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Original article

Global scientific research on elderly malnutrition: A bibliometric analysis

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Abstract. *Background:* The malnutrition in older adults increases rapidly with the accelerating development of the global aging. Malnutrition was considered to be a public health problem characterized by multifactorial physiological state. Bibliometric analysis and visualization to this field in the past 30 years may provide profound insights. *Methods:* Scientific citation index database was identified publications with author name, affiliation and origin country from 1991 to 2021 in this field, and systematically compiled the corresponding bibliometric data. Web of science database and excel were used to analyze generally, while VOSviewer and Citespace were used for bibliometric analysis and visualization. *Results:* In total, 2239 publications were found. The total number of publications increased substantially and exponentially in recent years, suggesting that more and more researchers pay attention to this field. The most contributor is the United States, whereas the highest average citations is Switzerland. Bibliographic coupling, coauthorship, cocitation, and co-occurrence analyses revealed that nutrition dietetics was the most research area. Vrije Universiteit Amsterdam and journal of Nutrition Health & Aging were the most contribution institution and journal. The publication in the Journal of the American Geriatrics Society by Kaiser MJ et al in 2010 had the most cited frequence. Co-occurrence analysis showed that the most research topics included "programming" "sarcopenia" "prevention" "risk" "nutrition support" "deglutition". *Conclusions:* Through the visual analysis of publication in recent 30 years, we found the publication trends and research characteristics in this field. These findings will hopefully provide new insight into the study of elderly malnutrition. *Implications for Practice:* Malnutrition in older adults leads to heavy burdens to the individual, social and economic. Relevant professionals, such as doctors, nurses, psychologists and many other health practitioners, should raise broad awareness and attention to the research hot spots and frontiers of this topic, in order to promote the screening, evaluation, diagnosis and grading treatment for malnutrition in elderly people with different health and functional states.

Key words: Malnutrition, older adults, risk, visualization, research

Introduction

Malnutrition was defined as "a state of nutrition in which a deficiency or excess (or imbalance) of energy, protein and other nutrients causes measurable adverse effects on tissue or body form (body shape, size and composition), function and clinical outcomes" (1), especially protein-energy malnutrition is common, increasing with age and leading to heavy burdens to the individual, social and economic (2,3). Systematic review and meta-analysis of recent studies using MNA have summarized the following estimates of malnutrition in older adults according to the setting of care: community, 3%; outpatients, 6%; home-care services, 9%; nursing homes, 17.5%; hospital, 22%; long-term care, 29%; rehabilitation/sub-acute care,

29% (4). Other studies have shown that 28–42% of the elderly were malnourished when they were admitted to nursing homes or emergency hospitals (5). The manifestations and severity of malnutrition vary, and the affected individuals may experience fatigue, immune compromise, cognitive impairment and depression. Muscle mass and bone strength decrease to lead decreased physical fitness and increased risk of falls and fractures (6,7). Multiple factors are associated with malnutrition in the elderly, such as lifestyle and social factors, medical factors, psychological, and additional risk factors in the hospital. One study found that recipients living in nursing homes were more likely to malnutrition than community-dwelling adults (8,9). Malnutrition was considered to be a public health problem characterized by multifactorial physiological state (10). The key to treatment is to identify the risk of malnutrition and take effective nutritional interventions (11). The first is the Subjective Global Assessment (SGA) introduced in 1982. Since then, dozens of screening tools have been developed (12). For example, CNS, MDS, SNAQ and SNAQ-RC are developed for the nursing home population to screen. Moreover developed tools for the older population are as follows, GNRI, NRI, MNA/MNA-SF, MUST, NUFFE and so on (13). These tools are designed to quickly identify malnutrition risks, conduct more in-depth nutritional assessment, or identify patients with increased risk of complications or even death.

Bibliometrics uses mathematical and statistical methods to study the distribution structure, quantitative relations, change rules and quantitative management of bibliometrics to evaluate and predict the research status and development trend of science and technology. Bibliometric analysis on the relationship between urban street space and residents' health (14), global health (15), eHealth (16), plant excavation (17), elderly in social participation (18) and elderly foods (19), were reported. However, there have been no relevant reports on the research on malnutrition in the elderly from the perspective of bibliometrics at home and abroad. Based on the core collection Web of Science database, using the principle and method of literature metrology to global elderly malnutrition time trend of the research literature, national/regional influence, research institutes and research hotspot and frontier analysis, review and summarise global elderly malnutrition in 30 years research and development trend, thus to provide a useful reference for researchers and nurses, inspiring their possible direction of further research and clinical practice of elderly malnutrition.

Data Sources and Methods

Data Sources

Web of Science (WoS) is the global authoritative scientific citation index database, providing the world's leading scholarly journals, books, and proceeding papers in the sciences, social sciences, arts, humanities and navigate in a complete citation network. To ensure the reliability of the scientific metrological analysis, the web of science core collection was chosen to obtain the publications. We explored by different keywords combination of "malnutrition/undernutrition/dystrophy/cacotrophy +older adults/the aged/older people/elderly people/senior citizens/person of advanced age". The total searches are our goal publications. The search date was on January 8, 2021. Finally 2239 publications including author names, origin country, affiliations, article title, publication year, journal name, keywords and abstract was found. Record was the full record and cited references, and file format was tab-delimited (Win, UTF-8). The detailed search strategy was showed in Figure1.

Data Visualization Analysis

The quality of publications of different countries and authors was evaluated based on statistical data, including the total number of publications, total citations, average citations and H-index values. The H-index is a mixed quantitative index used to evaluate the scientific impact of different countries in this paper, while the journal impact factor (JIF) value is used for individual publications. These values are calculated based on the number of citations for a given author and journal. While VOSviewer is used to visualize the bibliometric network based on bibliographic coupling, coauthorship, cocitation and co-occurrence analysis. VOSviewer and Citespace are very useful visualization softwares used in this paper.

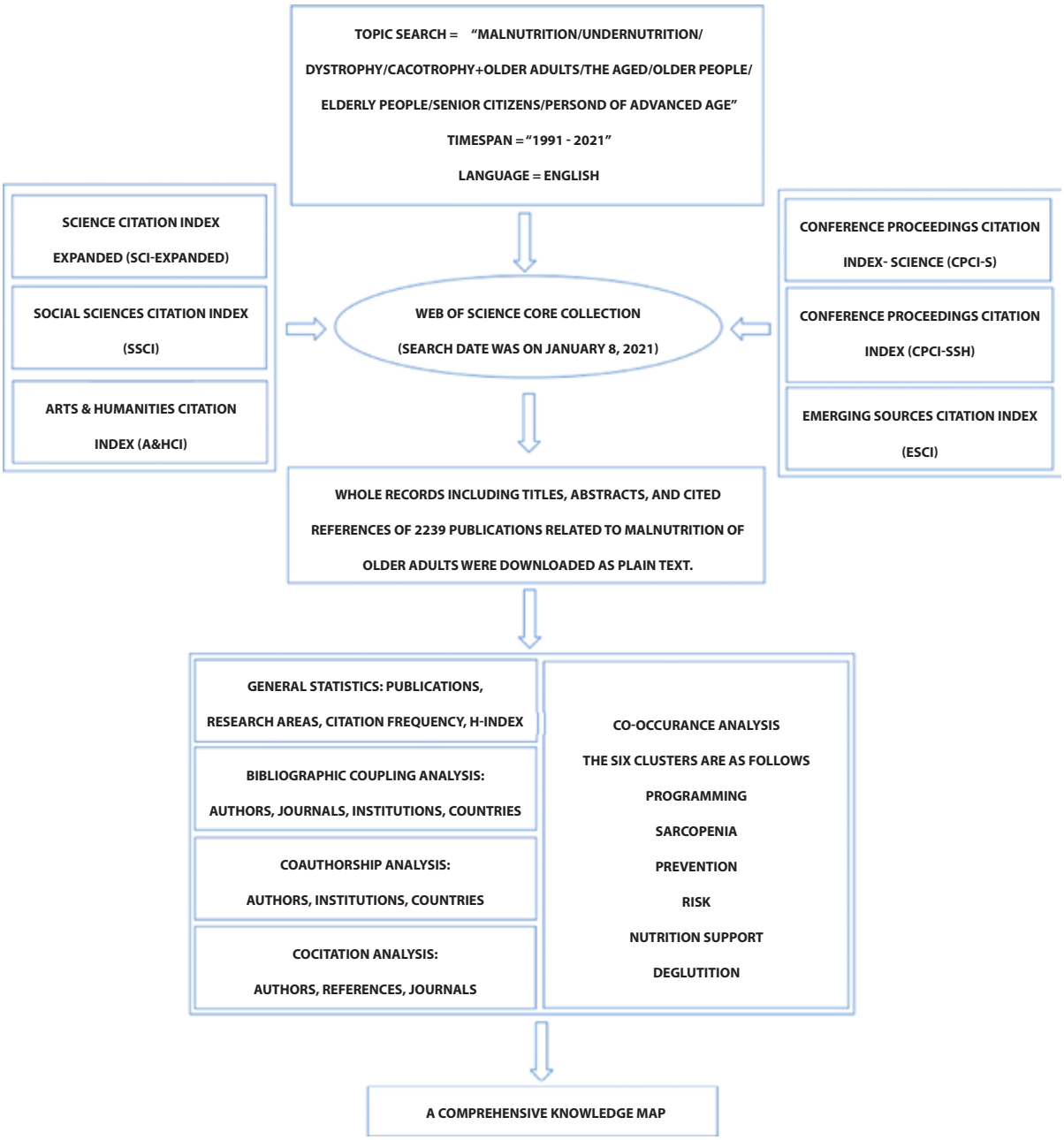

Figure 1. A research framework

Results

General Analysis

Total Global Publications

To a certain extent, the change of the number of scientific research achievements reflects the change of international experts and scholars' attention to a specific area. A total of 2239 publications on global malnutrition in older adults research were searched, including 1877 articles, 282 reviews, and 58 proceedings papers (Figure 2(a)). Figure 2(b) showed the details of annual change. The cumulative number of publications rose from 11 in 1991 to 382 in 2020. In general, the scientific achievements of malnutrition research in the

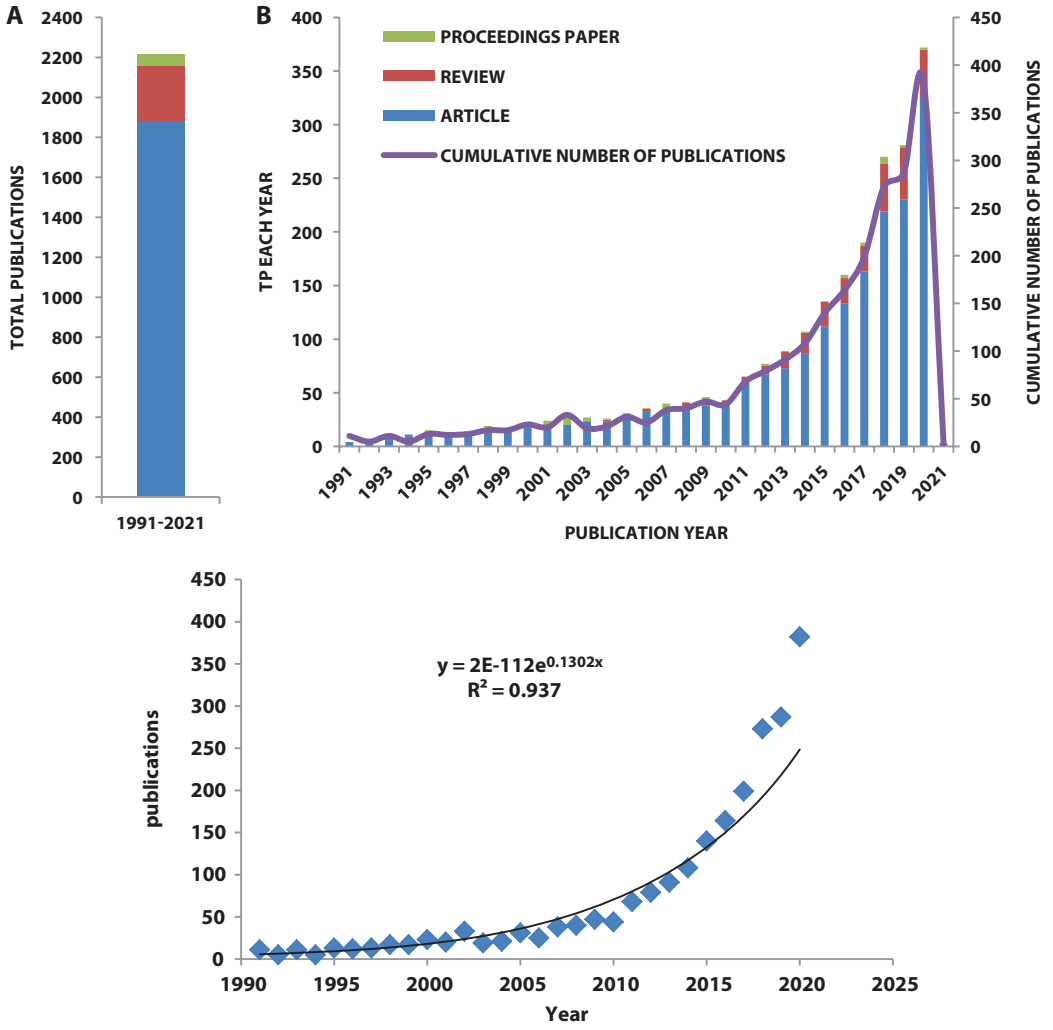

Figure 2. The global publications from 1991-2021(a). The annual number of publications is based on the ordinate axis (the left), and the cumulative number of publications is based on the secondary axis (the right)(b). Prediction of Global Publications(c).

elderly continue to rise. Specifically, the three types of documents (articles, reviews, and proceedings papers) also show an increasing trend. Next, A logistic regression model is used to predict future publishing trends in this field (Figure 2(c)), which indicates that the publication rates of this field will be in a rapid growth stage for a long time.

Global Publications by Country

A total of 2239 publications were retrieved from WoS. Global contributions to the field of malnutrition in older adults research indicated that the total publications of the United States (USA) was the greatest (515; 23.001%), followed by Australia (190; 8.486%), England (177;7.905 %), Netherlands (156; 6.967%), and Brazil (147;6.565%) (Figure 3(a)).

Total Citation Frequency by Country.

In this study, the United States was cited the most (15725), followed by England (125,405), Italy (5089), Netherlands (4654), Australia (4484) (Figure 3(b)).

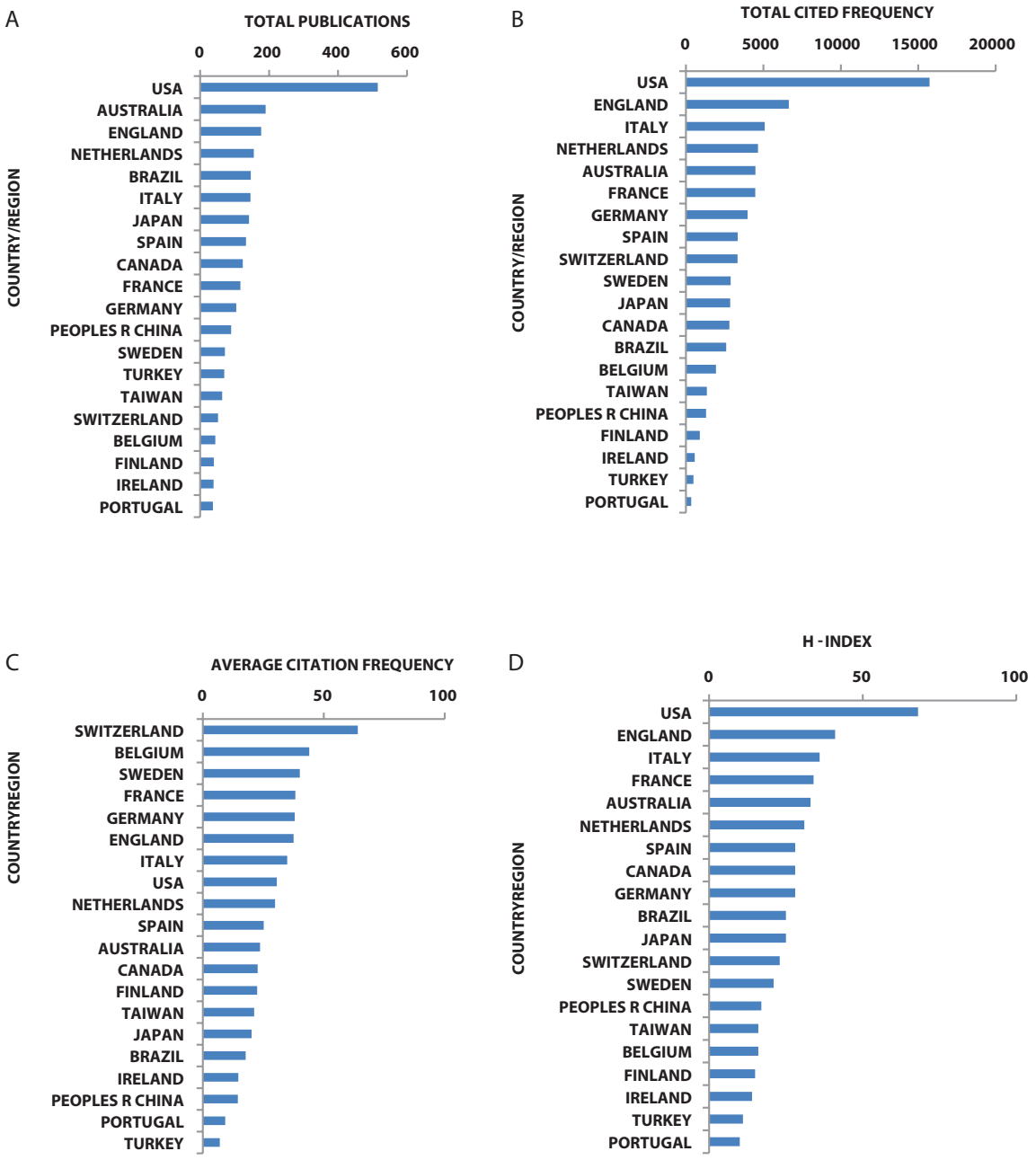

Figure 3. Global Publications by Country in malnutrition in older adults research: (a) total publications from different countries, (b) total citation frequency from different countries, (c) average citation frequency from different countries, (d) H-index of publications from different countries.

Average Citation Frequency by Country

In this study, Switzerland had the highest average number of citations per publication (64.02), followed by Belgium (43.95), Sweden (40.04), France (38.24), and Germany (37.95) (Figure 3(c)).

H-Index for Countries.

In this study, the United States had the highest average H-index (68), followed by England (41), Italy (36), France (34), and Australia (33) (Figure 3(d)).

Research areas.

Of the identified 2239 publications, 821 were classified as nutrition dietetics, followed by geriatrics gerontology (651), general internal medicine (156), public environmental occupational health (114), and nursing (102) (Figure 4).

Bibliographic Coupling Analysis.

The relationship between publications and the references cited in those publications was analyzed by bibliographic coupling analysis. When two publications cite the same article, they are considered to be "coupled", indicating that they share a common theme. The link strength between the two publications is measured by the number of common references cited by the two publications. This analysis was used to measure the strength of links between journals, countries and institutions that published on malnutrition in the elderly.

Journals.

Of the 734 journals, 77 journals were identified (Figure 5(a)). The top 5 journals with the greatest link strength values were Journal of Nutrition Health & Aging (total link strength = 65493times, JIF= 2.791), Clinical Nutrition (34532, 6.360), Nutrients (28941, 4.546), Journal of the American Medical Directors Association (22554, 4.367), and BMC Geriatrics (18527, 3.077). In particular, the journal impact factors mentioned above were in 2019, because there was a certain lag according to the calculation rules.

Institutions.

A total of 258 institutions were identified from 3040 institutions (Figure 5(b)). Vrije Universiteit Amsterdam had the highest linkage strengths (total link strength = 78780 times), followed by the University of Queensland (39378), the Friedrich-alexander University of Erlangen-Nurnberg (39108), Uppsala University (35623), and University of Southampton (35533).

Countries.

A total of 53 countries were identified from the 103 countries (Figure 5(c)). The United States had the highest linkage strengths (total link strength = 223839 times), followed by Netherlands (144079), Australia (131672), Italy (117370), and Spain (114895).

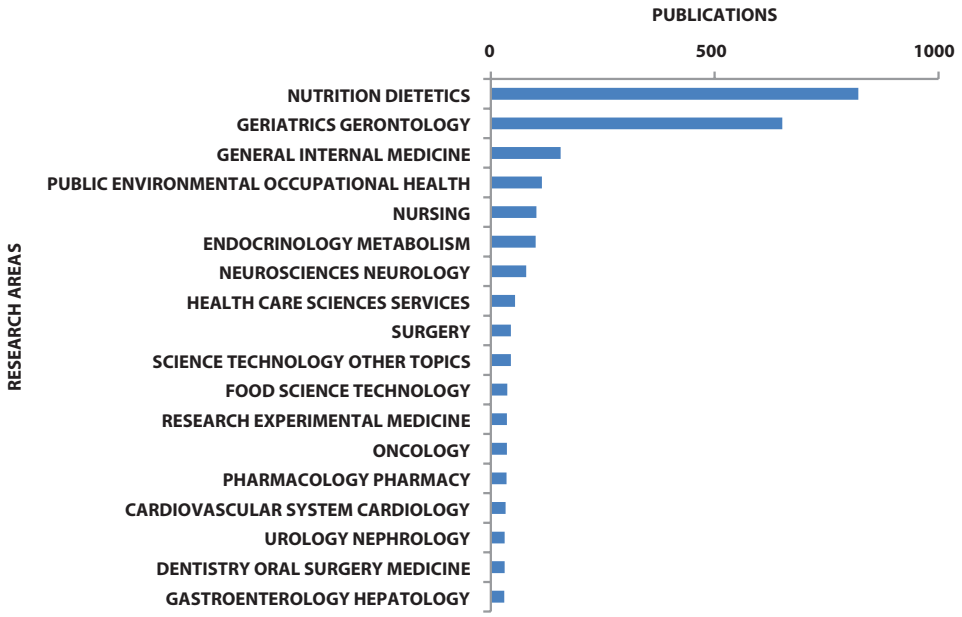

Figure 4. Global Publications of Research Areas.

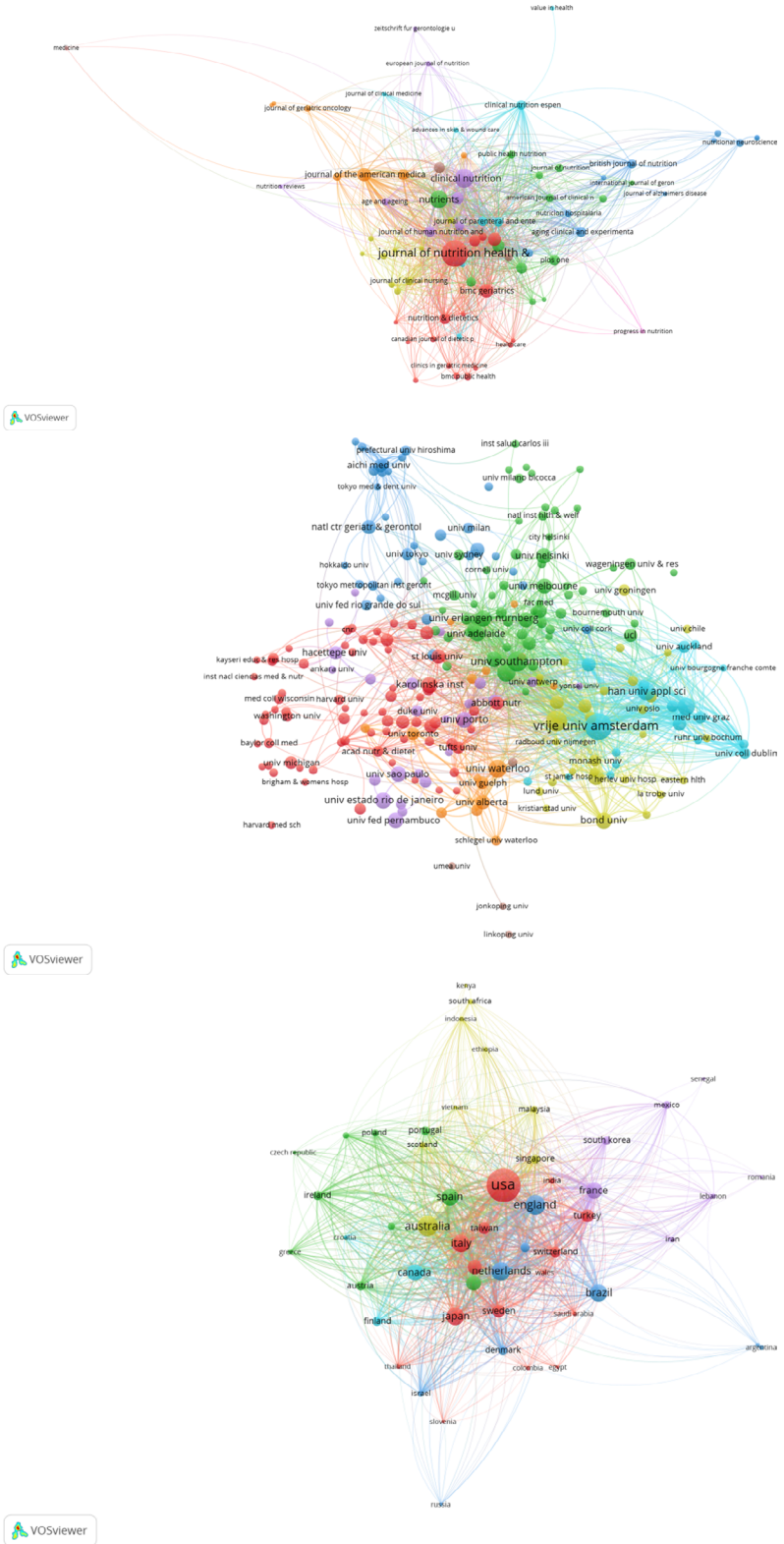

Figure 5: Bibliographic coupling analysis of global research on malnutrition in older adults. Mapping of (a) 77 identified journals, (b) 258 institutions, and (c) 53 countries on the research area.

Coauthorship Analysis.

A coauthor analysis was conducted to measure the interrelationships between researchers by the number of publications coauthored by a given pair of researchers. This method was used to assess the strength of the links between authors, countries and institutions.

Authors.

A total of 141 authors who had published a minimum of five publications were identified from the 9974 authors (Figure 6(a)). Evaluation based on total link strength, Visser Marjolein had the highest (total link strength = 64 times), followed by Volkert Dorothee (64), Mendonca Nuno (52), Maeda Keisuke (41), and Jagger Carol (33).

Institutions.

A total of 258 organizations published more than five publications were identified from 3040 organizations (Figure 6(b)). Evaluation based on total link strength, Vrije Universiteit Amsterdam had the highest (total link strength = 150 times), followed by Friedrich Alexander Universitat Erlangen Nurnberg (82), HAN University of Applied Sciences(77), Uppsala University (67), and University of Southampton (57).

Countries.

A total of 53 countries published more than five publications (Figure 6(c)). Evaluation based on total link strength, the United States had the highest (total link strength = 267 times), followed by Netherlands (220), England (205), Italy (177), and Germany (172).

Cocitation Analysis.

In order to evaluate the links between publications cited in other publications, a cocitation analysis was conducted. The total link strength was calculated based on the total number of publications cited together for a particular publication. The same method is also used to evaluate the strength of collaboration between authors and journals.

Authors.

A total of 466 authors were identified from the 41107 authors, each of whom was cited 20 times (Figure 7(a)). The top 5 authors were Morley JE (total link strength=12082 times), Goigoz Y (8923), Kaiser MJ (8167), Cederholm T(6361), and Elia M (6324) according to the total linkage strength values.

References.

A total of 237 references were cited 20 times (Figure 7(b)). The top 5 references were Kaiser MJ, 2010, Journal of the American Geriatrics Society (total link strength=1959 times), Kaiser MJ, 2009, Journal of Nutrition Health& Aging (1799), Rubenstein LZ, 2001, Journals of Gerontology Series a-Biological Sciences and Medical Sciences (1766), Fried LP, 2001, Journals of Gerontology Series a-Biological Sciences and Medical Sciences (1585), Folstein MF, 1975, Journal of Psychiatric Research (1511) according to the total linkage strength values.

Journals.

Journals were analyzed for references cited in all publications, and 587 journals were identified from the 13645(Figure 7(c)). The top 5 journals were Clinical Nutrition(total link strength=160979 times, JIF=6.360), Journal of the American Geriatrics Society (138590, 4.180), Journal of Nutrition Health & Aging (132777, 2.791), American Journal of Clinical Nutrition (102239,6.766), Journals of Gerontology Series a-Biological Sciences and Medical Sciences (93613,5.236) according to the total linkage strength values.

Co-Occurrence Analysis.

A co-occurrence analysis using software of Citespace was additionally carried out on future directions, analyzed the number of publications with specific keywords occurred simultaneously. In this study, a total of 6830 keywords were used, and 208 keywords were used over 20 times. Co-citation cluster analysis shows that the global research frontiers of malnutrition in

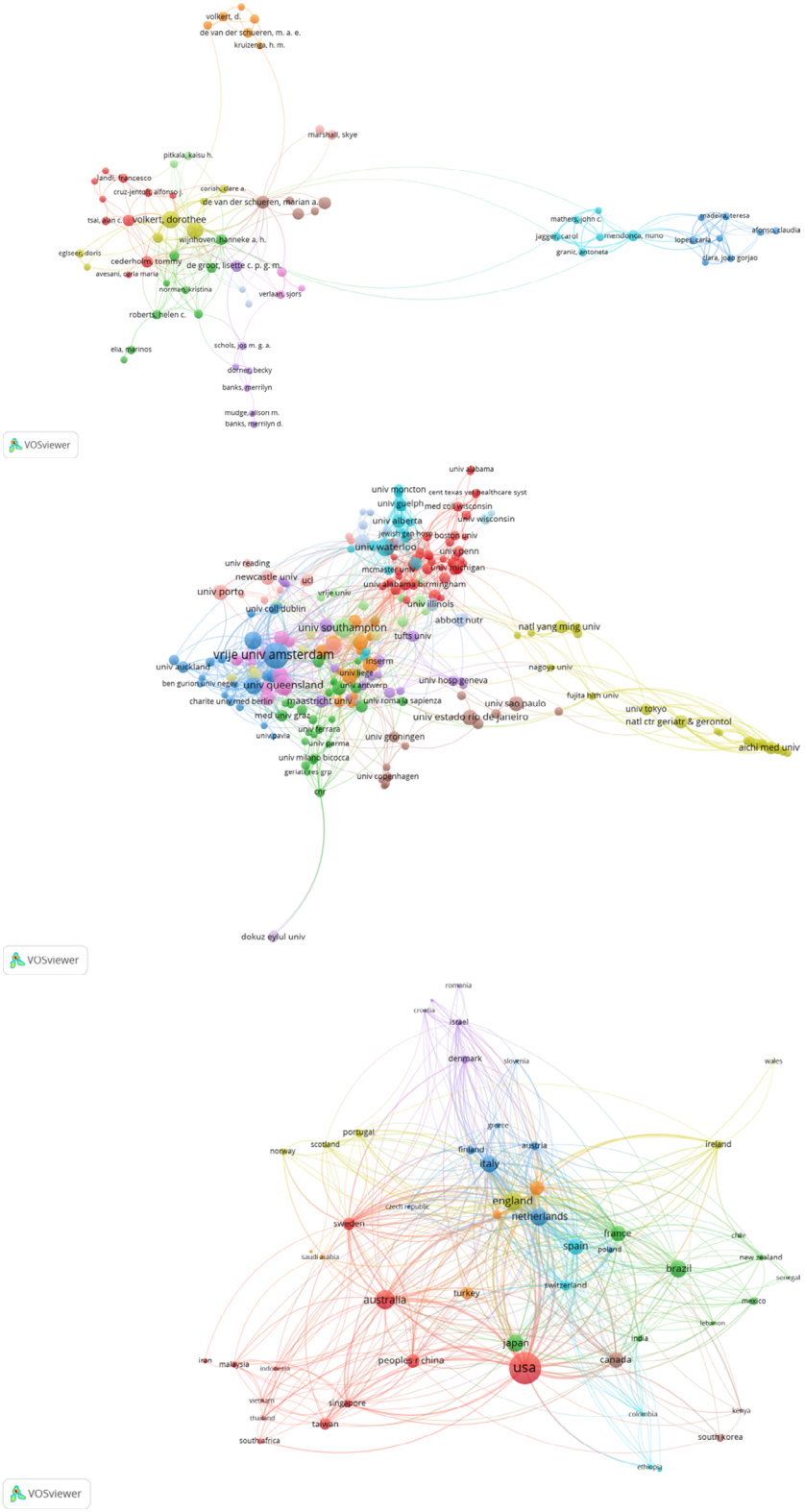

Figure 6. Coauthorship analysis of global research on malnutrition in older adults. Mapping of (a) 141 authors, (b) 258 institutions, and (c) 53 countries on the research area.

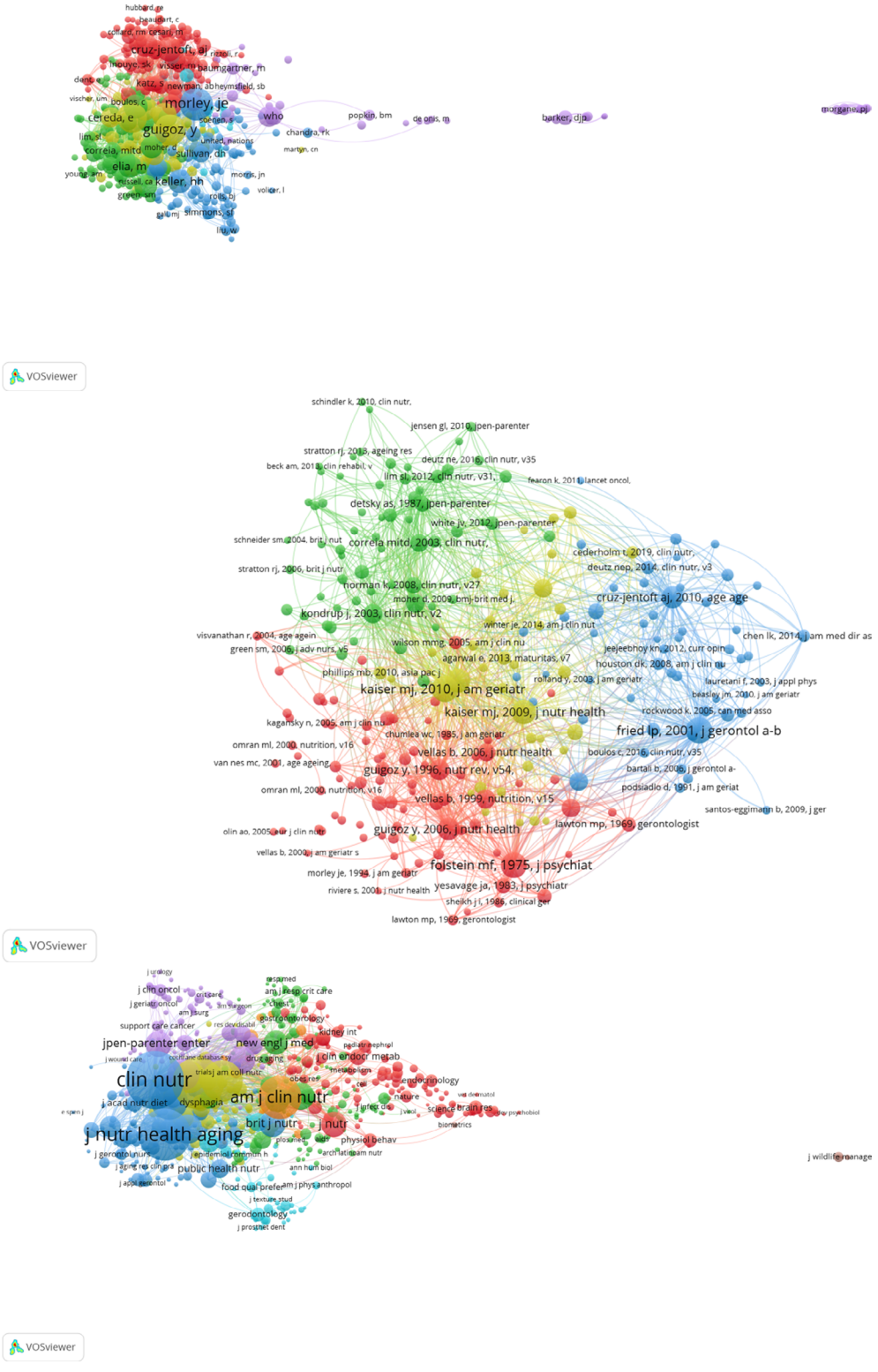

Figure 7. Cocitation analysis of global research on malnutrition in older adults. Points with the same colour belong to the same research topic. The number and size of points represents the citation frequency. Mapping of (a) 466 cocited authors, (b) 237 cited references, (c) 587 identified journals in this field.

older adults mainly focuse on the following six aspects "programming" "sarcopenia" "prevention" "risk" "nutrition support" "deglutition"(Figure 8).These clusters include most of the studies on malnutrition in the elderly published so far. According to previous analysis, we have drawn a comprehensive knowledge map of malnutrition in older adults research, as shown in Figure 9.

Discussion

Compare Publications by Country.

In general, the research on malnutrition in older adults in the United States is relatively high. According to the total publications, total citation frequency and H

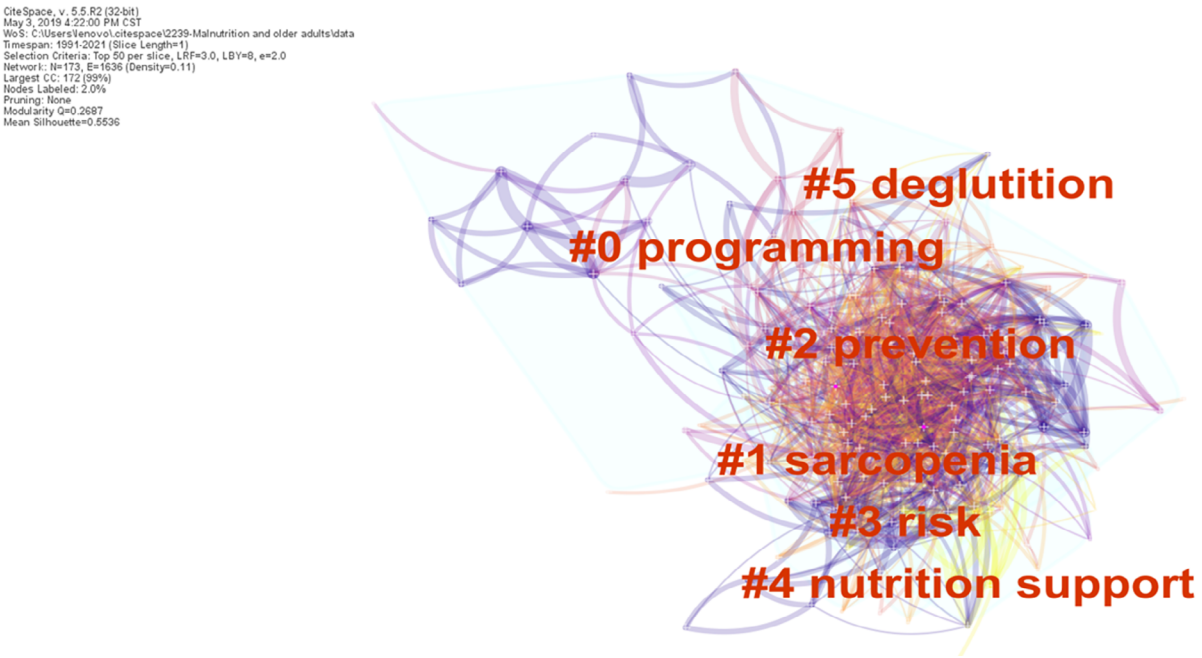

Figure 8. Co-citation cluster analysis of global research on malnutrition in older adults using software of Citespace

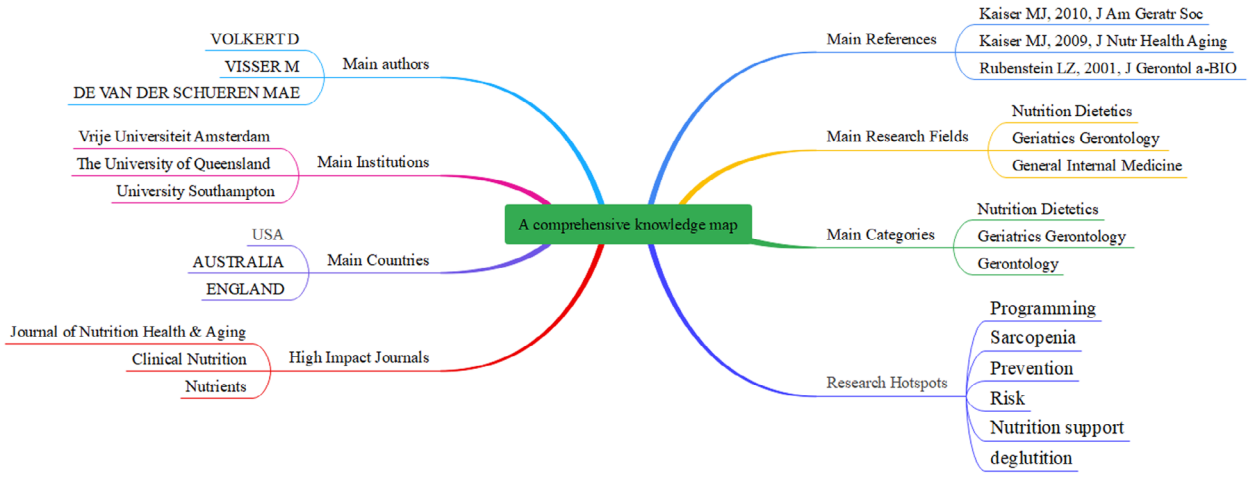

Figure 9. A comprehensive knowledge map of older adults research: 1991–2021.

index in this field, the United States is the best without doubt, far more than Australia, Netherlands, England, France, Italy and other developed countries. Citation frequency is a better indicator of the quality and impact of an article than the number of publications in the Science Citation Index. But in terms of the average number of citations, Switzerland, Belgium, Sweden, France, Germany, England, Italy have surpassed the United States, showing development potential.

The Research Topics and Emerging Trends.

We used several different visualization methods and bibliometric analyses to evaluate the research of malnutrition in elderly. We also highlight research topics that are likely to become major research focuses. Since the field began in 1991, the number of studies on malnutrition in old age has increased exponentially, with the most significant increase in the last 4-5 years, due to the increasingly severe global aging trend. Since 1991, this study has published more than 2000 articles, more than 103 countries, 3040 research institutions, 9974 authors, and 734 journals. The significant bibliographic coupling has emerged, highlighting the strength and breadth of knowledge in this field over the past 30 years.

Outlook.

At present, almost all developed countries in the world have entered the aging population, especially Japan, Italy and Germany, which are the most seriously aging countries. China entered the aging society in 1999 and is now in the accelerating stage. The global aging trends are becoming increasingly severe, and the malnutrition in older adults has aroused global concern. Although there are effective intervention measures, the prevention and treatment of malnutrition has not been given due attention, so malnutrition screening should be a mandatory component of the comprehensive assessment of older people. Future geriatric malnutrition research needs to be conducted at the cellular, metabolic, and clinical levels, and to integrate information from different research methods to better understand the transition from good nutritional health and independence in the elderly to malnutrition, dysfunction, and poor health.

Strengths and Limitations.

In order to understand the current and future research in this field, we conducted a comprehensive survey of the literature and a quantitative, qualitative and visual analysis of the publications on malnutrition in the elderly. Although this analysis method is very effective, our analysis still has some limitations. Firstly, we only include publications in English, which may lead to selection bias due to the exclusion of publications in other languages. Secondly, we used the Citespace tool to cluster the followings, “programming” “sarcopenia” “prevention” “risk” “nutrition support” “deglutition”, but do not explain in details.

Conclusions

From the perspective of the world aging urgent, malnutrition in older adults is a very serious subject, which affects the physical activity ability and closely related to cardiovascular, cerebrovascular and Alzheimer disease. Malnutrition is a serious threaten to physical and mental health, causing a heavy social and economic burden on families and individuals. Based on the publications in the web of science core collection from 1991 to 2021, the study analyzes malnutrition in older adults from several aspects of time and space influence, cooperation relationship of countries and institutions, research frontier and research hotspot using VOSviewer and Citespace visualization analysis software. From the perspective of comprehensive academic influence, 103 countries or regions studied with frequent inter-regional cooperation in this field. The United States is the major contributor to this research in the world. In addition, Australia, England, Netherlands, Italy, France, Switzerland, Belgium, Sweden and other countries research deeply. The major research areas involve nutrition, genetics, general internal medicine, public environmental occupational health and nursing, characterized by interdisciplinary and multidisciplinary integration. From the perspective of research hotspots, the high-frequency keywords, malnutrition in older adults research include malnutrition, the elderly, mortality, prevention, nutritional status, risk et al. The research frontier is focused

on "programming" "sarcopenia" "prevention" "risk" "nutrition support" and "deglutition". Undoubtedly, research hotspots are closely related to empirical research to reduce the rate of malnutrition among the elderly. To sum up, this study provides a novel method to visualise further information about elderly malnutrition research. With the aggravation of the aging of the world, the research on elderly malnutrition will grow rapidly in the next few years.

Abbreviations: MNA: Mini Nutritional Assessment.CNS: Chinese nutrition screen. MDS: Minimum Data Set. SNAQ: Simplified Nutrition Appetite Questionnaire. SNAQ-RC: Short Nutritional Assessment Questionnaire for Residential Care. GNRI: Geriatric Nutrition Risk Index. NRI: Nutrition Risk Index. MUST: Malnutrition Universal Screening Tool. NUFFE: Nutritional Form For the Elderly

Consent for publication: Both authors read and approved the publication.

Availability of data and materials: The data presented in this study are available on request from the corresponding author.

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Author's contributions: Huatian and Jiechen designed this study together. Huatian performed the statistical analysis and drafted the manuscript. Jiechen revised the manuscript.

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