusion, one in five older adults worldwide are expected to experience SI and factors associated with this underdiagnosed dysfunction included biological and physiological changes related to aging, physical and psychological conditions, and poor oral health. This information can be used by health professionals and policy makers to optimize the interdisciplinary care of older community-dwelling individuals. Our study also contributes summarizing the actual body of evidence available on this topic, and highlights that there is much to advance in this field, including a standardization in the screening and diagnosis of SI, the development of studies with higher methodological quality and designed to estimate the prevalence of SI in more diverse communities and countries.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s40520-022-02258-x.

Acknowledgements This work was supported by the Brazilian Ministry of Education; National Council for Scientific and Technological Development—CNPq. JBH and BNGG hold productivity fellowship from CNPq and RSR received a PhD scholarship. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (Capes)—Finance Code 001 (JBH and MAZM).

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights The study protocol is registered in the International Prospective Register of Systematic Reviews (PROSPERO: CRD42020153738).

Informed consent For this type of study, no informed consent is required.

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