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Factors associated with malnutrition
in nursing home residents:
a systematic review and meta-analysis

Supervised by Professor Park Heeok

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I. Introduction

1. Background

Nutrition plays important roles on well-being, any inadequate or unbalanced nutrition status poses risk to human health (Amarya et al., 2015; Lean, 2019). Malnutrition was defined as a body state which “resulting from lack of intake or uptake of nutrition that leads to altered body composition (decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease” (Cederholm et al., 2017, p. 42). Malnutrition status possibly is the result of nutrition starving, the existence of disease, ageing process, or the combinations of those causes (Pirlich et al., 2005). Older adults face higher risk of malnutrition than younger people because of changes in aging body combined with increase of prevalent disease (Meijers et al., 2008).

The natural aging process makes changes in body composition (Buffa et al., 2011), changes in gastro-intestinal system function and taste loss (Sergi et al., 2017), differences in economic status (Guthrie & Lin, 2002), and change in social influences (Vesnaver & Keller, 2011) cause older adults to vulnerable to malnutrition. Moreover, the existence of one or more chronic problems or health disorders and disease-related changes also lead older adults to face higher risk of malnutrition compared to younger counterpart (Amarya et al., 2015; Shlisky et al., 2017).

As a result, malnutrition presented a higher prevalent in older adults compared to younger ones (Ewunie et al., 2022; Kyle et al., 2002). In older adult, 2.2 to 77.3% African older adult suffer from malnutrition and pooled prevalence is 18% (Seid &

Babbel, 2022). In Europe, 15.2 to 37.7% older adult faced high malnutrition risk, pooled prevalence is 28% and expected to increase with the rise of aging population (Leij-Halfwerk et al., 2019). The prevalence of malnutrition in older population was found significantly different across settings. A previous meta-analysis showed that the prevalence is 3.1% in community, 6.0% among outpatients, 8.7% in homecare, 22.0% in hospital (Cereda et al., 2016). The higher malnutrition prevalence was found among nursing home and long-term care's population, with 17.5% and 29.4%, respectively (Cereda et al., 2016).

Malnutrition leads to negative impacts on older adults' health. Generally, malnutrition causes problems in muscle, cardiovascular and respiratory system, gastrointestinal system, immune function, wound healing, and psychosocial impacts (Saunders & Smith, 2010). Previous review study found that mortality is one of the common malnutrition's consequences among nursing home older people (Bell et al., 2015). Additionally, malnutrition is also a burden on health care, social care, and aged-care system (Dent et al., 2023). Malnutrition also decreases the health-related quality of life (Rasheed & Woods, 2013), and also increases hardship of caring cost (Elia et al., 2016). Malnutrition presents high prevalence and its negative impacts in nursing home residents; it is important to understand which factor is associated with malnutrition in nursing homes. That knowledge might contribute to appropriate treatment, and behavior change decisions and the design of afterward clinical trials in appropriate subjects.

Factors associated with malnutrition in nursing homes can be categorized into factors that share similarity with general older adults and factors related to nursing home setting specific characteristics. Factors that are similar with general older adults who free-live in community settings such as age, marital status, gender, education in demographic domain (Carrasco et al., 2023; Torbahn et al., 2022; Yap et al., 2019); daily

life activities dependency, cognitive impairment, mobility problem in health functional domain (Carrasco et al., 2023; Torbahn et al., 2022); poor appetite, chewing problem, swallowing problems, oral health, in eating/ oral intaking domain (Castaldo et al., 2022; Madeira et al., 2019; Nazemi et al., 2015); digestive tract disease, cancer, diabetes, pressure ulcer, dementia, depression in disease related domain (Stahl et al., 2023; Sun et al., 2023); polypharmacy in medication related domain (Velázquez-Alva et al., 2020); and other factors such as alcohol and smoking status, physical activity in lifestyle (Nazemi et al., 2015; Sun, 2023); and income and poor economic status or financial status in economic domain (Madeira et al., 2019).

Older adults living in nursing home nutrition care also influenced by nursing home setting specific characteristics high care levels, increase of required care level, immobility (Gaskill et al., 2008; Strathmann et al., 2013; Torbahn et al., 2021) in health function domain; eating half or less than half of food portion offered by nursing home staff, requiring supervision when eating, complaint of hunger (Borkent et al., 2023; Ho et al., 2022; Torbahn et al., 2021) in eating and oral intaking; pneumonia, oligophrenia, infectious disease, balance disorder, sleep problems (Borkent et al., 2023; van Nie-Visser et al., 2014) in disease related domain; number of specific medications (Fernández-Garza et al., 2023) in medication related domain; and social isolation (Vandewoude & Van Gossum, 2013) in social related domain.

Moreover, nutritional factors and nursing home facility also found in association to malnutrition among nursing home older adults. In nutritional factors, there were dietary diversity, energy intake, protein intake, proportion of nutrients and various kind of minerals and vitamins (Carrier et al., 2019) . In nursing home facility factors, there were less frequent weight check by staff (Papparotto et al., 2013), facility capacity (Pezzana et al., 2015), low facility daily food budget (Strathmann et al., 2013), nutritional intervention, staff ratio,

guideline for prevention and treatment malnutrition (Stahl et al., 2023), additional meal form family (Verbrugghe et al., 2013) showed the significant association with malnutrition in nursing home old people.

In previous literature, there are two reviews about factors associated with malnutrition in nursing home residents by Tamura (2013) and Bell (2015). The two reviews focused mainly on narrative synthesis without quantitative synthesis. After the two reviews, there were large numbers of factors which were reported including additional factors in each domain and new factors in nutritional domain. With the development in economic, living standard and high-quality health care, nutrition cares not only about fulfilling the amount of food or calories but also about the balance among nutrient groups (Hua et al., 2022) and pay more attention on micronutrient such as mineral and vitamins (Carrier et al., 2019). Moreover, according to the trend of growing aged population around the world, the need for nursing homes and similar long-term care settings is also increasing and more particular factors related to nutritional care process in nursing home setting such as the structural supporting for residents from nursing home during mealtimes, nursing home staff awareness about nutrition and malnutrition, and nutrition and food administrating process in nursing home have gained more attention (Stahl et al., 2023).

The nearest systematic review was conducted more than ten years ago (Tamura et al., 2013), after this review more updates and new added factors have been reported. To update the knowledge, an updating systematic review is needed. Moreover, the associations are still inconsistent across studies when conducted in different countries (Nazemi et al., 2015; Suominen et al., 2005; Verbrugghe et al., 2013), or conducted on different sample size (Papparotto et al., 2013; Valentini et al., 2009), it calls for the need of meta-analysis to estimate the pooled effect size to gain the larger view. Those are the

reasons why we did this systematic review study combined with meta-analysis about factors associated to malnutrition in nursing home residents.

2. Study purpose

- 1) To investigate the factors associated with malnutrition in nursing home residents.
- 2) To estimate pooled association strength of each factor with malnutrition in nursing home residents.

3. Definition of terms

1) Nursing home

Theoretical definition: Nursing home for aged people was defined as the settings that “provide 24-hour care or support for residents”, especially for people who “require assistance with activity of daily living and other identified health needs”; “provides long-term care and/or rehabilitation; and may provide palliative care or end of life hospice care” (Stanford et al., 2015).

Operational definition: In this study nursing home represented for nursing home, residential home, residential institution, long-term care facility, long-term residential care home, aged care home, senior home, skilled nursing facility, geriatric home, geriatric institution, or assisted living facility (Stanford et al., 2015).

2) Malnutrition

Theoretical definition: Malnutrition was defined as a body condition which “resulting from lack of intake or uptake of nutrition that leads to altered body composition

(decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease” (Cederholm et al., 2017, p. 42).

Operational definition: In this study, malnutrition is defined as follows:

Table 1. Literature Review of Malnutrition Assessment in Nursing Home Residents

	Instrument	Components	Definition
1	Mini Nutritional Assessment (Guigoz et al., 1994)	Food intake, weight loss, mobility, psychological stress or acute disease, neuropsychological problems, body mass index (BMI), lives in independently, take more than 3 prescription drugs per day, pressure sore or skin ulcer, number of full meals eat daily, selected consumption maker for protein, consume fruit and vegetables, consume of fluid, mode of feeding, self-view of nutritional status, consider about self-health status, mid-arm circumference, calf circumference.	Score < 17.
2	Mini Nutritional Short-Form Assessment (Rubenstein et al., 2001)	Food intake declining, weight loss; mobility, psychological stress or acute disease, neuropsychological problems, BMI/calf circumference	Score ≤ 7 .
3	Subjective Global Assessment (Baker et al., 1982)	Weight change, dietary intake, gastrointestinal symptoms, functional capacity.	Type B and C.
4	Malnutrition Universal Screening Tool (Elia, 2003)	BMI, weight loss, acute disease effect	Score 1-5.

(Table continued)

Table 1. (Continued)

Anthropometric measures		Definition
1	Age-specific BMI	BMI <18 kg/m ² in people younger than 65 years of age, and BMI <20 kg/m ² for people for 65 years of age and above (Everink et al., 2021)
		BMI between 20 and 23.9 kg/m ² plus no intake of nutrition for three days or poor intake for longer than ten days (van Nie-Visser et al., 2014).
2	Weight loss	> 5% loss of weight in last month, or > 10% loss of weight in the last six months (Stahl et al., 2023)
		loss > 6 kg in the previous six months or loss >3 kg in the last month (van Nie-Visser et al., 2014)
		weight loss of >3 kg in the previous 3 to 6 months (Kiesswetter et al., 2020)
		unintentional weight loss \geq 10% in previous six months (Everink et al., 2021).

II. Literature review

1. Malnutrition in nursing home residents

Nutrition plays a vital role on human health in any age or race, and an imbalance of nutrition include either uptake or lack of nutrition pose negative impact on human health (Lean, 2019). Nutrition affects the whole life course of humans. A newborn baby with low birthweight faces the risk of higher mortality, risk in mental development, and higher risk of adult chronic disease than a normal weight one. A child with imbalance of nutrition can be reduced mental function, inadequate growth process (Brown et al., 2017). In adolescents and adults, malnutrition can result to reduced physical capacity, increased maternal mortality and a high increase in the risk of malnutrition in older life. Malnutrition not only impacts on the whole lifetime but also negatively, indirectly on the next generations (Brown et al., 2017). When nutrition is the need of all the human system malnutrition leads to abnormal disorder or more serve of disease. Therefore, maintaining a balanced nutritious status is an important goal in health care.

Although the International Classification of Disease systems provided malnutrition codes, there are still inconsistent definitions of malnutrition. In a previous review, there are two common approaches that were used to define malnutrition, “nutrition-based definitions” and “nutrition- and outcome-based definition” (Elia et al., 2017). In nutrition-based definition, malnutrition was defined as “the condition that occur when body does not get enough nutrients” (US National Library of Medicine) or “diet is not provide adequate nutrition, or inadequate or unbalanced intake of nutrients, or doesn’t the right amount of nutrients” (England National Health Service). In other hand, nutrition- and outcome-based

approach, based on American Society for Parenteral and Enteral Nutrition malnutrition was known as an “acute, subacute or chronic state of nutrition, in which a combination of varying degrees of overnutrition or undernutrition with or without inflammatory activity have led to a change in body composition and diminished function” (American Society for Parenteral and Enteral Nutrition). Currently, in 2017 an evidence-based definition of malnutrition has been agreed by leading academic nutritional associations around the world. Malnutrition was defined “as a state resulting from lack of intake or uptake of nutrition that leads to altered body composition (decreased fat free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease” according to European Society for Clinical Nutrition and Metabolism (Cederholm et al., 2017, page 42).

Older adults face higher risk of malnutrition than younger counterparts. Compared to younger adults, elderly people are the more vulnerable object of malnutrition due to the aging process and the existence of comorbidity disease or illness (Amarya et al., 2015). In older adults, the natural process of aging makes changes in older adult body composition with higher body fat mass and lower muscle mass (Buffa et al., 2011). Changes in gastrointestinal system function and taste loss (Sergi et al., 2017) lead to reduced food intake and nutrition digestion and absorption problems. The presence of chronic disease/ health disorder in older adult is high, and with the existence of one/more chronic problem/health disorders and disease-related changes also lead older adults to face higher risk of malnutrition (Amarya et al., 2015; Shlisky et al., 2017). Moreover, changes in economic status and social influences were also related to the poor nutrition quality in older adults compared to younger ones (Guthrie & Lin, 2002; Vesnaver & Keller, 2011). The abovementioned factors affect older adults more vulnerable to malnutrition than younger counterparts.

Consistently, the malnutrition prevalence in older people were reported higher than younger people in previous studies (Ewunie et al., 2022; Kyle et al., 2002). In older adults, based on a previous meta-analysis study, 22.6% of European older people who live in developed countries, the prevalence of moderate and high malnutrition risk was nearly 50% (Leij-Halfwerk et al., 2019). In Africa population or developing countries, a wide range prevalence from 2.2% to 77.3% African older adults were reported malnourished across countries (Seid & Babbel, 2022). In other developing countries, the meta-analysis prevalence of malnutrition among older adults ranged from 6.1% to 20.63% in Thai, Iranian and Ethiopian (Chuansangeam et al., 2022; Khaleghi et al., 2023; Yisak et al., 2023).

Malnutrition causes many health consequences to older adults. Malnutrition adversely impacts muscle, cardiovascular and respiratory systems, gastrointestinal tract, immune system, wound healing, and psychosocial function (Saunders & Smith, 2010). The lack of energy in malnutrition also impacts muscle and bone and then leads to loss of functional capacity (Jackson et al, 2003; Stratton et al., 2003). Evidence indicated that malnutrition increases the risk of frailty/frailty (Boulos et al., 2016; Liu et al., 2020; Neyens et al., 2013; Verlaan et al., 2017); decrease daily living activities and physical performance (Damanti et al., 2021) and increases the risk of fall, (Liu et al., 2020; Neyens et al., 2013). Malnutrition also leads to worsening underlying disease, hospital admission (Larburu et al., 2022). Moreover, malnutrition related to depression (Smoliner et al., 2009), decrease the quality of life (Elia et al., 2016; Kuikka et al., 2009; Rasheed & Woods, 2013) and increase in the mortality rate (Nakazawa et al., 2012; Törmä et al., 2013) and mortality was reported as one of the main consequences of malnutrition among nursing homes (Bell et al., 2015).

Malnutrition directly causes negative health impacts, and then indirectly affects the health care agency and aged care system. Malnutrition related to increases the extra-cost for caring (Elia et al., 2016; Rasheed & Woods, 2013) due to higher demand of healthcare

resources related to nutritional assessment, following-up and malnutrition treatment (Abizanda et al., 2016). This extra cost was considered a significant burden to nursing homes (Meijers et al., 2012). Furthermore, malnutrition also indirectly causes adverse impacts on the social care system and the aged-care systems (Dent et al., 2023; Scholes, 2022).

Malnutrition was associated with functional dependence of older adults and there is higher prevalence of malnutrition in nursing home settings in comparison with general free-living older adults. Previous studies showed that older adults who have more functional dependencies face higher risk of malnutrition and malnutrition prevalence in older people statistical significantly difference across settings. The prevalence of malnutrition is around 17% in community dwelling (Almohaisen et al., 2022), 8.7% older adult in home-care setting, 22.0% older adult in hospital, whereas a significant higher prevalence of malnutrition by 28.7% was observed in of older adult who staying residential long-term care facility (Cereda et al., 2016). Similar evidence showed that nutritional status was significantly different in nursing home residents and community dwellings which the worse nutritional status was in favor to nursing home residents (Saghafi-Asl & Vaghef-Mehrabany, 2017).

Previous research has shown that the nutritional care for residents in nursing homes was not given enough attention (Håkonsen et al., 2019). Among nursing homes older adults, 20% to 39% of nursing home residents were reported to suffer from malnutrition and 47% to 62% were at risk for malnutrition (Bell et al., 2015). Other studies reported that from 8.2% to 21.1% residents stay in nursing homes were malnourished, and the prevalence of risk of malnutrition were also notably high, ranged from 35.8% to 66.4% around the world (Nazemi et al., 2015; Sahin et al., 2016; Vandewoude et al., 2019; Velázquez-Alva et al., 2020; Verbrugghe et al., 2013). With such high prevalence, various negative impacts on health and healthcare system, malnutrition in long term-care and nursing home setting should be paid

more attention and it is necessary to acknowledge what factors are associated with malnutrition among nursing home residents for contributing to afterward intervention.

2. Factors associated with malnutrition in nursing home residents

Understanding what factors are associated with malnutrition in nursing home resident synonym with acknowledging the magnitude (negative or positive associated) and its strength of the associations. The association information will contribute to appropriate intervention from nursing home administrator and staff, the behavior changes decisions among nursing home residents and the design of afterward clinical trials without wasting resources of the nursing homes.

In general community free-living older adults, factors associated with malnutrition were reported as the following domains: demographic factors, health function factors, eating/ oral intake factors with related to oral food intake, disease related factors, medication related factors, lifestyle factors, social and economic factors. In demographic factors, age, marital status, gender, education, financial status were found associated with malnutrition in older adults (Ganhão-Arranhado et al., 2018; Krzyminska-Siemaszko et al., 2016; Schilp et al., 2011). In terms of health function, there were frailty, daily life activities dependency, cognitive impairment, difficulties in mobility (Jung et al., 2017; Lahmann et al., 2016; Maseda et al., 2016). In terms of eating and oral intaking domain, poor appetite, chewing problem, swallowing problems, oral health, edentulism, nausea also significant associated with malnutrition in general older adults (Jung et al., 2017; Krzyminska-Siemaszko et al., 2016; Lahmann et al., 2016; Ramage-Morin & Garriguet, 2013).

In terms of psychological disease and disorder, depression, dementia, cognitive decline, loneliness also showed significant association (Ganhão-Arranhado et al., 2018; Gündüz et al., 2015; Krzyminska-Siemaszko et al., 2016). In terms of physical disease/disorders, associated factors were cancer, intestinal problems, diabetes, pressure ulcer, chronic disease, current hospitalization, pain (Akin et al., 2014; Ganhão-Arranhado et al., 2018; Jung et al., 2017; Sørbye et al., 2008). In terms of medication, polypharmacy was found to be associated with malnutrition (Maseda et al., 2016). In lifestyle domain, consumption of alcohol and smoking status, low physical activity (Jung et al., 2017; Schilp et al., 2011). In domain of economic factors, income and poor economic status showed significant association with malnutrition among older adults (Akin et al., 2014; Simsek et al., 2013). Those factors were also reported as factors associated with malnutrition among nursing home residents (Carrasco et al., 2023; Madeira et al., 2019; Nazemi et al., 2015; Sun et al., 2023; Torbahn et al., 2022; Yap et al., 2019). However, the difference in population characteristics between community dwellers and nursing home residents make the associations different across settings.

Beside those above-mentioned factors, residents' malnutrition is also influenced by nursing home setting specific factors. In health functional domain, there were high care levels (Gaskill, 2008), increase of required care level (Strathmann et al., 2013), immobility, bedbound or chairbound (Borkent et al., 2023; Torbahn et al., 2021). In eating and oral intaking domain, eating less than ½ offered food portion (Torbahn et al., 2021), feeding tools, feeding assistance (Castaldo et al., 2022), supervised eating (Borkent et al., 2023), complaint of hunger (Ho et al., 2022) was reported associated with malnutrition in residents. In physical disease domain, the associated factors were fever, pneumonia, oligophrenia, infectious disease, motor disorder (van Nie-Visser et al., 2014), balance disorder, sleep problems (Borkent et al., 2023). In psychological disease domain the factors were social

isolation (Bell et al., 2014). In medication related domain beside the number of prescription medication, more specific medications have been studied and be found associated with malnutrition (Fernández-Garza et al., 2023).

Additional nursing home setting specific factors associated with malnutrition are nutritional factors and nursing home facility and staff related factors. Nutritional factors including dietary diversity, energy intake, protein intake, proportion, sum relative to the recommended dietary allowance average of all nutrients and various kinds of minerals and vitamins (Carrier et al., 2019). The presence of nursing home related factors such as less frequent weight check by staff (Papparotto et al., 2013), facility capacity (Pezzana et al., 2015), low facility daily food budget (Strathmann et al., 2013), nutritional intervention, staff ratio, guideline for prevention and treatment malnutrition (Stahl et al., 2023), additional meal form family (Verbrugghe et al., 2013) also showed the significant association with malnutrition in nursing home residents.

There are vary nursing home aspects impact on those nursing home setting specific factors. Previous evidence showed that nursing home structure and staff characteristics significantly influenced their resident's outcome in general and nutritional status in particular (Shin, 2019; van Hoof et al., 2019). Activities of daily living function decline including self-eating function and dependence and more prevalent disease or health disorders are popular in nursing home and are the most reason made residents admitted to nursing home (Dramé et al., 2012; Gaugler et al., 2007). Those functions declined and dependence make resident required different level care from nursing home, the number of dependent residents, the prevalence of high-level dependence and the prevalence of residents with more prevent disease were increasing with time (Ng et al., 2020). Moreover, in nursing homes with the designed-fixed schedules for activities and eating in which nursing homes already calculated the average calories for group of residents and set up the

menu according to this calculation (Divert et al., 2015). It makes residents do not involve in the meal preparation and choose their favorite kind of food and quantities of meal based on their own individual favors and lead to less food intaking. The quality of resident nutritional care is influenced by institution structure such as presence of a dedicated nutrition team, responsibility and understanding about nutrition of care team, meal atmosphere, and institutional level policies or guidelines related to the prevention and treatment of malnutrition. Regarding caring process, those are the screening, assessment, and continuous monitoring nutritional status, the application of nutritional care plans as well as the systematical recording, and archiving nutritional documents of residents (Moick et al., 2020). Different study also resulted that higher professional level of nursing home staff were related to the greater value of maintaining a reasonable weight in resident (Shin, 2019); or the positive changes in nutritional health in the resident were associated with changes in practice and behavior among nursing home staff (Low et al., 2015).

While factors associated with malnutrition in nursing home residents were widely studied and reported, there are two reviews in this phenomenon in literature. In 2013, Tamura and colleagues reviewed studies until 2013 and reported factors in demographic, health function, eating/oral intaking, disease related, medication related factors which mostly share similarity with general community older adults such as older age, impaired function, dementia, depression, lack of appetite or swallowing problem; and nursing home setting specified factors such as high care level, fever and pneumonia or eating less than half offered food portion. After that, in 2015, Bell and colleagues reviewed 2013-2014 studies and found more factors in nursing home related factors such as low financial resource for food, social isolating feeling, small facility (Bell et al., 2015). The two reviews focused on systematic review and narrative synthesis factors until 2014 without conducting quantitative synthesis. After 2014, there were large numbers of new factors in each available domain and

new domain - nutritional factors were studied and published. However, the results were inconsistent across study across different countries (Nazemi et al., 2015; Suominen et al., 2005; Verbrugghe et al., 2013), across different sample sizes (Papparotto et al., 2013; Valentini et al., 2009), or across different definitions of exposure factors (Balci et al., 2019; Meguro et al., 2022; Pezzana et al., 2015).

In background of the inconsistent results across studies; the last updating review was conducted nearly ten years ago which mainly focused on factors narrative synthesis without quantitative synthesis; and there are many updating factors that have been reported associated with malnutrition in nursing homes but not yet systematically reviewed. This posed a gap in acknowledgement about factors associated with malnutrition in nursing home residents. To close the gap, it is necessary to conduct a new systematic review and meta-analysis to update new additional factors and to study the associations' consistence across studies by quantitative synthesis. Moreover, although there is still no significant evidence about the difference of malnutrition in nursing home residents across developed and developing countries. However, nursing home setting might be the new phenomenon in developing countries than developed countries and there is evidence about the lack of comprehensive care, lack of cooperation and resources in nursing homes in developing countries (Lloyd-Sherlock & Redondo, 2009; Yang et al., 2016). Therefore sub-group meta-analysis to assess the difference in factors associated with malnutrition between developing countries and developed countries is might necessary.

III. Methods

1. Study design

This systematic review and meta-analysis study was conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses PRISMA 2020 checklist and statement (Page et al., 2021). The study proposal also has got approval by Keimyung University Institutional Review, number: 40525-202310-HR-044-01 and study protocol has been registered in the International prospective register of systematic reviews registered ID: CRD42023425403, available at: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023425403.

2. Study selection

1) Inclusion criteria

In this study, we included all (1) studies was conducted in long-term aged care nursing home and similar settings or study conducted in multi-setting in which the result of nursing home residents was reported separately (2) study outcome was malnutrition which was assessed by validated assessment; (3) studies reported association data of at least one factor in studied of association with malnutrition by odds ratio, hazard ratio, prevalence ratio, relative risk; and (4) study design was quantitative observational studies, consisting of cohort study, cross-sectional study, and case-control study. Other inclusion criteria are (6) study was an original academic article which was published in peer-reviewed journal; (7)

study has written in English, and publication time was from inception date to the searching day (November 1st, 2023).

2) Exclusion criteria

We excluded (1) study was conducted in child-care nursing home (2) study conducted in aged care setting but not long-term setting such as acute care clinical setting, free-living community, or daycare center; (3) we exclude studies that used BMI cut-off point not age-specific; (4) studies used serum albumin as marker of malnutrition due to it is high influenced by inflammation in older adults (Dent, 2023) or (5) study not clearly mentioned the method to assess malnutrition; (6) duplicated data or in case there are more than two data from the same population, the largest sample size data will be selected; (7) full-text not available even after contacting responded author; (8) study was qualitative study, intervention study, psychometric evaluation study, review study; (9) study was case report, letter, editorial, or conference abstract.

3. Database and search strategy

The reviewer conducted searches on 4 databases including PubMed, EMBASE, CINAHL and Scopus. The search strategy is according to Medical Subject Headings term and manual words with the search keywords were “malnutrition”, “nursing home” and “factor” using Boolean connector words OR and AND. The search strategy was first made to systematically search on PubMed and was modified to be suitable to utilize in another database. The full search strategies are available in Appendix 1. Reviewer also did additional manual search via references, citation from included studies, academic nutritional journals, and Google Scholar database for more relevant study.

4. Study screening and data extraction

After systematic searching, data was imported into EndNote 21 software and was implemented duplication removal. Two reviewers screened titles and abstract's part on remaining findings. After that, reviewer Nguyen downloaded all full-text of related remaining studies and screened full-text. Included decision of each study according to available criteria. Two reviewers, Nguyen and Park discussed the results and any inconsistency in study screening and selection was resolved by discussion.

In the data extraction step, data were extracted based on the extraction form including information about first author name, publication year, study conducted country, type of study design, sample size, age average or range of age, female proportion, assessment instrument/tool/criteria, prevalence or proportion of malnutrition, associated factors, and odd ratios with its confidence intervals. Reviewer Nguyen extracted the required data using a pre-prepared extraction form and then discussed with reviewer Park about the extracted results to gain two reviewer agreed results.

5. Study critical appraisal assessment

We adopted the Joanna Briggs Institute critical appraisal checklists version 2020 (Moola et al., 2020) for assessing study quality of included studies.

In the analytical cross-sectional study checklists, there are 8 statements as below:

Statements

1. *"Were the criteria for inclusion in the sample clearly defined?"*
 2. *"Were the study subjects and the setting described in detail?"*
-

-
3. *“Was the exposure measured in a valid and reliable way?”*
 4. *“Were objective, standard criteria used for measurement of the condition?”*
 5. *“Were confounding factors identified?”*
 6. *“Were strategies to deal with confounding factors stated?”*
 7. *“Were the outcomes measured in a valid and reliable way?”*
 8. *“Was appropriate statistical analysis used?”*
-

In the cohort study checklist, there are 11 statements as below:

-
- | Statements |
|--|
| 1. <i>“Were the two groups similar and recruited from the same population?”</i> |
| 2. <i>“Were the exposures measured similarly to assign people to both exposed and unexposed groups?”</i> |
| 3. <i>“Was the exposure measured in a valid and reliable way?”</i> |
| 4. <i>“Were confounding factors identified?”</i> |
| 5. <i>“Were strategies to deal with confounding factors stated?”</i> |
| 6. <i>“Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?”</i> |
| 7. <i>“Were the outcomes measured in a valid and reliable way?”</i> |
| 8. <i>“Was the follow up time reported and sufficient to be long enough for outcomes to occur?”</i> |
| 9. <i>“Was follow up complete, and if not, were the reasons to loss to follow up described and explored?”</i> |
| 10. <i>“Were strategies to address incomplete follow up utilized?”</i> |
| 11. <i>“Was appropriate statistical analysis used?”.</i> |
-

Each statement was judged by “Yes”, “No”, “Unclear” or “Not applicable” answer according to the checklist using guides. If statement is “Yes”, the answer will be scored as 1; if statement is “No” and “Unclear” statement will be scored as 0; and the answer “Not applicable” was not scored (Moola et al., 2020). The percentage is calculated as Number of Yes / (Number of Yes + Number of No + Number of Unclear) x100%. The percentage be \geq

75% of highest score be identified as high quality study, be 50-74% be identified as medium quality and be <50% be identified as poor quality (Tiruneh et al., 2019). Reviewer Nguyen did the critical appraisal assessment and then discussed the results with reviewer Park, the uncertain in scoring also were solved by discussion between two reviewers.

6. Data analysis

Meta-analyses were conducted in factors that included at least 2 data in each factor (Valentine & Rothstein, 2010). In prevalence ratio, hazard ratio and risk relative, the included study if each factor is just one study. Therefore, just odds ratio and its confidence interval values were extracted to enter in meta-analysis to estimate the pooled effect size. The heterogeneity across studies was assessed according to Cochran's Q statistic and I^2 index. In this study, a Q statistic p value < 0.05 and/or an I^2 value > 50% was consider as important heterogeneity across studies (Higgins et al., 2003) and random-effects model was used, otherwise, a fixed-effects model was used.

Subgroup analyses were assessed by the difference between countries economic status according to United Nations classification (developed countries and developing countries). A p value < 0.05 of test for subgroup differences regarded significant differences. Publication biases were evaluated via visual funnel plots and p value Egger's test when there are 10 and above studies (Dalton et al., 2016). An asymmetrical funnel plot or a p -value < 0.05 of Egger's test be regarded as a witness of significant publication bias. All statistical analyses were implemented by R 4.3.1 software.

IV. Results

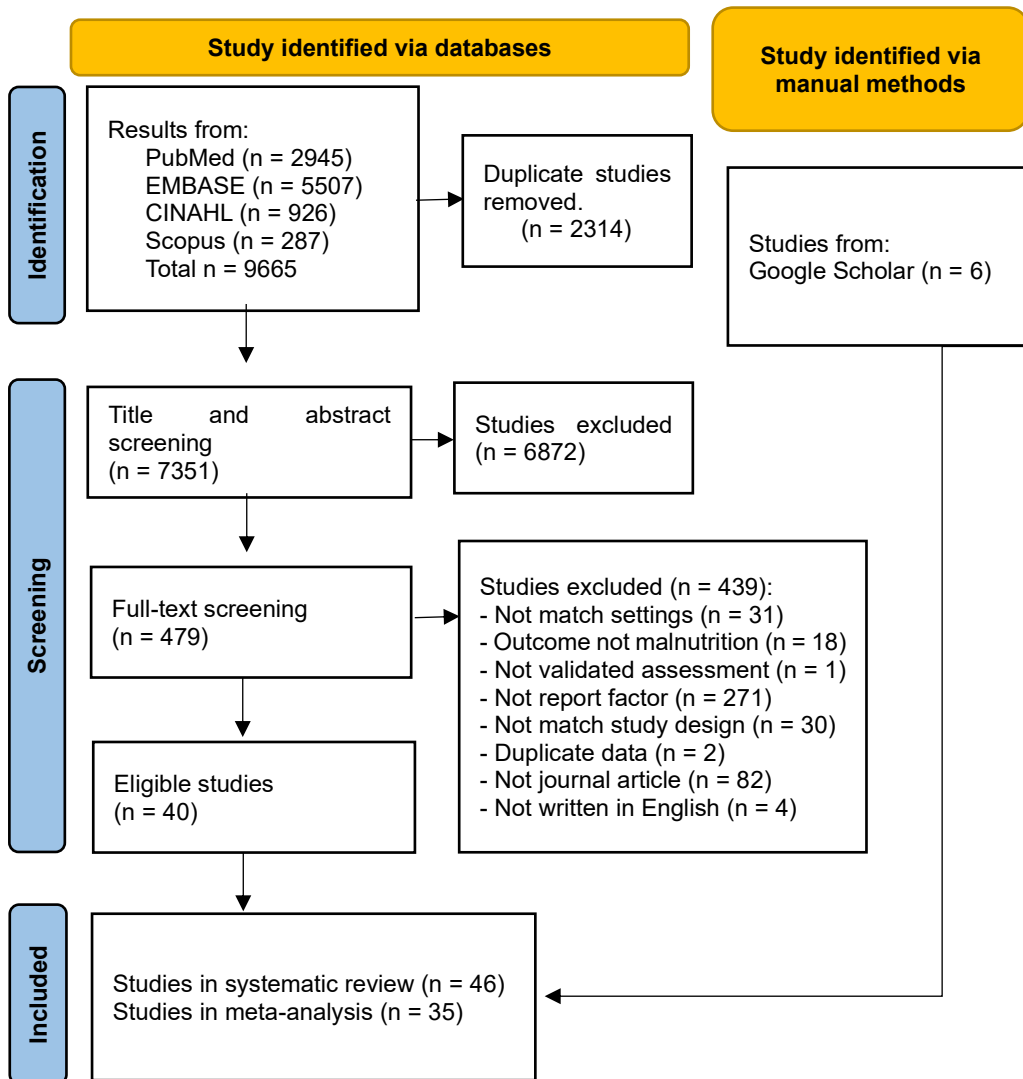


Figure 1. Flow diagram of study screening and selection.

1. Study selection

The systematic search from four databases identified a total of 9,665 studies. After duplicate removal by Endnote 21 software 7,351 studies have remained. In title and abstract screening, we excluded 6,872 unrelated studies and remained 479 studies for full-text screening. After full-text screening, 428 non-relevant studies were excluded due to following reasons: not matching study nursing home settings (31 studies), not matching study design (30 studies), not outcome is not malnutrition (18 studies), not using validated assessment (1 studies), not reported as least one studied factor (271 studies), duplicated data (2 studies), not a journal article (82 studies), not written in English (4 studies). Finally, 40 eligible studies have been selected. Manual search in via references, citation from included studies, academic nutritional journals, and Google Scholar database resulted 6 more eligible studies from Google Scholar were added. In total, the final 46 studies have been selected in this review, in which 11 studies reported factors that not included at least 2 data for meta-analysis, and 35 suitable studies were selected to apply meta-analysis. Details of the flow are available in Figure 1. List of included studies is available at Appendix 2.

2. Studies characteristics

46 including studies were conducted from 2001 to 2023. Among 46 included studies, there are two studies (Borkent, 2023; Borkent, 2022) that consisted of two parts: cross-sectional part and cohort part separately. Therefore the total cross-sectional study is 45 studies, and the total cohort study is 3 studies. In terms of cross-sectional studies, 45 studies (94.92% of total 48 studies) were conducted in which 16 studied were conducted

before 2015 and 29 studies conducted from 2015 and later. Those studies were conducted in 4 continents Europe (21 studies), Asia (15 studies), America (5 studies) and Australia (4 studies). 28 studies (62.2%) were conducted in developed countries and 17 studies (37.8%) were conducted in developing countries. The sample size ranged from 52 residents to 19,876 residents. Malnutrition was mostly assessed by Mini Nutritional Assessment (MNA) in 20 studies, followed by anthropometric measures in 12 studies, by Mini Nutritional Assessment-Short Form (MNA-SF) in 9 studies, and other assessment tools including Subjective Global Assessment (SGA) in 3 studies and Malnutrition Universal Screening Tool (MUST) in one study (detail results are available in Table 2).

In terms of cohort studies, three studies were published in 2022-2023, which two studies were conducted in Europe and one study was conducted in multi-continent: Europe and North America. All studies were conducted in developed countries after 2015. The sample size ranged from 3,836 residents to 11,923 residents. All three studies used anthropometric measurements to assess malnutrition. The follow-up time was 6 months in one study and routine care with median individual follow-up are 357 days and 372 days in two remaining studies (detail results are available in Table 3).

Regarding participants' characteristics, in cross-sectional studies, the total sample size consists of 78,776 residents. The prevalence of malnutrition widely ranged from 2% to 53%. According to the assessment method, malnutrition prevalence ranges by MNA from 3.2% to 40.9%, by anthropometric measure from 5% to 30%, by MNA-SF from 2% to 47.7%, and by SGA from 43% to 49.5%. Nursing home residents mean age ranged from 72.2 ± 8.8 to 86.8 ± 7.8 years old and female resident is more than male residents in all studies with prevalence account for from 50.4% to 85.7% (Table 2). In cohort studies, the total sample size is 20,737 nursing home residents. The malnutrition incidence ranged from 7.4% to 10.5% which was all assessed by anthropometric measure. Residents age ranged from age mean

83.6 \pm 7.0 to age range 86.0 [65-107] and female residents percentage account for from 68.1% to 71.3% (Table 3).

Factors associated with malnutrition can be categorized into demographic factors, health function related factors, eating and oral intaking related factors, nutrition related factors, disease related factors, medication related factors, nursing home staff and care process related factors and others. Demographic factors were reported to be significantly associated with malnutrition in 29/48 studies (60.4%). Health function related factors were studied and reported to be associated with malnutrition in 31/48 studies (64.6%). Eating and oral intaking related factors were studied and reported to be associated with malnutrition in 19/48 studies (39.6%). Nutritional related factors were reported associated with malnutrition in 3/48 studies (6.3%). Disease related factors were reported significantly associated with malnutrition in 20/48 studies (40.7%). Medication related factors were reported significantly associated with malnutrition in 4/48 studies (8.3%). Nursing home facility, staff and caring process factors were reported significantly associated with malnutrition in 9/48 studies (18.8%). And other factors were reported significantly associated with malnutrition in studies 19/48 studies (39.6%) The detailed results are available at Appendix 3.

Table 2. General Characteristics of Included Cross-sectional Studies.

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assessment	MN (%)	Significant factors	Non-significant factors	Quality
1	2001	Nordenram et al.	Sweden	192	84±8	80	BMI, WL	25	BMI, cognitive function, ADL function, chewing ability.	Age.	M
2	2005	Suominen et al.	Finland	2424	W:84.3±8.5 M:79.6±8.5	80.7	MNA	29	Female, length stay in NH >2 years, ADL dependence, stroke, dementia, number of medications, swallowing problems, eat less than half offered food portion, eating snack between meals, constipation, weight control once a year or less frequently, nutritional supplement.	Diabetes, coronary heart disease, hip fracture, Parkinson's disease, ventricular or duodenal ulcer, colitis, cancer	H
3	2005	Woo et al.	Hong Kong	1820	83.5±8.4	67.7	BMI, WL	26	Number of staff, female gender, age (per years increase), ADL function, need help with feeding.	NA	M

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age*	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
4	2007	Banks et al.	Australia	381	78.9±12.5	61.2	SGA	43	Male, advanced age (>80 vs 61-80), facility location is regional (vs metropolitan).	Facility location in rural or remote (vs metropolitan).	M
5	2008	Gaskill et al.	Australia	352	84.2±8.7	69.6	SGA	49.5	Advanced age (>90 vs 71-90), high level of care.	Female, age <70 (vs 71-90).	H
6	2009	Bourdel-Marchasson et al.	France	601	NH:84.6±9.0 LTC:81.8±10.4	74.7 79.8	MNA	17.3	BMI, mobility function, poor appetite led to food intake decline, weight loss during previous 3 months, psychological stress and acute disease, neuropsychological problems.	NA	M
7	2009	Meijers et al.	Netherlands	2061	80.3±10.0	68.3	BMI, WL, NI	19.2	Female, dementia.	NA.	M
8	2009	Valentini et al.	Austria, Germany	2137	84±9	79	MNA	9.2	Age, advanced age (>90 vs <75), swallowing problem (dysphagia), mobility function, number of medications, opiates.	Age 75-89 (vs <75).	H

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age * (%)	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
9	2011	Chang et al.	Taiwan	83	81.5±7 .52	59	MNA SF	Na	Female.	Age, number of medications, cognitive impairment, ADL, feeding difficulties, eating time.	H
10	2013	Cankurtaran et al.	Turkey	1708	78.0 [65–108]	51	MNA SF	11.9	Get up and go test, geriatric depression, hypertension, ADL function.	Duration of stay, number of medications.	H
11	2013	Papparotto et al.	Italy	186	83.7±8 .6	82.3	MNA	36	Age, female. ADL function, stroke, eat half or less amount of food at main mealtime, frequency of weight checks.	Length of stay in NH more than 37 months (37 months or less), four or more multiple illness, five or more multiple medication, constipation, main meals eaten in dining room.	M
12	2013	Verbrugghe et al.	Belgium	1188	84.3±7 .7	75.9	MNA	19.4	Recent hospitalized, cognitive function, presence of pressure ulcer, receiving nutritional intervention, additional meals provided by family, ingestion problem, deglutition problems, energy problems.	Age, female, diabetes, COPD, oncological problems, swallowing problems, diet.	H

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age * (%)	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
13	2013	Strathmann et al.	Germany	714	85 [81-91]	80 .8	MNA	10.2	Care level, daily food budget.	Female, dementia, capacity of institution, caring staff ratio.	H
14	2014	Doumit et al.	Lebanon	221	W:78.7±7.5, M:77.8±8.1	67	MNA	3.2	ADL function, oral health, depression.	Previous occupation status.	M
15	2014	Pereira et al.	Brazil	359	W:81.5±8.7 M:74.3±8.7	72.7	MNA	Na	ADL function.	Male, education level, dyslipidemia, cognitive function, depression.	M
16	2014	van Nie-Visser et al.	Netherlands Germany Austria	19876	Neth 84±7, Ger 83±8, Aus 85±8	73.7 , 78.2 , 85.7	BMI, WL, NI	18.9	Female, age, care dependency, infectious disease, cancer, diabetes, blood disease, dementia, cerebrovascular accident, respiratory disease, disease of digestive tract, motor disorder, injury resulting from accidents, total hip replacement, number of prevalent diseases.	Length of stay, endocrine/nutritional/metabolic disease, psychological disorder, nervous system disorder, eye/ear disorder, hemiparesis, disease of urinary tract, skin disorder, congenital disorder,	M

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
17	2015	Bonaccorsi et al.	Italy	2395	W:85.6±7.9 M:80.5±7.9	74.5	MUST	Na	Age, ADL function, cognitive function, eating in the bedroom, eating independent ability, chair, or platform scale.	Gender.	H
18	2015	Nazemi et al.	Iran	263	75.9±8.5	54.8	MNA	W: 13.2, M: 6.7	Eat half or less food, had teeth / good prosthesis, diabetes, smoking >20, studied in free time, prayed in free time.	Smoking 0-19 (vs non-smoker).	M
19	2015	Pezzana et al.	Italy	1394	84.0±8.3	73.6	MNA SF	35.2	Age (years), dementia, functional loss, oligophrenia, swallowing difficulties, pressure ulcer, totally dependent, number beds in the institution, length of stay.	Male, chronic psychiatric disorder, hypertension, artificial nutrition.	M
20	2015	Rathnayake et al.	Sri Lanka	311	75±8	55	BMI, MUA C, CC	30	Skipping meal, food allergies, lack of leisure activities, wearing denture.	Loss of appetite, depression.	M
21	2017	Huppertz et al.	Nether	3220	84.3±7.4	70.2	BMI, WL, NI	11.7	Teeth problem, chewing problem, xerostomia, poor oral health.	NA.	M

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
22	2017	Ziebo lz et al.	Ger-many	87	84.1±8 .6	72	MNA	Na	BMI, dementia, neuropsychological problem, mobility function.	Age (years), gender female, smoking status yes, permanently bedridden, edentulous, remaining teeth, dental health, periodontal health.	H
23	2018	Damo et al.	Brazil	399	≥ 60	69.9	MNA	26.6	Cognitive decline, unintentional weight loss.	Age (years), gender, ethnicity (skin color), type of facility.	M
24	2018	Madeira et al.	Portugal	1186	83.4 (≥ 65)	72.8	MNA	4.8	Female, financial situation is hard or very hard (vs comfort), appetite, eating difficulties due to oral health problem, depression, ADL function, loneliness feelings.	Age (years), marital status, education level,	H
25	2019	Carrier et al.	Canada	619	86.8 ± 7.8	68.8	PG-SGA	43.5	Energy intake, protein intake, MAR, folate, iron, calcium, copper, magnesium, phosphorus, selenium, vitamin A, B1, B2, B3, B6, B12, D, Zinc.	Vitamin C, E	H

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
26	2019	Yap et al.	Malay-sia	506	74.4±8 .7	61.9	MNA	11.1	Age, educational level (schooling), cognitive impairment, ADL function.	Gender, ethnicity, marital status.	M
27	2020	Balcı et al.	Turkey	1224	79.05± 8.3	52.8	MNA	23.4	ADL function, cognitive function, self-eating ability.	Age (years), gender female.	H
28	2020	Chatindiara et al.	New Zealand	174	85.5± 7.5	61	MNA SF	47.7	Residential aged care level, muscle strength, gait speed, frailty status.	ADL function, prior setting, type of admission, dental status, swallowing problem, cognitive status, number of nutrition supplements.	M
29	2020	Kiesswetter et al.	Ger-many	197	85.5±7 .9	73.6	BMI, WL	17.2	Age (years), mobility limitation, poor appetite,	Gender, polypharmacy, multimorbidity, diabetes, heart disease, stroke, cancer, respiratory, gastrointestinal, renal disease, arthropathy, cognitive impairment, depressive symptoms, eating difficulties, nausea, chewing problems, swallowing problem, fruit/vegetable intake.	M

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
30	2020	Izumi et al.	Japan	52	82.2±9.8	76.9	MNA SF	5.8.	BMI, tongue pressure, peak expiratory flow.	Age, gender, comorbidity, ADL function, modified water swallow test, functional tooth unit, number of teeth, tongue stain, plaque index, cognitive function.	H
31	2020	Velázquez-Alva et al.	Mexico	262	83.1±8.6	66.4	MNA	21.1	Age (years), polypharmacy, depression.	Gender female.	M
32	2021	Carrasco et al.	Portugal	98	84.1±6.7	67.3	MNA SF	2	Female, income level, history of falls with injuries.	Comorbidity, arthritis, balance disorder, dementia, cognitive impairment, suspected pathology.	H
33	2021	Everink et al.	Netherlands	8195	82.2±9.4	70.9	BMI, WL	16.7	Female, dementia, diabetes, stroke, pressure ulcer, psychogeriatric department, somatic department.	Disease of nervous system, respiratory diseases.	M
34	2021	van Kuijk et al.	New Zealand	981	[65-106]	70.4	MNA	W: 7.0 M: 5.6	Untreated carious teeth, severely impaired cognitive function.	Gender female, age, ethnicity, socioeconomic status, number of teeth, moderately impaired cognitive function.	H

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
35	2022	Borkent et al.	Netherlands	3722	83.1±7.1	67.6	BMI, WL	9.5	M: Social engagement, number of behavior-cognitive problems. W: Number of behavioral-cognitive problems.	M: Communication performance, depression, aggressive behavioral, cognitive performance. W: Communication performance, depression, aggressive behavioral, cognitive performance, social engagement.	M
36	2022	Castaldo et al.	Italy	1787	85.4±8.5	75.8	BMI, WL	15.4	Age (years), female, facility size >160 residents (vs 40-90 residents), pressure ulcer, psychiatric/metal disorder, ADL function, chewing problem, swallowing problem, feeding assistance.	Length of stay in NH, type of structure, facility size 91-160 (vs 40-90), type of unit, accidental falls.	M
37	2022	Ho et al.	Taiwan	131	80.3 ± 8.0	50.4	MNA	32.8	BMI, complaints of hunger, no feeding tools.	Swallowing problem, weight loss, complaints about food, no complaint, feeding tube.	H
38	2022	Hua et al.	China	386	80.6±9	56.7	MNA SF	Na	Age, number of children is 1, BMI, muscle mass, tooth loss	Number of children is ≥2, gait speed, minerals.	H

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
									affecting food intake, self-care status, moderate/insufficient dietary diversity, protein, body fat mass, percent body fat, skeletal muscle index, total body water, calf and upper arm circumference.		
39	2022	Meguro et al.	Japan	322	86.6±6.9	80.4	MNA SF	17.7	ADL function, number of teeth <20 with denture (vs <20	Age (year), gender, skeletal muscle mass index, type of staple food, number of teeth is ≥20, oral dryness.	H
40	2022	Mohsenpour et al.	Iran	160	72.16 ± 8.78	55	MNA	35	Age (years), BMI, psychological health, marital status is single.	Physical health, social relationship, environment, ADL function,	H
41	2023	Borkent et al.	Netherlands	3713	83.1±7.0	67.5	BMI, WL	9.5	Chronic pulmonary, cardiac disease, pressure ulcer, diabetes, psychiatric problems, GI tract problems, dental problems, aspiration, peripheral edema, locomotion	Neurological disease, musculoskeletal disease, infectious disease, cancer, balance problems, sleep problems, fever, aphasia, pain, locomotion wheelchair	M

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
									with walking device, bedbound, supervised eating, number of diseases.		
42	2023	Cheung et al.	Hong Kong	298	83.1±7.8	59.1	MNA	40.9	Cognitive function, self-care ability, mobility status.	Age, gender, length of stay in NH, number of chronic diseases, COPD, heart disease, hypertension, diabetes, renal dysfunction, gout.	M
43	2023	Fernández-Garza et al.	Mexico	280	85 [79-92]	72.1	MNA	12.5	Age (years), ADL function, cognitive function, BMI, urinary incontinence, stroke, benign prostatic hypertrophy, Parkinson's disease, angiotensin II receptor blockers, calcium channel blockers, atypical, risperidone, antiparkinsonian, anti-hypertensive, anti-psychotics, lipid lowering agents, laxatives, analgesics.	Gender, length of stay, weight, heart failure, beta blocker, ACE inhibitors medicines.	L

(Table continued)

Table 2. (Continued)

No.	Year	Authors	Country	Sample size	Age *	W (%)	Assess -ment	MN (%)	Significant factors	Non-significant factors	Quality
44	2023	Stahl et al.	Switzerland	5047	85.2±9 .1	71.5	WL	5	Presence of guideline for prevention and treatment of malnutrition.	Caring staffing ratio, staff grade mix, having a dietician, structural support during mealtimes, awareness of malnutrition, food administration process.	M
45	2023	Sun et al.	China	583	85.0±6 .6	65	MNA-SF	10.5	Swallowing problem (dysphagia), exercise frequency ≥ 3 (vs <3) times per week, possible sarcopenia, dementia.	NA	M

*: Mean of age or range of age; MN: Malnutrition prevalence; W: Women; M: Men; BMI: Body mass index; WL: Weight loss; NI: Nutrition intake; MNA: Mini nutritional assessment; MNA SF: Mini nutritional assessment Short form; SGA: Subjective global assessment; PG-SGA: Patient-generated Subjective global assessment; MUST: Malnutrition universal screening tool; NA: Data not available; ADL: Activities of daily living; MAR: Proportion consumed relative to the recommended dietary allowance average of all nutrients; L: Low quality; M: Medium quality; H: High quality.

Table 3. General Characteristics of Included Cohort Studies.

No.	Year	Author	Country	Sample size	Age *	W (%)	Assessment	Follow-up time	MN (%)	Significant factors	Non-significant factors	Quality
1	2022	Torbahn et al.	America, Europe	11923	86.0 65– 107	68.1	BMI, weight loss	6 months	10.5	Age, cognitive impairment, less than 50% food, immobility.	BMI, eat 50% problems, musculoskeletal disease, neurologic disease, number of medications, opiates, psychoactive substances.	M
2	2022	Borkent et al.	Netherlands	4978	83.9 ±7.0	71.3	BMI, weight loss	Total follow-up time: 7104 years Median individual: 357 days	M: 7.4 W: 9.5	Communication performance, number of behavioral cognitive problems.	Depression, aggressive behavioral, cognitive perform, social engagement.	M

(Table continued)

Table 3. (Continued)

No.	Year	Author	Country	Sample size	Age *	W (%)	Assessment	Follow-up time	MN (%)	Significant factors	Non-significant factors	Quality
3	2023	Borkent et al.	Netherlands	3836	83.6 ±7.0	69.8	BMI, weight loss	Total follow-up time: 5772 years Median individual: 372 days	8.9	Supervised/assisted eating, neurological disease, chronic pulmonary disease, balance problem, psychiatric problems, gastrointestinal tract problems, sleep problems, aphasia, number of diseases.	Musculoskeletal disease, cardiac disease, infectious disease, diabetes, cancer, pressure ulcer, dental problems, aspiration, fever, peripheral edema, pain, locomotion with walking device, bedbound.	M

*: Mean of age or Range of age; BMI: Body mass index; MN: Malnutrition incidence; W: Women; M: Men; M: Medium quality.

3. Study critical appraisal assessment

In this study, we adopted the Joanna Briggs Institute checklists to assess quality of analytical cross-sectional studies and resulted that 20/45 studies (44.4%) as high quality, 24/45 studies (53.3%) as medium quality and 1/45 studies (2.3%) as low quality. Scoring of each cross-sectional study is available at Appendix 4. In terms of cohort studies, all three included studies (100%) resulted as medium quality. Scoring results of each cohort study is available at Appendix 5.

4. Meta-analysis

The meta-analysis resulted that increased age, female gender, increased body mass index (BMI) in demographic domain; dependency in activities of daily living, eating assistance, immobility in health function domain; all eating/oral intaking factors including chewing problem, swallowing problem, eat half or less than half of offered food portion, loss of appetite; in disease related domain, digestive tract disease, constipation, respiratory disease, dementia, depression, cancer, diabetes, and pressure ulcer; increased number of prevalent disease and medication related factors including taking polypharmacy were found statistically significant associated with malnutrition in nursing home residents (Table 4).

Among significant associated factors, increased BMI and having diabetes were found to be associated with decreasing odds of malnutrition. Compared to residents with lower BMI residents, residents who have higher BMI are associated with lower odds of malnutrition with estimated association: heterogeneity I^2 0% ($p = 0.79$), pooled OR = 0.74 (95% CI 0.66 to 0.83). Compared to residents without diabetes, residents with diabetes

associated with lower odds of malnutrition with the pooled association: heterogeneity I^2 80% ($p < 0.01$), pooled OR = 0.76 (95% CI 0.58 to 0.99). All other remaining significant factors were related to greater odds of malnutrition in nursing homes residents. Residents who are older age are related to greater odds of malnutrition than younger residents with the estimated association: heterogeneity I^2 65% ($p < 0.01$), pooled OR = 1.02 (95% CI 1.00 to 1.03). Resident who be female associated with higher odds of malnutrition than one who be male with estimated association: heterogeneity I^2 64% ($p = 0.04$) pooled OR = 1.38 (95% CI 1.29 to 1.47). Residents with dependence on nursing home staff in activities of daily living is associated with higher odds of malnutrition compared to independent one, with the estimated association: heterogeneity I^2 0% ($p = 0.74$) pooled OR = 3.70 (95% CI 2.97 to 4.60). Residents who need assistance when eating are associated with higher odds of malnutrition compared to one who can feed them self during meals with estimated association heterogeneity I^2 65% ($p = 0.09$) pooled OR = 1.98 (95% CI 1.21 to 3.24). Immobility residents are associated with higher odds of malnutrition with the estimated association heterogeneity I^2 85% ($p < 0.01$) pooled OR = 2.50 (95% CI 1.39 to 4.47).

In eating and oral intaking domain, eating half or less than half of food portion which offered by nursing home and loss of appetite were found in strongest association with malnutrition. Eating half or less than half of offered food portion also found as the factors associated with higher odds of malnutrition in nursing home resident compared to one who eat fully offered food portion with the estimated association: heterogeneity I^2 75% ($p < 0.01$) pooled OR = 3.56 (95% CI 2.05 to 6.19). Losing of appetite or poor appetite also resulted associated with higher odds of malnutrition compared to the appetite one, with the estimated association: heterogeneity I^2 85% ($p < 0.01$) pooled OR = 3.60 (95% CI 1.36 to 9.57). Residents have chewing problem are associated with higher odds of malnutrition rather than resident have normal chewing function, with the estimated association: heterogeneity I^2 31%

($p < 0.22$) pooled OR = 1.42 (95% CI 1.15 to 1.76). Similarly, residents with swallowing problem associated with higher odds of malnutrition than the one who do not have swallowing problem, with the estimated association heterogeneity I^2 73% ($p < 0.01$) pooled OR = 1.71 (95% CI 1.21 to 2.42).

Presence of digestive tract disease was found associated with higher odds of malnutrition in nursing home with heterogeneity I^2 0% ($p = 0.77$) pooled OR = 1.31 (95% CI 1.19 to 1.43). Residents who suffer from constipation are associated with higher odds of malnutrition than those who do not have constipation with heterogeneity I^2 0% ($p = 0.33$) pooled OR = 1.81 (95% CI 1.36 to 2.41). The presence of respiratory disease was also found associated with higher odds of malnutrition with heterogeneity I^2 25% ($p = 0.26$) pooled OR = 1.18 (95% CI 1.07 to 1.30). Moreover, resident with dementia associated with facing higher odds of malnutrition compared to resident without dementia with heterogeneity I^2 74% ($p < 0.01$) pooled OR = 1.98 (95% CI 1.59 to 2.46). Residents suffer from depression also found in higher odds of malnutrition than one who free of depression with heterogeneity I^2 80% ($p < 0.01$) pooled OR = 1.84 (95% CI 1.18 to 2.85).

Study results indicated that residents with cancer are associated with higher odds of malnutrition than non-cancer resident with the estimated association heterogeneity I^2 0% ($p = 0.81$) pooled OR = 1.23 (95% CI 1.09 to 1.38). The presence of pressure ulcer also as risk factor of malnutrition when associated with higher odds of malnutrition with heterogeneity I^2 73% ($p < 0.01$) pooled OR = 2.14 (95% CI 1.54 to 2.97). Other factors including the increased number of diseases with heterogeneity I^2 22% ($p = 0.28$) pooled OR = 1.03 (95% CI 1.02 to 1.05) and taking polypharmacy with heterogeneity I^2 0% ($p = 0.50$) pooled OR = 1.75 (95% CI 1.24 to 2.47) also were found associated with higher odds of malnutrition in nursing home residents. Forest plots of meta-analysis are available at Appendix 6.

Table 4. Meta-analysis Results of Factors Associated with Malnutrition.

Factors		k	Heterogeneity I^2 (%), p		Model	Pooled OR (95% CI value)	p
Demographic	Increased age	14	65	<.01	R	1.02 (1.00-1.03)	<.01
	Gender female	18	39	.05	F	1.38 (1.29-1.47)	<.01
	Gender male	4	64	.04	R	0.98 (0.76-1.27)	0.89
	Single (vs married)	3	61	.08	R	1.11 (0.53-2.29)	0.79
	Divorced/widowed	2	0	.45	F	1.56 (0.75-3.28)	0.24
	Increased BMI	3	0	.79	F	0.74 (0.66-0.83)	<.01
Health function	ADL dependence	6	0	.74	F	3.70 (2.97-4.60)	<.01
	Eating assistance	3	36	.21	F	1.71 (1.43-2.04)	<.01
	Increased Bathel index	6	95	<.01	R	1.02 (0.96 – 1.08)	0.51
	Partial mobility	5	81	<.01	R	1.33 (0.88-2.02)	0.17
	Immobility	5	83	<.01	R	2.50 (1.39 -4.47)	<.01
Eating	Chewing problem	4	31	.22	F	1.42 (1.15 – 1.76)	<.01
	Swallowing problem	8	73	<.01	R	1.71 (1.21 – 2.42)	<.01
	Eat < 50% food	4	75	<.01	R	3.56 (2.05 – 6.19)	<.01
	Loss of appetite	4	85	<.01	R	3.60 (1.36-9.57)	<.01
Disease related	Digestive tract dis.	2	0	.77	F	1.31 (1.19 – 1.43)	<.01
	Constipation	2	0	.33	F	1.81 (1.36 – 2.41)	<.01
	Respiratory disease	3	25	.26	F	1.18 (1.07 – 1.30)	<.01
	COPD	2	0	.63	F	1.08 (0.55 – 2.10)	0.82
	Heart disease	2	0	.47	F	0.92 (0.55 – 1.57)	0.77
	Hypertension	3	55	.11	F	0.89 (0.73 – 1.09)	0.26
	Stroke	4	76	<.01	R	1.43 (0.62 – 3.29)	0.40
	Musculoskeletal dis.	2	0	.80	F	1.08 (0.92 – 1.28)	0.36
	Neurological disease	2	38	.20	F	0.99 (0.84 – 1.16)	0.88
	Dementia	8	74	<.01	R	1.98 (1.59 – 2.46)	<.01
	Increased MMSE	4	85	<.01	R	0.98 (0.93 – 1.03)	0.42
	Depression	5	80	<.01	R	1.84 (1.18-2.85)	<.01
	Urinary disease	2	31	.23	F	1.02 (0.93 – 1.13)	0.65
	Infectious disease	2	37	.21	F	1.21 (0.99 – 1.48)	0.07
	Cancer	4	0	.81	F	1.23 (1.09 – 1.38)	<.01
	Diabetes	7	80	<.01	R	0.76 (0.58 – 0.99)	<.05
	Pressure ulcer	5	73	<.01	R	2.14 (1.54 – 2.97)	<.01
	No. diseases	4	22	.28	F	1.03 (1.02 – 1.05)	<.01
Me	No. drugs per day	3	78	.01	R	1.01 (0.91 – 1.12)	0.85
	Polypharmacy	2	0	.50	F	1.75 (1.24 – 2.47)	<.01

Med-: Medication related factors; k: Number of studies; Model: Meta-analysis model; R: Random effect model; F: Fixed-effect model; ADL: Activities of daily living; dis: disease; COPD: Chronic obstructive pulmonary disease; MMSE: Mini mental status examination; GDS: Geriatric depression score.

Sub-group analysis between developed countries group and developing countries group found that there is a significant difference in the association of diabetes and malnutrition in nursing home between developed countries and developing countries ($p = 0.02$). While diabetes is associated with lower odds of malnutrition in developed countries nursing home residents with pooled OR = 0.61 95% CI 0.53 to 0.70, diabetes does not pose in a significant association with malnutrition in developing countries nursing home residents with pooled OR = 1.27 95% CI 0.71 to 2.28 (Appendix 7).

5. Publication bias

Two factors age and female gender were included in Egger's test analysis and visual funnel plot to examine if there exist of publication bias. Other factors were not applied due to the limit of included studies is smaller than 10 (Dalton et al., 2016). In factors age and female, the result of Egger's tests and the funnel plots showed that there is no publication bias in both factors increased age and gender female with no witness of asymmetrical funnel plot (Appendix 8) and Egger's test $p > 0.05$ (0.47 and 0.90, respectively).

V. Discussion

This systematic review was conducted to investigate factors associated with malnutrition in nursing home residents by systematic review and to estimate the effect size of the association of each factor by meta-analysis when appropriate.

Firstly, in included studies, there are many methods used for assessing malnutrition which can be categorized into: assessment tools and anthropometric measurements. In terms of assessment tools, there are two major sources of assessment tools including tools were developed to use in general older adults' population such as MNA, MNA-SF, MUST and tools were developed to use in adult population such as SGA. However, there are still concerns about the appropriateness of using those tools in nursing home setting and the lack of evidence about validity of the tool on true nutritional status of nursing home residents (van Bokhorst et al., 2014). In terms of anthropometric measurements, malnutrition was assessed by weigh, height, BMI, weight loss, arm or calf circumferences and so on. Those measurements can be a component in assessment tools or used independently. The most using measues are BMI and weight loss. However, this method poses limitations related to the change in older adult's body composition, the bias in weight and height measurements in older adults. Parallel with the aged process, older adults body composition changes forward to decreased lean mass, muscle mass and increased body fat mass (Buffa et al., 2011). It led to the BMI not being thoroughly reflected in the body composition. The measuring of height in older adults also easily make errors due to the change of aged spinal and standing posture problem especially in residents with mobility limitation (Drzał-Grabiec et al., 2014; Sperrin et al., 2016). Therefore, other anthropometric measures were added such as arm circumference, calf circumference, lean body mass that was agreed that easy to do in

nursing home, results a reliable result than BMI and can more clearly reflect the body composition in older population. In this review, most of studies used MNA to assess malnutrition among nursing home residents and large number of studied used the anthropometric measurements including BMI, weight loss. While MNA was recommended in nursing home settings, assess by BMI and weight loss remain argument in nursing home residents (van Bokhorst et al., 2014). It calls for the agreed-on malnutrition assessment “gold standard” in nursing home settings.

Secondly, this systematic review found more new factors compared to previous review by (Bell et al., 2015; Tamura et al., 2013). In demographic domain, with the shift in the resident-centered care approach in nursing homes (Li & Porock, 2014; Poey et al., 2017), more new demographic factors related to more details in residents’ background including educational level (Yap et al., 2019), number of children, race or ethnic (Damo et al., 2018), working status before moving to nursing home (Doumit et al., 2014) and financial status (Madeira et al., 2020) were studied and found significant associated with malnutrition in nursing home. More specific types of medication also were newly studied and reported significant associated with malnutrition in nursing home residents such as angiotensin II receptor blockers, calcium channel blockers, atypical, risperidone, anti-Parkinson, anti-hypertensive, anti-psychotics, lipid lowering agents, laxatives, analgesics (Fernandez-Garza et al., 2023). Its trend is supported by current evidence that each resident has their own unique background in demographic and medication status, therefore nutritional care for older adults should be more individual (Dent et al., 2023) to gain optimal effectiveness.

In eating and oral intaking domain, more new factors might influence on eating and oral intaking process were broadly added such as tongue pressure, peak expiratory flow, lip closure ability (Izumi et al., 2020) which resulted significant associated and different factors such as oral dryness, nausea, tongue strain, plaque index (Izumi et al., 2020) which

resulted non-significant. Moreover other factors related to nutritional care such as residents' complaint about hungry, proportion consumed relative to the recommended dietary allowance, vitamin and mineral supplements (Carrier et al., 2019), fruit/vegetable intaking (Kiesswetter et al., 2020) were also studied and found associated with malnutrition. Factors related to nutritional care process in nursing homes such as structure support during mealtimes, staff awareness of malnutrition, the food administration process (Stahl et al., 2023) though not found in significant association but reflect the new added compared to previous reviews (Bell et al., 2015; Tamura et al., 2013). A possible explanation for this addition is that nutritional care for older adults is a complicated process which needs collaboration from resident's perspective and oral intaking ability, nutrition consultant, the person who prepare food, the staff during meals time, and medical panel to consult about diet in special health status. Those more additional factors might reflect the effort to comprehend nutritional care in nursing homes and are suitable with current recommendation that nutritional care for older adults should be a multidisciplinary approach (Dent et al., 2023).

Thirdly, meta-analysis resulted in twenty factors that were significantly associated with malnutrition. In demographic domain, increased age and being female were found associated with increase odds of malnutrition. These results are consistent with previous meta-analysis studies (Crichton et al., 2019; Leij-Halfwerk et al., 2019; Streicher et al., 2018) in community living older adults. The prevalence of female gender is all higher than male gender in all included studies. And there is an increase of residents with advanced age admitted in nursing homes (Ng et al., 2020) appropriate nutrition care for different age groups could be put into consideration especially. In other hand, increased BMI was found associated with lower chance of being malnourished in nursing home residents. This result is consistent with previous evidence about low BMI is closely related to malnutrition and

keeping an appropriate weight and BMI is one of the steps in nutritional care (Reber et al., 2019). Low weight shows worse consequence than high weight in older adults and BMI range 31-32 for older female and 27-28 for older male were recommended (Kıskaç et al., 2022). Additionally, this study resulted that marital status is not associated with malnutrition in nursing homes while a significant association was found in community dwellers (Besora-Moreno et al., 2020). A possible explanation might be in nursing homes though the absence of partner, resident can find friends around and can minimum the effect of marital status on their daily lives.

In eating and oral intake domain, loss of appetite was found in the strongest association with higher odds of malnutrition in nursing home residents. This study is consistent with before evidence (Fielding et al., 2023; Pilgrim et al., 2015) that loss of appetite is significantly related with malnutrition in community older adults. In nursing homes, residents do not get involved in choosing ingredients and cooking food and feel that the food is not delicious, or food service is poor (Crogan et al., 2004). There are poor interactions between residents in nursing homes (Hauge & Kristin, 2008.) and connection between residents and staff is also weak, due to lack of time and resources (Hackman, 2023; Haunch, 2022). High prevalence of residents with mental problems (Elias, 2018) also influences reduced appetite. And while physical activities positively impact on appetite, residents are in low physical activities, mostly lying, or sitting, or just watching television (den Ouden et al., 2015) and institute's plan also erase the motivation to do activities in residents (Tak et al., 2014). Those factors and their combination led to the poor appetite situation in nursing home older people (Cox et al., 2020) and call for appropriate action to tackle this problem.

Eating half or less than half of the offered portion which offered by nursing home was found in the next strongest association with malnutrition. Offered food portion is a

special side of nursing home setting where residents' food was already calculated and provided by nursing home staff. Admission to nursing homes means that residents must change their previous living environment, food and eating habits. Combined with the fixed food and meal schedule from nursing home including menus, time, place to eat, how food was chosen and served (Divert et al., 2014) that prevent nursing home residents from choose their favorite food, plate decoration, time, and place to eat. Those reasons resulted in reducing food intake and leaving food on plate (Torbahn et al., 2021) and high portion of food waste from nursing home is widely reported (Hansen & Derdowski, 2020; Farapti et al., 2023).

Chewing problems were found associated with malnutrition in nursing homes. This result is consistent with previous evidence that chewing problem is a risk factor of malnutrition in general older adults (Zelig et al., 2022). The swallowing problem was also associated with an increase in odds of malnutrition in nursing home residents. This result is consistent with previous review and meta-analysis study that swallowing problem is risk factors of malnutrition among older adults (Banda et al., 2022) and stroke patients (Chen et al., 2017). There is still high prevalence of poor appetite, chewing problems, and swallowing problems in nursing home residents compared to community living older people (Doan et al., 2022; Malafarina et al., 2013; Porter et al., 2015) therefore nursing care in those eating and oral intaking need to be more consider in the effort to prevent residents from malnutrition.

In health function problem, activities of daily living dependency and eating dependency or needed of eating assistance were found associated with higher odds of malnutrition in nursing home residents. This study result is consistent with previous evidence of a significant association between low nutritional status and decreased activities of daily living function in older adults' population (Wojzischke et al., 2020). Immobility

was also found associated with higher odds of malnutrition in nursing homes. This result is supported by previous evidence that immobile lead to loss of muscle mass and loss weight, cause swallowing problem, constipation, pressure ulcer and increase incident of new diseases (Jaul et al., 2018; Rommersbach et al., 2020; Schirghuber & Schrems, 2022) then indirectly contributed to the malnutrition. Notably, this study resulted in the fact that partial mobility was not associated with malnutrition in nursing homes, while partial mobility was found as risk factor of malnutrition in community older adults (Streicher et al., 2018). A possible explanation might be in nursing home, with the presence of the care staff, the available of assisted equipment, and the prepared of food, difficulties of moving in nursing home do not significant impact that much compared to free-living older adults.

In psychological disease, this study found that dementia was associated with higher odds of malnutrition in nursing home residents. The result is consistent with previous study in community older adults (Bardon et al., 2021). The pooled dementia prevalence is also high in nursing home which more than half (53%) of residents suffer from dementia, and this prevalence is significantly higher than older adults who are living in their own home (Fagundes et al., 2021). Nutrition care for residents with dementia should be paid more attention and collaborated with dementia management. Depression was also found associated with increased malnutrition in nursing home residents. This result is consistent with previous evidence that depressed people faced higher odds of malnutrition among community dwelling older adults (Yisak et al., 2022) and among stroke patients (Chen et al., 2017). In nursing home, among 3 residents, there is more than one has depression (Tang et al., 2022) and there is various risk of depression in nursing home such as loneliness, comorbidities, or function impairment in comparing to free-living older adults (Thakur & Blazer, 2008; Zhao et al., 2018). Therefore, to prevent residents from malnutrition, appropriate mental health care should be properly considered.

In disease related domain, digestive tract disease and constipation were found as risk factors of malnutrition. These results are consistent with previous evidence that digestive tract is a system of organs that related to digest food, absorb nutrients, therefore, any problem in this tract can lead to low input of food or lack of nutrition that can lead to malnutrition (Rémond et al., 2015). Cancer as found to be a risk factor of malnutrition in nursing home residents. This result is consistent with previous evidence (Argilés, 2005) that cancer associated malnutrition which malnutrition can be resulted from cancer itself or cancer treating therapy side effects (Baracos, 2018). The number of prevalent diseases was found to be significantly associated with malnutrition in nursing homes. This result is supported by previous evidence that diseases impact on older adults by reduced appetite, systemic inflammation, change in endocrine, weight loss and sarcopenia, and there is a special type of disease-related malnutrition (Schuetz et al., 2021).

Conversely, diabetes resulted as a significant factor that reduces the odds of malnutrition in nursing homes. Evidence showed that the regular care provided by nursing homes to diabetes residents positively impacts on diabetes management and residents' health outcome including nutrition (Quinn et al., 2009). However, sub-group meta-analysis resulted that diabetes was not associated with malnutrition among residents in developing countries. The possible explanation is that in developing countries, there is still lack of a comprehensive policy about long term care for older adults (Lloyd-Sherlock, 2014) and for diabetes care in older adults (Werfalli et al., 2019). It leads to the diabetes care in nursing still not fulfill and evidence of high prevalence of malnutrition in nursing home residents with diabetes in developing country was found in previous study (Ozturk et al., 2021).

In medication related factors, polypharmacy was also found associated with malnutrition in nursing homes. This result is consistent with previous study that regardless instrument or malnutrition criteria, polypharmacy increases the risk of malnutrition in older

adults (Kok et al., 2022). By time, there is a change in the composition of residents living in nursing homes with an increase in people with more prevalent diseases/health disorders and increase in resident take polypharmacy (Ng et al., 2020) that make the nutrition care in nursing home should be given more consideration.

This study has several limitations. The first limitation is the selected study design is observational study and most of included studies are cross-sectional study so there will remain unknown about the causal relationship between each factor with malnutrition in nursing home residents, and based on the critical appraisal assessment most of studies is medium quality and one study is low quality. It is call for high-quality cohort studies in this topic need to be conducted. The second limitation is some factors resulting with the high heterogeneity across studies; to tackle this limitation, we used the random effect model to ensure the appropriate results. Sub-group analysis also applied in effort to find the source of heterogeneity. The third limitation is due to the limited of included study, other nursing home specific factors, such as frequency exercise, fall, duration of nursing home stay, low fruit/vegetables intake, additional meal from family, daily food budget or the presents of nutritional experts or present of guideline for prevent and treatment of malnutrition in nursing homes, which might be important in the relationship with malnutrition in nursing home residents, is not applied in meta-analysis so the association still remain unclear. The fourth limitation is in this study we only included studies that written by English so relevant study in other language was not found. It might lead to less comprehension of the study results. The last limitation of this study is the definition and instruments to assess malnutrition outcome are various across studies, it calls for uniting a “gold standard” in malnutrition assessment in aged population in near future.

Despite those limitations, to reviewer’s acknowledgement, this is the first systematic review and meta-analysis study about factors associated with malnutrition in

nursing homes. In this study, to gain comprehensive results, we have applied a comprehensive search strategy and did a comprehensive search in large electric databases. Handy manual searches have also been done on nutritional databases to make sure find and include as many relevant studies as possible. Additionally, in the whole review process, there are two reviewers who worked together to achieve the agreement of results that minimize the chance of errors in the review process. This study results will contribute to nutrition care in nursing homes and will provide information related to effective intervention to prevent vulnerable residents from malnutrition and its consequences and minimize consuming nursing home sources for upcoming studies.

VI. Conclusion

This study was conducted to summary factors and estimate the effects of factors associated with malnutrition among nursing home residents through a systematic literature review and meta-analysis. Factors were found statistically significant associated with decreasing odds of malnutrition in nursing home residents were increased BMI and having diabetes. Factors were significantly associated with higher odds of malnutrition in nursing home residents were increased age, being female, activities of daily living dependence, needing eating assistance, being immobility; chewing problem, swallowing problems, eating half or less than half of offered food portion, losing of appetite; presence of digestive tract disease, constipation, respiratory disease, dementia, depression, cancer, diabetes and pressure ulcer, number of prevalent diseases and polypharmacy. This study results will contribute to nutrition care and provide information for effective intervention in preventing malnutrition in high risk groups in aged-care nursing home settings.

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Appendix

Appendix 1: Search Strategy. (Searched date: November 1st, 2023)

	Database	Search strategy	Result
#1	PubMed (NLM)	((malnutrition OR malnourish* OR undernutrition OR undernourish* OR nutrition OR nutrition assess* OR nutritional status [MeSH Terms]) OR (malnutrition OR malnourish* OR undernutrition OR undernourish* OR nutrition OR nutrition assess* OR nutritional status [All Fields]))AND ((nursing home OR residential home OR residential care OR care home OR long-term care OR aged care home OR "institutionaliz* OR old age home OR aged home OR skilled nursing) [Title/Abstract]) AND ((factor* OR risk OR predict* OR determin* OR influen* OR regress* OR magnitud* OR input OR model OR "explain* OR drive* OR caus* OR contribut* OR associat* OR relat* OR etiolog* OR precipitat*) [Title/Abstract]) <i>Filter: human, English</i>	2,945
#2	EMBASE (Elsevier)	('malnutrition'/exp OR malnourish* OR 'undernutrition'/exp OR undernourish* OR 'nutrition'/exp OR 'nutrition assess*' OR 'nutritional status'/exp) AND ('nursing home':ti,ab,kw OR 'residential home':ti,ab,kw OR 'residential care':ti,ab,kw OR 'care home':ti,ab,kw OR 'long-term care':ti,ab,kw OR 'aged-care home':ti,ab,kw OR institutionaliz*:ti,ab,kw OR 'old age home':ti,ab,kw OR 'aged home':ti,ab,kw OR 'skilled nursing':ti,ab,kw) AND (factor*:ti,ab,kw OR risk:ti,ab,kw OR predict*:ti,ab,kw OR determin*:ti,ab,kw OR influen*:ti,ab,kw OR regress*:ti,ab,kw OR magnitud*:ti,ab,kw OR input:ti,ab,kw OR model:ti,ab,kw OR explain*:ti,ab,kw OR drive*:ti,ab,kw OR caus*:ti,ab,kw OR contribut*:ti,ab,kw OR associat*:ti,ab,kw OR relat*:ti,ab,kw OR etiolog*:ti,ab,kw OR precipitat*:ti,ab,kw) AND [humans]/lim AND [english]/lim	5,507
#3	CINAHL (EBSCO)	(AB (malnutrition OR malnourish* OR undernutrition OR undernourish* OR nutrition OR nutrition assess* OR nutritional status) AND AB (nursing home OR residential home OR residential care OR care home OR long-term care OR aged-care home OR institutionaliz* OR old age home OR aged home OR skilled nursing) AND AB (factor* OR risk OR predict* OR determin* OR influen* OR regress* OR magnitud* OR input OR model OR explain* OR drive* OR caus* OR contribut* OR associat* OR relat* OR etiolog* OR precipitat*) <i>Search modes: Boolean/Phrase</i> <i>Expanders - Apply equivalent subjects.</i> <i>Limiters: English Language; Human.</i>	926
#4	Scopus (Elsevier)	(TITLE-ABS-KEY (malnutrition OR malnourish* OR undernutrition OR undernourish* OR nutrition OR nutrition AND assess* OR nutritional AND status) AND TITLE-ABS-KEY (nursing AND home OR residential AND home OR residential AND care OR care AND home OR long-term AND care OR aged-care AND home OR institutionaliz* OR old AND age AND home OR aged AND home OR skilled AND nursing) AND TITLE-ABS-KEY (factor* OR risk OR predict* OR determin* OR influen* OR regress* OR magnitud* OR input OR model OR explain* OR drive* OR caus* OR contribut* OR associat* OR relat* OR etiolog* OR precipitat*)) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (EXACTKEYWORD , "Human"))	287
Total			9,665

Appendix 2: List of Included Studies

1. Nordenram, G., Ljunggren, G., & Cederholm, T. (2001). Nutritional status and chewing capacity in nursing home residents. *Aging Clinical and Experimental Research*, 13, 370-377. doi: 10.1007/BF03351505
2. Suominen, M., Muurinen, S., Routasalo, P., Soini, H., Suur-Uski, I., Peiponen, A., Finne-Soveri, H., & Pitkala, K. (2005). Malnutrition and associated factors among aged residents in all nursing homes in Helsinki. *European Journal of Clinical Nutrition*, 59(4), 578-583. doi: 10.1038/sj.ejcn.1602111
3. Woo, J., Chi, I., Hui, E., Chan, F., & Sham, A. (2005). Low staffing level is associated with malnutrition in long-term residential care homes. *European Journal of Clinical Nutrition*, 59(4), 474-479. doi: 10.1038/sj.ejcn.1602096
4. Banks, M., Ash, S., Bauer, J., & Gaskill, D. (2007). Prevalence of malnutrition in adults in Queensland public hospitals and residential aged care facilities. *Nutrition & Dietetics*, 64(3), 172-178. doi: 10.1111/j.1747-0080.2007.00179.x
5. Gaskill, D., Black, L. J., Isenring, E. A., Hassall, S., Sanders, F., & Bauer, J. D. (2008). Malnutrition prevalence and nutrition issues in residential aged care facilities. *Australasian Journal on Ageing*, 27(4), 189-194. doi: 10.3390/ijerph192417013
6. Bourdel-Marchasson, I., Rolland, C., Jutand, M.-A., Egea, C., Baratchart, B., & Barberger-Gateau, P. (2009). Undernutrition in geriatric institutions in South-West France: policies and risk factors. *Nutrition*, 25(2), 155-164. doi: 10.1016/j.nut.2008.07.016
7. Meijers, J. M., Halfens, R. J., Dassen, T., & Schols, J. M. (2009). Malnutrition in Dutch health care: prevalence, prevention, treatment, and quality indicators. *Nutrition*, 25(5), 512-519. doi: 10.1016/j.nut.2008.11.004
8. Valentini, L., Schindler, K., Schlaffer, R., Bucher, H., Mouhieddine, M., Steininger, K., Tripamer, J., Handschuh, M., Schuh, C., & Volkert, D. (2009). The first nutritionDay in nursing homes: participation may improve malnutrition awareness. *Clinical Nutrition*, 28(2), 109-116. doi: 10.1016/j.clnu.2009.01.021
9. Chang, C. C., & Roberts, B. L. (2011). Malnutrition and feeding difficulty in Taiwanese older with dementia. *Journal of Clinical Nursing*, 20(15-16), 2153-2161. doi: 10.1186/1471-2458-14-629

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Appendix 3: Summary of Significant Factors Associated with Malnutrition in Nursing Home Residents

No	Year	Author	Demo- graphic factors	Health function factors	Eating and oral intaking factors	Nutrition related factors	Disease/illness related factors	Medication related factors	NH staff, process and facility	Others
1	2001	Nordenram et al.	BMI	Cognitive function, ADL function	Chewing ability					
2	2005	Suominen et al.	Female, length of stay in NH	ADL dependence,	Swallowing problem, eat half or less than offered food portion, eating snack between meals.	Nutritional supplement	Stroke, dementia, constipation.	Number of medications.	Weight control once a year or less frequently	
3	2005	Woo et al.	Female, age	ADL function, need help with eating.					Number of staff	
4	2007	Banks et al.	Male, age.						Facility location	
5	2008	Gaskill et al.	Age	High level of care						
6	2009	Bourdel-Marchasson et al.	BMI, weight loss	Mobility function,	Poor appetite,		Psychological stress and acute disease, neuropsychological problem.			
7	2009	Meijers et al.	Female.				Dementia.			
8	2009	Valentini et al.	Age.	Mobility function.	Swallowing problem.			Number of medications, opiates.		
9	2011	Chang et al.	Female.							
10	2013	Cankurtaran et al.		ADL function, moving function			Depression, hypertension.			

(Table continued)

Appendix 3. (Continued)

No	Year	Author	Demo-graphic factors	Health function factors	Eating and oral intaking factors	Nutrition related factors	Disease/illness related factors	Medication related factors	NH staff, process and facility	Others
11	2013	Papparo to et al.	Age, female	ADL function,	Eat half or less than food portion.		Stroke,		Frequency of weigh check	
12	2013	Verbrugghe et al.		Cognitive function,			Pressure ulcer, ingestion problem, deglutition problem, energy problem.		Receiving nutritional intervention.	Recently hospitalized, additional meals from family,
13	2013	Strathmann et al.		Care level					Daily food budget	
14	2014	Doumit et al.		ADL function	Oral health impact on food intake		Depression			
15	2014	Pereira et al.		ADL function						
16	2014	van Nie-Visser et al.	Female, age	Care dependence.			Infectious disease, cancer, diabetes, blood disease, dementia, cerebrovascular accident, respiratory disease, disease of digestive tract, motor disorder, injury resulting from accidents, total hip replacement. Number of prevalent diseases.			
17	2015	Bonaccorsi et al.	Age	ADL function, cognitive function.	Eating in the bedroom, eating independent ability.					Chair or platform scale.
18	2015	Nazemi et al.			Eat half or less than food portion, have teeth or good prothesis.		Diabetes.			Smoking> 20, study, prayed in free time.

(Table continued)

Appendix 3. (Continued)

No	Year	Author	Demo- graphic factors	Health function factors	Eating and oral intaking factors	Nutrition related factors	Disease/illness related factors	Medication related factors	NH staff, process and facility	Others
19	2015	Pezzana et al.	Age	Functional loss, total dependence,	Swallowing problem,		Dementia, oligophrenia, pressure ulcer,		Number of beds in institution	Length of stay in NH.
20	2015	Rathnaya ke et al.			Skiping meal, wearing denture.					Food allergies, lack of leisure activities.
21	2017	Huppertz et al.			Chewing problem, poor oral health, xerostomia.					
22	2017	Ziebo lz et al.	BMI	Mobility function.			Dementia, neuropsychological problem.			
23	2018	Damo et al.	Weight loss.	Cognitive decline.						
24	2018	Madeira et al.	Female	ADL function	Appetite, eating difficulties due to oral health problem,		Depression.			Loneliness feeling.
25	2019	Carrier et al.				Protein intake, energy intake, proportion consumed relative to the recommended dietary allowance average of all nutrients, folate, iron, calcium, cooper, magnesium, phosphorus, selenium, zinc, vitamin A, B1,B2,B3,B6,B12,D.				

(Table continued)

Appendix 3. (Continued)

No	Year	Author	Demo-graphic factors	Health function factors	Eating and oral intaking factors	Nutrition related factors	Disease/illness related factors	Medication related factors	NH staff, process and facility	Others
26	2019	Yap et al.	Age, educational level.	Cognitive impairment, ADL function						
27	2020	Balci et al.		ADL function, cognitive function, self-eating ability						
28	2020	Chatindi ara et al.		Aged care level						Muscle strength, gait speed, frailty status.
29	2020	Kieessweter et al.	Age	Mobility limitation	Poor appetite					
30	2020	Izumi et al.	BMI							Tongue pressure, peak expiratory flow.
31	2020	Velázquez-Alva et al.	Age,				Depression	Poly-pharmacy		
32	2021	Carrasco et al.	Female				History of fall with injury			Income level
33	2021	Everink et al.	Female				Dementia, diabetes, stroke, pressure ulcer.			Stay in psycho-geriatric department, somatic department.

(Table continued)

Appendix 3. (Continued)

No	Year	Author	Demo-graphic factors	Health function factors	Eating and oral intaking factors	Nutrition related factors	Disease/illness related factors	Medication related factors	NH staff, process and facility	Others
34	2021	van Kuijk et al.		Impaired cognitive function	Teeth problem.					
35	2022	Borkent et al.								Social engagement, number of behavior-cognitive problems.
36	2022	Castaldo et al.	Female, age	ADL function, feeding assistance.	Chewing problem, swallowing problem.		Pressure ulcer, psychiatric/mental problem		Facility size	
37	2022	Ho et al.	BMI		No feeding tools.					Complaints of hunger.
38	2022	Hua et al.	Age, number of children. BMI	Self-care status,	Chewing problem,		Moderate/insufficient dietary diversity, protein.			Muscle mass, body fat mass, percent body fat, skeletal muscle index, total body water, calf and upper arm circumference.
39	2022	Meguro et al.		ADL function						number of teeth<20 with denture, lip closure ability.
40	2022	Mohsenpour et al.	Age, BMI, marital status	Psychological health						

(Table continued)

Appendix 3. (Continued)

No	Year	Author	Demo-graphic factors	Health function factors	Eating and oral intaking factors	Nutrition related factors	Disease/illness related factors	Medication related factors	NH staff, process and facility	Others
41	2023	Borkent et al.			Locomotion with walking device, bedbound, supervised/assisted eating.		Chronic pulmonary disease, cardiac disease, pressure ulcer, diabetes, psychiatric problem, digestive tract problem, aspiration, peripheral edema, number of diseases.			Dental problem
42	2023	Cheung et al.		Cognitive function. Self-care ability, mobility status						
43	2023	Fernández-Garza et al.	Age	ADL function, cognitive function			Urinary incontinence, stroke, prostatic hypertrophy, Parkinson's disease.	Angiotensin II receptor blockers, calcium channel blockers, atypical, risperidone, antipsychotic, antiparkinsonian, lipid lowering agents, antihypertensive, laxatives, analgesics.		
44	2023	Stahl et al.								Presence of guideline for prevention and treatment of malnutrition.

(Table continued)

Appendix 3. (Continued)

No	Year	Author	Demo-graphic factors	Health function factors	Eating and oral intaking factors	Nutrition related factors	Disease/illness related factors	Medication related factors	NH staff, process and facility	Others
45	2023	Sun et al.			Swallowing problem		Dementia, possible sarcopenia.			Exercise frequency.
46	2022	Borkent et al. (CH)	Age, BMI	Cognitive impairment, immobility.	Eat half or less than offered food portion.					
47	2022	Torbahn et al. (CH)								Communication performance, number of behavioral cognitive problems.
48	2023	Borkent et al. (CH)		Supervised/assisted eating.			Neurological disease, chronic pulmonary disease, balance problem, psychiatric problem, digestive tract problem, sleep problem, aphasia, number of diseases.			

NH: Nursing home; BMI: Body mass index; ADL: Activities of daily living; CH: Cohort study

Appendix 4: Critical Appraisal Assessment Results of Included Cross-sectional Studies

No.	Studies	1	2	3	4	5	6	7	8	%	Quality
1	Nordenram, 2001	Y	Y	?	?	Y	Y	?	Y	62.5	Medium
2	Suominen, 2005	Y	?	Y	?	Y	Y	Y	Y	75.0	High
3	Woo, 2005	?	Y	?	?	Y	Y	?	Y	50.0	Medium
4	Banks, 2007	?	?	Y	?	Y	Y	Y	Y	62.5	Medium
5	Gaskill, 2008	Y	Y	?	?	Y	Y	Y	Y	75.0	High
6	BourdelMarcha,2009	?	Y	?	?	Y	Y	Y	Y	62.5	Medium
7	Meijers, 2009	?	Y	Y	?	Y	Y	?	Y	62.5	Medium
8	Valentini, 2009	Y	Y	Y	?	Y	Y	Y	Y	87.5	High
9	Chang, 2011	Y	?	Y	?	Y	Y	Y	Y	75.0	High
10	Cankurtaran,2013	Y	?	Y	?	Y	Y	Y	Y	75.0	High
11	Papparotto,2013	?	?	Y	?	Y	Y	Y	Y	62.5	Medium
12	Verbrughe, 2013	Y	?	Y	?	Y	Y	Y	Y	75.0	High
13	Strathmann, 2013	Y	Y	?	?	Y	Y	Y	Y	75.0	High
14	Doumit, 2014	Y	Y	Y	?	?	?	Y	Y	62.5	Medium
15	Pereira, 2014	?	?	Y	?	Y	Y	Y	Y	62.5	Medium
16	van NieVisser, 2014	Y	Y	?	?	Y	Y	?	Y	62.5	Medium
17	Bonaccorsi, 2015	Y	Y	?	?	Y	Y	Y	Y	75.0	High
18	Nazemi, 2015	?	Y	?	?	Y	Y	Y	Y	62.5	Medium
19	Pezzana, 2015	Y	?	?	?	Y	Y	Y	Y	62.5	Medium
20	Rathnayake, 2015	Y	?	?	?	Y	Y	?	Y	50.0	Medium
21	Huppertz, 2017	Y	?	Y	?	Y	Y	?	Y	62.5	Medium
22	Ziebolz, 2017	Y	?	Y	?	Y	Y	Y	Y	75.0	High
23	Damo, 2018	?	Y	?	?	Y	Y	?	Y	50.0	Medium
24	Madeira, 2018	Y	Y	Y	?	Y	Y	Y	Y	87.5	High
25	Carrier, 2019	Y	Y	?	?	Y	Y	Y	Y	75.0	High
26	Yap, 2019	?	Y	?	?	Y	Y	Y	Y	62.5	Medium
27	Balcı, 2020	Y	?	Y	?	Y	Y	Y	Y	75.0	High
28	Chatindiara, 2020	?	?	Y	?	Y	Y	Y	Y	62.5	Medium
29	Kiesswetter, 2020	?	Y	Y	?	Y	Y	?	Y	62.5	Medium
30	Izumi, 2020	Y	Y	Y	?	Y	Y	Y	Y	87.5	High
31	VelázquezAlva, 2020	?	Y	?	?	Y	Y	Y	Y	62.5	Medium
32	Carrasco, 2021	Y	Y	Y	?	Y	Y	Y	Y	87.5	High
33	Everink, 2021	Y	Y	?	?	Y	Y	?	Y	62.5	Medium
34	van Kuijk, 2021	?	Y	Y	?	Y	Y	Y	Y	75.0	High
35	Borkent, 2022	Y	?	Y	?	Y	Y	?	Y	62.5	Medium
36	Castaldo, 2022	?	Y	Y	?	Y	Y	?	Y	62.5	Medium
37	Ho, 2022	Y	?	Y	?	Y	Y	Y	Y	75.0	High
38	Hua, 2022	Y	Y	Y	?	Y	Y	Y	Y	87.5	High
39	Meguro, 2022	?	Y	Y	?	Y	Y	Y	Y	75.0	High

40	Mohsenpour,2022	?	Y	Y	?	Y	Y	Y	Y	75.0	High
41	Cheung, 2023	Y	?	Y	?	Y	Y	Y	Y	75.0	High
42	Borkent, 2023	Y	?	Y	?	Y	Y	?	Y	62.5	Medium
43	FernándezGarz, 2023	?	?	Y	?	?	?	Y	Y	37.5	Low
44	Stahl, 2023	?	Y	?	?	Y	Y	?	Y	50.0	Medium
45	Sun, 2023	?	Y	?	?	Y	Y	Y	Y	62.5	Medium

Abbreviation: Y: Yes; ?: Unclear.

1: “Were the criteria for inclusion in the sample clearly defined?”

2: “Were the study subjects and the setting described in detail?”

3: “Was the exposure measured in a valid and reliable way?”

4: “Were objective, standard criteria used for measurement of the condition?”

5: “Were confounding factors identified?”

6: “Were strategies to deal with confounding factors stated?”

7: “Were the outcomes measured in a valid and reliable way?”

8: “Was appropriate statistical analysis used?”

Appendix 5. Critical Appraisal Assessment of Included Cohort Studies

No	Studies	1	2	3	4	5	6	7	8	9	10	11	%	Quality
1	Torbahn, 2022	?	Y	Y	Y	Y	Y	?	?	?	?	Y	54.5	Medium
2	Borkent 2022	?	Y	Y	Y	Y	Y	?	?	?	?	Y	54.5	Medium
3	Borkent 2023	?	Y	Y	Y	Y	Y	?	?	?	?	Y	54.5	Medium

Abbreviation:

Y: Yes; ?: Unclear.

1: “Were the two groups similar and recruited from the same population?”

2: “Were the exposures measured similarly to assign people to both exposed and unexposed groups?”

3: “Was the exposure measured in a valid and reliable way?”

4: “Were confounding factors identified?”

5: “Were strategies to deal with confounding factors stated?”

6: “Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?”

7: “Were the outcomes measured in a valid and reliable way?”

8: “Was the follow up time reported and sufficient to be long enough for outcomes to occur?”

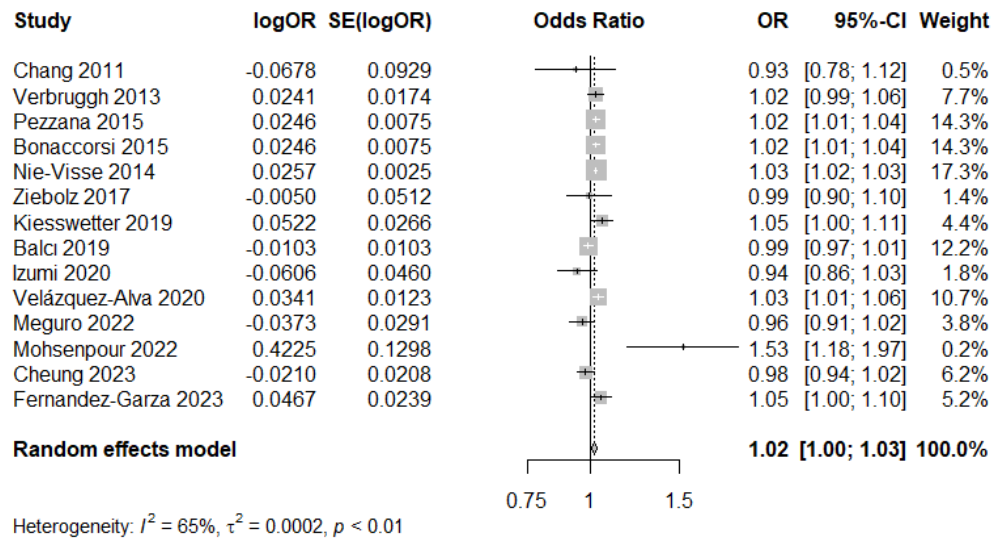
9: “Was follow up complete, and if not, were the reasons to loss to follow up described and explored?”

10: “Were strategies to address incomplete follow up utilized?”

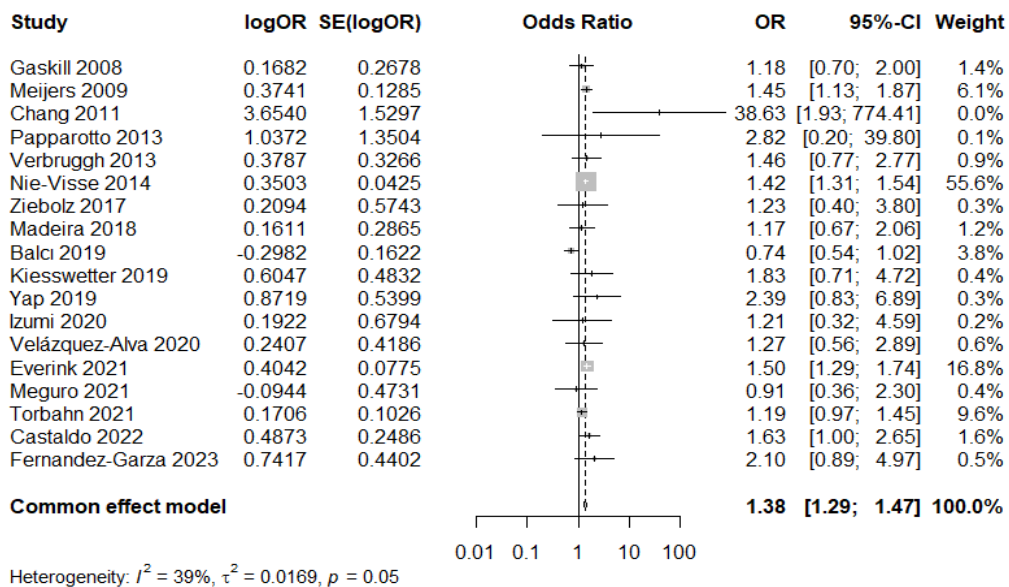
11: “Was appropriate statistical analysis used?”

Appendix 6. Forest Plots of Meta-analysis Results

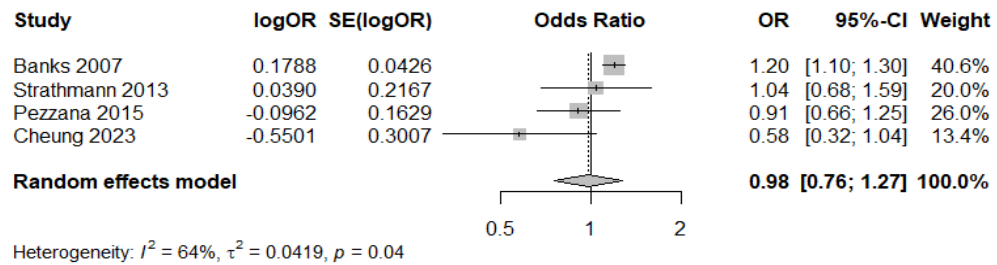
Age (per years increase)



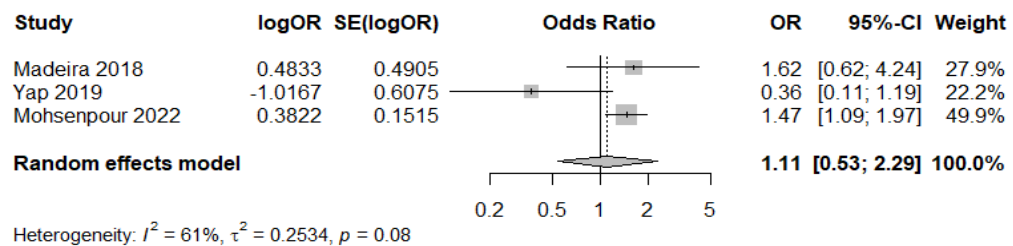
Gender female (vs male)



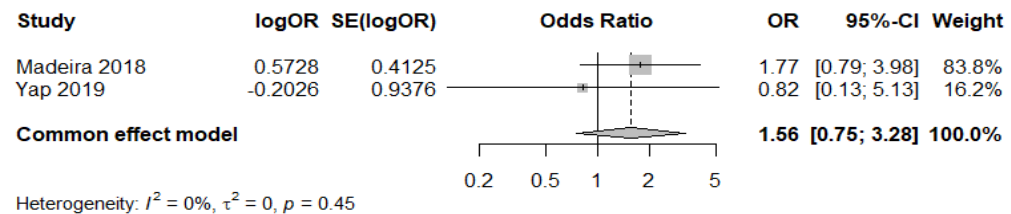
Gender male (vs female)



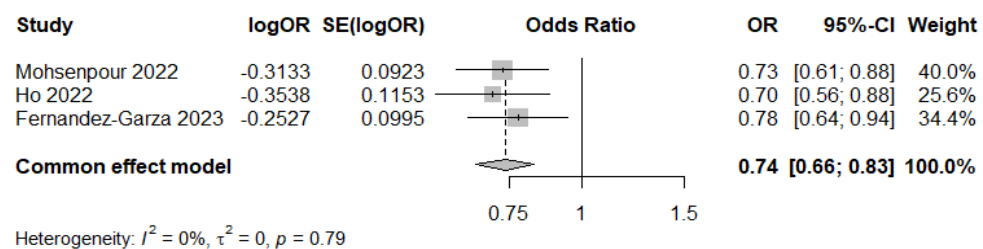
Marital status: single (vs married)



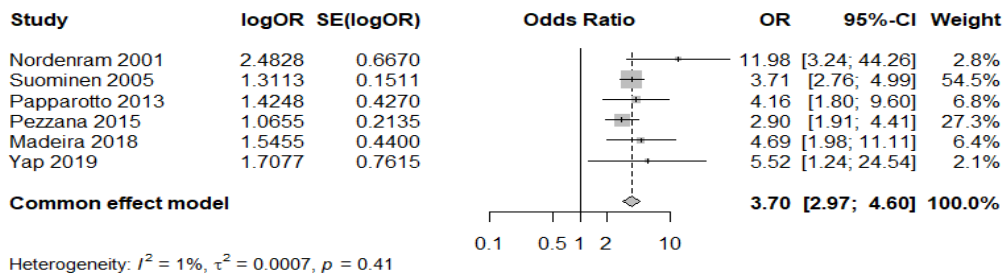
Marital status: divorced or widowed (vs married)



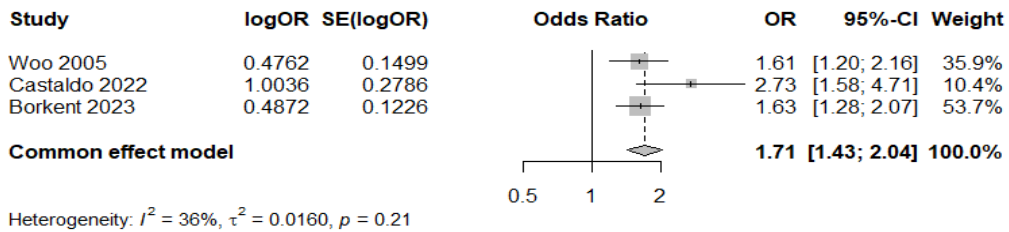
Increased BMI



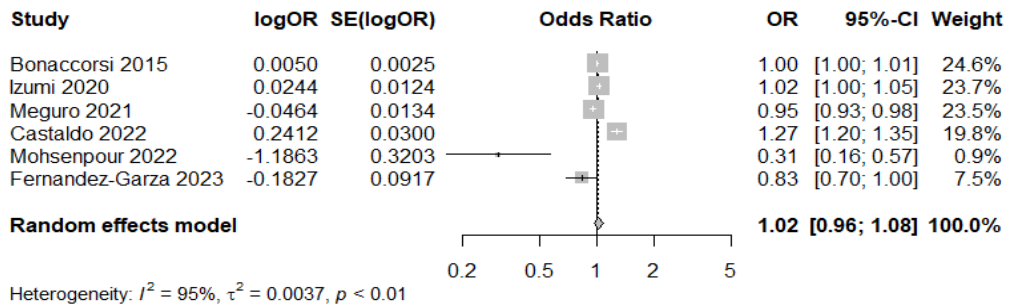
ADL dependence (vs none)



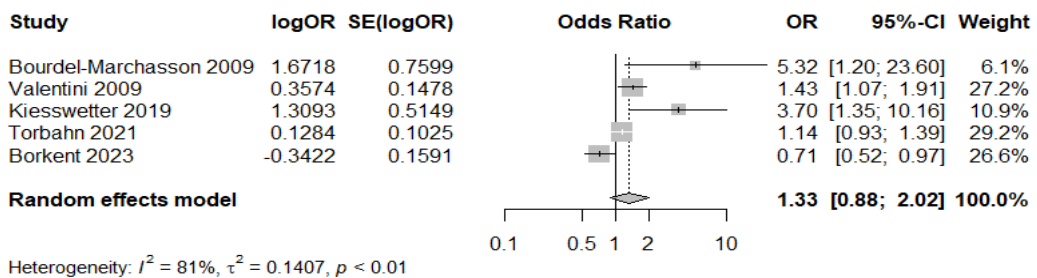
Eating assistance (vs none)



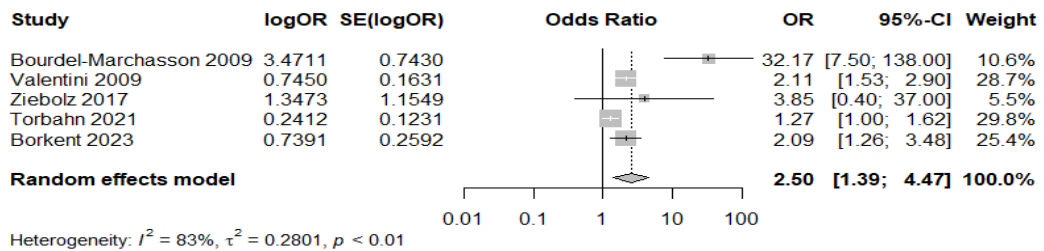
Increased Bathel index



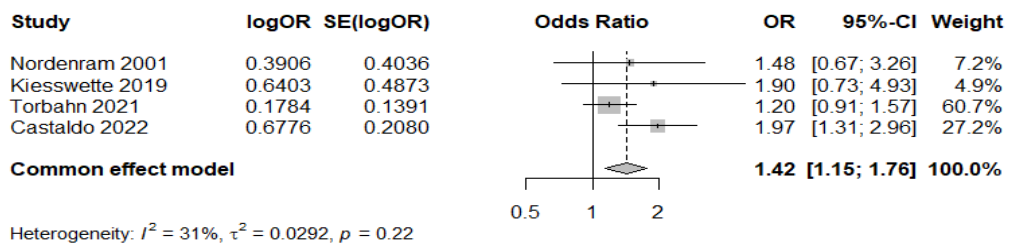
Partial mobility (vs normal mobility)



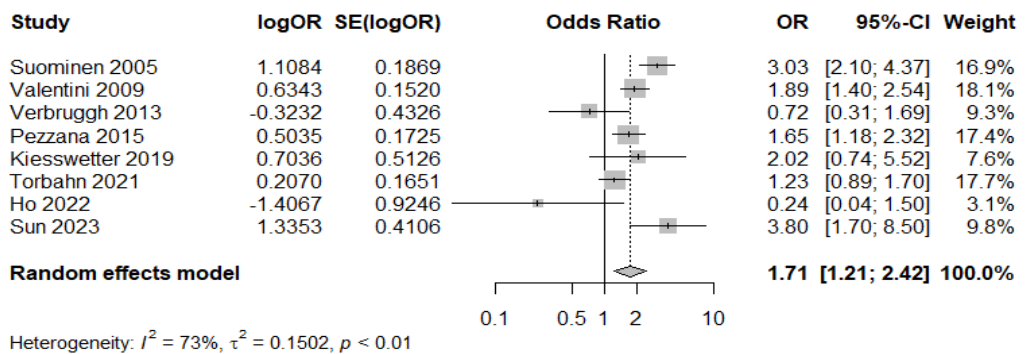
Immobility (vs normal mobility)



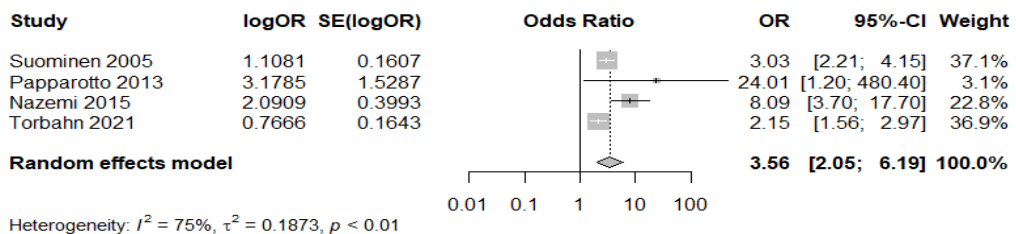
Chewing problem (vs none)



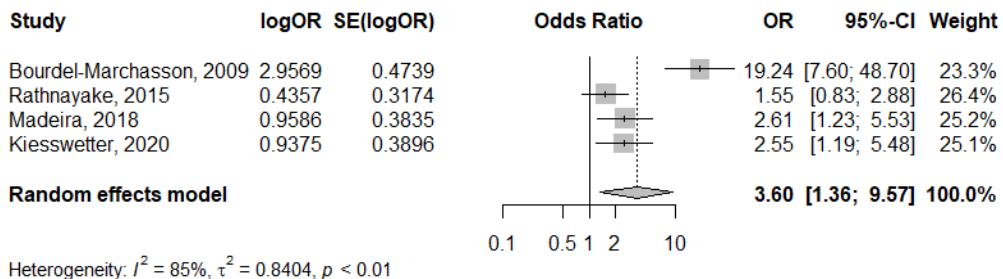
Swallowing problem (vs none)



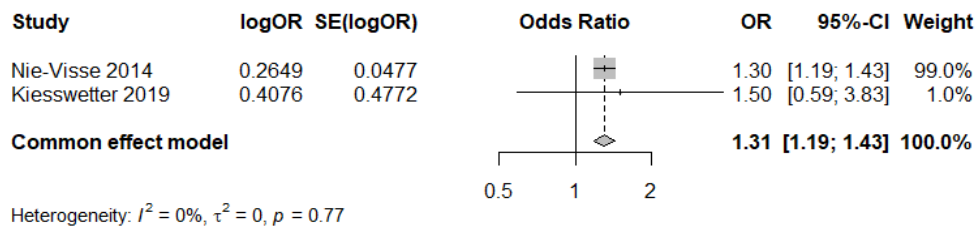
Eating less than half of offered food portion (vs eating full food portion).



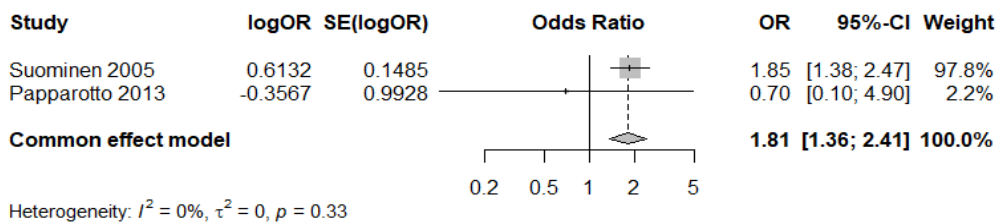
Poor appetite (vs normal appetite)



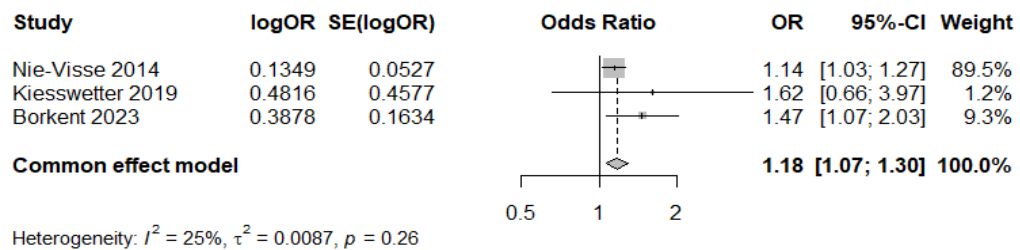
Digestive tract disease (vs none)



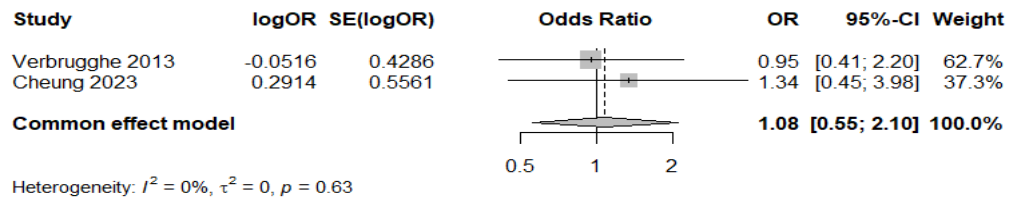
Constipation (vs none)



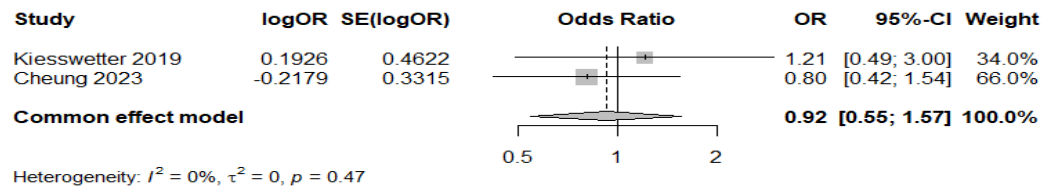
Respiratory disease (vs none)



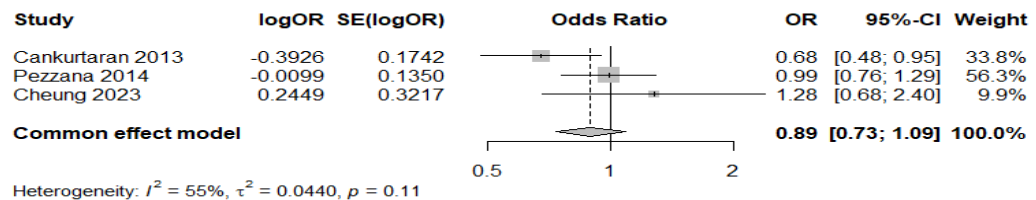
COPD (vs none)



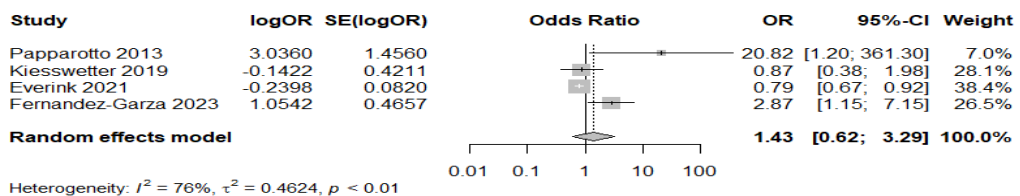
Heart disease (vs none)



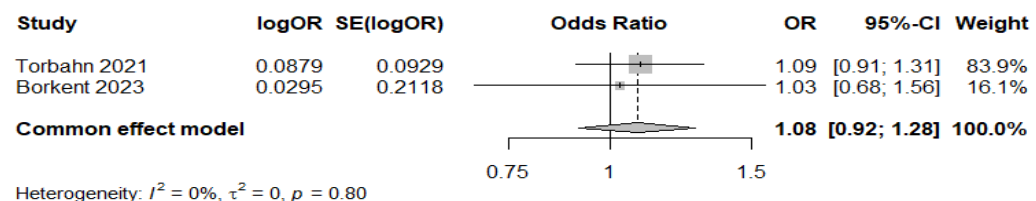
Hypertension (vs none)



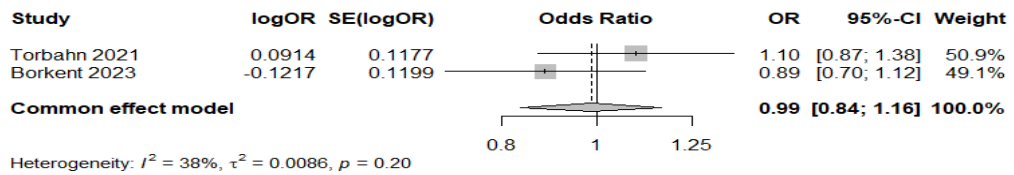
Stroke (vs none)



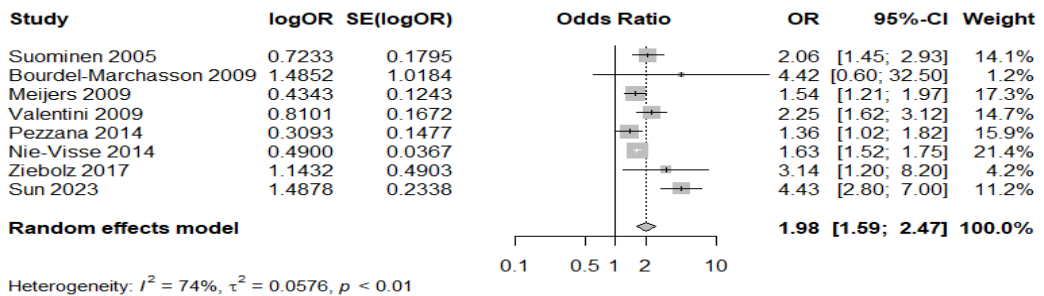
Musculoskeletal disease (vs none)



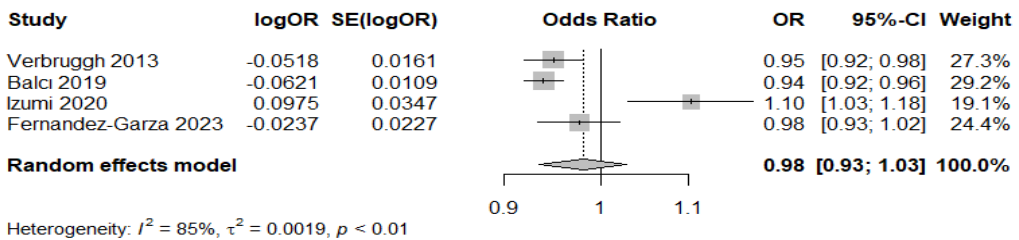
Neurological disease (vs none)



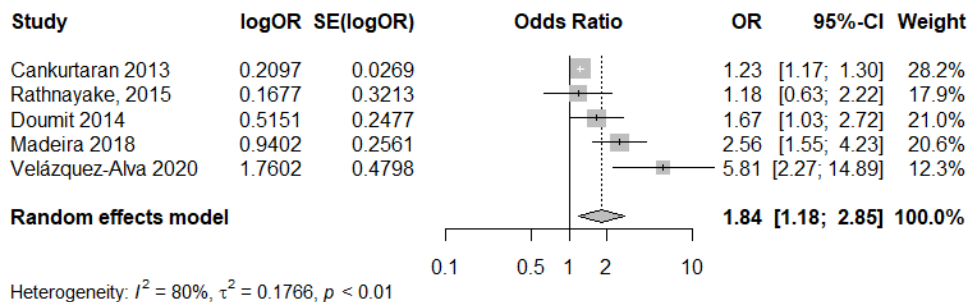
Dementia (vs none)



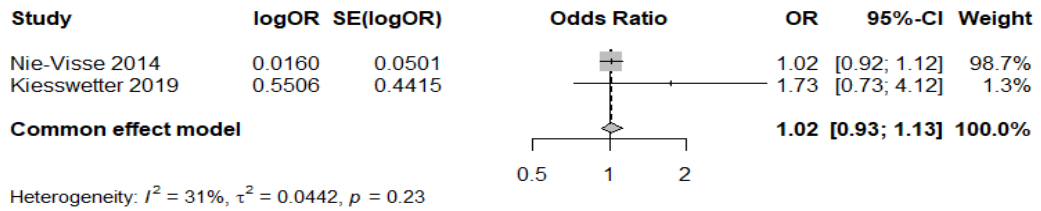
Increased cognitive score MMSE



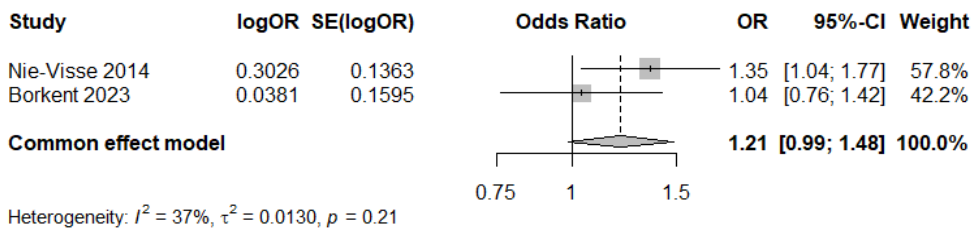
Depression (vs none)



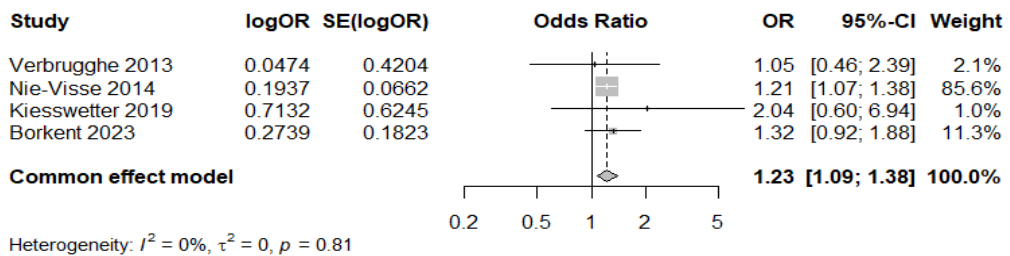
Urinary disease (vs none)



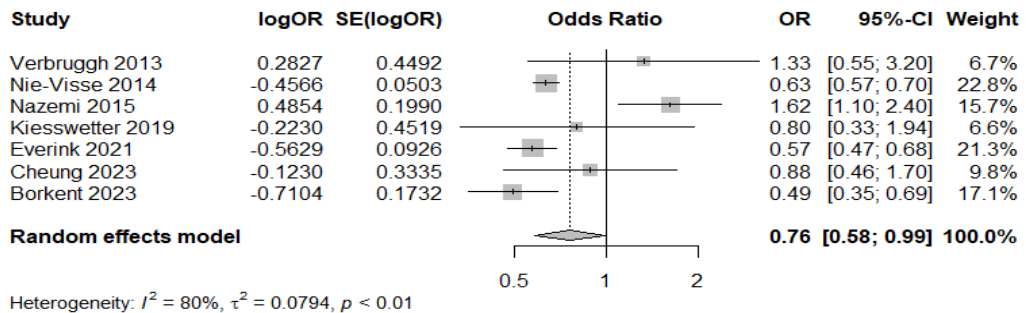
Infectious disease (vs none)



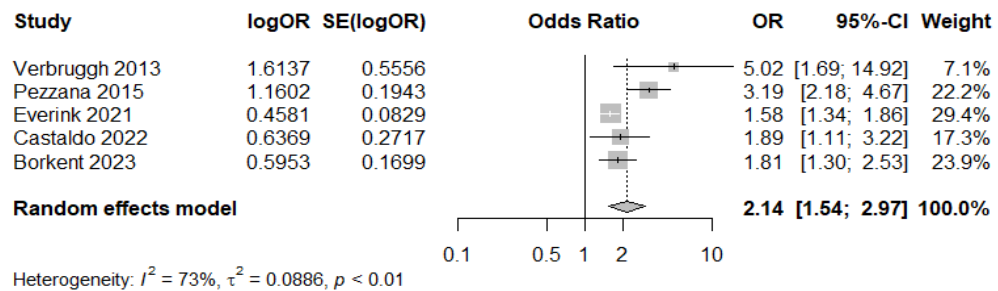
Cancer (vs none)



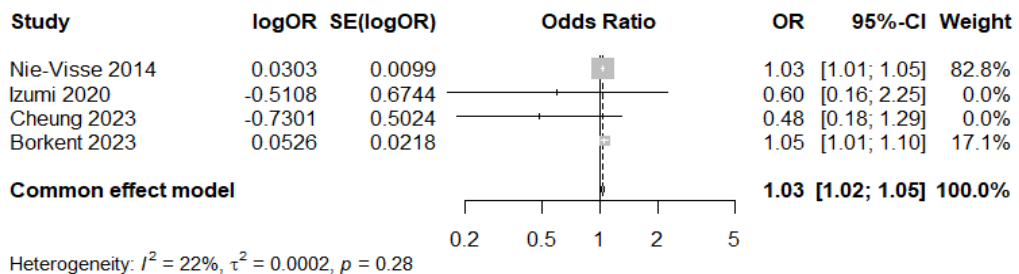
Diabetes (vs none)



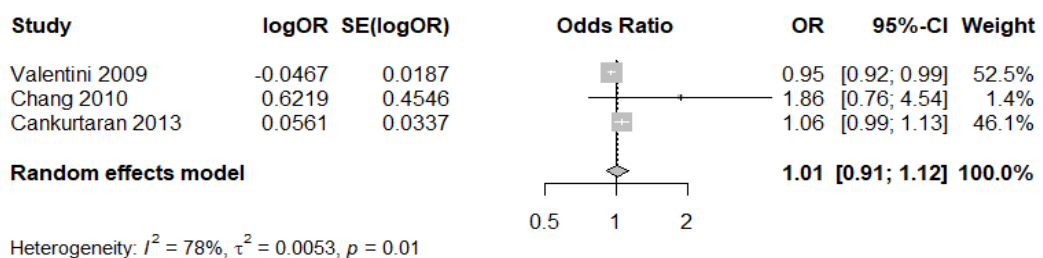
Pressure ulcer (vs none)



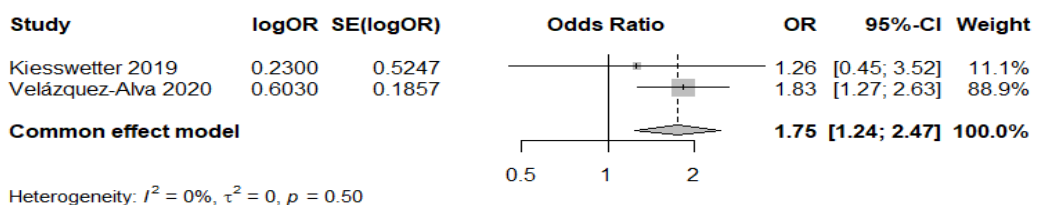
Increased number of prevalent diseases



Increased number of drugs per day



Polypharmacy (vs none)



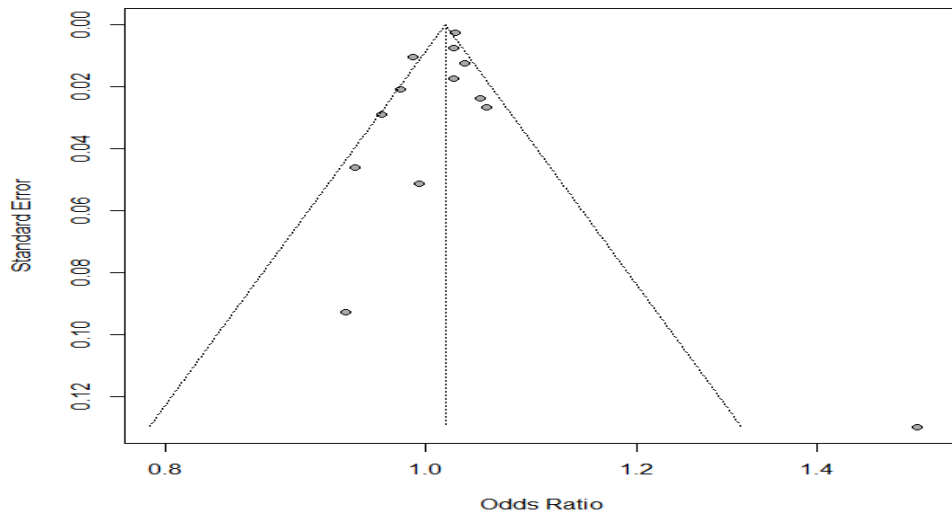
Appendix 7. Subgroup Meta-analysis Results Based on Economic Status.

Economic status		Developed		Developing		Subgroup
		k	OR (95% CI)	k	OR (95% CI)	difference (p)
Demographic	Increased age (years)	8	1.01 (1.00-1.03)	6	1.03 (0.99-1.06)	0.50
	Gender female	14	1.37 (1.29-1.46)	4	1.94 (1.16-3.23)	0.19
	Gender male		-			
	Single		-			
	Divorced/widowed		-			
	Increased BMI		-			
Health function	ADL dependence		-			
	Eating assistance		-			
	Bathel index	4	1.05 (0.99-1.11)	2	0.53 (0.20-1.41)	0.17
	Partial mobility		-			
	Immobility		-			
Eating	Chewing problem		-			
	Swallowing problem	6	1.69 (1.21-2.35)	2	1.09(0.08-15.89)	0.75
	Eat < 50% food		-			
	Loss of appetite		-			
Disease related	Digestive tract disease		-			
	Constipation		-			
	Respiratory disease		-			
	COPD		-			
	Heart disease		-			
	Hypertension		-			
	Stroke		-			
	Musculoskeletal disease		-			
	Neurological disease		-			
	Dementia		-			
	MMSE		-			
	Depression	2	1.70 (0.84-3.46)	3	2.07 (0.97-4.40)	0.71
	Urinary disease		-			
	Infectious disease		-			
	Cancer		-			
	Diabetes	5	0.61 (0.53-0.70)	2	1.27 (0.71-2.28)	0.02
	Pressure ulcer		-			
	No. prevalent diseases		-			
Med	No. drugs per day		-			
	Polypharmacy		-			

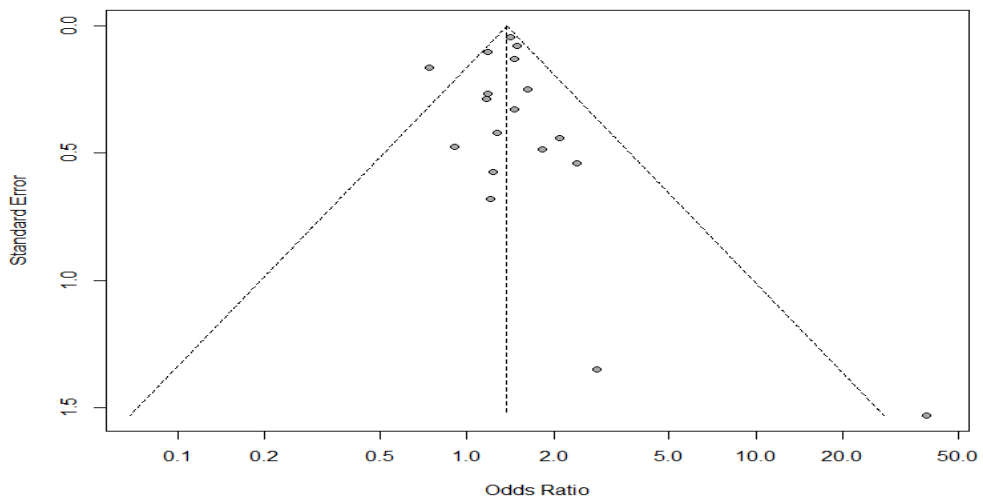
k: Number of studies.

Appendix 8. Funnel Plots.

Increased age



Female



English abstract

Factors Associated with Malnutrition in Nursing Home Residents: a Systematic Review and Meta-analysis

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Graduate School Keimyung University

Supervised by Professor Park Heeok

(Abstract)

This study is a systematic review and meta-analysis conducted to investigate the factors associated with malnutrition in nursing home residents. After protocol registered, systematic search was conducted on PubMed, EMBASE, CINAHL, Scopus and hand search on other related sources using keywords “malnutrition”, “nursing home” and “factor” in November 2023. 46 studies were included for the systemic review, and 35 studies met the inclusion criteria and entered in meta-analysis. R4.3.1 software was used to estimate the associations.

Narrative synthesis found that more new factors studied and reported compared to previous reviews. Meta-analysis showed that increased BMI and having diabetes were significantly associated with lower odds of malnutrition. Increased age, being female, activities of daily living dependence, needing eating assistance, immobility; chewing problem, swallowing problems, eating half or less than half of offered food portion, loss of appetite; digestive tract disease, constipation, respiratory disease, dementia, depression, cancer, diabetes and pressure ulcer. Other significant factors are the number of prevalent diseases and polypharmacy were significantly associated with higher odds of malnutrition in nursing home residents. Study results will contribute to nutrition care in nursing homes and will provide information related to intervention to prevent residents from malnutrition for upcoming studies.

Keywords: *Malnutrition, Nursing home, Factor, Meta-analysis*

Korean abstract

요양시설 거주 노인의 영양장애 관련 요인: 체계적 문헌고찰 및 메타분석

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간호학과

(지도교수 박희옥)

본 연구는 요양시설 거주 노인의 영양장애 관련 요인을 조사하기 위해 수행된 체계적인 문헌고찰 및 메타분석이다. 프로토콜이 등록된 후 2023 년 11 월 PubMed, EMBASE, CINAHL, Scopus 에 대한 체계적 문헌 검색을 실시하였고, 2023 년 11 월 키워드 “영양장애”, “요양시설” 및 “요인”을 사용하여 기타 소스에 대해 수기 손 검색을 수행하였다. 검색 결과 총 46 개의 연구가 체계적 문헌 고찰에 포함되었고, 그 중 35 개의 연구가 메타분석에 포함되었으며, R4.3.1 프로그램이 자료분석을 위해 사용되었다.

메타분석 결과, BMI 와 당뇨가 영양장애의 가능성과 낮은 정도의 유의한 관련이 있는 것으로 나타났다. 연령 증가, 여성, 일상생활 의존활동, 식사보조 필요, 부동, 씹는 문제, 삼킴 문제, $\leq 1/2$ 제공 음식 먹기, 식욕 상실, 소화관 질환, 변비, 호흡계 질환, 치매, 우울증, 암, 당뇨 질환, 욕창, 질병의 수, 다약제 사용이 요양시설 노인의 영양장애와 높은 정도의 유의한 관련이 있는 것으로 나타났다.

본 연구 결과를 바탕으로 확인된 요인을 체계적으로 관리하는 것이 요양 시설 노인의 영양 관리에 기여할 것이며 요양 시설 노인의 영양장애 예방을 위한 기초자료로 적용할 것이다.

Keywords: 영양장애, 요양시설, 요인, 메타분석.