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A review of the relationship between living alone and food and nutrient intake.

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Living alone and food and nutrition

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Abstract

The increase in individuals living alone has implications for nutrition and health outcomes. This review aimed to investigate whether there is a difference in food and nutrient intake for adults living alone compared to those living with others. Eight electronic databases were searched using terms related to living alone, nutrition, food and socioeconomic factors. Forty-one papers met the inclusion criteria with data of interest extracted. Results varied however suggested persons living alone compared to other living arrangements showed: lower diversity of food intake and consumption of some core foods groups (fruit, vegetables and fish) and higher likelihood of consuming an unhealthy dietary pattern. Associations between living alone and nutrient intake were unclear. Men living alone were more often observed to be at greater risk of undesirable intakes than women. The findings of this review suggest living alone could negatively impact aspects of food intake and contribute to the relationship between living alone and poor health outcomes, although associations could vary amongst socioeconomic groups and further research is required.

Key words

Living arrangements, food intake, nutrients, diet, one-person household

INTRODUCTION

The number of individuals living alone observed across the developed world continues to increase and is considered to be an important demographic and social change.[1,2] In 2010 the percentage of one person households ranged from 23 to 29% in Australia, Canada, the UK and US, 30 to 49% in Western Europe and 31% in Japan.[2] This socio-demographic change is of relevance to health organisations, health policy makers and healthcare professionals, such as dietitians, as nutrition behaviours are likely to be directly influenced by our living arrangements. In addition, nutrition behaviours are likely to also be influenced by financial, social, lifestyle and environmental factors[3] which themselves are also linked with the likelihood of living alone.[1,2] The complex social interaction between living arrangements, food, nutrition and dietary behaviours and their impact on long-term health and well-being is unclear. While evidence is not all consistent,[4] research has identified relationships between living alone and higher risk of adverse outcomes including diabetes,[5] mortality, cardiovascular death,[4] falls, functional impairment and social isolation.[6] Nutrition intake and nutritional status is one of numerous possible interacting factors explaining the difference in health outcomes.

A review investigating the nutritional circumstances of older people living alone concluded that compared to their cohabiting peers they are economically disadvantaged and face a greater struggle in daily living.[7] A review of psycho-social changes associated with reduced food intake in older persons identified living alone, widowhood and social isolation as important factors influencing psycho-social wellbeing.[8] However, to our knowledge the influence of living alone on multiple food and nutrition behaviours across a range of ages and genders has not been previously explored. As demographic data shows that persons living alone are a large, growing and diverse group[1] it is important to question stereotypes and assumptions around the types of people who live alone[2] and the influence it has on food and nutrition. Particularly as data highlight important gender differences with men living alone more likely to be younger and socially disadvantaged[1,2] while a

trend for persons living alone being from the highest and lowest socioeconomic groups is apparent across both genders.[1,2] This review aimed to explore quantitative evidence from observational studies comparing food and nutrient intake between non-institutionalised adults living alone and those living with others in order to investigate the implications of living alone in the development and treatment of nutrition problems. The null hypothesis for this review is that there is no difference in food and/or nutrient intake in persons that live alone compared to those in other living arrangements.

METHODS

Published guidelines for selecting studies and collecting data for systematic reviews were followed where possible.[9] In addition as no previous review on this specific topic was identified any eligible published research was considered to be of interest. The review therefore attempts to balance the strengths of both systematic and narrative reviews.[10] The presence of heterogeneity was anticipated in study designs, methods, participants, outcomes reported and the cohabiting groups compared to the target population. Associations between living alone and nutrition related behaviours were expected to be a component of studies, rather than the primary focus for many of the studies identified.

Literature search

Papers were identified by searching eight databases: CINAHL/Ebsco host, Embase, SCOPUS, Psycinfo, Proquest Health and Medical Complete, PubMed and Web of Science SSCI & Sci-expanded between 1990 and September 2nd 2014. The database search was performed by the first author. Search terms were identified by exploration of MeSH subject terms. The search terms used were: living alone, living arrangements, loneliness, social isolation, one-person household, single person, marital stat*, singleness*, divorce, widowhood, social class, socioeconomic stat, socioeconomic position and nutr*, food or diet*. To identify as many studies as possible a broad

search strategy was employed but restricted to English language publications only. All articles were exported into an Endnote™ version X6 library and duplicates removed. The reference lists of articles that met eligibility criteria were also reviewed.

Inclusion and exclusion criteria

Predetermined eligibility criteria guided study selection. Inclusion criteria included English language, published after 1990, quantitative and presentation of original research. Articles were excluded if they related only to marital status, solitude, isolation or loneliness or if the study population consisted of animals, pregnant women, infants, children, adolescents, groups with disease (e.g. cardiovascular disease or cancer) or hospitalized or institutionalized individuals. Studies designed to investigate the association between foods or nutrition and disease outcomes were also excluded. Articles were also excluded if they were conducted in locations where demographic living arrangement data was not available or where proportions living alone are below 10% (such as Africa, South America, China or South Korea). Articles were included in the review if the abstract, title, or key words indicated the study investigated food or nutrient intake in people living alone compared to those living with others. Cross-sectional, case-control or cohort studies were eligible for inclusion. Articles published only as abstracts from conference proceedings were excluded.

Recording and synthesis of research findings

The following data were recorded for each study: first author, year and nationality; sample characteristics including population, recruitment, sample size, gender, age of participants and the percentage living alone; research design; living arrangement groups examined; nutrition or food behaviours; and a summary of the significant associations that were identified (Table 1). Detailed information is available on-line as supplementary material. This information was recorded by the author and was cross-checked to identify any errors.

Study quality was appraised independently by both authors using the criteria presented in table 1 with any disagreements discussed. Criteria were derived from the National Institutes of Health for Observational, Cohort and Cross-sectional Studies. [11] Criteria identified as relevant to the studies included were: response or participation rates, study design (cross-sectional/retrospective or cohort/prospective), use of a validated method of dietary assessment, assessment of food portions, primary focus of the paper on living arrangements, nationwide study, random selection of participants and use of multivariate analyses to investigate possible confounding factors. Earlier references were obtained to confirm missing aspects of study design wherever possible.[12-19]

RESULTS

Figure 1 summarises the study selection process.[20,21] A total of 830 studies were identified as potentially eligible after screening based on the title. Of these 283 were excluded after review of the abstract due to the study not fulfilling the inclusion criteria resulting in 547 full manuscripts being reviewed. Eleven of these were potentially relevant articles identified by hand searching of the reference list of all included articles. Ten did not meet eligibility criteria and one represented grey literature comprising a government report.[22] Forty-one of these article met all of the inclusion criteria. Some of the papers included were derived from the same parent study however; with the exception of 3 studies[23-25] each paper was based upon a different subset of participants[26-37]. Nine of the studies focussed on investigating food and nutrient intake across different living arrangements, whereas the remaining 32 studies included living arrangements as one of multiple social factors.

Quality of studies included

Study characteristics relevant to quality are summarised in table 1. Further information on study populations is also available in online supplementary material. Thirty-eight of the forty-one papers

159 that met the selection criteria were based upon crossectional data and three featured cohort designs.
160 Twenty-four studies included some multivariate statistical analyses, although living alone was not
161 included in four studies where bivariate relationships were not shown.[37-40] One study conducted
162 separate multivariate analyses in the living alone and cohabiting groups[41] and one did not include
163 living alone in classification tree analysis although bivariate associations were shown.[31]
164
165 Thirty-three of the 41 studies included over 500 participants and 29 of these had more than 1000
166 participants. Whilst the studies contained large samples they were predominantly explorative and
167 so did not include power calculations to predict the ability of the study to detect real differences.
168 Generalisability of results is also influenced by recruitment methods and this is also a strength of
169 the research in this area with 26 studies including participants from large nation-wide studies. In
170 addition 28 studies randomly recruited participants. Response or participation rates were included
171 where relevant and available, ranging from 17 to 88%, with 24 of the 28 studies that included rates
172 reporting 50% or greater.
173 Interpretation of results is complicated by the variety of methodologies used to assess food and
174 nutrient intake. Each of these has strengths and limitations.[42,43] However 33 of the 41 studies used a
175 method of dietary assessment that has been validated (Table 1). Table 2 identifies they key
176 methods used to assess food and nutrient intake. Eight studies did not specify the validity of tools
177 used.
178
179 ***Study results***
180 The outcomes measured by each study have been grouped as: food group intake; nutrient intake; a
181 summary score of food and/or nutrient intake; and food based analysis of dietary patterns (Table 2).
182 Studies that included more than one category are grouped separately. All associations and
183 differences described are significant at the level of $P<0.05$ or below.
184

185 *Food Group Intake.* Eighteen studies investigated associations between living alone and intake of
186 one or more food groups as either absolute intake or compliance with food based recommendations.
187 Fourteen studies investigated fruits and/or vegetables intake with ten finding that men and/or
188 women living alone had a lower fruits and/or vegetables intake or were less likely to comply with
189 recommendations than people cohabiting. This relationship was seen in men but not women in five
190 of the studies.[31,34,36,44,45] Two studies that analysed men and women separately found lower intakes
191 of fruits but not vegetables[46] or fruits and vegetables[35] in those living alone. A study of women
192 only found lower fruits and vegetables intake in those living alone.[33] Two studies that analysed men
193 and women together found lower intakes of fruits[6] or fruits and vegetables[47] in those living alone.
194 Of the four studies that found no associations, two involved all female participants.[37,48] A third was
195 based on a single question with unspecified validity.[41] However the fourth included men and
196 women and intake was assessed by seven day food record[49] whereas most other studies used
197 questionnaires.
198
199 Seven studies investigated frequency of consumption or compliance with recommendations for
200 meat, fish and poultry. Of those that looked at fish or seafood separately all three found that men
201 and women living alone were less likely to consume fish.[26,35,46] Results for meat, fish, poultry and
202 eggs are less clear. One found that men and women living alone were more likely to consume meat
203 as a main meal[46] or to consume recommended amounts of meat, fish and poultry.[31] However
204 another found that women, but not men, were less likely to report regular meat consumption.[35]
205 Murphy et al., (1993) found that women living alone at two time points were less likely than those
206 with a spouse at both or baseline only to consume recommended serves of meat and alternatives.[36]
207 Another study found that men and women living alone had a lower variety of intake of meat,
208 seafood and eggs.[23]
209

No clear pattern was evident for intake of grains and/or potatoes or milk and milk products. Two studies found that consumption of cereals or compliance with recommendations was lower in men and women[35] or women only[31]. However two found no association with adherence to recommendations for starchy food [25] or consumption of grain foods.[36] With milk and milk products one study found that men but not women aged 18 and over were more likely to consume recommended amounts of dairy,[31] whereas two found no associations with adherence to recommendations in men or women aged between 45 and 74 years.[24,36] Of the studies that included grains and/or dairy, only Friel (2005) included adults below the age of 45, which could limit generalizability to younger adults.

Four studies investigated living alone and consumption of foods high in fat and/or sugar with conflicting results. Of the two that looked at compliance with recommendations one found that men and women living alone were more likely to comply with recommendations for intake of foods high in fat and sugar[31] although a second involving women only found no associations.[48] However, both studies that reported a difference only performed bivariate analyses and Ball (2004) also found similar results at bivariate level.[48] Consistent with these findings are those that women, but not men, are less likely to consume foods high in fat at bivariate level[41] whereas a second study found no association with likelihood of consuming high fat foods at multivariate level in men and women.[6] For all the studies looking at food groups the influence of age is not clear as studies did not specifically investigate this and a mix of age groups were involved in studies that did and did not report results.

Nutrient intake. Six studies investigated macronutrient and/or micronutrient intakes per day. Three of these found no differences in intakes between persons living alone and in other arrangements[40,50,51] however they were all small studies ranging from 33 to 190 participants. Three larger studies did find multiple differences in daily energy, macronutrient and micronutrient intakes.

Two reported no clear patterns with some nutrients higher in persons living alone and others lower.[34,52] The third found that intakes that differed were all lower in persons living alone, with a greater number in men than women.[30] Two of these studies only looked at difference in absolute intakes at a bivariate level.[51,52] Friel (2003) did complete multivariate analyses to investigate the independent association with proportion of energy from macronutrients, finding a negative association in persons living alone for fat and a positive association for carbohydrate.[30] Five of these six studies involved persons aged over 50 years and two were conducted with participants that were all female which could influence generalizability of results.

Two studies did investigate compliance with recommendations for specific nutrients. One of these involving women aged 50-55 years found no differences at the multivariate level.[48] Another study reporting only on calcium found that women living alone had a higher prevalence of inadequate intake, however this was not assessed at the multivariate level.[24]

Summary scores based on food and/or nutrient intakes. Six studies investigated living alone compared to other arrangements and summary scores based upon intakes of food. Although the methods used to calculate the scores varied they primarily were based upon assessing quality in terms of variety of intake and/or compliance with food based recommendations. Four of these studies found that living alone was negatively associated with dietary quality in individuals[36,46,53] or households[54] whereas two studies found no association.[55,56] Of the studies that found no association one was comparatively smaller and only involved low income participants.[56] While the second was larger and involved men and women aged 25 years and over the validity of the scoring system used to classify diets as more or less healthful was not clear.[55] Of the studies that did find an association two specified that the scoring system used was validated[53,54] whereas two did not.[36,46] Any association with age is not clear as studies that did and did not find associations involved participants with a mix of ages.

Four studies calculated a summary score based upon the percentage of nutrient recommendations consumed tallied across multiple individual nutrients in men and women.[27-29,32] One study also calculated a moderation index based upon energy from fat, saturated fat, cholesterol and sodium.[32] With respect to adequacy of nutrient intake, two found that individuals living alone[32] or one person households[29] had lower adequacy, although the first of these investigated bivariate associations only. The two that found no associations had participants aged 50 and above whereas participants in the studies that found associations were aged over 19 years[32] or with household heads aged 60 years and above.[29] The single study that looked at moderation found that compliance with standards was higher in men and women living alone.[32] While multivariate analysis was not conducted it was stated that this was seen across a range of socio-demographic variables. However a fifth study looking only at fat intake behaviours found no difference between groups at the multivariate level of analysis.[57]

Three studies calculated a summary score based upon a combination of food and nutrients. The validity of the score was discussed for all but one study.[39] Two of these found no association between the score and living arrangements in men and women aged 61-80 years[38] and 16 to 74 years.[39] The third paper calculated results using data from four different national studies of adults aged over 50 years. They found negative associations for males or females living alone compared to couples for the scores used for Finland, Italy and the UK, although no association was seen in Sweden.[34] Data for Finland and the UK were at the household level.

Food Patterns. Seven studies used cluster or principle component analysis to classify different dietary patterns. The specific clusters/components chosen ranged from two to four. While comparison is complicated by the variation in studies some patterns are apparent. Three studies found an increase in popularity of unhealthy dietary patterns amongst persons living alone for: men

and women aged over 18 years[58]; men and women aged between 50 and 69 years, although the cluster was mainly male;[59] and men but not women aged 45-60 years.[60] One study found that single adult households in Mediterranean and Scandinavian populations were less likely to purchase foods characteristic of a healthier pattern of eating.[61] A fifth study with a longitudinal design further found that amongst men and women aged 18-65 years those living alone were more likely to shift to a less healthy diet between baseline and follow-up.[62] In contrast one of these studies found that women but not men were more likely to consume a diet high in fruits and vegetables and low in fatty foods[58] and another found that elderly one person households in central or northern Europe were less likely to be beverage or convenience food buyers compared to other arrangements. Two of the seven studies found no associations with dietary cluster/component scores.[63,64] Again a mixture of age ranges was seen across all the studies. All but one of the studies[59] used a nation-wide sample, the number of participants was less than 1000 in two[59,62] and one study analysed results only at the bivariate level.[64]

The relationship between study findings and socioeconomic factors that could be related to living alone is difficult to establish. Only two studies involved all low income/socioeconomic position individuals with one finding an association in an entirely female group[37] and one finding no associations.[56] Of the studies that investigated the relationship between living arrangements and food or nutrient intake using multivariate analyses only three did not specifically consider at least one indicator of socioeconomic position such as income, education or occupation,[40,44,47] suggesting that results are likely to be independent of these factors. One was restricted to low income participants[56] and a fifth did not specify the variables adjusted for. However marital status was included in multivariate analyses in only seven[23-25,30,34,49,55] and location (region or rural vs. urban) included in thirteen papers[23-25,29,30,34,48-50,58,60,61,63], including three based upon the same participants[23-25], which provides limited evidence on interactions between living alone and marital status or location.

DISCUSSION

This review is thought to be the first to investigate the relationship between living alone and food and nutrient intake. Significant differences were reported in 32 of the 41 eligible studies identified, although six of these found that the results did not remain significant at the multivariate level of analysis. There was heterogeneity in results which could be due to variation in the studies included, but also could reflect the diversity of persons who live alone. In spite of these complexities some patterns were suggested. Studies that looked more broadly at dietary patterns or clusters found that persons living alone were less likely to follow healthy diets, although this was not consistent with some studies suggesting that women and/or older age groups living alone were more likely to follow a healthier diet. The studies that used summary scores based on food intake indicate that dietary variety was lower in persons living alone, although again this was not seen in all. Results from summary scores including nutrients were less consistent. For the studies that focussed on food groups the most consistent evidence is available for lower intake in persons living alone of fruit, vegetables and fish. Although one of the studies that found no relationship with vegetables used a seven day food record which is least susceptible to recall bias, most of the studies that did find a link used validated tools. Fish intake was consistently seen to be lower in people living alone, however findings on meat were not consistent. Few conclusions can be drawn with respect to nutrient intakes with studies reporting variable results.

Of the nine studies that reported no significant results two were small studies of 33 and 190 people.[50,51] One involved only low income participants,[56] two did not specify if dietary assessment methods were validated[39,63] and one was not a nationwide study.[55] Another was one of three papers reporting on the same study participants,[25] with the other two showing some significant associations.[23,24] If only study results at multivariate level are considered no definite conclusions on study quality and results can be drawn as larger national studies that used validated tools were seen

across the papers that did and did not report significant findings. However significant associations were seen in all four studies conducted at the household level. Interaction with socioeconomic factors such as age, education, income, rural/urban location and marital status is also difficult to interpret, particularly as most studies were not designed with the purpose of investigating the association between living alone and diet, but included living arrangements as one of multiple socioeconomic factors. A combination of different potential confounding factors were adjusted for in studies that did and did not find significant results. Discussion of this topic must therefore consider the complex context within which these socioeconomic and dietary factors interact.

Socioeconomic factors and living alone

A combination of inter-related changes has resulted in an increase in persons living alone. Discussion of the changes that have contributed to the rise in living alone are discussed elsewhere.[1,2] Briefly these include: changed population age structure including disparity in life expectancy between men and women and age difference between partners; encouragement of youth independence; delay in partnering and having children; increases in childlessness; decline in family size; likelihood of women having custody of children after divorce; higher rates of couple dissolution; "living apart together" arrangements and demise of the multi-generational family household.[1,2] Given the range of factors that have influenced the rise in living alone it is not surprising that research demonstrates this is a diverse and changing group, indicating their nutrition and health needs and risks are likely to also be varied. This is consistent with this review's findings of variation in the food and nutrient intakes of participants living alone compared to those in other arrangements. Elements of the interconnected systems of demographic change that should be given particular prominence in consideration of the links between living alone and food and nutrition include diversity in gender, socioeconomic position and age.[1,2] There are characteristics that can influence the likelihood of living alone which could themselves have implications for food and nutrition behaviours and outcomes. Further, there are many aspects of living alone that could

influence food and nutrition practices. The diverse characteristics of people living alone and the complex social and demographic changes thought to underlie the rise in sole person households could shape the influence of living alone on food and nutrition in ways that are both enablers toward and barriers against compliance with recommendations to optimise nutrition status. This could partly explain why, although most studies found living alone was linked with undesirable food intake, there were findings in some groups of more healthy behaviours in persons living alone, whilst others found no differences.

Living alone could represent a barrier against healthy eating related to the cultural and social roles of food and cooking. Jamieson and Simpson (2013) commented that "how people reflect on and manage eating in the context of living alone is a specific focus that…sheds light on processes of social integration given that eating with others is a universal means of sustaining and celebrating relationships".[2] Multiple studies have highlighted a reduction in motivation and enjoyment in cooking and/or eating when alone often manifested as the preparation of simple meals or use of ready-made meals.[2,65-69] Another potential consequence is the absence of support or encouragement to comply with healthy eating guidelines[66] and difficulty complying with portion control.[2] Study findings of lower diversity in food intake, lower consumption of fruit and vegetables and a higher likelihood of consuming an unhealthy food pattern are consistent with this.

A lack of cooking skills can also contribute to difficulties preparing meals when alone, a particular risk in bereaved or divorced persons previously reliant on their partner for food preparation. [69] In some circumstances the problem may be an inability to adapt to cooking for only one person.[2,70] Lack of assistance in purchasing and preparing food can also increase the burden of acquiring food or preparing meals, an especial problem if challenges with lifting and transporting food exist.[67,69,70] The higher presence of barriers against obtaining and preparing meals in persons living alone is supported by findings from four studies investigating living arrangements and use of supplemental

food programmes such as Meals on Wheels. All four studies found that persons living alone were more likely than other groups to use these services.[71-74] Challenges in acquiring and preparing food could also contribute to the lower diversity in food intake seen in persons living alone.

The increased cost of living, cost of food per head and energy costs associated with living alone could also influence eating practices as persons living alone are less able to take advantage of economies of scale due to issues such as spoilage, taste fatigue and storage constraints.[2,32,54] An increased likelihood of food insecurity or reduced food access in persons living alone compared to other arrangements has been reported in five studies[75-79] and supports the suggestion that food cost is a problem for many people that live alone. Demographic data suggest that the groups living alone most likely to be affected by economic factors are men and elderly women who have lower incomes than persons of the same age living with others.[1,2] Economic factors could explain lower consumption of foods such as fish, fruit and vegetables which require more frequent purchase and consumption and can also be more expensive.

Psychological and mental health factors associated with living alone could also influence intake. The correlations between living alone, isolation and loneliness are complex.[80] Having a large social network does not necessarily indicate the absence of loneliness[80] and living alone is not synonymous with being alone or loneliness.[80,81] The link with isolation is possibly stronger as while not all persons who live alone are isolated, most who are isolated live alone[80] and research indicates risk is higher for both loneliness and social isolation in persons living alone.[6,81,82] Evidence suggests that in different persons psychological factors can result in increased or decreased intake. For example in a review of social and emotional origins of comfort eating Grant discussed that, with reference to loneliness, eating provides a sense of comfort that replaces human connections that persons long for but do not have.[83] Research has also found that loneliness is a significant predictor of malnutrition in the elderly.[84] Living alone also entails an absence of social

418 constraints around what constitutes a proper meal.[85] The impact of the presence of others when
419 eating also should be considered. A review of the effect of the presence of others highlighted that
420 social influences on eating are profound[86] and discussed evidence from different research areas
421 indicating that it can result in either increased or decreased intake.[86] Evidence on the psycho-social
422 implications of living alone on eating are consistent with the variable findings reported in the
423 current review whereby both higher and lower intakes were seen in individuals living alone
424 compared to those with others.
425
426 There are some aspects of living alone that could enhance the ability to comply with healthy eating
427 guidelines. Enabling characteristics of living alone that could be present include independence and
428 autonomy.[2] A person living alone does not have to take into account the food likes and needs of
429 other people.[65] The increase in control over the types of foods purchased and available in the home
430 could support behaviour change techniques such as stimulus control. Another implication is that
431 living alone could reflect social advantage because of the relative expense of this lifestyle
432 arrangement, a pattern that appeared to be more common in women than men.[1,2] de Vaus also
433 suggested that their finding of social advantage in women living alone could indicate that they may
434 "as a results of their learning and success in the education system be more confident about relying
435 on their own resources in managing life".[1] This could extend to their ability to manage food and
436 nutrition needs. While results were not entirely consistent the current review did find a pattern
437 suggesting gender differences in some studies that included men and women, with men more likely
438 to show undesirable food intakes.
439
440 *Implications of review findings*
441 The studies reviewed indicate that persons who live alone may be more likely to have an inadequate
442 intake of some core foods, especially fruit, vegetables and fish. Low intake of core foods is linked
443 with chronic diseases such as cardiovascular disease, diabetes mellitus and some cancers.[87,88] This

444 review indicates the possible importance of considering living alone in different stages of the
445 nutrition care process. Further, persons living alone are diverse in terms of age, gender,
446 socioeconomic status and education with likely different needs which should be accounted for. In
447 assessment of individuals dietitians could collect data on living arrangements as possible barriers
448 and enablers towards compliance with recommendations. It is also important that living
449 arrangement data is considered when assessing need for interventions at group and population level
450 and those interventions are not just targeted at couples and families.
451
452 Specific nutrition strategies that could address some of the possible barriers linked with living alone
453 include: cooking skills programmes and recipes focussing on preparation of meals for one person
454 across a range of budgets; education that addresses purchasing and storage of food; improved
455 availability of healthy foods that can be purchased, prepared and stored easily; supplemental food
456 programmes and development of socially acceptable opportunities for eating in communal settings.
457 For other health professionals, results indicate that in managing the care of people living alone, the
458 potential role of nutrition and referral to a nutrition professional should be considered.
459
460 *Strengths, limitations and further research*
461 The results of this review may have been affected by publication bias whereby studies not finding
462 an association are less likely to be published. Non-English language publications were excluded
463 due to a lack of resources for translation which could introduce language bias. The inclusion of all
464 studies regardless of quality could also be a limitation. However given the novelty of this topic the
465 inclusion of all research was deemed warranted and quality was considered in the interpretation of
466 results. A strength of the review was the number of large, national studies included. However there
467 was a reliance on cross-sectional data with only three studies investigating whether a change in
468 living arrangements is linked with changes in dietary patterns.[36,62,63] Variation in study design and
469 type and validity of methods used to assess outcomes also complicates ability to compare studies.

Most studies included multivariate analysis however the range of covariates included was not consistent, particularly for inclusion of marital status. As the review was only based upon quantitative research limited insight is given into the reasons why people living alone show different behaviours. In addition the focus of the review was sole person households. People living in shared households responsible for preparing their own foods are likely to experience similar barriers against healthy eating.

While randomized controlled trials are unfeasible, larger studies where living arrangements are a focus of the research and possible confounding and effect modifying variables are included are needed. Longitudinal research could investigate the influence of duration of time living alone or change in living arrangements and add to the small number of longitudinal studies. For example, there is potential for use of life course cohort or panel data that has information on living arrangements, food or nutrient intake and related co-variates.

Conclusions

This study provides the first comprehensive review of research investigating associations between living alone and nutrient and food intake. While results do suggest differences in the food and nutrient intakes of people that live alone compared to people in other circumstances, further research is needed to investigate this and to consider the interaction with the myriad complex factors that lead to living alone and reasons why living alone influences nutrient intake. This could contribute towards understanding of the relationship between living alone and poor health outcomes and inform the development of interventions for individuals, groups and populations.

Authorship

KLH conceived the study, performed the database search, data interpretation and analysis, wrote the first draft and participated in the review. PFC participated in data interpretation and analysis and participated in the revision of the article. Both authors read and approved the final manuscript.

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Declaration of Interest

No conflicting interests to declare.

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727

728 **Figures**

729 Figure 1: Flow chart summary of the search strategy

Table 1: Study quality in relation to criteria[a]

Author (date)	Sample (n)	Response rate (%)	Cross sectional/ Retrospective	Prospective or cohort	Validated dietary assessment	Food portions assessed	Primary focus on living arrangements	Multivariate analysis	Nation wide study	Randomly selected
Individuals										
Bae at al (2007)[41]	6331	NS	Y	N	NS	Y	Y	Y	N	Y
Ball et al (2003)[48]	10561	82	Y	N	Y	Y	N	Y	Y	Y
Barberger-Gateau et al (2005)[26]	9280	40*	Y	N	NS	N	N	Y	Y	Y
Davis et al (1990)[28]	4402	NS	Y	N	Y	Y	Y	N	Y	Y
Davis et al (2000)[27]	6525	NS	Y	N	Y	Y	Y	Y	Y	Y
Dean (2009)[53]	3200	N	Y	N	NS	N	N	Y	N	N
Donkin et al (1998)[44]	369	67	Y	N	Y	Y	Y	Y[†]	N	N
Dynesen et al (2003)[46]	995	62	Y	N	Y	N	N	Y	Y	Y
Friel et al (2003)[30]	6539	62	Y	N	Y	Y	N	Y	Y	Y
Friel et al (2005)[31]	5979	62	Y	N	Y	N	N	Y	Y	Y
Gerrior et al (1995)[32]	5841	NS	Y	N	Y	Y	Y	N	Y	Y
Gillman et al (2001)[55]	1322	60	Y	N	Y	Y	N	Y	N	Y
Hart et al (2006)[57]	2507	68	Y	N	Y	N	N	Y	N	Y

Holmes et al (2011)[56]	662	55	Y	N	Y	Y	N	Y	Y	Y
Hunter et al (2010)[33]	473	50	Y	N	Y	Y	Y	Y	N	Y
Irz et al (2014)[34‡]	9587	NS	Y	N	Y	N	N	Y	Y	Y
Itoh et al (1995)[50]	190	NS	Y	N	Y	Y	N	Y	N	N
Kesse-Guyot et al (2009)[60]	5194	88*	Y	N	Y	Y	N	Y	Y	N
Kharicha et al (2007)[6]	2601	60	Y	N	NS	N	Y	Y	N	N
Larrieu et al (2004)[35]	9250	40*	Y	N	NS	N	N	Y	N	Y
Maynard et al (2006)[38]	1647	52	Y	N	Y	N	N	Y	Y	N
Murphy et al (1993)[36]	2627	NS	N	Y	Y	Y	Y	Y	Y	Y
Pearson et al (1998)[52]	1909	34-81	Y	N	Y	Y	Y	N	N	Y
Prevost et al (1997)[63]	Study 1 9003 Study 2 5090	73.5 NS	N	Y	NS	N	N	Y	Y	Y
Pryer et al (2001)[64]	1097	59	Y	N	Y	Y	N	N	Y	Y
Rogers et al (2012)[49]	2197 1724	70 47	Y	N	Y	Y	N	Y	Y	Y
Sharkey et al (2010)[47]	582	17	Y	N	Y	Y	N	Y	N	N
Shelton et al (2005)[39]	7319	76	Y	N	NS	NS	N	Y	Y	Y

Small et al (1994)[51]	34	NS	Y	N	Y	Y	N	N	N	N
Touvier et al (2010a)[23]	4574	88*	Y	N	Y	Y	N	Y	Y	N
Touvier et al (2010b)[25]	4574	88*	Y	N	Y	Y	N	Y	Y	N
Touvier et al (2011)[24]	4574	88*	Y	N	Y	Y	N	Y	Y	N
Villegas et al (2004)[59]	851	70	Y	N	Y	N	N	N	N	Y
Wakita Asano et al (2009)[45]	4261	NS	Y	N	Y	Y	N	Y	Y	Y
Walthouwer et al (2014)[62]	379	51	N	Y	Y	Y	N	Y	Y	N
Whichelow et al (1996)[58]	9003	78	Y	N	NS	N	N	Y	Y	Y
Williams et al (2010)[37]	355	44	Y	N	Y	Y	N	Y	N	Y
Zipp et al (1992)[40]	100	NS	Y	N	Y	Y	Y	Y	N	N
Households										
Deeming et al (2011)[29]	5600	60	Y	N	Y	Y	N	Y	Y	Y
Irz et al (2014)[34] ‡	7743	NS	Y	N	Y	Y	N	Y	Y	Y
Naska et al (2006)[61]	94564	NS	Y	N	Y	N	N	Y	Y	Y
Temple (2006)[54]	1898	NS	Y	N	Y	N	N	Y	Y	Y

[a]Criteria derived from the National Institutes of Health for Observational, Cohort and Cross-sectional Studies[11])

Abbreviations: Y – Yes; N – No; NS – Not specified; * - Participation; †Adjusted for sex and age only; ‡Data from Finland and Italy from households. Data from the UK and Sweden from individuals

Table 2: Summary of food and nutrient intakes in persons living alone compared to other living arrangements[a]

Author Y Location	Number, % Living Alone, Gender, Age	Explanatory variable	Outcome variable	Results[bc]
Food Groups				
Donkin et al (1998)[44] UK	n=369 38.8% living alone; 48%M; ≥ 65 y	─ Living alone ─ Married	FFQ → Frequency of consumption of fruits & veg	**MV**: F&V consumption in M living alone 2.66 (0.33) portions/d *cf* 4.1 (0.22) overall. Living status & gender significant for: fruit consumption F(3,210)=5.66 P<0.001, veg consumption F(3,210)=6.14 P<0.001
Larrieu et al (2004)[35] France	n=9250 35.8% living alone; 39.3% M; 65+ Y	─ Living alone ─ Living with a spouse or co-tenant	FFQ → Frequency of consumption of 9 food groups	**BV[d]:** Higher proportion of people living with others than living alone reported regular consumption of food groups in M (fish, eggs, cereals, raw veg, cooked fruit and veg, pulses) & F (meat, fish, eggs, cereals, raw fruit , raw veg, cooked fruit and veg and pulses. **MV:** Patterns confirmed in MV analysis. Results not presented
Barberger-Gateau et al (2005)[26] France	n=9280 37.8% living alone; 39% M; 65+ Y	─ Living alone ─ Living with a spouse/partner ─ Living with others	FFQ → Fish (including seafood) frequency of consumption	**MV:** Persons living with a spouse/partner more likely to consume fish at least weekly compared to living alone (OR 95%CI: 1.86(1.61-2.16))
Friel et al (2005)[31] Ireland	n=5979 13.8% living alone; 45.8% M; 18+ Y	─ Living alone ─ Living with others	FFQ → Percentage consuming recommended number of food group servings: CBP. cereals, breads and potatoes; FV. fruit & veg; Dairy. dairy and alternatives; MFP. meat, fish &	**BV:** Persons living alone less likely than living with others to consume the recommended number of servings of CBP & FV in M. Persons living alone more likely than living with others to consume the recommended number of serves of dairy in M & MFP, foods high in sugars & fats in M &

			poultry; Top. foods high in sugars and fats.	F. **MV:** Living alone not included.
Bae et al (2007)[41] US	n=6331 19.8% living alone; 39.2% M; 18+ Y	─ Single member household ─ Multiple member household	Questionnaire. Yes or no for: Consumption of 5 or more serves of F&V/d Consumption of foods high in fat 7 d/wk	**BV:** Living alone less likely to consume foods high in fat than multiple member households in F only (17.9% vs. 31.5%). **MV:** Analysed separately for single & multi-member households
Kharicha et al (2007)[6] UK	n=2601 33.1% living alone; 45.6%M; 65+ Y	─ Living alone ─ Living with others	Questionnaire. Yes or no for: Consumption of > 2 high fat food items/d Consumption of < 5 fruit/fibre items/d	**MV:** Living alone more likely than living with others to have low fruit and fibre in diet (OR (95% CI) 1.42 (1.2-1.7).
Wakita Asano et al (2009)[45] Japan	n=4261 7.6% living alone; 40.9% M; 20-69 Y	─ Living alone ─ 2 people ─ 3 people ─ 4+ people	One day weighed food record → Veg intake g/d	**MV:** Lower veg consumption in M LA for all age groups. Compared to lowest of other living arrangements veg consumption in living alone was 27% lower in 20-39 Y, 24% lower in 40-59 Y & 18% lower in 60-69 Y in M only. Adjusted for age only. Living alone not included in other MV models.
Hunter et al (2010)[33] Australia	n=473 11% living alone; 100%F; 43-72 Y	─ Living alone ─ Living with others	FFQ Fruit: high (≥2) vs. low (< 2 serves/d) Veg: high (≥ 3) vs. low (< 3 serves/d)	**MV:** Living alone associated with lower consumption of fruit (regression co-efficient c=1.87, P<0.05) & veg (c=1.096, P<0.05)
Sharkey et al (2010)[47] US	n=582 27.7% living alone; 31.8% M; 60-90 Y	─ Lives alone ─ Lives with others	Two item screener → Fruit and veg intake (separate and combined).	**MV[d]:** All analyses for lives alone compared to living with others. Negative associations between living alone and veg intake or combined fruit and veg intake (for all models). Associations modelled for network distance from participant residence to nearest supermarket, food store

				with a good selection of fresh fruit or veg or food store with a good selection of fresh & processed fruit or veg.
Touvier et al (2010)[25] France	n=4574 13.8% living alone; 54.7%M; 45-60 Y	─ Living alone ─ LWO	- 6x24-h dietary records →Adherence to starchy food recommendation → Variety & type of starchy foods consumed	**MV:** No significant results
Touvier et al (2010)[23] France	n=4574 13.8% living alone; 54.7%M; 45-60 Y	─ Living alone ─ Living with others	6x24-h dietary records → Variety &type of meat/seafood/eggs consumed	**MV:** Intake of number of different meat/seafood/eggs consumed lower in living alone than cohabiting (adjusted mean±SE 4.57±0.04 vs. 4.66±0.02)
Williams (2010)[37] Australia	n=355 77.5% LA; 100%F; 18-65 Y	─ Living alone ─ Not living alone	FFQ → Fruit & veg intake	**BV:** No significant associations between living arrangements and likelihood of high fruit and veg consumption. **MV:** Living alone not included
Rogers (2012)[49] UK	n=2197 (1986-87) & 1724 (2000-2001) 7.1% living alone (1986-87) ; 20.6% living alone (2000-2001) ; 49.9% M (1986-87); 58.5% M (2000-01); 16-64 Y (1986-87); 19-64 Y (2000-01)	1. Living alone 2. With spouse/partner, no children 3. With other adults, no spouse/partner, no children 4. With children & spouse/partner 5. With children no spouse/partner	7d weighed food record → Compliance with fruit & veg recommendations	**MV:** No significant results
Nutrient Intakes				
Zipp et al	n=100	─ Living alone	FFQ	**BV:** No significant results. **MV:** Living alone not

(1992)[40] US	54% living alone; 100% F; 65+ Y	─ Living with a spouse	→ Intake & %of RDA for energy, protein, & selected micro nutrients /d	included.
Small et al (1994)[51] Canada	n=33 66.7% living alone; 100% F; 65-83 Y	─ Living alone ─ Living with others	1 x 24-hr recall →Intake of energy & selected macro & micro nutrients /d	**BV:** No statistically significant differences in energy or nutrient intakes by living arrangement
Itoh et al (1995)[50] Japan	n=190 5.8% living alone; 45.8% M; 65-80 Y	─ Living alone ─ Living with a spouse ─ Living with others	3-d food record → Intake of iron, thiamine, riboflavin & ascorbic acid /1000 Kcal	**MV:** No significant results
Pearson et al (1998)[52] 8 European countries	n=1909 27% living alone; 49.9% M; 70-75 Y	─ Living alone ─ Living with spouse/partner ─ Living with others	3-day food record + food checklist →Intake of energy, macronutrients & micronutrients /d	**BV[d]:** M living alone: lower than spouse/partner for ; higher than spouse/partner for cholesterol, vitamin A; lower than others for, vitamin C; higher than others for saturated fat, cholesterol, riboflavin, calcium. F living alone lower than spouse/partner for nil; higher than spouse/partner for riboflavin, calcium; lower than others for, energy, protein, carbohydrate; higher than others for vitamin A, riboflavin, calcium
Friel et al (2003)[30] Ireland	n=6539 M: 14.6% living alone; F: 13% living alone; 46.6% M; 18+ Y	─ Living alone ─ Living with others	FFQ → Intake energy, macronutrients and micronutrients /d	**BV[d]:** In males living alone lower than living with others for energy, protein, cholesterol, fibre, vitamin C, vitamin D, folate, thiamin, iron, selenium, zinc. In females living alone lower than living with others for cholesterol, vitamin B12, selenium, zinc. **MV:** Lower % energy from fat in living alone (β (t value) -0.062 (-2.04)).

				Higher % energy from carbohydrate in living alone (0.047 (1.52)). Micronutrients not included.
Summary score based on food intake				
Murphy et al (1993)[36] US	n=2627 Spouse to alone M: 7.9% F: 21%; Living alone at both M : 5.7% F 24.1%; 49.1%M; 45-74 Y at baseline	─ Lived with spouse at baseline, alone at FU ─ Lived with spouse at baseline & FU ─ Lived alone at both time periods	FFQ →Food groups →Food quality – average of the % of recommended serves of four food groups (Dairy, protein foods, fruit and vegetables, grains)	**MV:** M living alone at both time points compared to spouse at both consumed a lower % of recommended for fruit & veg (Difference (95% CI) -9.8% (-16.9 to -2.8). F living alone at both time points compared to spouse at both consumed a lower % of recommended for protein foods (-5.2% (-8.4 to -1.9). Food quality negatively related to y living alone. Regression coefficients : M ─0.23 (P=0.04); F: ─0.5 (P=0.44)
Gillman et al (2001)[55] US	n=1322 15.6% living alone; 31.5% M; 25+ Y	─ Living alone ─ Not living alone	FFQ → Food groups categorised as most (0 pts), less (1pt) & least desirable (2 pts). Scores >1.3 classed as failed for the group More healthful ≤1 failed domains; Suboptimal ≥2 failed domains	**MV:** NS difference in % living alone within sub optimal Vs. more healthful
Temple (2006)[54] Australia	n=1898 households 38.3% living alone households (26.7%F; 11.5% M); % M&F not reported overall; 55+ Y (head of household)	─ Couple only ─ Lone female ─ Lone male ─ Couple with children ─ Living with others	Diary recording weekly household expenditure on 110 food items. → Dietary Variety Score (DVS)	**MV:** M & F living alone purchased ~40% & 25% less food items respectively than couple households (incidence rate ratio (IRR) (95%CI) 0.597 (0.564, 0.631) for M; 0.752(0.719, 0.786) for F). Couples with children and living with others had a higher DVS (IRR (95% CI) 1.127

				(1.07, 1.186) for C+Ch; 1.127 (1.045, 1.2 16) for LWO).
Dean et al (2009)[53] 8 European countries	n=3200 (n=400 per country) 48 to 52% living alone; 48 to 52% M; 65+ Y	─ Living alone ─ Living with a partner	Consumption of food groups- food group scored once if portion ≥ 2 tablespoons → Food variety score >15/w = adequate; >30/w=excellent	**MV:** Significant independent effects for living arrangement (ß= -0.08, P<0.001) suggesting that those living with a partner eat a more varied diet than those who live alone. Not significant when resources and goals included.
Summary score based upon nutrient intakes				
Davis et al (1990)[28] US	n=4 402 28.6% living alone; 42.3%M; 55 + Y	─ Living alone ─ Living with a spouse	1 x 24-hr recall + 2d written diet record → Dietary quality - Low = intake <60% of RDA for selected micro nutrients . Poor quality = low intake for ≥ 5	**MV:** No significant results
Gerrior et al (1995)[32] US	n=5841 12.5% living alone; 45%M; 19+ Y	─ Single person household ─ Multiple person household	1 x 24-hr recall +2-d written food record → Adequacy % of the RDA for: protein; & selected micronutrients. Score/100 → Moderation % energy from fat, saturated fat, cholesterol & sodium. Score/100 Higher scores indicate better compliance.	**BV:** Dietary adequacy index lower in living alone than multi-person household for F 19-34 Y (26.4±3.6 vs. 38.2±1.4) & M 35-54 Y (39.1±6.2 vs. 53.0±1.6) Dietary moderation index higher in living alone than multi-person household for F all ages (46.6±1.9 vs. 39.1±0.9), F 19-34 Y (44.9±3.4 vs. 36.7±1.3), M all ages (32.0±3.2 vs. 21.8±1.0) & M 19-34 Y (32.1±4.6 vs. 21.2±1.4). DMI higher in living alone *cf.* multi person household for: income, urbanization, white or non-white, overweight or normal weight, region & supplement use.
Davis et al	n=6525	─ Living alone	1 x 24h recall	**MV:** No significant results

(2000)[27] US	22.9% living alone; 47.4% M; 50+ Y	– Spouse only – Spouse plus others –Other than spouse	→Diet quality score (number of low nutrients of a possible 15, with low defined as <67% of the RDA)	
Hart et al (2006)[57] US	n=2507 22.5% living alone; 14% M; 18+ Y	– Alone – Spouse/partner – Other	Fat and Fibre-Related Behaviour Questionnaire → Fat score derived from questionnaire (lower score indicates lower fat intake)	**MV:** Living alone did not make a significant contribution to the model.
Deeming (2011)[29] UK	n=5600 households 3069 single persons & 2556 couples (M&F) Overall gender % not specified; 60y+	– Single woman – Single Man – Couple	Two wk food diary – household consumption → Intake of energy & selected nutrients → Food nutrition security based on meeting ≥70% of minimum dietary standards.	**MV:** Living alone less likely than couples to meet ≥ 70% of minimum dietary standards for energy (OR 0.72), food and nutrition (OR 0.69) in males only.
Summary score based upon food and nutrient intakes				
Maynard et al (2006)[38] UK	n=1234 17.4% living alone; 54.5% M; 61-80 Y	– Household size: 1, 2, 3+	FFQ →Healthy Diet Score based on intake of saturated & polyunsaturated fats, protein, carbohydrate, fibre, fruit , veg, pulses, nuts, sugars, cholesterol, fish, red meat & calcium	**BV:** Non-significant difference in Healthy Diet Score by number of people in household. **MV:** Living alone not included in MV analysis
Shelton et al (2005)[39] Scotland	n=7319 %LA not reported; 50%M; 16-74 Y	– Living alone – Living with others	Food frequency interview →Healthy Eating Score : tertiles for selected dietary targets (saturated fat, sugar, salt, fruit, veg, starches, oily fish, fibre). Total scores	**BV:** No significant differences between groups for healthy eating score. **MV:** Living alone not included

			dichotomized into unhealthy/healthy eating.	
Holmes et al (2011)[56] UK	n=725 73% living alone; 32.3% M; 65+ Y	─ Living alone ─ Not living alone	4 x24-hr recall → Diet Quality Index	**BV:** NS association between DQI & living alone **MV:** Living alone included as a confounding factor however results not shown.
Food groups and nutrients				
Ball et al (2004)[48] Australia	n=10 561 9% living alone; 100% F; 50-55 Y	1. Living alone 2. Partner only 3. Children only 4. Partner & children 5. Others	FFQ →Compliance with dietary guidelines for food groups & nutrients	**MV:** No significant results
Touvier et al (2011)[24] France	n=4574 13.8% living alone; 54.7%M; 45-60 Y	─ Living alone ─ LWO	- 6x24-h dietary records → Adherence to dairy recommendation →Variety &type of dairy foods consumed →Dietary calcium intake & adequacy	**MV:** Living alone more likely than living with others to have inadequate calcium intakes. (OR (95% CI) (0.7 (0.6-0.9))
Food groups and food and/or nutrition based summary scores				
Irz et al (2014)[34] 4 European countries	Finland - n=2994 households Italy - n=7564 individuals Sweden - n=2023 individuals UK: n=4749 households % living alone not reported; %M & F not specified; 50+ Y	─ Male alone ─ Female alone ─ Couple 3+ households excluded	Finland: Two week food diary plus receipts Italy: FFQ Sweden: Semi-quantitative FFQ UK: Two week diary of all food and drink purchases → Diet Quality Index (UK, Sweden, Finland) →Recommendation Compliance Index (Italy)	**MV[d]:** M living alone with reference to couples (β±se) had a lower intake of F&V in Italy (-0.366±0.047) and Finland (0.110±0.042). Mixed results for nutrients across countries & sex. Males living alone and females living alone with reference to couples (β±se) had a lower Diet Quality Index in the UK (─1.772±0.649 in M & ─1.443±0.507 in F) and Finland (─2.040±0.832 in M & ─1.390±0.622 in F) and a

				trend for a lower Recommended Compliance Index in Italy (−0.025±0.004 in M & −0.009±0.003 in F, P<0.1). Living alone not a significant determinant of diet quality in Sweden.
Dynesen et al (2003)[46] Denmark	n=995 24.7% living alone; 48.2% M; 15-90 Y	1 Single household 2 Multi person household excl. children 3 Multi person household incl. children	FFQ →Adherence to food based dietary guidelines → Healthy Diet Index Score (0-15) based on adherence to guidelines (0 no adherence)	**MV[d]:** Multi-person households incl. & excl. children more likely to adhere to guidelines for fruit & fish as a main meal. Multi-person households incl. children more likely to adhere to guidelines for fish with sandwiches. Multi-person households incl. & excl. children more likely than living alone to have a HDI score in the top Vs. lowest quintile for M ((2.54 (1.07-6.05)) for incl., (6.06 (2.33-15.77) for excl.) & F ((2.15 (1.01-4.58) for incl., (3.60 (1.41-9.17) for excl.).
Dietary patterns/ clusters based upon foods				
Whichelow et al (1996)[58] UK	n=9003 12% living alone; 43.1%M; 18+ Y	─ Household size: 1,2,3,4,5,6+	FFQ → 4 dietary patterns 1. freq. fruit, salad, veg, infrequent high-fat food; 2. freq. high-starch foods, most veg & meat; 3. freq. high-fat foods; 4. sweets, biscuits & cakes, with low veg	**MV**: Component 1 most popular with women but not men living alone (P<0.001); Component 2 increased in popularity with increasing household size, with those living alone unlikely to follow this pattern (P<0.001); Component 4 was most favoured by those living alone (P<0.001)
Prevost et al (1997)[63]	n= 5090 for baseline and follow-up	─ Family baseline & follow-up ─Alone baseline & follow-up	FFQ →Dietary Component Scores	**MV**: No significant association between household size and dietary component scores at baseline or follow-up.

UK	9.0% living alone (baseline); 14.2% living alone (follow-up); 43%M; 18+ Y	─Alone baseline family follow-up ─Family baseline alone follow-up	1. Freq fruit, salad, brown bread, fruit juice, veg, low fat spread & milk; 2. Freq dessert, potatoes, cream, meat, pulses, confectionery, preserves, eggs, light desserts; 3. Freq crisps, soft drink, fried food, coffee, pasta, rice, proc. meat; 4. Freq confectionery biscuits, cake	Change in dietary component scores from baseline to follow-up not significant.
Pryer et al (2001)[64] UK	n=1097 35.4% living alone; 49% M; 65+ Y	─ Living alone ─ Not living alone	4d weighed food record →Identification of clusters 1. Mixed; 2. Healthy; 3. Traditional	**BV:** No significant difference in the proportion living alone within each dietary pattern
Villegas et al 2004[59] Ireland	n=851 13.6% living alone; 49.1% M; 50-69 Y	─ Living alone	FFQ → 3 dietary patterns 1. Traditional diet; 2. Prudent diet; 3. Alcohol & convenience foods	**BV:** Higher percentage of living alone within alcohol and convenience foods (25.8%) compared with prudent diet (12.8%) and traditional diet (13.4%). Cluster 3 97% M.
Naska et al 2006[61] 10 European Countries	- 94 564 households - % LA, gender and age not reported	- Adult household (single) - Adult household (2 members) - Adult + Children (lone parents) Adult + children Elderly household (single) Elderly household (2 members)	Goods and services available to household members →Principle components: 1. Wide range of foods incl. fruits, veg, cereals, meat, fish , dairy 2. Beverage & convenience food buyers	**MV[d]:** Mediterranean & Scandinavian populations: adults LA more likely to have lower scores in PC1. Central/N European populations: elderly LA more likely to have lower PC2 scores.
Kesse-Guyot et al	n=5194 F 17.5% living alone; M 9.6%	─ Living alone ─ Not living alone	Repeat 24-hr diet records (≥6 over 2 y) → 4 food patterns	**MV:** Living alone positively associated with higher intake of convenience foods among men OR (95% CI) = 1.33

(2009)[60] France	living alone; 52.6%M; 45-60 Y		1. Alcohol & meat; 2. Prudent diet; 3. Convenience foods; 4. Starch, sauces & veg	(1.01-1.75).
Walthouwer et al (2014)[62] the Nether lands	n=483 at baseline, 379 at follow-up 17.2% living alone; 53.8% M; 18-65 Y	─ Living alone ─ Not living alone	FFQ → 3 dietary clusters 1. Healthy cluster; 2. Moderately healthy cluster; 3. Unhealthy cluster	**MV:** People who lived alone more likely than people who lived with others to be in the group that shifted towards an unhealthier cluster compared with stable group (OR (95%CI) 3.48 (1.01-11.99), P=0.05)

[a]All studies cross-sectional design except Murphy et al, 1993; Prevost et al, 1997; Walthouwer et al, 2014; [b]Significant results only presented; [b]Bivariate results only presented if no further multivariate analyses conducted; [d]Results too extensive to present all data. See online supplementary materials for further information; *Abbreviations:* FFQ, Food Frequency Questionnaire; Veg, vegetables; Y, year; M, male; F, female; wk, week; d, day; h, hour