REVIEW

Risk Factors for Malnutrition in Older Adults: A Systematic Review of the Literature Based on Longitudinal Data[1–3]

Nádia Cristina Fávaro-Moreira,[4] Stefanie Krausch-Hofmann,[4] Christophe Matthys,[5,8] Carine Vereecken,[9] Erika Vanhauwaert,[5,9] Anja Declercq,[6] Geertruida Elsiena Bekkering,[10] and Joke Duyck[4,7]*

[4]Population Studies in Oral Health, Department of Oral Health Sciences, [5]Department of Clinical and Experimental Medicine, [6]LUCAS, Centre for Care Research and Consultancy, [7]BIOMAT Research Cluster, Department of Oral Health Sciences, Katholieke Universiteit Leuven, Leuven, Belgium; [8]Clinical Nutrition Unit, Department of Endocrinology, University Hospitals Leuven, Leuven, Belgium; [9]University College Leuven-Limburg, Knowledge and Information Center FOOD, Leuven, Belgium; and [10]Belgian Center for Evidence Based Medicine, Leuven, Belgium

ABSTRACT

The present systematic review critically examines the available scientific literature on risk factors for malnutrition in the older population (aged ≥65 y). A systematic search was conducted in MEDLINE, reviewing reference lists from 2000 until March 2015. The 2499 papers identified were subjected to inclusion criteria that evaluated the study quality according to items from validated guidelines. Only papers that provided information on a variable's effect on the development of malnutrition, which requires longitudinal data, were included. A total of 6 longitudinal studies met the inclusion criteria and were included in the systematic review. These studies reported the following significant risk factors for malnutrition: age (OR: 1.038; $P = 0.045$), frailty in institutionalized persons (β: 0.22; $P = 0.036$), excessive polypharmacy (β: −0.62; $P = 0.001$), general health decline including physical function (OR: 1.793; $P = 0.008$), Parkinson disease (OR: 2.450; $P = 0.047$), constipation (OR: 2.490; $P = 0.015$), poor (OR: 3.30; P value not given) or moderate (β: −0.27; $P = 0.016$) self-reported health status, cognitive decline (OR: 1.844; $P = 0.001$), dementia (OR: 2.139; $P = 0.001$), eating dependencies (OR: 2.257; $P = 0.001$), loss of interest in life (β: −0.58; $P = 0.017$), poor appetite (β: −1.52; $P = 0.000$), basal oral dysphagia (OR: 2.72; $P = 0.010$), signs of impaired efficacy of swallowing (OR: 2.73; $P = 0.015$), and institutionalization (β: −1.89; $P < 0.001$). These risk factors for malnutrition in older adults may be considered by health care professionals when developing new integrated assessment instruments to identify older adults' risk of malnutrition and to support the development of preventive and treatment strategies. *Adv Nutr* 2016;7:507–22.

Keywords: nutritional condition, malnutrition, older population, risk factors, longitudinal studies

Introduction

Older adults (aged ≥65 y) tend to be more prone to nutritional deficiencies (1), because aging may come with an accumulation of diseases and impairments. These include cognitive and physical decline, depressive symptoms, emotional variations (2), and poor oral health (3), along with socioeconomic changes (1). All of these factors may directly influence the balance between nutritional needs and intake (2). Even in cases of adequate nutrient and energy intake, the nutritional status of older adults can be challenged by a compromised nutrient metabolism (such as absorption, distribution, storage, utilization, and excretion), drug–nutrient interactions, or altered nutrient needs (4).

The prevalence of malnutrition in Europe and North America is 1–15% in noninstitutionalized older adults, 25–60% for older adults in geriatric care facilities, and 35–65% in older adults in hospitals (5). Between 2010 and 2050, with a predicted global increase in life expectancy, the population over the age of 80 y will grow from 11.5% to 21.0% worldwide and from 9.0% to 19.0% in the developed countries (6). This will result in an increase of older adults at risk of malnourishment (7).

Malnutrition is related to a decline in general functional status and to decreased bone mass, immune dysfunction,

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[3] Supplemental Tables 1 and 2 and supplemental references are available from the "Online Supporting Material" link in the online posting of the article and from the same link in the online table of contents at http://advances.nutrition.org.

*To whom correspondence should be addressed. E-mail: joke.duyck@med.kuleuven.be.

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delayed postsurgery recovery, high hospitalization and readmission rates, and increased mortality (8), among other problems. Although malnutrition is a prognostic factor associated with morbidity, mortality, and costs of care (9, 10), nutritional problems in older adults often remain undetected or unaddressed (11). One-fourth of the patients who are nutritionally at risk do not receive nutritional support or counseling, despite having been in contact with health care professionals (12). This suggests that the condition of older adults at risk of malnutrition should be investigated and improved forthwith. For this, identification of prognostic determinants of malnutrition is required. Several studies analyzed factors associated with malnutrition. Most of these studies, however, had a cross-sectional design, whereby causality cannot be established.

This systematic review therefore aims to critically review the available scientific literature with a focus on studies with a longitudinal design on risk factors for malnutrition in the older population. Evaluation of the evidence for such risk factors is needed to facilitate the development of an assessment instrument that enables health care professionals to identify older adults' risk of malnutrition and to support the development of preventive strategies.

Methods

Data sources and search strategy. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (13, 14) and the guidelines described by the Cochrane Community (15) were used to plan, to conduct, and to report this systematic review. Potential studies were identified by searching the MEDLINE database (National Library of Medicine and National Institutes of Health) by using the PubMed interface. The following MeSH terms and operators were used: malnutrition OR malnourished AND risk factor AND (the following PubMed filters) full text AND "2000/01/01":"2015/03/30" AND Humans AND English AND aged 65+ y. The authors also reviewed the reference lists from the review articles reported in the PubMed search to identify possible additional articles for inclusion.

Selection of studies and data synthesis. All papers written in English and published between 1 January 2000 and 30 March 2015 were evaluated for inclusion if they presented data about risk factors for malnutrition in older adults (≥65 y). Studies of all types of populations (community dwelling, institutionalized, hospitalized, rural or urban) were included.

A 2-step screening process was used. In step 1, one investigator scanned the titles and abstracts of studies identified by the search for their eligibility. At step 2, full-text articles were screened by one investigator for eligibility. To be included in the present review, the study was required to meet the following criteria:

1. The study presented information about the nutritional status of older adults (≥65 y) based on data of validated measurements.
2. The study sample size was calculated based on a power analysis or included ≥100 subjects.
3. The study population was clearly specified and defined.
4. Key potential confounding variables (e.g., malnutrition/risk of malnutrition at baseline, age, sex, functional capacity, current health status, etc.) were measured and statistically adjusted for their impact on the relation between exposure(s) and outcome(s).
5. The study presented longitudinal data, implying that the comparable nutritional state data of ≥2 time points were measured in the same population and presented, enabling a relation of causality between the variables under investigation and the nutritional status.
6. The time frame between the measurements was appropriate to allow malnutrition to develop as a result of the potential risk factor. This time frame may have depended on the variable under investigation (e.g., a shorter time frame would be considered for acute illness compared to loneliness). The appropriateness of the time frames was discussed with all authors until a consensus was reached.

Data were first extracted from the longitudinal articles to an Excel table containing information such as title, authors, country where the study was performed, publication year and journal, information on how malnutrition was assessed, information about the population under study (age, number, setting), whether the study was interventional or not, the time frame between the measurements, the outcomes, the statistical analyses and results, and whether the results were corrected for possible bias identified by the authors. The data were then extracted from the Excel table into standardized tables by one of the investigators. In the tables, results of studies are reported only for the outcome measures interest. The results are reported as significant at $P < 0.05$, and no exclusions were made for type of statistical approach.

The concept of malnutrition was accepted as described by the authors of the included articles. The authors of only one paper explicitly defined malnutrition as a disorder of nutritional status resulting from reduced nutrient intake or impaired metabolism (16). The same applies for the concept of other variables analyzed by the longitudinal articles, such as polypharmacy, cognitive decline, low education, etc. The variables under investigation were considered risk factors when they correlated with the development of malnutrition between baseline and the time of reassessment. This implies that only longitudinal studies were eligible for inclusion in this systematic review.

Review of study strength and quality. The strength and quality of the studies were determined by using items from Downs and Black (17) and the Newcastle scale (18), as well as the Cochrane (15) and PRISMA consort guidelines (13, 14). A review of strength and quality of the longitudinal studies, including risk of bias and appropriate statistical analysis, was assessed independently by 2 researchers (NCFM and CV). In case of disagreement, another researcher (SK-H) was consulted and participated in the discussion until agreement was reached. The decisions were then discussed with all co-authors until a consensus was reached.

Results

The search resulted in 2499 articles. After analyzing titles and abstracts, 1849 articles not related to malnutrition in older adults were excluded. From the 650 remaining articles, 112 reported on associations of malnutrition in older adults (65 of the studies were performed in European countries, 19 in Asia, 19 in North America, 6 in Oceania, and 3 in Africa). The other 538 articles were excluded because they did not report on associations with malnutrition (399 articles) or they reported on a population of <65 y of age (139 articles). Of the 112 articles reporting on associations of malnutrition in older adults, 103 cross-sectional studies and 3 literature reviews (19–21) were excluded. The reference lists from the 3 review studies previously identified in the PubMed search did not result in additional longitudinal studies. As a result, a final number of 6 longitudinal studies were included in the systematic review. The flow of articles through the review process is displayed in **Figure 1**.

There was no difference between the primary agreement that was established by the first reviewers (NCFM and CV) and the consensus that was reached by all authors on which papers to include. The strength and quality of studies were considered high, with all 6 longitudinal studies meeting the criteria defined by Downs and Black (17) and the Newcastle

scale (18), as well as the Cochrane (15) and PRISMA consort guidelines (13, 14).

Nutritional status in the selected studies was assessed by using the following anthropometric measures: body weight (or percentage of initial body weight), weight loss (22), or BMI data (in kg/m^2); or through the following validation methods or tools: Mini Nutritional Assessment (23), Mini Nutritional Assessment-Short Form (24, 25), or Elderly Nutrition Screening tool (26).

Table 1 presents the longitudinal studies sorted by publication year and also presents potential risk factors under investigation, population, malnutrition assessment instrument, and summarized results. In **Table 2**, the factors evaluated for their association with malnutrition (after correction for confounding factors) in the longitudinal studies are categorized into one of the following: physical, psychological, social, oral health-related, and eating-related factors. Table 2 also includes information on the malnutrition assessment instrument, the applied statistical methodology, and the results. The outcome column shows whether the potential risk factor under investigation was positively (+) or negatively (−) related to malnutrition or whether no association was found (0). The statistical analysis used to evaluate the association is also mentioned in Table 2.

In the 6 longitudinal studies, the following factors were found to statistically correlate with the development of malnutrition. Physical factors were frailty (for institutionalized people) (27), excessive polypharmacy (defined as taking ≥10 drugs) (30), functional decline (28, 30, 31), difficulty walking stairs (for persons <75 y old) (16), decline in cognitive capacity and dementia, Parkinson disease, constipation (28), loss of >5% of initial handgrip strength (31), and poor or moderate self-reported health status (29, 30).

Of the 5 studies that evaluated age, 2 (28, 30) presented this variable as a risk factor for malnutrition, whereas the others (16, 29, 30) did not observe an association. Excessive polypharmacy was identified as a risk factor for malnutrition in women, but not in men. Taking 1–2 drugs reduced the risk of malnutrition compared with taking no drugs in female participants (16).

Basal oral dysphagia and signs of impaired swallowing efficacy were statistically significant oral risk factors for malnutrition when assessed by the Mini Nutritional Assessment questionnaire but not when assessed by means of weight loss measurements (basal OD $P = 0.010$, impaired efficacy of swallow $P = 0.015$) (31). Moreover, daily oral hygiene was shown to lead to a better nutritional status (28). Poor appetite (16, 27) and needing assistance to eat (28) were statistically significant eating-related risk factors for malnutrition, whereas the ability to eat independently was related to the improvement of the nutritional status (27).

The only psychological factor related to the development of malnutrition was the loss of interest in life among institutionalized and community dwelling persons. A sustained interest in life was shown to predict a higher weight (27). Depressive symptoms, anxiety, loneliness, and not having a partner, as independent variables, were not related to the development of malnutrition (16).

Social factors demonstrated to be predictors for malnutrition were institutionalization (30) and residence in Ontario or British Columbia (27). Shatenstein et al. (27) looked at the risk of malnutrition in different regions in Canada, observing higher malnutrition incidence in Ontario or British Columbia compared with Quebec. Low educational level (defined as completion of 0–6 y of school) was not related to the progress of malnutrition over time (30).

The review articles ($n = 3$) and cross-sectional ($n = 103$) studies are presented as supplemental information (**Supplemental Tables 1** and **2**, respectively). All 103 cross-sectional studies were observational cohort studies, and no interventional studies were found. Of the 3 reviews identified, only Tamura et al. (19) performed a systematic literature review. The reviews conducted by Pauly et al. (20) and Bocock et al. (21) were not performed by using a systematic review approach. In the latter reviews, no rigid quality control was performed, resulting in a mere presentation of the identified papers.

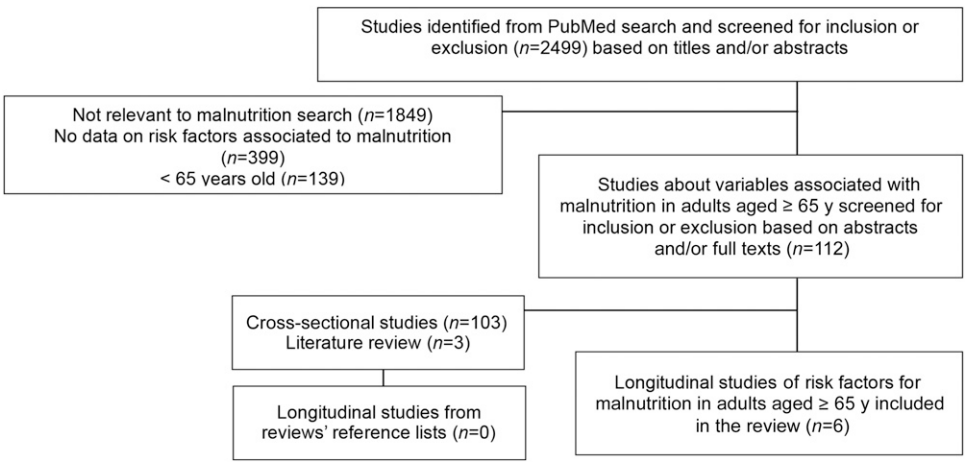

FIGURE 1 Flow diagram of the study selection for the review process.

TABLE 1 Longitudinal studies on risk factors for malnutrition in older adults[1]

Author, year (reference)	Potential risk factors	Population	Assessment method	Results
Shatenstein et al., 2001 (27)	Age Cognitive function Study region Ability to eat independently Depression Self-reported interest in life Loss of appetite Weight loss Frailty For community subjects: Ability to shop Bereavement	Baseline: 1529 community and 1174 institutionalized subjects Follow-up: 584 community and 237 institutionalized subjects	Percentage of initial body weight retained: Prevalence analyses: >95%, no risk of malnutrition 85–95%, low risk of malnutrition <85%, moderate/severe risk of malnutrition Regression analyses: >95%, no risk of malnutrition ≤95%, risk of malnutrition	Multiple regression: for % of initial body weight[2] Institutionalized subjects: Frailty, β: −1.23; $P = 0.039$ Residence in Ontario, β: −9.02; $P = 0.000$ Residence in British Columbia, β: −5.62; $P = 0.026$ Residence in Atlantic, β: −3.41; $P = 0.225$ Residence in prairies, β: −4.54; $P = 0.087$ Community subjects: Ability to eat unaided, β: 4.24; $P = 0.000$ Reported sustained interest in life, β: 2.22; $P = 0.013$ Logistic regression: for malnutrition Institutionalized subjects: Frailty, β: 0.22; 95% CI: 1.01, 1.54; $P = 0.036$ Loss of interest in life, β: −0.63; 95% CI: 0.30, 0.93; $P = 0.027$ Community subjects: Loss of appetite, β: −1.52; 95% CI: 0.12, 0.42; $P = 0.000$ Loss of interest in life, β: −0.58; 95% CI: 0.34, 0.90; $P = 0.017$
Mamhidir et al., 2006 (28)	Underweight Weight loss Cognitive function Depression Functional impairment Age Sex Medical factors: vision problems, eating dependencies, constipation, heart failure, hip fracture, stroke, dementia, Parkinson disease, cancer Chewing and swallowing disorders Mouth pain Complaints about the taste of the food Hunger Often leaves 25% of food uneaten	Baseline: 719 institutionalized subjects Follow-up: 503 institutionalized subjects	BMI < 22 and loss of 5% of body weight after 1 mo and 10% after 6 mo	Multiple logistic regression: for malnutrition Dementia, OR: 2.139; 95% CI: 1.343, 3.407; $P = 0.001$ Parkinson disease, OR: 2.450; 95% CI: 1.006, 5.965; $P = 0.047$ Eating dependencies, OR: 2.257; 95% CI: 1.676, 3.038; $P = 0.001$ Constipation, OR: 2.490; 95% CI: 1.185, 4.964; $P = 0.015$ Daily dental hygiene was associated with better weight status (values not given) Logistic regression: predictive factors for malnutrition Cognitive capacity, OR: 1.844; 95% CI: 1.267, 2.683; $P = 0.001$ Functional decline, OR: 1.793; 95% CI: 1.163, 2.765; $P = 0.008$ Age, OR: 1.038; 95% CI: 1.001, 1.077; $P = 0.045$

(Continued)

TABLE 1 (*Continued*)

Author, year (reference)	Potential risk factors	Population	Assessment method	Results
	Intake of dietary supplements Dental status Number of medications (last 7 d)			
Roberts et al., 2007 (29)	Sex Age at baseline Highest level of education Income satisfaction Medical conditions (chronic disease score) Measure of physical limitations Current health status, and status compared with the previous year Psychological variables and distress Type of housing Number of cohabitants Marital status Perceived satisfaction with social support	Baseline: 839 community subjects Follow-up: 779 community subjects	ENS (low, moderate, or high risk of malnutrition classification)	Bivariate model: for malnutrition risk[3] Sex (ref = female), OR: 0.83; 95% CI: 0.52, 1.32 Age (y), OR: 1.01; 95% CI: 0.95, 1.07 Some high school education, OR: 1.00; 95% CI: 0.45, 2.20 High school education complete, OR: 1.49; 95% CI: 0.67, 3.32 College or technical education, OR: 1.36; 95% CI: 0.60, 3.09 University education, OR: 1.21; 95% CI: 0.56, 2.62 Income satisfaction (ref = no), OR: 0.60; 95% CI: 0.31, 1.14 Physical limitations, OR: 1.12; 95% CI: 0.87, 1.44 ADL, OR: 1.26; 95% CI: 0.65, 2.45 IADL, OR: 1.61; 95% CI: 1.02, 2.55 Chronic disease score, OR: 1.02; 95% CI: 0.98, 1.07 Stomach aches (ref = no), OR: 1.49; 95% CI: 0.89, 2.49; *P* value not given Dental problems (ref = no), OR: 1.39; 95% CI: 0.87, 2.22 Good current self-rated health (ref = excellent), OR: 1.66; 95% CI: 1.01, 2.75 Poor current self-rated health (ref = excellent), OR: 3.74; 95% CI: 1.65, 8.51 Worse self-rated health compared with the previous year (ref = the same), OR: 1.38; 95% CI: 0.62, 3.08 Better self-rated health compared with the previous year (ref = the same), OR: 0.55; 95% CI: 0.30, 0.99 Psychological distress (ref = low), OR: 1.35; 95% CI: 0.51, 3.60 Marital status (ref = not married), OR: 0.77; 95% CI: 0.48, 1.25 Satisfaction with social support (ref = no), OR: 0.56; 95% CI: 0.29, 1.08 1 cohabitant (ref = 0), OR: 0.80; 95% CI: 0.49, 1.29 ≥2 cohabitants (ref = 0), OR: 1.61; 95% CI: 0.56, 4.63 Living in a house (ref = apartment), OR: 1.15; 95% CI: 0.69, 1.93 Living in a senior's residence, OR: 1.45; 95% CI: 0.68, 3.10

(Continued)

TABLE 1 (*Continued*)

Author, year (reference)	Potential risk factors	Population	Assessment method	Results
				Living in subsidized or nonprofit housing, OR: 0.94; 95% CI: 0.27, 3.33 Other kind of housing, OR: 3.29; 95% CI: 0.59, 8.47 Multivariable model: for malnutrition risk[3] Sex (ref = female), OR: 0.93; 95% CI: 0.58, 1.51 Age (y), OR: 1.00; 95% CI: 0.94, 1.07 Good current self-rated health (ref = excellent), OR: 1.48; 95% CI: 0.87, 2.50 Poor current self-rated health (ref = excellent), OR: 3.30; 95% CI: 1.42, 7.67 Worse self-rated health compared with the previous year (ref = the same), OR: 1.09; 95% CI: 0.47, 2.50 Better self-rated health compared with the previous year (ref = the same), OR: 0.55; 95% CI: 0.30, 1.00
Jyrkkä et al., 2011 (30)	Polypharmacy status Residential status Self-reported health status Nutritional status - MNA-SF Functional ability Cognitive capacity Functional comorbidity index BMI > 30	Baseline: 294 community or institutionalized subjects Follow-up: 294 community or institutionalized subjects	MNA-SF (≤11 = malnourished or at risk, ≥12 = well-nourished)	Linear mixed model: for decline in nutritional status (points compared with ref) Excessive polypharmacy (ref = nonpolypharmacy), β: −0.62; 95% CI: −0.98, −0.27; $P = 0.001$ Age, β: −0.04; 95% CI: −0.08, −0.01; $P = 0.016$ Institutionalized (ref = home), β: −1.89; 95% CI: −2.38, −1.39; $P < 0.001$ Self-reported health status moderate (ref = good), β: −0.27; 95% CI: −0.49, −0.05; $P = 0.016$ Self-reported health status poor (ref = good), β: −1.05; 95% CI: −1.38, −0.73; $P < 0.001$ Time of measurement 2005 (ref = 2004), β: −0.28; 95% CI: −0.50, −0.06; $P = 0.011$ Time of measurement 2006 (ref = 2004), β: −0.42; 95% CI: −0.65, −0.20; $P < 0.001$ Time of measurement 2007 (ref = 2004), β: −0.37; 95% CI: −0.60, −0.15; $P = 0.001$ Polypharmacy (ref = nonpolypharmacy), β: −0.12; 95% CI: −0.37, 0.13; $P = 0.333$ Male sex (ref = female), β: 0.11; 95% CI: −0.20, 0.42; $P = 0.471$ 0–6 y of education (ref = 7 y), β: −0.03; 95% CI: −0.32, 0.26; $P = 0.823$ Functional comorbidity index, β: 0.01; 95% CI: −0.08, 0.09; $P = 0.950$

(Continued)

TABLE 1 (*Continued*)

Author, year (reference)	Potential risk factors	Population	Assessment method	Results
Schilp et al., 2011 (16)	Education level Monthly household income Cognitive functioning Depression Anxiety Presence of chronic diseases (comorbidity) Medication use Appetite during the last week Subjective pain Problems biting and chewing Visual or hearing impairment Limitation of normal activities because of a health problem Physical performance Difficulty walking stairs Smoking status Alcohol use Physical activity in the previous 2 wk Loneliness Individuals without a partner inside or outside the household Type of housing (independent and nonindependent living)	Baseline: 1120 subjects (98% living in the community) Follow-up: 839 subjects	BMI < 20 or self-reported involuntary weight loss ≥5% in the last 6 mo	Univariate model: for incidence of malnutrition[3] Female sex, HR: 1.40; 95% CI: 1.01, 1.92 Light alcohol use, HR: 0.67; 95% CI: 0.46, 0.98 Loneliness, HR: 1.47; 95% CI: 1.06, 2.04 No partner present, HR: 1.70; 95% CI: 1.24, 2.33 Depressive symptoms, HR: 1.96; 95% CI: 1.32, 2.93 Anxiety symptoms, HR: 1.75; 95% CI: 1.11, 2.78; *P* value not given ≥2 chronic diseases, HR: 2.08; 95% CI: 1.31, 3.28 Poor appetite, HR: 1.99; 95% CI: 1.32, 3.00 Limitations performing normal activities because of a health problem, HR: 1.76; 95% CI: 1.28, 2.43 ≥3 medications, female, HR: 2.57; 95% CI: 1.50, 4.38 Low physical performance test score (<75 y old), HR: 0.89; 95% CI: 0.81, 0.96 Difficulty walking stairs (<75 y old), HR: 2.50; 95% CI: 1.59, 3.91 Pain data missing, female, HR: 1.62; 95% CI: 1.01, 2.61 Age ≥ 75 y, HR: 1.30; 95% CI: 0.95, 1.79 Medium education, HR: 0.78; 95% CI: 0.56, 1.09 High education, HR: 0.94; 95% CI: 0.56, 1.58 Medium income, HR: 0.98; 95% CI: 0.66, 1.44 High income, HR: 0.89; 95% CI: 0.57, 1.39 Missing income data, HR: 0.93; 95% CI: 0.54, 1.62 Poor cognitive status, HR: 0.94; 95% CI: 0.49, 1.78 1 chronic disease, HR: 1.23; 95% CI: 0.76, 2.00 1–2 medications, male, HR: 0.47; 95% CI: 0.23, 0.95 1–2 medications, female, HR: 0.36; 95% CI: 0.76, 2.41 ≥3 medications, male, HR: 1.51; 95% CI: 0.86, 2.66 Pain, male, HR: 1.29; 95% CI: 0.70, 2.37 Pain, female, HR: 1.37; 95% CI: 0.82, 2.27 Pain data missing, male, HR: 0.62; 95% CI: 0.29, 1.33 Frequent problems biting or chewing, HR: 1.81; 95% CI: 0.57, 1.16 Missing data on problems biting or chewing, HR: 0.83; 95% CI: 0.52, 1.32 Vision problems, HR: 1.00; 95% CI: 0.65, 1.52 Hearing problems, HR: 1.42; 95% CI: 0.93, 2.16 Low physical performance test score (≥75 y old), HR: 1.01; 95% CI: 0.92, 1.11 Difficulty walking stairs (≥75 y old), HR: 1.08; 95% CI: 0.67, 1.75

(*Continued*)

TABLE 1 (*Continued*)

Author, year (reference)	Potential risk factors	Population	Assessment method	Results
				Former smoker, HR: 0.82; 95% CI: 0.50, 1.33 Current smoker, HR: 1.08; 95% CI: 0.73, 1.61 Moderate alcohol use, HR: 0.82; 95% CI: 0.52, 1.30 Excessive alcohol use, HR: 1.16; 95% CI: 0.52, 2.58 Physical activity, HR: 0.99; 95% CI: 0.997, 1.000 Independent housing, HR: 3.13; 95% CI: 0.44, 22.33 Multivariate model: for incidence of malnutrition[3] Poor appetite, HR: 1.63; 95% CI: 1.02, 2.61 Difficulty walking stairs (<75 y old), HR: 1.91; 95% CI: 1.14, 3.22 1–2 medications, female (interaction with sex), HR: 0.39; 95% CI: 0.18, 0.83 Female sex, HR: 0.73; 95% CI: 0.38, 1.39 Age ≥ 75 y, HR: 0.88; 95% CI: 0.29, 2.63 Depressive symptoms, HR: 0.89; 95% CI: 0.52, 1.52 Anxiety symptoms, HR: 1.26; 95% CI: 0.72, 2.21 1 chronic disease, HR: 1.10; 95% CI: 0.64, 1.88 ≥2 chronic diseases, HR: 1.32; 95% CI: 0.75, 2.33 1–2 medications, male, HR: 1.10; 95% CI: 0.60, 2.02 ≥3 medications, male, HR: 1.80; 95% CI: 0.99, 3.27 ≥3 medications, female, HR: 1.03; 95% CI: 0.54, 1.96 Limitations of normal activities due to a health problem, HR: 1.20; 95% CI: 0.81, 1.77 Low physical performance test score, age < 75 y, HR: 0.98; 95% CI: 0.89, 1.08 Low physical performance test score, age ≥ 75 y, HR: 1.06; 95% CI: 0.95, 1.18 Difficulty walking stairs (≥75 y old) (interaction with age), HR: 0.88; 95% CI: 0.51, 1.50 Light alcohol use, HR: 0.82; 95% CI: 0.55, 1.96 Moderate alcohol use, HR: 1.11; 95% CI: 0.67, 1.83 Excessive alcohol use, HR: 1.42; 95% CI: 0.58, 3.46 Loneliness, HR: 1.11; 95% CI: 0.75, 1.64 Partner present, HR: 1.37; 95% CI: 0.92, 2.02
Serra-Prat et al., 2012 (31)	Age Sex Education Family support	Baseline: 254 community subjects (69 subjects with OD and 185 without OD); Follow-up: 227 community subjects	MNA (>23.5 = well nourished, ≤23.5 = malnourished or at risk of malnutrition)	Logistic regression: for M/RM Basal OD (on prevalence of M/RM), OR: 2.72; 95% CI: 1.25, 5.95; $P = 0.010$ Impaired efficacy of swallow (on prevalence of M/RM), OR: 2.73; 95% CI: 1.19, 6.26; $P = 0.015$

(Continued)

TABLE 1 (*Continued*)

Author, year (reference)	Potential risk factors	Population	Assessment method	Results
	Toxic habits Comorbidities Physical exploration (weight, height, waist circumference, and handgrip strength) Functional capacity Nutritional status Frail condition			Basal OD (on weight loss > 5%), OR: 1.33; 95% CI: 0.55, 3.24; $P = 0.336$ Impaired efficacy of swallow (on weight loss > 5%), OR: 1.30; 95% CI: 0.49, 3.46; $P = 0.380$ Effect adjusted by age, Barthel score, basal nutritional status: Impaired efficacy of swallow, OR: 2.31; 95% CI: 0.96, 5.57; $P = 0.062$ Age, OR: 1.03; 95% CI: 0.96, 1.08; $P = 0.448$ Barthel score, OR: 0.99; 95% CI: 0.95, 1.02; $P = 0.443$ M/RM at baseline, OR: 0.70; 95% CI: 0.26, 1.89; $P = 0.481$ Loss of >5% of initial handgrip strength, male, OR: 2.33; 95% CI: 1.02, 5.36; $P = 0.043$

[1] All studies (16, 27–31) are from Europe, except Shatenstein et al. (27), which is from North America. ADL, activities of daily living; ENS, Elderly Nutrition Screening tool; IADL, instrumental activities of daily living; MNA, Mini Nutritional Assessment; MNA-SF, Mini Nutritional Assessment-Short Form; M/RM, malnutrition/risk of malnutrition; OD, oral dysphagia; ref, reference; β, standardized regression coefficient.
[2] 95% CI values not given.
[3] *P* values not given.

Discussion

This systematic review presents information on potential risk factors for malnutrition in older adults, which allows the development of a malnutrition screening instrument that takes the multifactorial nature of malnutrition into account. Because a risk factor can only be identified if it causes an effect over time, the present systematic literature review includes only longitudinal studies in order to evaluate potential risk factors for malnutrition (16, 27–31).

When combining risk factors, the prevalence of malnutrition is higher in the older population than in younger adults (32). However, aging emerged as a risk factor for malnutrition in only 2 (28, 30) of the 5 longitudinal studies that included the effect of age, indicating that age as an isolated factor is not always confirmed as a risk factor for malnutrition (33, 34). Rather than age, the gradual deterioration of health status and body function caused by aging (35), also known as frailty, is suggested to be an important determinant for malnutrition among older individuals (36, 37). The concept of frailty denotes the multidimensional syndrome of the loss of reserves such as energy, physical ability, and cognition and an increase in vulnerability (38). As a result, a vast number of approaches have been used to assess frailty in the older population, which makes frailty a challenging parameter to discuss, especially because it is commonly defined based on variables that can be studied as isolated risk factors. Functional decline is an example of a physical performance measure of frailty, which is also identified as a significant risk factor for malnutrition (functional decline $P = 0.008$) (28), when defined as having difficulty walking stairs at < 75 y of age (16), loss of >5% of initial handgrip strength in men with oral dysphagia (31), or needing assistance to eat (27, 28). These results are in contrast to the findings of Jyrkkä et al. (30) and Serra-Prat et al. (31), showing no association between general physical performance or performance of daily life activities and the development of malnutrition. The conflicting observations may be due to the higher mean age and percentage of female participants in the Mamhidir et al. (28) study (85.8 y, 71.0% women) than in the studies by Jyrkkä et al. (30) (81.4 y, 69% female) and Serra-Prat et al. (31) (78.2 y, 46.5% female). Female sex as an isolated factor could not be identified as a risk factor for malnutrition (16) but, as well as older ages, is shown to be associated with greater overall prevalence of disability and functional limitation (39), which is likely to increase the probability of an association between functional impairment and malnutrition. Moreover, the Mamhidir et al. (28) study was conducted in individuals living in sheltered housing, in which the proportion of functionally disabled and malnourished subjects ≥65 y of age is expected to be higher (40) than in the general population in which the studies by Jyrkkä et al. (30) and Serra-Prat et al. (31) were performed.

Aging, and consequently frailty progress, can also be indirectly related to the development of malnutrition caused by health decline, which comes with onsets of physical and psychological diseases, increased medication intake

TABLE 2 Risk factors for malnutrition in older adults identified in the included longitudinal studies[1]

	Risk factor	Reference	Assessment method	Analysis	Statistics	Outcome[2]
Physical factors	Frailty (institutionalized subjects)	(27)	% of initial body weight	Multivariate model	β: −1.23; 95% CI: values not given; $P = 0.039$	+
		(27)	% of initial body weight	Logistic regression	β: 0.22; 95% CI: 1.01, 1.54; $P = 0.036$	+
	1−2 medications	(16)	BMI	Multivariate model	Female (interaction with sex), HR: 0.39; 95% CI: 0.18, 0.83; *P* value not given	−
		(16)	BMI	Multivariate model	Male, HR: 1.10; 95% CI: 0.60, 2.02; *P* value not given	0
	≥3 medications	(16)	BMI	Multivariate model	Male, HR: 1.80; 95% CI: 0.99, 3.27; *P* value not given	0
		(16)	BMI	Multivariate model	Female, HR: 1.03; 95% CI: 0.54, 1.96; *P* value not given	0
	Polypharmacy	(30)	MNA-SF	Linear mixed model	β: −0.12; 95% CI: −0.37, 0.13; $P = 0.333$	0
	Excessive polypharmacy	(30)	MNA-SF	Linear mixed model	β: −0.62; 95% CI: −0.98, −0.27; $P = 0.001$	+
	1 chronic disease	(16)	BMI	Multivariate model	HR: 1.10; 95% CI: 0.64, 1.88; *P* value not given	0
	≥2 chronic diseases	(16)	BMI	Multivariate model	HR: 1.32; 95% CI: 0.75, 2.33; *P* value not given	0
	Limitations of normal activities because of a health problem	(16)	BMI	Multivariate model	HR: 1.20; 95% CI: 0.81, 1.77; *P* value not given	0
	Low physical performance test score	(16)	BMI	Multivariate model	Age < 75 y, HR: 0.98; 95% CI: 0.89, 1.08; *P* value not given	0
		(16)	BMI	Multivariate model	Age ≥ 75 y, HR: 1.06; 95% CI: 0.95, 1.18; *P* value not given	0
	Functional comorbidity index	(30)	MNA-SF	Linear mixed model	β: 0.01; 95% CI: −0.08, 0.09; $P = 0.950$	0
	Functional decline	(28)	BMI	Logistic regression	OR: 1.793; 95% CI: 1.163, 2.765; $P = 0.008$	+
	Barthel score	(31)	MNA	Logistic regression	OR: 0.99; 95% CI: 0.95, 1.02; $P = 0.443$	0
	Difficulty walking stairs	(16)	BMI	Multivariate model	≥75 y old (interaction with age), HR: 0.8; 95% CI: 0.51, 1.50; *P* value not given	0
		(16)	BMI	Multivariate model	<75 y old, HR: 1.91; 95% CI: 1.14, 3.22; *P* value not given	+
	Light alcohol use	(16)	BMI	Multivariate model	HR: 0.82; 95% CI: 0.55, 1.96; *P* value not given	0
	Moderate alcohol use	(16)	BMI	Multivariate model	HR: 1.11; 95% CI: 0.67, 1.83; *P* value not given	0
	Excessive alcohol use	(16)	BMI	Multivariate model	HR: 1.42; 95% CI: 0.58, 3.46; *P* value not given	0
	Dementia	(28)	BMI	Multiple logistic regression	OR: 2.139; 95% CI: 1.343, 3.407; $P = 0.001$	+
	Cognitive capacity	(28)	BMI	Logistic regression	OR: 1.844; 95% CI: 1.267, 2.683; $P = 0.001$	+
	Parkinson disease	(28)	BMI	Multiple logistic regression	OR: 2.450; 95% CI: 1.006, 5.965; $P = 0.047$	+
	Constipation	(28)	BMI	Multiple logistic regression	OR: 2.490; 95% CI: 1.185, 4.964; $P = 0.015$	+
	Age (y)	(28)	BMI	Logistic regression	OR: 1.038; 95% CI: 1.001, 1.077; $P = 0.045$	+
		(31)	MNA	Logistic regression	OR: 1.03; 95% CI: 0.96, 1.08; $P = 0.448$	0
		(30)	MNA-SF	Linear mixed model	β: −0.04; 95% CI: −0.08, −0.01; $P = 0.016$	+
		(29)	ENS	Multivariate model	OR: 1.00; 95% CI: 0.94, 1.07; *P* value not given	0
		(16)	BMI	Multivariate model	≥75 y old, HR: 0.88; 95% CI: 0.29, 2.63; *P* value not given	0
	Loss of >5% of initial hand-grip strength (male)	(31)	MNA	Logistic regression	OR: 2.33; 95% CI: 1.02, 5.36; $P = 0.043$	+
	Sex	(29)	ENS	Multivariate model	Ref = female, OR: 0.93; 95% CI: 0.58, 1.51; *P* value not given	0

(Continued)

TABLE 2 (*Continued*)

	Risk factor	Reference	Assessment method	Analysis	Statistics	Outcome[2]
		(30)	MNA-SF	Linear mixed model	Male, β: 0.11; 95% CI: −0.20, 0.42; $P = 0.471$	0
		(16)	BMI	Multivariate model	Female, HR: 0.73; 95% CI: 0.38, 1.39; *P* value not given	0
	Good current self-rated health	(29)	ENS	Multivariate model	Ref = excellent, OR: 1.48; 95% CI: 0.87, 2.50; *P* value not given	0
	Moderate current self-rated health	(30)	MNA-SF	Linear mixed model	β: −0.27; 95% CI: −0.49, −0.05; $P = 0.016$	+
	Poor current self-rated health	(29)	ENS	Multivariate model	Ref = excellent, OR: 3.30; 95% CI: 1.42, 7.67; *P* value not given	+
		(30)	MNA-SF	Linear mixed model	β: −1.05; 95% CI: −1.38, −0.73; $P < 0.001$	+
	Worse self-rated health compared with the previous year	(29)	ENS	Multivariate model	Ref = the same, OR: 1.09; 95% CI: 0.47, 2.50; *P* value not given	0
	Better self-rated health compared with the previous year	(29)	ENS	Multivariate model	Ref = the same, OR: 0.55; 95% CI: 0.30, 1.00; *P* value not given	0
Psychological factors	Reported loss of interest in life (institutionalized subjects)	(27)	% of initial body weight	Logistic regression	β: −0.63; 95% CI: 0.30, 0.93; $P = 0.027$	+
	Reported loss of interest in life (community subjects)	(27)	% of initial body weight	Logistic regression	β: −0.58; 95% CI: 0.34, 0.90; $P = 0.017$	+
	Reported sustained interest in life (community subjects)	(27)	% of initial body weight	Multivariate model	β: 2.22; 95% CI values not given; $P = 0.013$	−
	Depressive symptoms	(16)	BMI	Multivariate model	HR: 0.89; 95% CI: 0.52, 1.52; *P* value not given	0
	Anxiety symptoms	(16)	BMI	Multivariate model	HR: 1.26; 95% CI: 0.72, 2.21; *P* value not given	0
	Loneliness	(16)	BMI	Multivariate model	HR: 1.11; 95% CI: 0.75, 1.64; *P* value not given	0
	Partner present	(16)	BMI	Multivariate model	HR: 1.37; 95% CI: 0.92, 2.02; *P* value not given	0
Oral health-related factors	Daily dental hygiene	(28)	BMI	Logistic regression	Not given	−
	Basal OD (on prevalence of M/RM)	(31)	MNA	Logistic regression	OR: 2.72; 95% CI: 1.25, 5.95; $P = 0.010$	+
		(29)	Weight loss > 5%	Logistic regression	OR: 1.33; 95% CI: 0.55, 3.24; $P = 0.336$	0
	Impaired efficacy of swallow (on prevalence of M/RM)	(29)	MNA	Logistic regression	OR: 2 0.73; 95% CI: 1.19, 6.26; $P = 0.015$	+
		(29)	Weight loss > 5%	Logistic regression	OR: 1.30; 95% CI: 0.49, 3.46; $P = 0.380$	0
Social factors	Residence in Ontario (institutionalized subjects)	(27)	% of initial body weight	Multivariate model	β: −1.23; 95% CI values not given; $P = 0.039$	+
	Residence in British Columbia (institutionalized subjects)	(27)	% of initial body weight	Multivariate model	β: −5.62, 95% CI values not given; $P = 0.026$	+
	Residence in Atlantic (institutionalized subjects)	(27)	% of initial body weight	Multivariate model	β: −3.41, 95% CI values not given; $P = 0.225$	0
		(27)	% of initial body weight	Multivariate model	β: −4.54, 95% CI values not given; $P = 0.087$	0

(Continued)

TABLE 2 (*Continued*)

	Risk factor	Reference	Assessment method	Analysis	Statistics	Outcome[2]
	Residence in prairies (institutionalized subjects)					
	Institutionalized	(30)	MNA-SF	Linear mixed model	β: −1.89; 95% CI: −2.38, −1.39; $P < 0.001$	+
	0–6 y of education	(30)	MNA-SF	Linear mixed model	β: −0.03; 95% CI: −0.32, 0.26; $P = 0.823$	0
Eating-related factors	Loss of appetite (community-living subjects)	(27)	% of initial body weight	Logistic regression	β: −1.52; 95% CI: 0.12, 0.42; $P = 0.000$	+
	Poor appetite	(16)	BMI	Multivariate model	HR: 1.63; 95% CI: 1.02, 2.61; *P* value not given	+
	Eating dependency	(28)	BMI	Multiple logistic regression	OR: 2.257; 95% CI: 1.676, 3.038; $P = 0.001$	+
	Ability to eat unaided (community-living subjects)	(27)	% of initial body weight	Multivariate model	β: 4.24, 95% CI values not given; $P = 0.000$	−

[1] ENS, Elderly Nutrition Screening tool; MNA, Mini Nutritional Assessment; MNA-SF, Mini Nutritional Assessment-Short Form; M/RM, malnutrition/risk of malnutrition; OD, oral dysphagia; ref, reference; β, standardized regression coefficient.
[2] + indicates positive association with malnutrition; 0 indicates no association; and − indicates negative association.

(26), cognitive impairment, and dementia. Although one could expect a great number of diseases to be related to malnutrition development, only Parkinson disease, constipation (28), and basal oral dysphagia and signs of impaired swallowing (30) were observed to have a significant impact on the nutritional status because of the advanced age of the population included in the study (Parkinson disease $P = 0.047$, constipation $P = 0.015$, basal oral dysphagia $P = 0.010$, impaired efficacy of swallow $P = 0.015$). Some diseases are a challenge to investigate in advanced age because of the high mortality rates. In this context, a number of other diseases known to be risk factors for malnutrition in younger adults could be considered, such as head and neck (41) or gastric (42) oncology or congestive heart failure (43). The onset of Parkinson disease, on the other hand, often occurs at an older age (44), which enables investigation of the relation between this disease and malnutrition in this population. Parkinson disease is usually accompanied by severe motor symptoms (45–48), decreased mobility (49), reduced ability to carry out the activities of daily living (48, 50, 51), increased medication intake (45, 51), and cognitive impairment (52), all factors leading to a higher risk of developing malnutrition in the individuals with this condition (53–55). Constipation is also more prevalent in older adults because of slowing of the gastrointestinal transit (56), which is due to several factors such as increased rectal compliance, delayed colonic transit, low intake of dietary fiber, and neuromuscular disorders (57). Increased prevalence of dysphagia, on the other hand, is due to a vicious cycle in which dysphagia contributes to malnutrition and malnutrition contributes to further deterioration of functional capacity and muscle debilitation, which, in turn, favors dysphagia.

Cognitive decline and dementia were found to be statistically significant risk factors for malnutrition (28), which is consistent with numerous cross-sectional studies (dementia $P = 0.001$, cognitive decline $P = 0.001$) (5, 40, 58–70). The relation between cognitive impairment and nutritional risk seems to be a complex and reciprocal problem (71) because a variety of factors that were found to have an impact on malnutrition were also associated with a lower cognitive state, such as oral health-related problems (36, 70, 72–86), which was found to comply with the results of Mamhidir et al. (28), demonstrating that daily dental hygiene leads to a decrease in malnutrition prevalence over time.

Although many cross-sectional studies found an association between malnutrition and depression (19, 33, 34, 65–70, 87–91), anxiety (83, 92), and loneliness (81, 93–95), these factors were not identified as risk factors in the longitudinal study performed by Schilp et al. (16). However, poor or moderate self-reported health status was observed to be a significant risk factor for malnutrition (29, 30), whereas better self-rated health compared with the previous year was observed to be protective (poor $P < 0.001$, moderate $P = 0.016$) (29). These findings might be explained by the fact that those people who have a positive opinion about their general health are more alert and probably have an increased awareness of their nutritional needs (58). Poor or moderate

self-reported health status was also related to loss of interest in life, the only psychological factor that was significantly correlated with increased weight loss in institutionalized and community-dwelling older adults (27).

As the occurrence of diseases that require pharmacologic treatment becomes more common with aging, higher age is accompanied by an increasing prevalence of (excessive) polypharmacy (96, 97). The extent of medication intake is a factor that influences, either directly or indirectly, the risk of malnutrition (16, 30). Whereas moderate medication intake seems to protect from malnutrition in older female participants (16), excessive medication intake (>10 drugs) has an inverse effect (30). All cross-sectional studies but one (34) also observed a positive correlation between polypharmacy and malnutrition. However, the findings from this systematic review regarding polypharmacy are difficult to compare because cross-sectional studies do not distinguish between various levels of polypharmacy (1, 34, 66, 82, 90, 98). Furthermore, the side effects of excessive polypharmacy can indirectly affect the development of malnutrition. Examples of such pharmacologic side effects are poor appetite or loss of appetite (56), also shown to be a risk factor for malnutrition (16, 27); physical and cognitive decline (56, 99, 100); dry mouth (hyposalivation and/or xerostomia) (101); nausea (102); and constipation (56).

Institutionalization of older adults was found to be a factor that contributes to the development of malnutrition in this specific population (28), which is in line with the available cross-sectional studies in the literature that comprehensively reports a decrease in nutritional status when moving to a long-term care institution (40, 64, 103–106). However, the reasons for this association should be carefully investigated. The hypothesis that poor care or care-related factors play a role in residents' malnourishment was not confirmed in a study by Suominen et al. (40). Also other confounding variables in institutionalized older adults are shown to be related to nutritional deficiencies such as age, advanced dementia with immobility, functional dependence, and severe chewing/swallowing problems (19).

One limitation of this review concerns the relative heterogeneity in the variables analyzed, concept definitions, methodology, and populations among the 6 longitudinal studies identified. This complicates comparison of the studies and is likely to be the reason why some conflicting results were found.

The longitudinal nature of the studies included in this systematic review allows for determination of the impact of certain independent variables on the development of malnutrition over time. The identified risk factors for malnutrition were age, frailty in institutionalized persons, excessive polypharmacy, general health decline (including physical function and cognition), loss of interest in life, basal oral dysphagia and signs of impaired efficacy of swallowing, and institutionalization. The identification of these factors is crucial for being able to develop an integrated malnutrition assessment tool that takes the multifactorial nature of malnutrition into consideration. The current available screening instruments do not include all identified risk factors, which urges the development of an efficient comprehensive assessment instrument that will identify older adults' risk of malnutrition and supports the development of preventive strategies. Because only longitudinal studies are able to detect causality, this feature was one of the inclusion criteria for this systematic review. Nevertheless, the numerous cross-sectional studies that reported significant associations between malnutrition and a variety of parameters are valuable, because they generate hypotheses for further longitudinal research on risk factors for malnutrition. For this reason, the cross-sectional studies are provided as Supplemental Tables 1 and 2.

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JD conceived and designed the review, interpreted the results, and wrote the manuscript. NCFM designed and performed the review, interpreted the results, and wrote the manuscript. SKH, CM, CV, EV, AD, and GEB contributed to the review design, interpretation of the results, and to the manuscript revision. All authors discussed the results and commented on the manuscript. All authors read and approved the final manuscript.

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