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## **Low fruit and vegetable consumption is associated with low knowledge of the details of the 5-a-day fruit and vegetable message in the UK findings from two cross-sectional questionnaire studies**

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1 **LOW FRUIT AND VEGETABLE CONSUMPTION IS ASSOCIATED WITH LOW KNOWLEDGE OF THE**  
2 **DETAILS OF THE 5-A-DAY FRUIT AND VEGETABLE MESSAGE IN THE UK: FINDINGS FROM TWO**  
3 **CROSS-SECTIONAL QUESTIONNAIRE STUDIES**

4

5 **KM Appleton<sup>1</sup>, K Krumplevska<sup>1</sup>, E Smith<sup>1</sup>, C Rooney<sup>2</sup>, MC McKinley<sup>2</sup>, JV Woodside<sup>2</sup>.**

6 <sup>1</sup>**Bournemouth University, UK,**

7 <sup>2</sup>**Queen's University, Belfast, UK.**

8

9 **Correspondence: Prof. KM Appleton, Research Centre for Behaviour Change, Department of**  
10 **Psychology, Faculty of Science and Technology, Bournemouth University, Poole House, Fern**  
11 **Barrow, Poole, BH12 5BB; tel: +44 (0)1202 965985; fax: +44 (0)1202 965413; email:**  
12 **[k.appleton@bournemouth.ac.uk](mailto:k.appleton@bournemouth.ac.uk)**

13

14 **Short title: Knowledge of the 5-a-day FV message**

15

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18 interest.

19

20 **Authorship**

21 The work was conceived by KMA, with input from MCM and JVW. Materials were developed by  
22 KMA, KK, ES and CR, and the studies were undertaken by KMA, KK and ES. KMA undertook all  
23 analyses and wrote the first draft of the manuscript. All authors reviewed the draft of the  
24 manuscript and offered critical comments.

25

26 **Keywords:** fruit and vegetables, 5-a-day message, knowledge, questionnaires, portion sizes, variety

27

28 **ABSTRACT**

29 Background: This project aimed to understand the details of the 5-a-day fruit and vegetable (FV)  
30 message (which foods are included, portion sizes, the need for variety, reasons for consumption)  
31 least known by UK consumers, and most associated with low FV consumption.

32 Methods: Study 1 assessed FV consumption, knowledge of the details of the message, and  
33 relationships between these, using a short questionnaire administered face-to-face to an  
34 opportunity sample of one large UK city. Study 2 assessed the same variables using a comprehensive  
35 postal questionnaire administered across the UK to a representative population sample.

36 Setting: UK.

37 Results: 507 respondents completed Study 1, and 247 respondents completed study 2. The majority  
38 of individuals in both studies were aware of the 5-a-day message and could recount this correctly. In  
39 both studies, however, knowledge of the details of the message was low, and lower knowledge was  
40 associated with lower FV consumption. Respondents had lowest knowledge of the details of the  
41 message related to portion sizes and the need for variety. However, FV consumption was not  
42 independently associated with knowledge of any one aspect of the message.

43 Conclusions: These findings suggest that, while most of the UK population sampled were aware of  
44 the 5-a-day FV message and could recount this correctly, the details of the 5-a-day FV message were  
45 not well known, and that FV consumption was related to this knowledge. These findings suggest that  
46 strategies to increase FV consumption will benefit from increasing UK consumers' knowledge of the  
47 details of the 5-a-day FV message.

48

49

50 **INTRODUCTION**

51 A high consumption of fruits and vegetables (FV) is associated with reduced risk of a number of  
52 global health concerns (<sup>1-10</sup>), and as a result, the World Health Organisation (WHO) currently  
53 recommends consumption of at least 400g FV/day (<sup>3-6</sup>). Governments around the world have  
54 operationalised and promoted the WHO recommendations as recommended consumption of a  
55 number of portions of FV per day, which in the UK is currently the consumption of five 80g portions  
56 of different FV per day, or the 5-a-day FV message (<sup>11,12</sup>). Impacts of these population-wide  
57 promotional campaigns for consumption, however, appear limited (<sup>13-16</sup>). Populations seem largely  
58 aware of the campaigns (<sup>13,15-19</sup>), and message awareness has been associated with improved  
59 consumption (<sup>15,17,20,21</sup>), but despite the campaigns, population FV intakes in Europe, in the US and  
60 across the world, remain low (<sup>15,22-26</sup>).

61  
62 Reasons for the low implementation of FV messages, despite awareness of the campaigns, can be  
63 suggested. For message implementation, individuals are required to understand which foods are  
64 included in the recommendations, how much of each food is required, and that a variety of these  
65 foods are required (<sup>11,12</sup>). Some researchers would also argue that knowledge of the reasons for  
66 consumption may also be necessary (<sup>27,28</sup>). Various qualitative studies suggest low understanding or  
67 confusion surrounding each of these particular aspects of the FV message (<sup>27-31</sup>). Dixon and  
68 colleagues (<sup>30</sup>) report confusion about numbers of servings and the size of servings. Dibsall et al (<sup>29</sup>)  
69 and Carter et al (<sup>27</sup>) report confusion regarding portion sizes and the necessity and benefits of a high  
70 FV consumption. In a study by Herbert et al (<sup>31</sup>) and a study of our own (<sup>28</sup>), participants report  
71 difficulties with all three main aspects of the message (which foods are included, portion sizes, the  
72 need for variety).

73  
74 Questionnaire studies also report poor knowledge specifically of portion sizes (<sup>13,18-20</sup>), but, to our  
75 knowledge, no questionnaire study to date has investigated population-wide knowledge of all four  
76 individual aspects of the 5-a-day message that may be important for message implementation  
77 (which foods are included, portion sizes, need for variety, and reasons for consumption), nor has this  
78 detailed knowledge been investigated in relation to FV consumption. Identification of which aspect/s  
79 of the 5-a-day message create the greatest confusion, and the associations between knowledge and  
80 FV consumption may demonstrate a public health education need, and allow maximal efficiency of  
81 any ensuing public health campaign.

82

83 This project aimed to understand the aspect/s of the 5-a-day FV message of most confusion for UK  
84 consumers, and most associated with poor FV consumption. Two questionnaire studies were  
85 undertaken. Study 1 used a short seven-item questionnaire administered face-to-face to an  
86 opportunity sample on the streets of one large UK city. Study 2 used a comprehensive 10-item postal  
87 questionnaire administered across the UK, to a representative population sample. Both studies  
88 assessed FV consumption and knowledge of the 5-a-day FV message, and investigated relationships  
89 between these variables. Study 1 was intended to describe a snap-shot of self-reported FV message  
90 awareness and knowledge, free from the reporting biases of many questionnaire studies. Study 2  
91 was intended to expand and enhance the understanding gained from Study 1. Ethical approval for  
92 both studies was gained from the Research Ethics Committee of Bournemouth University, UK, prior  
93 to commencement, and both studies were run in accordance with the Ethical Guidelines of the  
94 British Psychological Society.

95

## 96 **STUDY 1**

### 97 **Method**

98 Study 1 used a short seven-item questionnaire administered face-to-face to an opportunity sample  
99 on the streets of one large UK city.

100

101 **Questionnaire:** The questionnaire consisted of seven short open-response questions: one question  
102 on FV consumption, three questions on self-perceived FV knowledge and three questions on  
103 demographic characteristics. These questions were respectively: '1. *How many portions of fruit and*  
104 *vegetables do you think you consume per day, on average?*'; '2. *Have you heard of the 5-a-day*  
105 *message?*', '3. *What do you think it means?*', '4. *Which aspect or aspects of the message do you think*  
106 *is/are most confusing? for example, do you know what counts as a fruit or vegetable?, or how much*  
107 *is needed for a portion?, or do you know you need 5 different fruits and vegetables?, or why you*  
108 *should be eating fruits and vegetables?*'; '5. *Gender?*', '6. *Age by decade?*', and '7. *How would you*  
109 *describe your current or most recent occupation if retired? – manual worker, non-manual worker,*  
110 *manager or professional or no job?*'. These questions were designed to elicit simple self-report  
111 answers, reflecting each individual's consumption and knowledge as far as they were aware.  
112 Individuals who were not aware of the 5-a-day message were not asked questions 3 and 4, but were  
113 instead given the details of the message. An early version of the questionnaire asked '4. *Is there*  
114 *anything about the message you find confusing?*', thus confusion was not assumed. This question,  
115 however, elicited very little further detail when piloted to a sample of 25 respondents from the same

116 source as our final sample, and so was replaced. No other amendments to the questionnaire were  
117 made following piloting.

118

119 **Questionnaire Administration:** Researchers administered the questionnaire face-to-face on the  
120 streets of Bournemouth, UK, to all adults who were willing to stop, able to answer the questions,  
121 and resided locally. Bournemouth is a city on the South coast of England, of diverse socio-economic  
122 status. On two separate days during June 2014, three researchers (KMA, KK, ES) were positioned on  
123 a major shopping street and near central bus stops in Bournemouth City Centre, and all passers-by  
124 between 10:00am-12:00pm and 14:00-16:00pm were asked if they would be willing to stop to  
125 answer 'a five minute survey on fruits and vegetables'. Efforts were made to ask all types of  
126 individuals, and so increase demographic variety and generalizability. All individuals who were  
127 willing and suitable completed the survey. Individuals who were not able to answer the questions  
128 due to language or cognitive difficulties, and individuals who were not local residents (e.g.  
129 holidaymakers) were thanked for their time and not questioned further.

130

131 **Data Analysis:** Data were entered into and analysed in SPSS. Descriptive statistics were used to  
132 describe responses to all questions. Differences between socio-demographic groups were  
133 investigated using Chi-squared tests. Impacts of message awareness and message knowledge on FV  
134 consumption were investigated using t-tests and ANOVA. There were no missing data. FV  
135 consumption data were normally distributed.

136

## 137 **Results**

138 Complete responses were gained from 507 suitable individuals. Demographic details are given in  
139 Table 1.

140

141 Table 1 about here

142

143 **FV Consumption:** Mean (standard deviation) self-reported FV consumption was 3.7 (1.8)  
144 portions/day, range = 0-10 portions.

145

146 **Awareness of the 5-a-day message:** Of 507 individuals, 450 (88.8%) were aware of the 5-a-day FV  
147 message, and all of these recounted the message correctly. More individuals in both the youngest  
148 and oldest age groups were unaware of the message than would be expected ( $\chi^2=17.03$ ,  $df=7$ ,

149 p=0.02), but no differences were found dependent on gender or occupation group (largest ( $\chi^2=8.66$ ,  
150 df=5, p=0.12).

151

152 Individuals who were aware of the message reported greater FV consumption (mean (standard  
153 deviation) = 3.9 (1.8) portions/day) than those not aware (mean (standard deviation) = 2.8 (1.4)  
154 portions/day) (t(505)=4.42, p<0.01).

155

156 **Knowledge of the 5-a-day message:** In those who were aware of the message (n=450), aspects of  
157 the FV message of greatest confusion are given in Table 2. FV consumption was higher in those who  
158 reported no confusion (mean (standard deviation) = 4.1 (1.8) portions/day) than in those who  
159 reported any confusion (mean (standard deviation) = 3.5 (1.7) portions/day) (t(431)=3.35, p<0.01).  
160 However, there was not one aspect of the message that caused more confusion than any other  
161 (F(5,190)=1.26, p=0.29).

162

163 Table 2 about here

164

## 165 **STUDY 2**

### 166 **Method**

167 Study 2 used a comprehensive 10-item postal questionnaire administered across the UK, to a  
168 representative population sample.

169

170 **Questionnaire:** The questionnaire consisted of two questions on FV consumption, two questions on  
171 awareness of the 5-a-day message, four questions on knowledge of the details of the message, and  
172 two questions on demographic and lifestyle characteristics, in this order.

173

174 FV consumption was assessed using two open-response questions. The first question was used to  
175 *calculate* quantities of FV consumed by the respondent at various time points (before breakfast,  
176 breakfast, morning, lunch, afternoon, evening meal, evening) on a typical weekday and weekend day.  
177 Amounts were reported as household measures e.g. tablespoons, and converted into portions by a  
178 researcher. Prompts were included to ensure consideration of all types of fruits and vegetables. The  
179 second question asked respondents to estimate overall FV consumption using the question '*How*  
180 *many portions of fruit and vegetables do you think you consume per day, on average?*'. The  
181 questions were used to determine *calculated* and *estimated* FV consumption respectively, and  
182 demonstrate any discrepancies between the two measures.

183

184 To assess awareness of the message, respondents were asked two open-response questions on  
185 awareness of the 5-a-day FV message '*Are you aware of the 5-a-day FV message?*' and '*What do you*  
186 *think it means?*'.

187

188 FV knowledge was assessed in all respondents who were aware of the message, using four  
189 structured closed-response questions on: 1) the foods that are included in the message; 2) the  
190 portion sizes that are required for the message; 3) the variety that is required for the message; and  
191 4) the reasons for FV consumption. The question on the foods that are included in the message  
192 asked respondents whether 35 commonly consumed food items <sup>(23)</sup> (5 standard fruits, 5 standard  
193 vegetables, 5 processed fruits, 4 processed vegetables, 3 pulses, 5 composite dishes, 4 types of  
194 potatoes, 4 obvious errors (coffee, chocolate, jam, wine) were considered FV according to the  
195 message, using response options '*yes*', '*no*', '*don't know / not sure*'. The question on portion sizes  
196 asked respondents to specify the number of FV portions in example quantities of 27 commonly  
197 consumed food items <sup>(23)</sup> (4 standard-sized fruit, 4 small fruit, 4 large fruit, 10 standard vegetables, 5  
198 composite dishes). The question used the format '*According to the 5-a-day FV message, how much*  
199 *of a portion would be provided by: 1 apple?; ½ banana?; 7 cherries?;* etc. Response options were  
200 '*0*', '*1/3*', '*1/2*', '*1*', '*2*', '*don't know / not sure*'. The question on the variety required for the message  
201 asked respondents to specify the number of portions that would be provided in a day, if a person  
202 consumed 15 combinations of specified portions of FV. Eight combinations used standard single  
203 portions of FV, and seven combinations used duplicate portions of FV that should only be counted as  
204 one portion, e.g. 3 bananas. The question used the format '*According to the 5-a-day message, how*  
205 *many portions would be provided if a person consumed the following in a single day: 1 apple, 1*  
206 *banana, and 1 glass of orange juice?; 3 bananas?;* etc. Response options were '*0*', '*1*', '*2*', '*3*', '*4*',  
207 '*don't know / not sure*'. The question on reasons for the message asked respondents whether 25  
208 different health conditions were impacted by FV consumption, using response options '*yes, and*  
209 *there is plenty of evidence for this*' (11 conditions), '*yes, possibly, but there is only a little evidence for*  
210 *this*' (10 conditions), '*no*' (4 conditions), '*don't know / not sure*'. All questions were designed to allow  
211 a detailed understanding of participants' knowledge of each of the aspects of the 5-a-day FV  
212 message. For all questions, a correct response, based on current recommendations from the UK  
213 Government<sup>(12)</sup>, was scored +1, an incorrect response was scored -1, and '*don't know / not sure*' was  
214 scored 0. Missing values were also completed with 0 where found. Respondents who were unaware  
215 of the message were asked to bypass the knowledge questions, and complete only the following



216 demographic and lifestyle questions. The complete questionnaire is provided in supplementary  
217 materials.

218

219 Demographic and lifestyle characteristics assessed were: gender, age, marital status, living status,  
220 region of residence, number of years of education, smoking habits, alcoholic drinking habits, dietary  
221 supplement taking habits, height and weight (used to calculate BMI), and month of questionnaire  
222 completion. These characteristics have all previously been associated with FV consumption and  
223 dietary knowledge (<sup>13,14,16,17,20-22,25,31-33</sup>).

224

225 **Questionnaire Administration:** The questionnaire was administered by post to 1200 individuals  
226 residing across the whole of the UK in 2013, and to 500 additional individuals in 2015. Names and  
227 addresses were gained for a sample of individuals representative of the UK population according to  
228 the UK 2011 census in gender, age, and region of residence from data sampling company  
229 SampleAnswers (London, UK). Questionnaires were sent to 100 individuals per month from Jan. –  
230 Dec. 2013. Questionnaires were sent throughout the year to capture seasonal variation in fruit and  
231 vegetable intake, but from this initial questionnaire administration, disproportionately low  
232 responses were gained from young people and in the months of January, February, May, September  
233 and October, thus a further 100 questionnaires from the original sample and a further 10  
234 questionnaires for Bournemouth University students were administered in these months in 2015.

235

236 **Data Analysis:** Data were entered into SPSS and analysed using descriptive statistics and multiple  
237 linear regression. Only questionnaires with one measure of FV consumption and less than 20%  
238 missing data were used. Missing data were completed with 'don't know / not sure' responses.  
239 Multiple linear regression models investigated associations between calculated and estimated FV  
240 consumption and knowledge of the 5-a-day FV message, where FV consumption was predicted by  
241 each aspect of message knowledge. Demographic and lifestyle characteristics were also included in  
242 all models to account for known variation between FV consumption, knowledge and various  
243 demographic and lifestyle characteristics. Scores out of 100 (percent knowledge) were used in  
244 regression models comparing knowledge of the different aspects of the message to allow  
245 comparability.

246

## 247 **Results**

248 Of 1750 questionnaires, complete responses were gained from 247 (14%) individuals. Details of the  
249 sample are given in Table 3. The sample was representative of the UK population in terms of age

250 ( $\chi^2=10.9$ ,  $df=7$ ,  $p>0.05$ ), but more females and more individuals living in the South completed the  
251 questionnaire than would have been expected (smallest  $\chi^2=11.8$ ,  $df=1$ ,  $p<0.05$ ). Number of  
252 questionnaires completed per month was even across the year ( $\chi^2=15.4$ ,  $df=11$ ,  $p>0.05$ ).

253

254 **FV Consumption:** Mean (standard deviation) calculated FV consumption was 4.2 (2.0) portions/day,  
255 range = 0-9 portions and mean (standard deviation) estimated FV consumption was 4.1 (1.6)  
256 portions/day, range = 0-10 portions. These two measures were highly correlated ( $r=0.53$ ,  $p<0.01$ ),  
257 and did not significantly differ ( $t(246)=0.79$ ,  $p=0.43$ ). Calculated FV consumption was higher in  
258 females than males ( $t(240)=2.20$ ,  $p=0.03$ ), and was positively associated with taking vitamin  
259 supplements ( $r=0.13$ ,  $p=0.04$ ). Estimated FV consumption was higher in married than non-married  
260 individuals ( $t(241)=4.53$ ,  $p<0.01$ ), and was associated with a higher age ( $r=0.31$ ,  $p<0.01$ ) and taking  
261 vitamin supplements ( $r=0.13$ ,  $p=0.04$ ).

262

263 **Awareness of the 5-a-day message:** Of 247 individuals, 239 (96.8%) were aware of the 5-a-day FV  
264 message, and all those who recounted the message (209 individuals (87.4%)) did so correctly.  
265 Differences between those who were and were not aware of the message were not investigated due  
266 to the low numbers who reported not being aware of the message and then completed the  
267 questionnaire.

268

269 **Knowledge of the 5-a-day message:** Number of correct responses to each of the knowledge  
270 questions is given in Table 4. Knowledge of all individual aspects of the message were correlated  
271 (smallest  $r=0.16$ ,  $p=0.01$ ). Percentage knowledge was higher for which foods are included > reasons  
272 for consumption > portion sizes > the need for variety (smallest  $t(238)=6.23$ ,  $p<0.01$ ).

273

274 Total knowledge was higher in married than non-married respondents ( $t(234)=5.42$ ,  $p<0.01$ ), and  
275 was associated with a higher age, living further South, and smoking less (smallest  $r=-0.19$ ,  $p<0.01$ ).  
276 Knowledge of which foods are included was higher in females than males ( $t(233)=3.70$ ,  $p<0.01$ ).  
277 Knowledge of portion sizes and reasons for consumption was higher in married than non-married  
278 respondents (smallest  $t(234)=4.28$ ,  $p<0.01$ ), and was associated with a higher age, living further  
279 South, and smoking less (smallest  $r=-0.13$ ,  $p=0.04$ ). Knowledge of the need for variety was higher in  
280 married than non-married respondents (smallest  $t(234)=2.17$ ,  $p=0.03$ ).

281

282 Table 4 about here

283

284 To further explore the sources of errors for each of the types of knowledge, number of correct  
285 answers to each of the individual elements were also investigated. Mean and standard deviation (st.  
286 dev.) scores out of 100 are provided in Table 5 for each question.

287

288 In relation to the question on which foods are included, more correct answers were obtained for the  
289 questions on standard fruits > standard vegetables, processed fruit and obvious errors > processed  
290 vegetables and pulses > potatoes > composite dishes (smallest  $t(238)=2.85$ ,  $p<0.01$ ). Considering the  
291 question on portions sizes, more correct answers were obtained for questions on standard fruits >  
292 large-sized fruit > small-sized fruit, standard vegetables and composite dishes (smallest  $t(238)=3.32$ ,  
293  $p<0.01$ ). Considering the question on the need for variety, more correct answers were given in  
294 response to the questions using standard combinations > questions using combinations involving  
295 duplicates ( $t(238)=16.45$ ,  $p<0.01$ ). Considering the question on reasons for consumption, more  
296 correct answers were given for the questions on conditions not associated with FV > conditions  
297 definitely associated with FV consumption > conditions possibly associated with FV consumption  
298 (smallest  $t(238)=2.20$ ,  $p=0.03$ ).

299

300 Table 5 about here

301

302 **Knowledge of the message and FV consumption:** Both calculated and estimated FV consumption  
303 were predicted by total number of correct answers to the knowledge questions (calculated:  
304  $Beta=0.15$ ,  $p=0.06$ ; estimated:  $Beta=0.17$ ,  $p=0.02$ ). When individual types of knowledge were  
305 assessed, both calculated and estimated FV consumption were predicted by number of correct  
306 answers to the which foods are included question (smallest  $Beta=0.15$ ,  $p=0.03$ ), the portion size  
307 question (smallest  $Beta=0.24$ ,  $p<0.01$ ) and the reasons for consumption question (smallest  
308  $Beta=0.16$ ,  $p=0.03$ ), but when included together no one aspect of knowledge was more important  
309 than the other two (largest  $Beta=0.18$ ,  $p=0.11$ ).

310

## 311 **DISCUSSION**

312 Several key findings emerge from these two studies: 1) the majority of individuals were aware of the  
313 5-a-day message and could recount this correctly (Studies 1 and 2); 2) awareness of the message was  
314 associated with greater FV consumption (Study 1); 3) potential confusion over the details of the  
315 message was high (Study 1) and knowledge of the details of the message was low (Study 2); 4) the  
316 elements of the message of greatest confusion / lowest knowledge related to portion sizes (Studies  
317 1 and 2) and the need for variety (Study 2); 5) knowledge differed for different types of FV and

318 different reasons for consumption (Study 2); 6) greater confusion / lower knowledge of the details of  
319 the message were associated with lower FV consumption (Studies 1 and 2); but 7) no one element of  
320 confusion or knowledge was associated with FV consumption (Studies 1 and 2).

321

322 Regarding awareness, high awareness of the 5-a-day message has been reported in other populations  
323 (<sup>13,15</sup>). We suspect that the relatively higher rates of awareness reported in study 2 may be due to a  
324 reporting bias, where individuals who were unaware of the message were simply less likely to return  
325 the (mostly incomplete) questionnaire and that population rates of awareness of the 5-a-day  
326 message are likely to be closer to 85% of the population as in Study 1. Levels of awareness of around  
327 80-85% of the population have been reported previously both in the UK (<sup>17,18</sup>) and elsewhere (<sup>13,16,27</sup>).  
328 This awareness is likely to have resulted from a variety of sources including Government campaigns,  
329 e.g. Change for Life; TV, billboard and magazine advertising; local health promotion campaigns in GP  
330 surgeries, schools and workplaces; and advertising campaigns in supermarkets and on food  
331 packaging (<sup>11,13-16,18</sup>). An association between awareness of the message or a FV message campaign  
332 and higher FV consumption has also previously been reported (<sup>15-17,20,21</sup>).

333

334 High confusion surrounding the message and low knowledge of the details of the message have also  
335 previously been reported. Qualitative studies suggest poor knowledge in the majority of participants  
336 (<sup>27-31</sup>), and the few questionnaire studies that have been conducted suggest poor knowledge across  
337 populations (<sup>13,18-20</sup>).

338

339 Particular confusion over portion sizes has also previously been reported (<sup>18,19,27,28,30</sup>), and both  
340 qualitative and quantitative earlier studies suggest particular difficulties with smaller FV items,  
341 vegetables and composite dishes as was found in our data (<sup>19,20,28,31</sup>). Errors in particular are  
342 suggested to be more likely, where different portion sizes are used for different FV items (<sup>28</sup>), and  
343 this is particularly the case for small items. Difficulties with estimating portions of vegetables and the  
344 components of composite dishes may also arise as a result of their usual small contribution to a  
345 portion. Greater ease has previously been noted where one portion is equivalent to one 'whole' and  
346 'discrete' FV item (<sup>28,31</sup>).

347

348 Confusion over portion sizes was also, in some individuals, related to confusion over the number of  
349 servings required: in the UK, some individuals reported believing the 5-a-day message relates to 5  
350 portions of fruit and 5 portions of vegetables per day (<sup>28</sup>), as was also found here in Study 1, and in  
351 Australia, where the FV message specifies 2 fruits and 5 vegetables, individuals report confusion as

352 to whether they should consume 5 different vegetables, 5 cups of vegetables, or 5 plates of  
353 vegetables, while the actual recommendation is 5 half cups (<sup>27</sup>).

354

355 Qualitative studies have also reported a lack of understanding over the need for variety. Several  
356 studies report a failure among participants to appreciate the need for a variety of FV for health  
357 benefits (<sup>20,28,29,31</sup>), or the need even for fruits and vegetables (<sup>31</sup>). Correct answers were particularly  
358 low in our data for the combinations containing duplicates compared to those using single items.  
359 The low knowledge of variety in our study may also relate to low knowledge of portion sizes, as  
360 variety was assessed by asking for number of portions consumed in a day, so some (simple) portion  
361 size knowledge was required.

362

363 Limited studies have also reported a positive association between knowledge of portion sizes and FV  
364 consumption (<sup>20</sup>). Nutritional knowledge is a known predictor of healthy eating, including FV  
365 consumption (<sup>21,32-36</sup>), and studies of other specific aspects of dietary knowledge have been  
366 associated with specific dietary practices and healthier diets (<sup>34-36</sup>).

367

368 Interestingly, in our study, while total knowledge of the 5-a-day FV message was positively  
369 associated with FV consumption, knowledge of no one particular aspect of the message was more  
370 important than any other aspect. These findings may plausibly suggest that it is not one particular  
371 type of knowledge that is important, but the combination of all types of knowledge that results in a  
372 higher FV consumption. Thus while consumers can highlight confusion over portion sizes, and while  
373 portion size knowledge can be related to FV consumption, knowledge on portion sizes is only part of  
374 the picture, and the other elements of the message should not be ignored. Reassuringly, these  
375 findings might also suggest that general knowledge of all elements of the message may be more  
376 beneficial for consumption than detailed knowledge of any one aspect, or alternatively, that  
377 different consumers may struggle with different elements of the message. In both cases, it would  
378 appear that as a population, education is still needed on all elements of the 5-a-day message.

379

380 Appropriate routes for this education can be suggested. Some Government campaigns have been  
381 revised to specify number of fruits and vegetables separately to address the need for variety. For  
382 example in the Netherlands, consumers are asked to aim for 2+2 fruits and vegetables, and in  
383 Australia, consumers are asked to aim for 2&5 fruits and vegetables respectively (<sup>1</sup>). In New Zealand,  
384 the campaign logo depicts a hand as a suggestion for portion size (<sup>13</sup>). Preferences for portion size  
385 measures (grams, handfuls, cups, spoons), however have been found to vary widely (<sup>13,28,31</sup>).

386 Alternatively, more detailed knowledge may be provided via campaign and promotional materials,  
387 such as posters, leaflets or magazine articles (<sup>11,13-16,18,28</sup>), and through increased information on food  
388 packaging and menus (<sup>28</sup>). Other suggestions largely incorporate knowledge as part of a wider  
389 intervention (<sup>37-39</sup>). These types of intervention, however, tend to be more complex and individually  
390 based, and while success on an individual basis is often reported (<sup>37-39</sup>), these types of intervention  
391 can be costly and time-consuming to implement and so impractical on a population-wide basis (<sup>37</sup>).

392

393 Nonetheless, the argument for increased FV intakes on a population-wide basis is compelling.  
394 Recent estimates suggest that 1.8% total global burden of disease (<sup>40</sup>) and approximately 16 million  
395 global disability adjusted life years (DALYs) (<sup>40</sup>) can be attributed to inadequate FV intakes. Estimates  
396 for the UK suggest 2-7% burden of disease (assessed using DALYs) (<sup>41</sup>) from inadequate FV intakes,  
397 and that an increase in consumption of one additional FV portion/day across the population could  
398 reduce risk of CHD incidence and stroke by approximately 4 and 5% respectively (<sup>42,43</sup>). We make no  
399 suggestion here for the ideal route for increasing knowledge of the details of the 5-a-day FV message  
400 on a population-wide basis. Further work is clearly needed. We also make no suggestion that  
401 increasing knowledge of the details of the 5-a-day message may increase FV consumption more  
402 effectively or efficiently than other (non-knowledge) types of intervention. Interventions aiming to  
403 improve taste or motivation, and interventions using environmental changes and ‘nudging’  
404 principles are also demonstrating some success (<sup>e.g.1,44-46</sup>).

405

406 The strengths of our research include the comparability of the results from the two studies, our  
407 consideration of knowledge in relation to the 5-a-day FV message and use of detailed measures of  
408 knowledge, and our consideration also of FV consumption. Socio-demographic associations with FV  
409 consumption are also similar to those found in other studies of the UK population (<sup>e.g.22,23</sup>). Our Study  
410 1 may be confounded to some extent by social desirability (<sup>15</sup>), but, given the detail required, this is  
411 less likely in Study 2. Conversely, study 2 may be confounded by possible responder bias (<sup>19</sup>), but this  
412 is unlikely to have affected the results of Study 1. Females and individuals living in the South of the  
413 UK were over-represented in our final sample, limiting the conclusions that can be drawn about the  
414 UK population as a whole. Both females and those living in the South (as a result of a warmer climate  
415 and higher affluence) are also more likely to consume FV and more likely to hold higher FV  
416 knowledge (<sup>22,23,32,33</sup>), but we have no reason to believe the associations between these variables  
417 would differ by gender or region. Both studies are limited by the use of self-report measures for FV

418 consumption, and poor knowledge will result in inaccuracies. Self-report measures of dietary intake,  
419 however, are necessary and commonly used in questionnaire studies such as these (13,18-22,45,46).

420

## 421 **CONCLUSIONS**

422 These findings suggest that, while most of the UK population are aware of the 5-a-day FV message  
423 and can recount this correctly, the details of the message are not well known, and that FV  
424 consumption is related to this knowledge. These findings suggest that strategies to increase FV  
425 consumption will benefit from increasing consumers' knowledge of the details of all aspects of the 5-  
426 a-day FV message. The findings also suggest that greatest confusion and least knowledge surrounds  
427 the details of portion sizes and the need for variety, although knowledge of these details does not  
428 explain FV consumption.

429

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434 undertook all analyses and wrote the first draft of the manuscript. All authors reviewed the draft of  
435 the manuscript and offered critical comments.

436

## 437 **Transparency statement**

438 The lead author affirms that this manuscript is an honest, accurate, and transparent account of the  
439 study being reported. The reporting of this work is compliant with STROEBE guidelines. The lead  
440 author affirms that no important aspects of the study have been omitted and that any discrepancies  
441 from the study as planned have been explained.

442

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551 Table 1: Demographic details of the sample gained for Study 1 (N=507).

552

Characteristic	Description	Number (%) of respondents
Gender	Male	190 (37.5%)
	Female	314 (61.9%)
Age	Individuals aged < 20 years	165 (32.5%)
	Individuals aged 20-29 years	13 (2.6%)
	Individuals aged 30-39 years	67 (13.2%)
	Individuals aged 40-49 years	55 (10.8%)
	Individuals aged 50-59 years	69 (13.6%)
	Individuals aged 60-69 years	61 (12.0%)
	Individuals aged 70-79 years	48 (9.5%)
	Individuals aged ≥ 80 years	26 (5.1%)
Employment	Professionals	93 (18.3%)
	Skilled non-manual workers	115 (22.7%)
	Skilled manual workers	80 (15.8%)
	Non-skilled manual workers	73 (12.4%)
	Students	118 (23.3%)
	Unemployed	37 (7.3%)

553

554

555 Table 2: Aspects of the FV message of greatest confusion, in those who were aware of the message  
556 (n=450)

557

Aspect of the message	Number (%) of respondents <sup>#</sup>
Confused by which foods count as fruit and vegetables	23 (5.0%)
Confused by how much was needed for a portion	135 (29.9%)
Confused by the need for 5 different fruits and vegetables	27 (5.9%)
Confused by the reasons for consuming fruit and vegetables	10 (2.2%)
Thought the number 5 referred to 5 fruits and 5 vegetables per day	4 (0.9%)
Thought the number was more or less than 5	4 (0.9%)
Not confused by any aspect of the message	240 (53.3%)

558 <sup>#</sup>Percentages do not total 100% because multiple responses were allowed.

559

560

561 Table 3: Demographic details of the sample for Study 2 (n=247).

Characteristic	Description	Number (%) of respondents
Gender	Males	80 (32.4%)
	Females	167 (67.6%)
Age	Individuals aged < 20 years	27 (10.9%)
	Individuals aged 20-29 years	53 (21.4%)
	Individuals aged 30-39 years	30 (12.1%)
	Individuals aged 40-49 years	24 (9.7%)
	Individuals aged 50-59 years	32 (13.0%)
	Individuals aged 60-69 years	36 (14.6%)
	Individuals aged 70-79 years	25 (10.1%)
	Individuals aged ≥ 80 years	11 (4.4%)
Marital status	Married	103 (41.7%)
	Single / Divorced / Separated	140 (56.7%)
Living status	Living alone	42 (17.0%)
	Lving with others	201 (81.4%)
Region of residence	Scotland and Northern Ireland	17 (6.9%)
	North England	22 (8.9%)
	Midlands and Wales	46 (18.6%)
	South	158 (64.0%)

562

563

564

565 Table 4: Mean, standard deviation (st. dev.) range, and maximum possible (max. poss.) number of  
 566 correct answers to the questions on 1) what was included in the message; 2) portion sizes; 3) the  
 567 need for variety; and 4) reasons for consumption – Study 2 (N=239). Mean and standard deviation  
 568 (st. dev.) scores out of 100 have also been calculated to allow comparison between knowledge of  
 569 the different aspects of the message.  
 570

	Mean <sup>#</sup>	St. dev.	Min. #, Max.	Min. #, Max. poss.
Which foods are included in the 5-a-day FV message – scores (scores out of 100)	20.8 (59.4) <sup>a</sup>	6.9 (19.6)	-17, 35	-35, 35
Portion sizes for the 5-a-day FV message – scores (scores out of 100)	3.9 (14.4) <sup>c</sup>	8.6 (31.7)	-19, 18	-27, 27
Need for variety in the 5-a-day FV message – scores (scores out of 100)	-0.6 (-4.0) <sup>d</sup>	6.0 (40.0)	-13, 15	-15, 15
Reasons for consumption – scores (scores out of 100)	7.0 (27.6) <sup>b</sup>	7.2 (28.9)	-15, 20	-25, 25
Total	30.1	20.0	-23, 80	-102, 102

571 <sup>#</sup>a negative score implies more incorrect answers than correct answers

572 <sup>a,b,c,d</sup>different superscripts denote significant differences between questions (p<0.01)

573

574

575 Table 5: Mean and standard deviation (st. dev.) number of correct answers scored out of 100 for  
 576 each knowledge question – Study 2 (N=239)

577

<b>Which foods are included in the 5-a-day FV message</b>	Mean <sup>#</sup>	St. dev.
Standard fruit, e.g. apple (5 items)	97.3 <sup>a</sup>	15.6
Standard vegetables, e.g. green beans	86.8 <sup>b</sup>	24.7
Processed fruit, e.g. tinned pineapple	83.8 <sup>b</sup>	31.2
Processed vegetables, e.g. fried onion	42.1 <sup>c</sup>	48.0
Pulses, e.g. lentils	38.0 <sup>c</sup>	60.9
Composite dishes, e.g. stew (1/3 meat, 1/3 onions and root vegetables, 1/3 potatoes)	-0.1 <sup>e</sup>	60.1
Potatoes, e.g. chips	27.5 <sup>d</sup>	57.6
Obvious errors, e.g. wine	87.1 <sup>b</sup>	24.7
<b>Portion sizes for the 5-a-day FV message</b>		
Standard fruit, e.g. one apple	44.2 <sup>a</sup>	29.8
Small-sized fruit, e.g. 7 cherries	8.9 <sup>c</sup>	54.8
Large sized fruit, e.g. quarter of a melon	19.9 <sup>b</sup>	41.8
Standard vegetables, e.g. one tablespoon of green beans	4.6 <sup>c</sup>	33.3
Composite dishes, e.g. 3 tablespoons of stew (1/3 meat, 1/3 onions and root vegetables, 1/3 potatoes)	1.1 <sup>c</sup>	49.9
<b>Need for variety in the 5-a-day FV message</b>		
8 straightforward combinations, e.g. one apple, one banana, one glass of fruit juice	16.3 <sup>a</sup>	47.2
7 combinations involving duplicates, e.g. 3 bananas	-27.1 <sup>b</sup>	57.2
<b>Reasons for consumption</b>		
Conditions definitely associated with FV consumption, e.g. stroke	29.4 <sup>b</sup>	37.2
Conditions possibly associated with FV consumption, e.g. sunburn	21.1 <sup>c</sup>	40.3
Conditions not associated with FV consumption, e.g. measles	38.4 <sup>a</sup>	48.4

578 <sup>#</sup>a negative score implies more incorrect answers than correct answers

579 <sup>a,b,c,d,e</sup>different superscripts denote significant differences between question parts (p<0.05)

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581

582