REVIEW

The impact of home-delivered meal services on the nutritional intake of community living older adults: a systematic literature review

K. Walton,[1,2] V. A. do Rosario[1,2] (iD) H. Pettingill,[1] E. Cassimatis[1] & K. Charlton[1,2]

[1]School of Medicine, Faculty of Science, Medicine and Health, University of Wollongong, Wollongong, NSW, Australia
[2]Illawarra Health & Medical Research Institute, University of Wollongong, Wollongong, NSW, Australia

Abstract

Background: There is a global increase in populations aged over 65 years. Physiological changes that occur during ageing may increase the nutritional risk for older adults. To avoid malnutrition and address some of the barriers to obtain an adequate food supply, home-delivered meals services provide meals in the home or in congregate settings for older adults who require nutritional support.

Methods: This systematic literature review explored whether nutritional intake is improved in community-living older adults when receiving meal services compared to when meal services are not received. Four electronic databases were searched up to 31 January 2019. In total, 13 original studies were included in this analysis with the components: intervention of home-delivered meal or congregate meal services to older adults; comparison with groups not receiving meal services or days not receiving the meal service; and nutritional intake as an outcome measured by food history, dietary recall and/or food frequency questionnaire.

Results: The results supported a beneficial effect of home-delivered meals on dietary intake of energy, protein and/or certain micronutrients in older adults.

Conclusions: The increased total energy intake is a positive influence on malnutrition risk in frail older adults and the increased protein intake supports good health, promotes recovery from illness and assists in maintaining functionality in older adults. Additionally, there was a particular increase in calcium intake, which is relevant in ageing, especially for bone health.

Introduction

There is a global increase in populations aged over 65 years. The social and cultural aspects associated with this ageing phenomenon adversely impact on the ability of frail older adults to maintain adequate access to food [1]. Additionally, physiological changes that accompany the normal ageing process place older adults at increased nutritional risk [2].

Malnutrition is defined as a deficiency or imbalance in nutrient intake and has a relevant prevalence in community-living older adults, resulting in a worsening of health conditions, frailty and disability [2]. Given the multiple causes and consequences of malnutrition in older adults, it can be challenging to improve dietary intake. Shopping, cooking and eating independently can be a burdensome activity to older adults, particularly if living alone [3]. To address such barriers and to obtain adequate access to nutrition, various services are available to provide meals for older adults who require nutritional support [4]. Meals-on-Wheels (MOW), the most widely recognised of these home delivery meals (HDM) services, is a community-based not-for-profit organisation that operates in many countries. HDM can improve dietary intake,

especially when meals reach the most vulnerable individuals [3]. HDM also decreases institutionalisation of older adults and it is a potential mechanism for decreasing healthcare expenditure [5].

There are several types of HDM services that exist, with variations on how programmes operate, the services offered, the eligibility requirements of clients who can access the services, the type of meals delivered and whether there are provisions made for special dietary needs. Such services can be either provided individually at home or via congregate meals, in which meals are provided in group settings such as senior citizens centres, allowing people the opportunity to socialise when eating their meals [6].

Other studies have explored the association of such services with nutritional status, food safety and insecurity, dietary patterns, socio-emotional aspects, and several other outcomes [7,8]; however, an updated review exploring the impact of HDM on dietary intakes and its implication on older adults is lacking. Thus, the current systematic review of the scientific literature aimed to investigate whether dietary intake is improved in community-living older adults when receiving meal services compared to when meal services are not received.

Materials and methods

A systematic literature review was undertaken using the procedures outlined in the Evidence Analysis Manual: Steps in the Academy Evidence Analysis [9] and in the PRISMA statement [10]. The study selection, quality assessment, data extraction and synthesis were conducted independently by three researchers and then reviewed by all authors.

Search strategy

Four electronic databases were searched: Scopus, Medline, Science Direct and Web of Science. Various combinations of the following keywords were used: 'Meals on Wheels', 'Elderly Nutrition Program', 'home delivered meal', 'weekend meal', 'meal service', 'nutrient intake', 'nutritional intake', 'dietary intake' and 'nutritional risk'. All database searches were completed up to 31 January 2019.

Study selection criteria

Selection criteria were formed using the population intervention comparison outcome (PICOS) format [10]. These criteria were used to screen the titles and abstracts of literature returned via database searching. Study selection criteria included:

(i) participants: older adults living at home; (ii) interventions: home-delivered meal (HDM) or congregate meal services; (iii) comparators: a comparison group not receiving meal services or occasions where a meal service participant did not receive a meal; (iv) outcomes: nutritional intake measured by food history, dietary recall and/or food frequency questionnaire (FFQ); and (v) study design: cross-sectional, pre-post quasi-experimental and cohort studies.

Eligibility of articles for inclusion was extended to include only peer reviewed journal articles that were published in the English language, whereas review articles were excluded. After the removal of nonrelevant and duplicate articles, the remaining articles were retrieved for further evaluation of the full-text. Articles that met all study selection criteria were eligible for inclusion in the review. The study selection process was based on PRISMA guidelines and is outlined in Fig. 1 [6].

Data extraction and synthesis

A data extraction form was used to collate the characteristics from each study: author(s), year of publication, study design, study population, sample size, intervention (if applicable), comparison measure, outcome measure and study outcomes.

Study quality assessment

The quality of each study was assessed for scientific soundness using the Quality Criteria Checklist for Primary Research [5]. Study quality was determined by identifying the presence or absence of 10 validity criteria. An overall quality rating was then assigned to each study, according to positive, neutral or negative rankings.

Results

Study selection

In total, 867 articles were returned via database searching. Seventy-four duplicates were removed and 746 articles were excluded during title and abstract screening (Fig. 1). The full-text of the remaining 47 articles were accessed and evaluated against the study selection criteria. Thirty-four articles were excluded because they did not meet all criteria (Fig. 1) and the remaining 13 studies were eligible for the review.

Characteristics of the studies included in the review

The characteristics of the 13 studies reviewed are summarised in Table 1. Eight of the studies were cross-sectional in design [11–18], four were pre-post quasi-experimental studies [19–22] and one was a cohort study [23]. Eleven studies had relatively smaller sample sizes
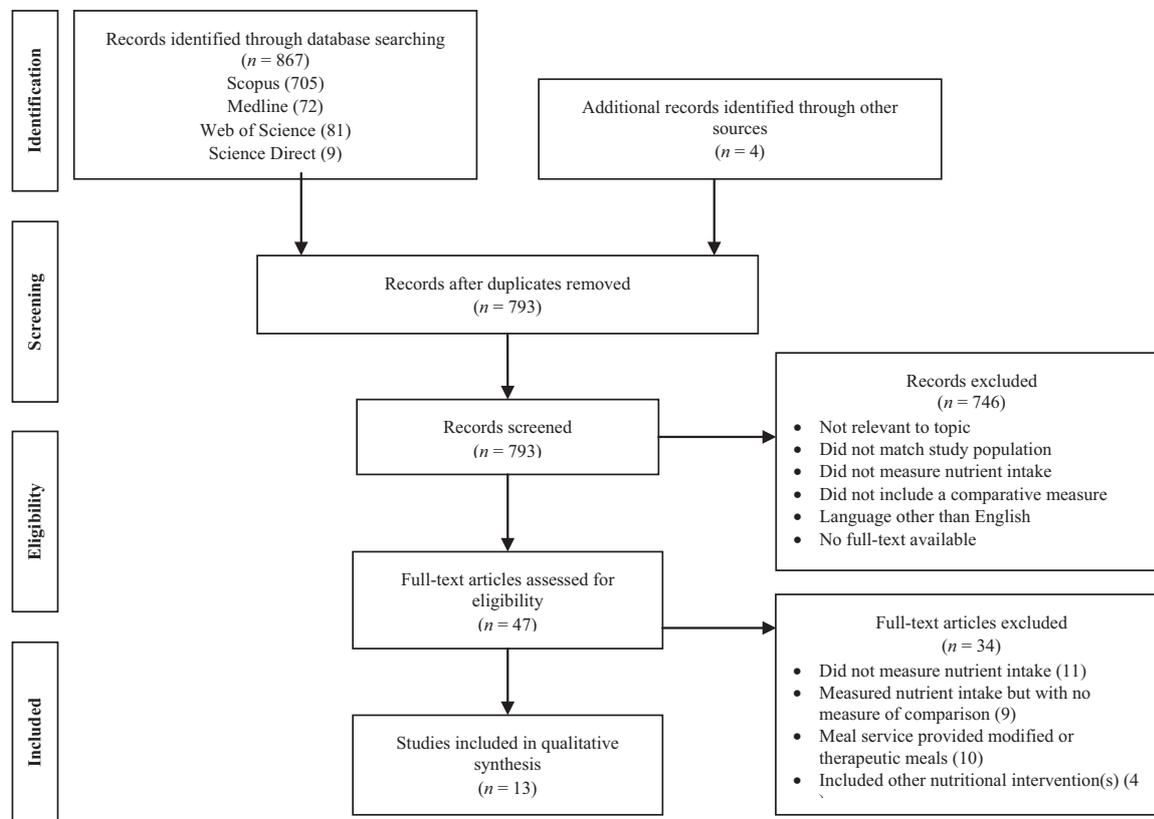
Figure 1 Study selection process.

ranging from 16 to 445 participants, wherea two of the studies obtained larger samples, ranging from 1065 to 2691 participants. The age categorisation used to classify older adults in the studies ranged from over 50 years to over 70 years. Two studies did not specify the age range used during recruitment [14,16], whereas one study recruited adults aged >18 years but specified a sub-category of adults >60 years [11], with this comprising the sub-group of data reported in the present review.

In the cohort study [23] and four pre-post studies [19–22], participants commenced the use of HDM services at recruitment to the study, whereas all other cited studies investigated the dietary intake of existing participants enrolled in HDM or congregate meal services as the independent variable. Four studies used a single group of participants as their own control and made comparisons between the nutrient intakes on occasions when meals were and were not received [11,14,18,21]. Five studies [12,13,15–17] compared the nutrient intakes of two separate groups who were either participating in a meal programme or not. Two studies combined both methods and made comparisons between those participating in a meal programme (either on a meal or non-meal day) and those who had never participated in a meal programme [22,23]. Regarding the type of meal programme, three studies included participants receiving congregate meal services [13,15,17], whereas all others were traditional HDM services.

A food record was the only method used for measuring nutrient intake in two studies [17,20], whereas another study used only a FFQ [19]. All other studies used a 24-h dietary recall method, although two studies also combined this with a FFQ [15] or a FFQ and a 1-day food record [16]. The frequency of data collection within studies ranged from one occasion to seven occasions. Four studies measured the impact of participation in a meal programme over time where the length of intervention ranged from 8 weeks to 12 months [20–23].

Study quality

One study received a positive overall quality rating [11] and one study received a negative rating [14], whereas all others received a neutral quality rating. This was mainly the result of a number of factors related to the study design (e.g. no inclusion of randomised clinical trials) and a lack of information reported in the studies, particularly for the questions related to validity, as shown in Table 2.

Table 1 Characteristics and outcomes of included studies

Author(s); year; Country	Study design	Population	Sample size	Intervention	Comparison	Outcome measure	Outcomes
An; 2015; USA [11]	Cross-sectional	Adults >18 years participating in HDM programme	106	Existing use of HDM service	HDM day and non-HDM day	24-h dietary recall (two nonconsecutive days)	On days of service use there was a significant net increase in the daily intake of protein (8.39 g, SE: 4.55), fibre (3.39 g, SE: 1.06), calcium (145.94 m, SE: 58.19), copper (0.16 mg, SE: 0.06), magnesium (45.37 mg, SE: 13.93), potassium (317.39 mg, SE: 139.81), selenium (14.04 mg, SE: 5.98), and sodium(327.52 mg, SE: 160.91). There was no significant effect on the daily intake of energy, fat and vitamin D
Steele & Bryan; 1985; USA [12]	Cross-sectional	Home-bound adults >60 years	54	Existing use of HDM service	Participation and nonparticipation in HDM service	24-h dietary recall	There was no significant difference between HDM participants and nonparticipants intake of energy, protein, fat, or other vitamins and minerals
Frongillo & Wolfe; 2010; USA [23]	Cohort	Adults >60 years newly referred to HDM or other non-meal care services	100	Commencing use of HDM service	HDM day, non-HDM day, and nonparticipation in HDM service	24-h dietary recall (baseline, 6-months and 12-months)	At 6 months the HDM group had significantly greater intake of energy ($\beta = -283$, $P = 0.04$), protein ($\beta = -16.2$, $P < 0.01$), vitamin A (-0.67, $P = 0.02$), thiamine ($\beta = -0.39$, $P = 0.02$), riboflavin (β-0.66, $P \leq 0.01$), vitamin B_6 ($\beta = -0.58$, $P = 0.01$), vitamin B_{12} ($\beta = -0.63$, $P = 0.02$), calcium ($\beta = -232$, $P = 0.03$) and zinc ($\beta = -4.01$, $P = 0.01$) compared to the HDM group not receiving a meal on the day of recall. At 12 months, the HDM group had significantly greater intake of energy ($\beta = -501$, $P \leq 0.01$), protein ($\beta = -27.7$, $P < 0.01$), vitamin A (-0.57, $P = 0.02$), thiamine ($\beta = -0.39$, $P = 0.02$), riboflavin (β-0.57, $P = 0.02$), vitamin B_6 ($\beta = -0.47$, $P = 0.01$), vitamin B_{12} ($\beta = -0.95$, $P = 0.01$) and zinc ($\beta = -3.17$, $P < 0.01$) compared to the HDM group not receiving a meal on the day of recall. At 6 months, the HDM group had significantly greater intake of vitamins A ($\beta = -0.56$, $P = 0.03$), B_6 ($\beta = -0.32$, $P = 0.04$), B_{12} ($\beta = -0.50$, $P = 0.03$), D ($\beta = -1.45$, $P = 0.03$), E ($\beta = -0.35$, $P = 0.05$) and calcium ($\beta = -236$, $P = 0.02$), magnesium ($\beta = -45.4$, $P = 0.01$) and phosphorous ($\beta = -259$, $P = 0.01$) compared to the nonparticipant group. There was no significant difference between these groups at 12 months
Roy & Payette; 2006; Canada [22]	Pre-post	Nonrecipients of MOW >65 years	51	Commencing use of HDM service	Before and after receiving HDM, and nonparticipation in HDM service	24 hr dietary recall on two consecutive days (pre-test) and five nonconsecutive days (post-test, 8-weeks)	HDM group had significantly higher intake of energy (121 kcal, $P = 0.05$), protein (7.4 g, $P = 0.03$), lipid (7.9 g, $P = 0.03$) and thiamine (0.2 mg, $P = 0.03$) after 8 weeks of programme use compared to nonparticipants in HDM programme
Millen *et al.*; 2002; USA [13]	Cross-sectional	Adults >60 years participating in ENP and matched nonparticipant sample	2691	Existing use of HDM or congregate meal service	Participation and nonparticipation in HDM or congregate meal service	24-h dietary recall	ENP participants had significantly ($P > 0.001$) higher intakes of energy (8.5%), protein (8.3%), vitamins A (24.6%), C (13.6%), D (30.6%), E (14.1%), thiamine (5.9%), riboflavin (15.6%), niacin (6.1%), B_6 (8.9%), folate (8.3%), calcium (24.2%), magnesium (14.3%), zinc (12.0%) and phosphorous (14.5%)

Table 1 Continued

Author(s); year, Country	Study design	Sample size	Population	Intervention	Comparison	Outcome measure	Outcomes
Walden et al.; 1989; USA [14]	Cross-sectional	16	Older adults participating in HDM programme	Existing use of HDM service	HDM day and non-HDM day	24-h dietary recall (meal delivery day and non-meal delivery day)	HDM participants had significantly lower intake of energy, carbohydrate and fat on weekends when they did not receive a meal compared to on weekdays when a meal was received ($P < 0.05$)
Heuberger & Wong; 2014; USA [15]	Cross-sectional	1,065	Women >60 years who were depressed, widowed, or both	Existing use of HDM or congregate meal service	Participation and nonparticipation in HDM or congregate meal service	24-hr dietary recall and food frequency questionnaire	The use of congregate and/or home-delivered meals made no significant contribution to the intake of any nutrient.
Kohrs et al.; 1980; USA [16]	Cross-sectional	445	Older adults participating in ENP	Existing use of HDM service	Participation in HDM programme 2–5 times per week, <2 times per week or 0 times per week	24-h dietary recall, 1-day food record and diet history using food frequencies	There was no significant association between frequency of programme participation and long-term energy intake. Frequency of participation was significantly associated with dietary intake of riboflavin and thiamine ($P < 0.05$)
Neyman et al.; USA; 1996 [17]	Cross-sectional	135	Adults >60 years	Existing use of congregate meal service	Participation and nonparticipation in congregate meal programme	3-day food record (2 week days and 1 weekend day)	There was no significant difference in the nutrient intake of participants on days when they ate at the meal programme and the days when they did not. There was no significant difference in the nutrient intakes of participants and nonparticipants
Wright et al.; 2015; USA [21]	Pre-post	62	Adults >55 years newly enrolled in MOW service	Commencing use of HDM service	Before and after receiving HDM	24-h dietary recall (baseline and 2-months)	There was a significant increase in participants' energy (355.06 kcal, $P < 0.0005$) and protein (19.63 g, $P < 0.0005$) intake between baseline and 2-months. No other nutrients were assessed
Denissen et al.; Netherlands; 2016 [20]	Pre-post	44	Adults >70 years unable to prepare their own dinner	Commencing use of HDM	Participation and nonparticipation in HDM service	2-day food record (baseline and 3-months)	HDM group had significant higher intake of calcium (115 mg, $P = 0.02$) compared to control group
Ullevig et al.; USA; 2018 [19]	Pre-post	49	Adults >60 years	Commencing use of HDM	Participation and nonparticipation in HDM service	153-item Food Frequency Questionnaire (baseline and 3-months)	HDM group had a significant ($P < 0.001$) increase in numbers of participants that met or exceeded the recommended dietary allowances for magnesium (8 participants, 18.6% increase) and zinc (10 participants, 23.2% increase)
Walton et al.; 2015 [18]	Cross-sectional	42	Adults >50 years	Existing use of HDM service	HDM day and non-HDM day	24-h dietary recall (meal delivery day and non-meal delivery da)	On HDM service days, there was an increase in daily energy intake in women (126.7 kcal, $P = 0.045$), but not overall neither in men compared to non-HDM day. There were no significant changes in protein intake

β, regression coefficient; ENP, elderly nutrition programme; MOW, meals on wheels.

Table 2 Study quality criteria checklist and rating

	An, 2015[11]	Steel & Bryan, 1985[12]	Frongillo & Wolfe, 2010[23]	Roy & Payette, 2006[22]	Millen et al., 2002[13]	Walden et al., 1989[14]	Heuberger & Wong, 2014[15]	Kohrs et al., 1980[16]	Neyman, et al., 1996[17]	Wright et al., 2015[21]	Denissen et al., 2016[20]	Ullevig et al., 2018[19]	Walton et al., 2015[18]
Overall Quality Rating	+	Ø	+	Ø	Ø	-	Ø	Ø	Ø	Ø	Ø	Ø	Ø
Validity questions													
1. Was the research question clearly stated?	y	y	y	y	y	y	y	y	y	y	y	y	y
2. Was the selection of study subjects/patients free from bias?	y	n	y	n	y	n	n	n	n	n	n	n	n
3. Were study groups comparable?	y	n	y	y	n	n	n	n	n	n	n	n	n
4. Was the method of handling withdrawals described?	n	n	y	y	y	n	y	y	n	y	y	y	n
5. Was blinding used to prevent introduction of bias?	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6. Were intervention/ therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were intervening factors described?	y	n	n	y	n	n	n	y	n	n	y	n	y
7. Were outcomes clearly defined and the measurements valid and reliable?	y	y	y	y	y	y	y	y	y	y	y	y	y
8. Was the statistical analysis appropriate for the study design and type of outcome indicators?	y	y	y	y	y	n	y	y	y	y	y	y	y
9. Were conclusions supported by results with biases and limitations taken into consideration?	y	y	y	y	y	n	y	y	y	y	y	y	y
10. Is bias due to study's funding or sponsorship unlikely?	n	y	n	y	y	n	y	y	n	n	y	y	y

+, positive; -, negative; Ø, neutral; y, yes; n, no; u, unclear; NA, not applicable.

Outcomes of meal service programmes

Protein and energy were the only nutrients measured in all studies, where improvements associated with meal delivery services were reported in six studies [11,13,14,18,21–23]. Three of five studies that showed improvements in protein intake were those in which the meal delivery commenced within the trial period [21–23], whereas the two other studies found higher intakes of existing HDM service clients on days where a meal was received compared to a non-HDM day [11], or between participants and nonparticipants of the service [13]. An increase in energy intake was found in five studies [13,14,21–23], with four of these also reporting a simultaneous increase in protein intake [13,21–23]. The findings for energy intake were similar to those for protein, such that the studies introducing an HDM service [21–23] performed best, followed by the two studies that compared meal and non-meal days in existing clients [14] or participants versus nonparticipants [13]. Additionally, another study reported an increase in energy intake, although only in women, comparing a MOW and a non-MOW day [18].

In relation to micronutrient intake, seven of 12 studies [13,15,16,19,20,22,23] that assessed this outcome found increased intake for at least one vitamin [11,13,16,22,23] and/or mineral [11,13,19,20,23], whereas three studies reported an increase in more than five micronutrients [11,13,23]. Three of the 13 studies included in this review did not find improvements in dietary intake associated with participation in a HDM service for either energy, protein, other macronutrients or micronutrients [12,15,17]. Two of these studies [15,17], related to congregate meal services, had limited result details.

Discussion

The aim of this systematic literature review was to explore whether dietary intake is improved in community-living older adults when receiving meal services compared to when meal services are not received. The review identified 13 eligible studies, which presented cross-sectional, pre-post quasi-experimental and cohort studies designs. The results supported a beneficial effect of home-delivered meals on improvements in dietary intake of energy, protein and/or certain micronutrients (calcium, vitamin A, B complex vitamins, vitamin D, zinc, magnesium and others) in older adults.

Physiological changes that occur during the normal ageing process modify nutritional requirements in older adults and are determined by various factors, such as ingestion, digestion and absorption of nutrients; thus, energy expenditure and caloric requirements may be altered [2]. Additionally, factors related to the inability of providing one's own meals, such as a lack of resources and access to food, disability or limited mobility, are usually eligibility requirements for populations that have access to HDM services. Therefore, the risk of malnutrition in these older adults is usually linked to an inability to access sufficient food to meet nutrient requirements, including total energy intake. Hence, the increased energy intake associated with home-delivered meals found in five studies [11,13,14,18,21–23] can be considered as a beneficial outcome to assist in reducing malnutrition risk in frail older adults. Higher protein requirements in older age are recommended to support good health, promote recovery from illness and maintain functionality in older adults via prevention of sarcopenia [24]. Inadequate protein intake is recognised as a determinant of frailty [25,26], as well as being associated with an increased risk of falls [27] in the older population. Recent evidence suggests that a dietary intake of 1.0–1.3 g protein kg^{-1} is required to optimise physical function, particularly when undertaking resistance exercise recommendations and/or to compensate for the inflammatory and catabolic conditions associated with chronic and acute diseases [24]. It is well recognised that older adults often consume less protein than younger adults [24,28] and also that the anabolic response to protein is often blunted in ageing [29,30]; thus, the findings of increased protein intake from five of the studies included in the present review are promising.

Studies that reported improvements in both energy and protein intake in HDM recipients were more likely to be those in which new, rather than existing, clients were investigated [21–23]. Older adults commencing the use of a HDM service are likely to be at greater nutritional risk than those who have been receiving support for some time. All three studies that did not present significant results had interventions with people already utilising HDM [12,15,17]. Nonetheless, the other study [23] reporting improvements not only for energy and protein intake, but also for several micronutrients was the one that recruited a nationally representative sample of participants. In addition, the same study found that HDM services (both home-delivered and congregate meals) provided 75% of older people's daily energy requirements and between 30% and 50% of their daily nutrient intake, whereas the mean daily nutrient intake approached or exceeded the recommended daily allowances for 11 of 16 nutrients examined. The meals served in this successful programme were produced in accordance with the dietary guidelines for its population and met the nutritional requirements established.

In relation to micronutrients, insufficient dietary intake of several nutrients has been reported in older community adults (vitamins A, B$_{12}$, D and zinc), with a higher prevalence in long-term care facilities (vitamins A, D and E) [31].

7

In Europe, USA and Canada, deficiencies in dietary intake of one or more nutrients are present in 35% of individuals aged 50 years or older [32]. A higher life expectancy may lead to higher risk of deficiency, especially for vitamins B_{12}, A, C, and D, iron, calcium and folate [33]. In addition, a lower food intake has been associated with lower intakes of calcium, iron, zinc, B vitamins and vitamin E [32]. Despite the numerous nutritional issues present in ageing, recommended dietary allowances for older adults are mostly similar [34]. However, some micronutrients have high dietary intake requirements such as calcium, vitamins D and B_6, whereas others, even presenting equal requirements, are crucial for healthy aging and are associated with lower intake in older adults such as vitamin B_2 (riboflavin), folic acid and vitamin B_{12} [2,32–34]. Seven studies included in this review found positive results in at least one micronutrient when comparing older adults with and without HDM services [11,13,16,19,20,22,23]. In particular, the increase in calcium intake found in four studies [11,13,20,23] has an important relevancy in ageing, especially for bone health. This micronutrient usually presents an impaired absorption as a result of changes gastrointestinal tract in ageing, which is enhanced if there is a concomitant vitamin D deficiency. Individuals between 70 and 90 years of age absorb approximately one-third less calcium than younger adults [2,32]. The decrease in kidney function to retain calcium decreases may also affect its reabsorption, as well as a decreased efficiency of the kidneys to convert vitamin D into its most active form (i.e. 1,25 dihydroxyvitamin D) may be present [2,35]. Only two studies [13,23] included in this review found an improvement in vitamin D intake, and such a modest result might been influenced by the high rates of supplementation of this vitamin in this age range.

Several other studies have evaluated the effects of home-delivered meals in older adults grouping studies of various designs, including a review that included pooled results from 13 quasi-experimental studies providing HDM interventions, including between-meal snacks, more food choices and provision of nutrition advice. Overall, these interventions improved nutrition and functional status, hospital readmission rates and quality of life [8]. A further similar review was conducted by Zhu *et al.* [7], who evaluated the impact of HDM services on diet and nutrition among recipients but included a wider range of outcomes such as effectiveness of home-delivered meal services, food insecurity and dietary patterns. In accordance with the review reported in the present study, six of eight studies included in their study found that HDM programmes significantly improved diet quality, increased nutrient intakes, and reduced food insecurity and nutritional risk among participants. Other beneficial outcomes include increased socialisation opportunities, an improvement in dietary adherence and a higher quality of life. Although these

topics were not evaluated in this review, food safety and social connections related to HDM are relevant to this discussion. HDM clients are especially vulnerable to food-borne illness as a result of a high prevalence of health conditions that can suppress the immune system [36]. A food safety course for more than 1500 staff and volunteers with HDM programmes reported the most important food safety information concerned meal delivery and client handling of meals, especially with respect to ensuring that meals were kept at appropriate temperatures, as well as checking clients' refrigerator temperatures, adding labels with reheating instructions, checking use-by dates and instructing drivers not to leave meals at clients' doors [37]. Other positive results were found in a study that used the USDA Six-Item Food Security Scale to identify food-insecure households and households with very low food security. Two months after starting the HDM programme, there was an overall improve of 41.2% of participants' food security level, with 15.7% moving from very low to high food secure [21]. Loneliness and well-being also were significantly improved. Studies employing a qualitative approach found that HDM clients appear to have benefits that are beyond the actual meal itself, with the drivers providing additional support to their clients and the social bonds between drivers and clients strengthening over time [38]. In addition to the social contact, HDM may also help to restimulate an interest in meals and regularising mealtimes [39].

A number of factors may contribute to the discrepancies in the results within studies. First, certain outcomes are not comparable as a result of differences in study design and methods. For example, some studies examined differences in nutrient intake within the same individuals, whereas other studies made comparisons between those receiving meals and not receiving meals. A limitation of all studies was that they did not provide any information about the nutritional composition of the meals received by participants. Additionally, there was often little description of details, such as the type or frequency of meals received, the amount of the meal consumed on the day of dietary recall or to what degree the meal contributed to the participant's total dietary intake for that day. Further consideration of the impact of these variables is required to improve the validity of results. Furthermore, the majority of studies did not focus on whether participants met the recommended dietary requirements for optimal health, even if they had increased their nutrient intakes, making this issue an important need with respect to further research in this area. The level of results details also varied among the studies, which made it difficult to present a more homogeneous set of results. Still, regarding the methodology limitations of this review, only articles in English were

screened, which excludes many potential articles that, in this area of knowledge, are often published in the native language of its country. Only one included study was conducted in a country that does not have the English as native language [20].

The search of the current review did not return any randomised controlled trials because ethically meal services cannot be randomly allocated to one population and withheld from another. The use of blinding within studies to reduce bias is also not possible in the case of meal provision. Furthermore, the method of data collection in the studies relied on recall by participants and the accuracy of this information may be impacted by error in memory or conceptualisation of food portions, as well as it being subject to under- or over-reporting.

Conclusions

Home-delivered meal services are able to promote beneficial results in nutritional intake in community-living older adults. This review summarised the results of 13 studies and found a relevant increase in the dietary intake of energy and protein, as well as micronutrients such as calcium, vitamin A, B complex vitamins, vitamin D, zinc and magnesium. This indicates that these services can address the food access pillar of food security in this population, thus decreasing the risk of malnutrition and related harmful conditions.

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with PRISMA guidelines [10]. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained (Prospero registration number: CRD42017070495).

References

1. United Nations, Department of Economics and Social Affairs, Population Division. World population ageing, 2017 highlights, 2017.
2. Bernstein M & Munoz N (2012) Position of the Academy of Nutrition and Dietetics: food and nutrition for older adults: promoting health and wellness. *J Acad Nutr Diet* **112**, 1255–1277.
3. Whitelock Emily & Ensaff Hannah (2018) On your own: older adults' food choice and dietary habits. *Nutrients* **10**, 413.
4. Sahyoun NR & Vaudin A (2014) Home-delivered meals and nutrition status among older adults. *Nutr Clin Pract* **29**, 459–465.
5. Thomas KS & Mor V (2013) Providing more home-delivered meals is one way to keep older adults with low care needs out of nursing homes. *Health Aff (Millwood)* **32**, 1796–1802.
6. Gualtieri MC, Donley AM, Wright JD *et al.* (2018) Home delivered meals to older adults: a critical review of the literature. *Home Healthc Now* **36**, 159–168.
7. Zhu H & An R (2013) Impact of home-delivered meal programs on diet and nutrition among older adults: a review. *Nutr Health* **22**, 89–103.
8. Campbell AD, Godfryd A, Buys DR *et al.* (2015) Does participation in home-delivered meals programs improve outcomes for older adults?: results of a systematic review. *J Nutr Gerontol Geriatr* **34**, 124–167.
9. Evidence Analysis Manual Academy of Nutrition and Dietetics, 2016[Internet]. [cited 2019 June 2]. Available from: https://www.andeal.org/vault/2440/web/files/2016_April_EA_Manual.pdf
10. Liberati A, Altman DG, Tetzlaff J *et al.* (2009) The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med* **6**, e1000100.
11. An R (2015) Association of home-delivered meals on daily energy and nutrient intakes: findings from the national health and nutrition examination surveys. *J Nutr Gerontol Geriatr* **34**, 263–272.
12. Steele MF & Bryan JD (1986) Dietary intake of homebound elderly recipients and nonrecipients of home-delivered meals. *J Nutr Elder* **5**, 23–34.
13. Millen BE, Ohls JC, Ponza M *et al.* (2002) The elderly nutrition program: an effective national framework for preventive nutrition interventions. *J Am Diet Assoc* **102**, 234–240.

14. Walden O, Hayes PA, Lee DY *et al.* (1989) The provision of weekend home delivered meals by state and a pilot study indicating the need for weekend home delivered meals. *J Nutr Elder* **8**, 31–43.

15. Heuberger R & Wong H (2014) The association between depression and widowhood and nutritional status in older adults. *Geriatr Nur* **35**, 428–433.

16. Kohrs MB, Nordstrom J, Plowman EL *et al.* (1980) Association of participation in a nutritional program for the elderly with nutritional status. *Am J Clin Nutr* **33**, 2643–2656.

17. Neyman MR, Zidenberg-Cherr S & McDonald RB (1996) Effect of participation in congregate-site meal programs on nutritional status of the healthy elderly. *J Am Diet Assoc* **96**, 475–483.

18. Walton K, Charlton KE, Manning F *et al.* (2015) The nutritional status and energy and protein intakes of MOW clients and the need for further targeted strategies to enhance intakes. *Appetite* **95**, 528–532.

19. Ullevig SL, Sosa ET, Crixell S *et al.* (2018) Impact of Home-Delivered meals on nutrition status and nutrient intake among older adults in central Texas. *J Nutr Health Aging* **22**, 861–868.

20. Denissen KFM, Janssen LMJ, Eussen SJPM *et al.* (2017) Delivery of nutritious meals to elderly receiving home care: feasibility and effectiveness. *J Nutr Health Aging* **21**, 370–380.

21. Wright L, Vance L, Sudduth C *et al.* (2015) The impact of a home-delivered meal program on nutritional risk, dietary intake, food security, loneliness, and social well-being. *J Nutr Gerontol Geriatr* **34**, 218–227.

22. Roy M-A & Payette H (2006) Meals-on-wheels improves energy and nutrient intake in a frail free-living elderly population. *J Nutr Health Aging* **10**, 554–560.

23. Frongillo EA & Wolfe WS (2010) Impact of participation in home-delivered meals on nutrient intake, dietary patterns, and food insecurity of older persons in New York state. *J Nutr Elder* **29**, 293–310.

24. Bauer J, Biolo G, Cederholm T *et al.* (2013) Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. *J Am Med Dir Assoc* **14**, 542–559.

25. Coelho-Júnior HJ, Rodrigues B, Uchida M *et al.* (2018) Low protein intake is associated with frailty in older adults: a systematic review and meta-analysis of observational studies. *Nutrients.* **10**, E1334.

26. Lorenzo-López L, Maseda A, de Labra C *et al.* (2017) Nutritional determinants of frailty in older adults: a systematic review. *BMC Geriatr* **17**, 108.

27. Zoltick ES, Sahni S, McLean RR *et al.* (2011) Dietary Protein Intake and subsequent falls in older men and women: the Framingham study. *J Nutr Health Aging* **15**, 147–152.

28. Robinson S, Reginster J, Rizzoli R *et al.* (2018) Does nutrition play a role in the prevention and management of sarcopenia? *Clin Nutr* **37**, 1121–1132.

29. Katsanos CS, Kobayashi H, Sheffield-Moore M *et al.* (2005) Aging is associated with diminished accretion of muscle proteins after the ingestion of a small bolus of essential amino acids. *Am J Clin Nutr* **82**, 1065–1073.

30. Wall BT, Gorissen SH, Pennings B *et al.* (2015) Aging is accompanied by a blunted muscle protein synthetic response to protein ingestion. *PLoS ONE* **10**, e0140903.

31. Yoshikawa TT & High KP (2001) Nutritional strategies to boost immunity and prevent infection in elderly individuals. *Clin Infect Dis* **33**, 1892–1900.

32. Maggini S, Pierre A & Calder PC (2018) Immune function and micronutrient requirements change over the life course. *Nutrients* **10**, E1531.

33. Watson J, Lee M & Garcia-Casal MN (2018) Consequences of inadequate intakes of vitamin A, vitamin B12, vitamin D, calcium, iron, and folate in older persons. *Curr Geriatr Rep* **7**, 103–113.

34. 2015-2020 Dietary Guidelines- health.gov [Internet]. [cited 2019 Mar 1]. Available from: https://health.gov/dietaryguidelines/2015/guidelines/

35. Advances in Nutrition Therapy Research and Application: 2011 Edition: ScholarlyBrief. Atlanta, GA: ScholarlyEditions; 2012. 53 p.

36. Abdullah Sani N & Siow ON (2014) Knowledge, attitudes and practices of food handlers on food safety in food service operations at the Universiti Kebangsaan Malaysia. *Food Control* **37**, 210–217.

37. Anderson AL, Netterville LL & Sahyoun NR (2014) 'Food safety on the go': a course for home-delivered meal programs. *J Nutr Educ Behav* **46**, 148–150.

38. Thomas KS, Gadbois EA, Shield RR *et al.* (2018) Dosa DM. 'It's not just a simple meal. it's so much more': interactions between meals on wheels clients and drivers. *J Appl Gerontol* Dec 20:733464818820226. [Epub ahead of print]https://doi.org/10.1177/0733464818820226.

39. Timonen V & O'Dwyer C (2010) 'It is nice to see someone coming in': exploring the social objectives of Meals-on-Wheels. *Can J Aging* **29**, 399–410.