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

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7 Living alone and food and nutrition

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26

27 *Abstract*

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

40

41 *Key words*

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

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## 55 INTRODUCTION

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

70

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

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

88

## 89 **METHODS**

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

98

### 99 **Literature search**

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

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

110

### 111 **Inclusion and exclusion criteria**

112 Predetermined eligibility criteria guided study selection. Inclusion criteria included English  
113 language, published after 1990, quantitative and presentation of original research. Articles were  
114 excluded if they related only to marital status, solitude, isolation or loneliness or if the study  
115 population consisted of animals, pregnant women, infants, children, adolescents, groups with  
116 disease (e.g. cardiovascular disease or cancer) or hospitalized or institutionalized individuals.  
117 Studies designed to investigate the association between foods or nutrition and disease outcomes  
118 were also excluded. Articles were also excluded if they were conducted in locations where  
119 demographic living arrangement data was not available or where proportions living alone are below  
120 10% (such as Africa, South America, China or South Korea). Articles were included in the review  
121 if the abstract, title, or key words indicated the study investigated food or nutrient intake in people  
122 living alone compared to those living with others. Cross-sectional, case-control or cohort studies  
123 were eligible for inclusion. Articles published only as abstracts from conference proceedings were  
124 excluded.

125

### 126 **Recording and synthesis of research findings**

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

133

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

142

## 143 **RESULTS**

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

155

### 156 ***Quality of studies included***

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

159 that met the selection criteria were based upon cross-sectional 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.<sup>37-40</sup> One study conducted  
162 separate multivariate analyses in the living alone and cohabiting groups<sup>41</sup> and one did not include  
163 living alone in classification tree analysis although bivariate associations were shown.<sup>31</sup>  
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.<sup>42,43</sup> However 33 of the 41 studies used a  
175 method of dietary assessment that has been validated (Table 1). Table 2 identifies the 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.<sup>31,34,36,44,45</sup> Two studies that analysed men and women separately found lower intakes  
191 of fruits but not vegetables<sup>46</sup> or fruits and vegetables<sup>35</sup> in those living alone. A study of women  
192 only found lower fruits and vegetables intake in those living alone.<sup>33</sup> Two studies that analysed men  
193 and women together found lower intakes of fruits<sup>6</sup> or fruits and vegetables<sup>47</sup> in those living alone.  
194 Of the four studies that found no associations, two involved all female participants.<sup>37,48</sup> A third was  
195 based on a single question with unspecified validity.<sup>41</sup> However the fourth included men and  
196 women and intake was assessed by seven day food record<sup>49</sup> 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.<sup>26,35,46</sup> 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<sup>46</sup> or to consume recommended amounts of meat, fish and poultry.<sup>31</sup> However  
204 another found that women, but not men, were less likely to report regular meat consumption.<sup>35</sup>  
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.<sup>36</sup>  
207 Another study found that men and women living alone had a lower variety of intake of meat,  
208 seafood and eggs.<sup>23</sup>

209



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

219

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

231

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

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

244

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

249

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

262

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

275

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

283

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

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

301

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

314

315 **DISCUSSION**

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

333

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

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

348

#### 349 *Socioeconomic factors and living alone*

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

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

373

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

384

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

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

395

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

406

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



418 constraints around what constitutes a proper meal.<sup>85</sup> 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<sup>86</sup> and discussed evidence from different research areas  
421 indicating that it can result in either increased or decreased intake.<sup>86</sup> 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.<sup>2</sup> A person living alone does not have to take into account the food likes and needs of  
429 other people.<sup>65</sup> 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.<sup>1,2</sup> 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”.<sup>1</sup> 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.<sup>87,88</sup> 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.<sup>36,62,63</sup> Variation in study design and  
469 type and validity of methods used to assess outcomes also complicates ability to compare studies.

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

476

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

483

#### 484 *Conclusions*

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

492

#### 493 **Authorship**

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

497

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502 No conflicting interests to declare.

503

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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<sup>a</sup>**

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
<b>Individuals</b>										
Bae et al (2007) <sup>41</sup>	6331	NS	Y	N	NS	Y	Y	Y	N	Y
Ball et al (2003) <sup>48</sup>	10561	82	Y	N	Y	Y	N	Y	Y	Y
Barberger-Gateau et al (2005) <sup>26</sup>	9280	40*	Y	N	NS	N	N	Y	Y	Y
Davis et al (1990) <sup>28</sup>	4402	NS	Y	N	Y	Y	Y	N	Y	Y
Davis et al (2000) <sup>27</sup>	6525	NS	Y	N	Y	Y	Y	Y	Y	Y
Dean (2009) <sup>53</sup>	3200	N	Y	N	NS	N	N	Y	N	N
Donkin et al (1998) <sup>44</sup>	369	67	Y	N	Y	Y	Y	Y <sup>†</sup>	N	N
Dynesen et al (2003) <sup>46</sup>	995	62	Y	N	Y	N	N	Y	Y	Y
Friel et al (2003) <sup>30</sup>	6539	62	Y	N	Y	Y	N	Y	Y	Y
Friel et al (2005) <sup>31</sup>	5979	62	Y	N	Y	N	N	Y	Y	Y
Gerrior et al (1995) <sup>32</sup>	5841	NS	Y	N	Y	Y	Y	N	Y	Y
Gillman et al (2001) <sup>55</sup>	1322	60	Y	N	Y	Y	N	Y	N	Y
Hart et al (2006) <sup>57</sup>	2507	68	Y	N	Y	N	N	Y	N	Y

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

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

<sup>a</sup>Criteria derived from the National Institutes of Health for Observational, Cohort and Cross-sectional Studies<sup>11</sup> )

*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<sup>a</sup>**

Author Y Location	Number, % Living Alone, Gender, Age	Explanatory variable	Outcome variable	Results <sup>bc</sup>
<b>Food Groups</b>				
Donkin et al (1998) <sup>44</sup> UK	n=369 38.8% living alone; 48%M; ≥ 65 y	– Living alone – Married	FFQ → Frequency of consumption of fruits & veg	<b>MV:</b> F&V consumption in M living alone 2.66 (0.33) portions/d <i>cf</i> 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) <sup>35</sup> 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	<b>BV<sup>d</sup>:</b> 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. <b>MV:</b> Patterns confirmed in MV analysis. Results not presented
Barberger- Gateau et al (2005) <sup>26</sup> 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	<b>MV:</b> 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) <sup>31</sup> 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 &	<b>BV:</b> 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. <b>MV</b> : Living alone not included.
Bae et al (2007) <sup>41</sup> 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	<b>BV</b> : Living alone less likely to consume foods high in fat than multiple member households in F only (17.9% vs. 31.5%). <b>MV</b> : Analysed separately for single & multi-member households
Kharicha et al (2007) <sup>6</sup> 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	<b>MV</b> : 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) <sup>45</sup> 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	<b>MV</b> : 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) <sup>33</sup> Australia	n=473 11% living alone; 100%F; 43-72 Y	— Living alone — Living with others	FFQ Fruit: high ( $\geq 2$ ) vs. low (< 2 serves/d) Veg: high ( $\geq 3$ ) vs. low (< 3 serves/d)	<b>MV</b> : 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) <sup>47</sup> 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).	<b>MV<sup>d</sup></b> : 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) <sup>25</sup> 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	<b>MV:</b> No significant results
Touvier et al (2010) <sup>23</sup> 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	<b>MV:</b> 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) <sup>37</sup> Australia	n=355 77.5% LA; 100%F; 18-65 Y	— Living alone — Not living alone	FFQ → Fruit & veg intake	<b>BV:</b> No significant associations between living arrangements and likelihood of high fruit and veg consumption. <b>MV:</b> Living alone not included
Rogers (2012) <sup>49</sup> 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	<b>MV:</b> No significant results
<b>Nutrient Intakes</b>				
Zipp et al	n=100	— Living alone	FFQ	<b>BV:</b> No significant results. <b>MV:</b> Living alone not

(1992) <sup>40</sup> 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) <sup>51</sup> 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	<b>BV:</b> No statistically significant differences in energy or nutrient intakes by living arrangement
Itoh et al (1995) <sup>50</sup> 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	<b>MV:</b> No significant results
Pearson et al (1998) <sup>52</sup> 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	<b>BV<sup>d</sup>:</b> 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) <sup>30</sup> 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	<b>BV<sup>d</sup>:</b> 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. <b>MV:</b> Lower % energy from fat in living alone ( $\beta$ (t value) -0.062 (-2.04)).

				Higher % energy from carbohydrate in living alone (0.047 (1.52)). Micronutrients not included.
<b>Summary score based on food intake</b>				
Murphy et al (1993) <sup>36</sup> 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)	<b>MV:</b> 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) <sup>55</sup> 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	<b>MV:</b> NS difference in % living alone within sub optimal Vs. more healthful
Temple (2006) <sup>54</sup> 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)	<b>MV:</b> 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) <sup>53</sup> 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 $\geq 2$ tablespoons → Food variety score >15/w = adequate; >30/w=excellent	<b>MV:</b> Significant independent effects for living arrangement ( $\beta = -0.08$ , $P < 0.001$ ) suggesting that those living with a partner eat a more varied diet than those who live alone. Not significant when resources and goals included.
<b>Summary score based upon nutrient intakes</b>				
Davis et al (1990) <sup>28</sup> 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 $\geq 5$	<b>MV:</b> No significant results
Gerrior et al (1995) <sup>32</sup> 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.	<b>BV:</b> Dietary adequacy index lower in living alone than multi-person household for F 19-34 Y (26.4 $\pm$ 3.6 vs. 38.2 $\pm$ 1.4 ) & M 35-54 Y (39.1 $\pm$ 6.2 vs. 53.0 $\pm$ 1.6) Dietary moderation index higher in living alone than multi- person household for F all ages (46.6 $\pm$ 1.9 vs. 39.1 $\pm$ 0.9), F 19-34 Y (44.9 $\pm$ 3.4 vs. 36.7 $\pm$ 1.3), M all ages (32.0 $\pm$ 3.2 vs. 21.8 $\pm$ 1.0) & M 19-34 Y (32.1 $\pm$ 4.6 vs. 21.2 $\pm$ 1.4). DMI higher in living alone <i>cf.</i> 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	<b>MV:</b> No significant results

(2000) <sup>27</sup> US	22.9% living alone; 47.4% M; 50+ Y	<ul style="list-style-type: none"> <li>– Spouse only</li> <li>– Spouse plus others</li> <li>–Other than spouse</li> </ul>	→Diet quality score (number of low nutrients of a possible 15, with low defined as <67% of the RDA)	
Hart et al (2006) <sup>57</sup> US	n=2507 22.5% living alone; 14% M; 18+ Y	<ul style="list-style-type: none"> <li>– Alone</li> <li>– Spouse/partner</li> <li>– Other</li> </ul>	Fat and Fibre-Related Behaviour Questionnaire → Fat score derived from questionnaire (lower score indicates lower fat intake)	<b>MV:</b> Living alone did not make a significant contribution to the model.
Deeming (2011) <sup>29</sup> UK	n=5600 households 3069 single persons & 2556 couples (M&F) Overall gender % not specified; 60y+	<ul style="list-style-type: none"> <li>– Single woman</li> <li>– Single Man</li> <li>– Couple</li> </ul>	Two wk food diary – household consumption → Intake of energy & selected nutrients → Food nutrition security based on meeting ≥70% of minimum dietary standards.	<b>MV:</b> 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.
<b>Summary score based upon food and nutrient intakes</b>				
Maynard et al (2006) <sup>38</sup> 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	<b>BV:</b> Non-significant difference in Healthy Diet Score by number of people in household. <b>MV:</b> Living alone not included in MV analysis
Shelton et al (2005) <sup>39</sup> Scotland	n=7319 %LA not reported; 50%M; 16-74 Y	<ul style="list-style-type: none"> <li>– Living alone</li> <li>– Living with others</li> </ul>	Food frequency interview →Healthy Eating Score : tertiles for selected dietary targets (saturated fat, sugar, salt, fruit, veg, starches, oily fish, fibre). Total scores	<b>BV:</b> No significant differences between groups for healthy eating score. <b>MV:</b> Living alone not included

			dichotomized into unhealthy/healthy eating.	
Holmes et al (2011) <sup>56</sup> UK	n=725 73% living alone; 32.3% M; 65+ Y	— Living alone — Not living alone	4 x24-hr recall → Diet Quality Index	<b>BV:</b> NS association between DQI & living alone <b>MV:</b> Living alone included as a confounding factor however results not shown.
<b>Food groups and nutrients</b>				
Ball et al (2004) <sup>48</sup> 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	<b>MV:</b> No significant results
Touvier et al (2011) <sup>24</sup> 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	<b>MV:</b> Living alone more likely than living with others to have inadequate calcium intakes. (OR (95% CI) (0.7 (0.6-0.9))
<b>Food groups and food and/or nutrition based summary scores</b>				
Irz et al (2014) <sup>34</sup> 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)	<b>MV<sup>d</sup>:</b> M living alone with reference to couples ( $\beta_{\pm se}$ ) had a lower intake of F&V in Italy (-0.366 $\pm$ 0.047) and Finland (0.110 $\pm$ 0.042). Mixed results for nutrients across countries & sex. Males living alone and females living alone with reference to couples ( $\beta_{\pm se}$ ) had a lower Diet Quality Index in the UK (-1.772 $\pm$ 0.649 in M & -1.443 $\pm$ 0.507 in F) and Finland (-2.040 $\pm$ 0.832 in M & -1.390 $\pm$ 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) <sup>46</sup> 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)	<b>MV<sup>d</sup></b> : 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.).
<b>Dietary patterns/ clusters based upon foods</b>				
Whicelow et al (1996) <sup>58</sup> 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	<b>MV</b> : 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) <sup>63</sup>	n= 5090 for baseline and follow-up	— Family baseline & follow-up —Alone baseline & follow-up	FFQ →Dietary Component Scores	<b>MV</b> : 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) <sup>64</sup> 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	<b>BV:</b> No significant difference in the proportion living alone within each dietary pattern
Villegas et al 2004 <sup>59</sup> 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	<b>BV:</b> 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 <sup>61</sup> 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	<b>MV<sup>d</sup>:</b> 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	<b>MV:</b> Living alone positively associated with higher intake of convenience foods among men OR (95% CI) = 1.33

(2009) <sup>60</sup> 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) <sup>62</sup> the Netherlands	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	<b>MV:</b> 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)

<sup>a</sup>All studies cross-sectional design except Murphy et al, 1993; Prevost et al, 1997; Walthouwer et al, 2014; <sup>b</sup>Significant results only presented; <sup>c</sup>Bivariate results only presented if no further multivariate analyses conducted; <sup>d</sup>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

