



## Knowledge and attitudes towards Vitamin D food fortification

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## Knowledge of vitamin D

**Abstract**

**Purpose:** Vitamin D deficiency is a well-recognised public health problem within the UK, with specific population groups more vulnerable to deficiency. Two pilot studies were used to explore awareness of vitamin D deficiency and attitudes towards food fortification.

**Methodology:** A survey of 120 participants from five at risk groups (South Asians, Blacks, Middle Eastern, Far Eastern and Caucasian older adults over 65 years) plus a **group of British Caucasians who do not avoid sun exposure**, explored awareness of vitamin D, sun exposure knowledge and behaviour, and attitudes towards food fortification. **The latter group was included to provide a comparison group who were at a reduced risk of deficiency.** Chi-square ( $\chi^2$ ) was used to test associations between categorical variables and the study groups. The second study utilized three focus groups and two interviews, conducted on young South Asian females and examined knowledge and awareness of vitamin D and vitamin D fortified foods.

**Findings:** A lack of knowledge and misconceptions were highlighted by both studies in relation to at risk factors **including sunlight exposure ( $p=0.037$ ), dietary intakes ( $p=0.0174$ ), and darker skin pigmentation ( $p=0.023$ ),** sources of vitamin D and the health benefits associated with optimal consumption. Attitudes to mandatory fortification of some foods varied significantly ( $p = 0.004$ ) between the groups with acceptance rates for Blacks (68%), those over 65 years (50%), Middle Eastern (67%) and Far Eastern (73%), whereas the control (71%) showed no acceptance, and South Asians gave a mixed response (48% No). Focus group findings highlighted positive views towards fortification although this was less for mandatory as opposed to voluntary fortification. Both pilot studies highlight the need for more research into this area, in order to create more effective public health policies.

Knowledge of vitamin D

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27 **Originality/value:** The research presents novel insights into a topical area where there is  
28 limited research.

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31 **Key words:** vitamin D deficiency, knowledge, consumer attitudes, fortification, at risk  
32 groups

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34 **Classification:** research paper

## Knowledge of vitamin D

35 **Introduction**

36 Vitamin D deficiency has gained great interest recently both in the UK and further afield  
37 (Palacios and Gonzalez, 2014), with a number of new health conditions now being associated  
38 with deficiency, which is on the increase globally (Borradale and Kimlin, 2009, Chowdhury  
39 et al., 2014, Holick, 2017). The UK, and countries of similar latitude, are particularly  
40 susceptible to vitamin D deficiency due to inadequate UVB-sunlight exposure from October  
41 to April.

42 In addition to latitude, additional factors increase the risk of developing deficiency including;  
43 aging, obesity, sunscreen use, cultural practices which cover the skin and darker skin  
44 pigmentation, with individuals with higher amounts of melanin requiring longer sun exposure  
45 to synthesise vitamin D (Battault et al., 2013, McAree et al., 2013, Reeder et al., 2012). This  
46 is exacerbated when those with darker pigmentation migrate to northern latitudes such as  
47 northern Europe, including the UK, making them more prone to vitamin D deficiency  
48 (Ashwell et al., 2010, Kift et al., 2013, Meyer et al., 2008, Pearce and Cheetham, 2010).

49 As minimal vitamin D is synthesised during winter, a greater dependence on dietary sources  
50 occurs (Cashman, 2007, Ashwell et al., 2010). UK dietary recommendations have been  
51 reviewed and updated by the Scientific Advisory Committee on Nutrition (SACN, 2016)  
52 calling for a **Reference Nutrient Intake** of 10µg/ day for the vitamin for the first time,  
53 including the elderly, pregnant and lactating women and those from ethnic groups who have  
54 pigmented skin, where again 10µg/day is recommended. However, it has been suggested the  
55 UK South Asian population are unaware of these recommendations (Farrar et al., 2011).

56 In the UK dietary sources include oily fish, egg yolk, and meat (Ashwell et al., 2010).  
57 However, these foods are infrequently consumed (Cashman, 2012). Black et al. (2012)  
58 propose a typical Western-style diet is currently unable to provide 10 – 20 µg of vitamin  
59 D/day, with evidence from the National Diet and Nutrition Surveys supporting this, with

## Knowledge of vitamin D

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3 60 typical mean daily intakes being considerably lower than the **Reference Nutrient Intake** for  
4  
5 61 both children and the elderly (Bates et al., 2012).

6  
7 62 There have been calls nationally among certain vitamin D researchers to introduce a more  
8  
9 63 comprehensive **fortification of food with vitamin D** policy in the UK where very few foods  
10  
11 64 are currently fortified. This position is in stark contrast to the fortification practices in the  
12  
13 65 USA and Canada where fortified foods are the main dietary source of vitamin D (Calvo and  
14  
15 66 Whiting, 2006). Furthermore, the introduction of **the fortification of food with vitamin D** of  
16  
17 67 all liquid dairy products and fat spreads in Finland in the mid 2000's has resulted in clear  
18  
19 68 benefits to population vitamin D status (Boucher, 2012, Jääskeläinen et al., 2017),  
20  
21 69 highlighting the potential for food fortification in addressing vitamin D deficiency.

22  
23  
24 70 Dietary staples such as milk, dairy products, juice, cereals and bread are typically fortified  
25  
26 71 with vitamin D (Kiely and Black, 2012). However, these will only target selected groups of  
27  
28 72 the population and do not take into account variations in dietary habits, which should be  
29  
30 73 considered (Black et al., 2012) especially for at risk groups who may have culturally diverse  
31  
32 74 dietary habits.

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35 75 A review of fortification policy is becoming increasingly pertinent in light of the SACN  
36  
37 76 review. However, prior to any changes in food policy it is imperative to consider consumers  
38  
39 77 understanding of vitamin D and fortified foods, especially those most at risk of deficiency, so  
40  
41 78 as to develop effective public health policies.

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43  
44 79 There is very little information available regarding consumers' knowledge and awareness of  
45  
46 80 vitamin D and its dietary sources, especially in at risk groups of the population (Kung and  
47  
48 81 Lee, 2006). This project therefore describes two pilot studies that investigate awareness of  
49  
50 82 **dietary** vitamin D and attitudes towards food fortification among at risk groups living within  
51  
52 83 Newcastle-upon-Tyne, an area of the UK at increased risk of deficiency due to its latitude.

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Knowledge of vitamin D

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3 85 **Methodology**

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5 86 *Introduction*

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7 87 Two pilot studies were used; the first to establish awareness and knowledge of vitamin D by  
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9 88 means of a survey in five at risk groups of the population, and the second providing a more  
10  
11 89 in-depth exploration of attitudes towards the fortification of food with vitamin D by means of  
12  
13 90 both focus groups and interviews with one specific at-risk population group, so as to provide  
14  
15 91 insights into barriers and drivers of acceptance of vitamin D fortified foods. Studies were  
16  
17 92 conducted a year apart, with no individuals participating in both studies. Results of both  
18  
19 93 studies are then discussed together in the discussion so as to provide greater insight into  
20  
21 94 vitamin D awareness.

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24 95 *Study 1: Quantitative Pilot Study*

25  
26 96 The survey was adapted from a pre-existing questionnaire (Alemu and Varnam, 2012), being  
27  
28 97 modified to meet the research aims of this study. Questions were either updated or removed  
29  
30 98 and replaced by additional questions on sunshine exposure and dietary habits, ethnicity, UK  
31  
32 99 residency, vitamin D levels, and mandatory food fortification. Occupational categories were  
33  
34 100 deemed more appropriate than questions on income, and terms defined in a similar study by  
35  
36 101 Kung and Lee (2006) were used. Ethnicity categorisation was taken from the Economic and  
37  
38 102 Social Data Service Government publication (Afkhani, 2012), with the exception of the  
39  
40 103 Arabic/Middle Eastern category, that was added to reflect the inclusion of this target group.  
41  
42 104 The resulting survey consisted of 41 questions divided into four sections: demographics,  
43  
44 105 vitamin D awareness and knowledge, sun exposure habits and dietary intake, and attitudes  
45  
46 106 towards food fortification. Food groups were in the form of a short semi-quantitative Food  
47  
48 107 Frequency Questionnaire (FFQ).  
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50  
51 108 The study took place in Spring 2013. Participants were recruited from groups identified as  
52  
53 109 being at risk of deficiency included: older adults aged over 65 years, South Asians, Blacks,

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## Knowledge of vitamin D

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3 110 Middle Eastern, Far Eastern, and a group of **British** Caucasians who do not avoid sun  
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5 111 exposure. **This latter group was included so as to provide a comparison to a group who were**  
6  
7 112 **at a reduced risk of deficiency.** Research was conducted in line with the university ethics  
8  
9 113 policy (approval obtained October 2012 – see supplementary material).

10  
11 114 A screening questionnaire consisting of seven questions was also used to assign a target  
12  
13 115 group to each participant. **All surveys were completed on paper hard copies.** The majority of  
14  
15 116 surveys were completed face-to-face with a researcher with only a few exceptions, **whereby**  
16  
17 117 **surveys were taken home by participants,** and once completed surveys were either posted  
18  
19 118 back to the University or collected at a later date **from community group locations by a**  
20  
21 119 **researcher. As the survey was only available in English** assistance was offered in reading the  
22  
23 120 questions. **This was provided by English speaking community group members in the presence**  
24  
25 121 **of a researcher so as to enable any questions to be asked.**

122 *Study 2: Qualitative Pilot Study*

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29 123 Qualitative methods were chosen for the second pilot study due to their ability to provide in-  
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31 124 depth information and elicit underlying reasoning from participants, something that is not  
32  
33 125 always possible during quantitative research (Threlfall, 1999). Both focus groups and  
34  
35 126 interviews were used.

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39 127 Careful consideration was paid to controllable aspects known to contribute towards focus  
40  
41 128 group best practice, including focus group environment, the research team and participant  
42  
43 129 recruitment. Both focus groups and interviews were held on campus in Spring 2014, and were  
44  
45 130 recorded to enable transcription and subsequent analysis. A moderator and an assistant  
46  
47 131 researcher were also present to help record participant body language and facial expression,  
48  
49 132 to help inform the face validity of the results.

## Knowledge of vitamin D

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3 133 Although debate still exists as to the best composition of focus groups, pre-existing friendship  
4  
5 134 groups were used in this research to make use of the “naturalistic exchanges” between  
6  
7 135 participants, and to encourage the disclosure of information.  
8

9 136 Convenience, purposeful sampling was used to ensure that young South-Asian females were  
10  
11 137 recruited for the study. Participation was restricted to those who could speak English, but  
12  
13 138 there was no restriction on how long participants had resided in the UK. Awareness of the  
14  
15 139 focus groups was raised at three locations around campus known to be frequented by  
16  
17 140 international students, with students being invited to leave their contact details with  
18  
19 141 researchers so that they could be provided with more information  
20  
21

22 142 A semi-structured approach was taken, with a discussion guide being created from a detailed  
23  
24 143 literature review in relations to the aims of the investigation. Questions were asked to  
25  
26 144 establish participants’ baseline awareness and attitudes towards vitamin D, sources and health  
27  
28 145 benefits, with further information provided about the health consequences of deficiency after  
29  
30 146 initial discussions were held.  
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33 147 Due to participant non-attendance at focus groups, two individual interviews were also  
34  
35 148 conducted using the same discussion guide as the focus groups. These provided a further  
36  
37 149 opportunity to explore participants’ attitudes and knowledge, whilst not being affected by  
38  
39 150 group bias, a potential risk in focus groups (Threlfall, 1999).  
40  
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42 151  
43 152 *Data Analysis*

44 153 SPSS version 19.0 (SPSS, 2010) was used for analysis. Chi-square ( $\chi^2$ ) tests were used to  
45  
46 154 examine associations between the study groups and the questions at the 5% significance level  
47  
48 155 ( $p < 0.05$ ). Analysis of the awareness of the health benefits of vitamin D and preference for  
49  
50 156 voluntarily fortified foods included the study groups as a total group ( $n=120$ ). Therefore, no  
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## Knowledge of vitamin D

157  $\chi^2$  associations were made, however the frequency (and percentage) of the stated health  
158 benefits are shown.

159 A thematic approach was taken to data analysis, which enabled key themes to be identified  
160 and reported across data sets (Braun and Clarke, 2006) relevant to the aims of the study. After  
161 having familiarised themselves with the transcripts researcher notes, codes were ascribed to  
162 describe meaning of the data. These codes were then organised into themes that helped to  
163 explain the codes, in relation to the research aims.

**Results*****Study 1******Demographics***

168 Table 1 summarises participant demographic information in addition to their knowledge of  
169 sunlight as a source of vitamin D. 120 completed surveys were obtained, by significantly  
170 more females (53%) than males (45%;  $p = 0.001$ ), with their being a significant differences  
171 in age distribution across groups ( $p = <0.001$ ), period of residence in the UK ( $p=<0.001$ ),  
172 occupation ( $p<0.001$ ), and highest level of education ( $p<0.001$ ) across groups. A similar  
173 number of responses were obtained across at risk and the control groups as highlighted in  
174 table 1.

***Health benefits of vitamin D***

177 Table 2 summarises awareness of the health benefits associated with vitamin D among the  
178 whole group (n=120), with  $\chi^2$  analysis was not performed on this question due to the  
179 inclusion of the whole group. Bone health was the most common benefit mentioned, with  
180 37% of respondents stated that vitamin D is beneficial for this, with the next most frequent  
181 categories being healthy skin (18%) and general health/fitness (11%). More specific health

## Knowledge of vitamin D

182 conditions, such as those listed in Table 2, were spontaneously associated by no more than  
183 8% of respondents each.

184

185 *Risk Factors for vitamin D deficiency*

186 The belief that inadequate sun exposure is a risk factor for vitamin D deficiency, was  
187 significantly different between the groups ( $p = 0.037$ ). South Asians were most likely to  
188 know that inadequate sun exposure is a risk factor with 84% believing that it increased the  
189 risk of deficiency, followed by the British Caucasian group (71%). However, just 45% of  
190 those over 65 years believed it increases risk whilst a further 40% did not know. This was  
191 also evident among Black respondents, whereby 50% said it increases risk and 32% did not  
192 know.

193 Figure 1 highlights that awareness of natural darker skin pigmentation as a risk factor for  
194 vitamin D deficiency, was significantly different across groups ( $p=0.023$ ). Interestingly,  
195 almost half of South Asians (40%) thought having natural darker skin pigmentation does not  
196 affect the risk of vitamin D deficiency, whilst half of the Black respondents did not know. A  
197 similar response was also found among Middle Eastern and British Caucasian respondents  
198 whereby just over half (52%) said they did not know.

199 Awareness of inadequate dietary consumption as a risk factor for vitamin D deficiency, was  
200 not significantly different across groups ( $p = 0.174$ ). The majority of the South Asian and  
201 British Caucasian groups believed it increases risk (80% and 71%, respectively). However,  
202 there was much variation across the Middle Eastern group, in that 48% of respondents  
203 responding that it increases yet 43% did not know.

204 Although sun cream use was notable across the groups, over 40% of respondents in each  
205 group, except for Far Eastern respondents (only 27%), did not know that using sun cream is a

## Knowledge of vitamin D

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3 206 risk factor for deficiency. Few respondents in all groups said it increases risk, in the range of  
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5 207 2-3 respondents (data not shown).  
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7 208 Those over 65 years had the highest 'don't know' response as to whether inadequate sun  
8  
9 209 exposure is a risk factor for vitamin D deficiency; with 40% who did not know whilst just  
10  
11 210 45% said it increases risk. Likewise, 55% did not know that using sun cream is a risk factor  
12  
13 211 for deficiency thereby suggesting that those over 65 years have limited awareness of vitamin  
14  
15 212 D.

213 *Awareness and preference of fortification of foods with vitamin D*

214 Over 60% respondents in each at risk group, in particular 90% of Black respondents, were  
215 unaware of foods currently fortified with vitamin D. Interestingly the majority of the British  
216 Caucasian group (71%), as a group not as at-risk of deficiency, were aware of such foods. In  
217 terms of preferences of fortified products, breakfast cereals were most preferred (64%),  
218 followed by cow's milk (58%), fortified fruit juice (55%) and margarine and spreads (47%).  
219 Mandatory fortification of some foods would be accepted by Blacks (68%), those over 65  
220 years (50%), Middle Eastern respondents (67%), and the Far Eastern respondents (73%).  
221 However, the Caucasian British group (71% no) did not show acceptance whilst South Asians  
222 gave a mixed response (48% said yes, and 52% said no). This was significantly different  
223 between the groups ( $p=0.004$ ).

224 *Study 2*

225 In total three focus groups and two individual interviews were conducted on 16 South-Asian  
226 females all under the age of 25, with nine students from South-Asian countries having lived  
227 in the UK for less than a year.

228 General unawareness was a key theme to emerge across all focus groups and interviews in  
229 relation to dietary sources and vitamin D's role in health, with the sun being cited as a source

## Knowledge of vitamin D

of vitamin D by the majority of participants. However, the long-known association with bone health was less frequently identified by participants, although still the most frequently mentioned health benefit. Participants were therefore shocked by some of the consequences of vitamin D deficiency presented to them during the focus groups.

A number of participants, specifically those who had lived in the UK for less than a year, were unable to identify a source of vitamin D, with others, again who were not long-term UK residents, being unaware that vitamin D could be obtained from dietary sources, despite correctly identifying the sun as the main source of vitamin D. This general theme of unawareness also extended to participants' knowledge of at risk groups from vitamin D deficiency, with participants admitting to not knowing who would be most at risk. Interestingly, a small number of participants did cite pale skinned persons as being more at risk of deficiency, when in fact the opposite is true.

For those who indicated some previous awareness of vitamin D the media was cited as the main source, including recent advertising appeals;

*"I have heard about vitamin D because of yoghurt advert on T.V."* Focus Group 1,  
Participant 4

As well as a general unawareness of vitamin D, misconceptions also arose in relation to dietary sources of vitamin D and the health benefits from achieving and obtaining adequate vitamin D levels. This was highlighted by one participant citing that the main purpose of vitamin D within the body was to induce a sun tan.

Participants were also unaware as to the key concepts associated with fortification with "extra supplements" being the closest suggestions made by participants as to what fortification entailed, with the majority being unsure, despite their awareness of fortified

## Knowledge of vitamin D

255 foods adverts on television, indicating that they may not be entirely aware of **why products**  
256 **are fortified**.

257 In light of participants lack of knowledge of vitamin D, a definition of fortification was  
258 provided in focus groups and interviews to enable participants' opinions on the subject to be  
259 obtained. Subsequently views on fortification were categorised as a theme, in relation to both  
260 voluntary and mandatory fortification, with the former being received in a positive light and  
261 raising little concern;

262  
263 *“If it is good for people’s health then it is fine”* Focus Group 1, Participant 4

264  
265 *“Prevention is better than cure”* Focus Group 2, Participant 5

266  
267 The naturalness of fortification was raised as a concern, indicating a need to take this into  
268 consideration and use appropriate communications when marketing fortified foods;

269  
270 *“I think if they want to fortify foods with it, then they should probably put the nutrients in*  
271 *foods that intrinsically have similar properties that could contain such vitamins, because it*  
272 *wouldn’t make sense if you put it in something that is not used to such kind of nutrition, it*  
273 *may cause some kind of imbalance”* Focus Group1, Participant 2

274  
275 *“I would worry that it not natural and so, against nature and could be bad for you”* Focus  
276 Group 2, Participant7

277  
278 Despite the general positive views towards voluntary fortification, mandatory fortification of  
279 **foods with vitamin D** received more of a mixed response with concerns being raised by  
280 **individuals** in relation to consumer choice and toxicity, the latter of which being raised in  
281 every focus group and interview indicating that it is not an isolated concern.

282 Despite the concerns raised in relation to fortification, most participants would prefer to  
283 consume fortified food products rather than take supplements, with the view that supplements  
284 were unnatural, inconvenient and seemed far too medical.

## Knowledge of vitamin D

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3 285 Participants were asked to suggest specific foods that they would like to see fortified with a  
4  
5 286 range of responses given including bread, milk and dairy products, vegetables, cereals,  
6  
7 287 chocolate, eggs and water. The range reflects their personal dietary preferences, with the  
8  
9 288 majority of participants reported consuming a diet that is a mixture of the two cultures,  
10  
11 289 reflecting either a UK upbringing or current residential status in the UK, with selected food  
12  
13 290 products being mentioned due to participants' beliefs that they would benefit the population  
14  
15  
16 291 as a whole e.g. bread and milk.  
17

292

293 **Discussion**

20 294 This paper presents two pilot studies of the awareness of vitamin D and attitudes towards  
21  
22 295 food fortification in at risk groups in the North East of England. Consideration of food  
23  
24 296 fortification with vitamin D in order to improve vitamin D intakes at a population level have  
25  
26 297 been proposed in the literature (Lamberg-Allardt, 2006, Kiely and Black, 2012, O'Mahony et  
27  
28 298 al., 2011, Calvo and Whiting, 2006). Therefore, this study provides an insight into specific at  
29  
30 299 risk consumers' attitudes and acceptance towards foods fortified with vitamin D as well as  
31  
32 300 their awareness of vitamin D. This is particularly important research for research nutritionists,  
33  
34 301 food manufacturers and scientists involved in setting public health nutrition policy.  
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36

37 302 **The findings of this research support those in** a study by Alemu and Varnam (2012), whereby  
38  
39 303 minimal awareness was evident among men and older adults and they suggest age as an  
40  
41 304 important factor in determining level of awareness. Similarly, Kung and Lee (2006) found a  
42  
43 305 lack of awareness among older Chinese women, with **awareness appearing to decrease in age.**  
44  
45 306 Farrar *et al.*, (2011) indicated that there is a lack of data on sunshine exposure habits of UK  
46  
47 307 South Asians and they suggest that South Asians may adopt less sun-seeking behaviours.  
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50 308 **Although the majority of participants across all groups knew that sunlight was a source of**  
51  
52 309 **vitamin D, most were unaware of the time required to obtain sufficient vitamin D from**  
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## Knowledge of vitamin D

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3 310 sunlight exposure. This lack of awareness, and avoidance of sun-seeking behaviours amongst  
4  
5 311 at-risk groups, indicates a need for greater communication of safe sun exposure information.  
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7 312 School was the major source of information for all the groups, bar the British Caucasians and  
8  
9 313 those over 65 years (data not shown), with the media also being cited as a key source of  
10  
11 314 information, especially for focus group participants where the media was the main source of  
12  
13 315 information, including recent adverts of fortified foods. These main sources of information  
14  
15 316 are similar to previous studies (Alemu and Varnam, 2012). This suggests school and media  
16  
17 317 have an important role in increasing awareness of vitamin D and sun exposure, and could be  
18  
19 318 key mediums for dissemination information for increasing vitamin D intakes.  
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21  
22 319 Less than half of participants across all groups identified bone health as a benefit of optimum  
23  
24 320 vitamin D, which was reflected in the qualitative findings, with considerably fewer  
25  
26 321 participants being able to identify other benefits. This reflects previous research in Saudi  
27  
28 322 Arabia, where Christie and Mason (2011) found awareness of vitamin D benefits restricted to  
29  
30 323 musculoskeletal health. Although other health benefits were commonly reported in the  
31  
32 324 present study were healthy skin and general health/fitness, yet few participants did not know  
33  
34 325 that vitamin D was beneficial, again as evident in previous research (Bonevski et al., 2013).  
35  
36 326 This indicates that people are aware that vitamins in general are beneficial yet many are  
37  
38 327 unaware of the specific benefits associated with vitamins, in this case vitamin D. Given the  
39  
40 328 association of vitamin D with an increasing number of health conditions, conveying the  
41  
42 329 health benefits of ensuring vitamin D sufficiency to increase awareness would seem of  
43  
44 330 critical importance, given such limited awareness currently exists.  
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46  
47 331 Further to the results indicating a lack of awareness of the benefits associated with vitamin D,  
48  
49 332 the findings from both studies indicate a lack of awareness, or inability of participants to  
50  
51 333 correctly identify at-risk factors for vitamin D deficiency, including factors that would put  
52  
53 334 themselves at risk, such as having a naturally darker skin pigmentation. This was particularly  
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## Knowledge of vitamin D

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3 335 the case in the qualitative research for those who had lived in the UK for less than a year,  
4  
5 336 who had particularly limited awareness. Given that research has indicated several cases of  
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7 337 vitamin D deficiency in the UK in at-risk groups (Moy et al., 2012), ensuring that these  
8  
9 338 groups are reached with communications to enable themselves to identify as being at risk is  
10  
11 339 essential. Otherwise, at-risk individuals may not view fortified products, or supplements, as  
12  
13 340 relevant or necessary for themselves. This was exemplified in the results of the survey, with  
14  
15 341 the majority in all at risk groups being unaware of foods currently fortified with vitamin D.  
16  
17 342 However, the majority of the British Caucasian group (71%), those at a reduced risk of  
18  
19 343 deficiency, were aware of such foods fortified with vitamin D. This indicates that current  
20  
21 344 fortified food products are not currently targeting those at risk of deficiency or are not  
22  
23 345 communicating effectively that they have been fortified. Given the potential for fortified  
24  
25 346 foods to increase vitamin D levels (Jääskeläinen et al., 2017), the identification of appropriate  
26  
27 347 foods to fortify for at risk groups is essential, and future research should look to explore this  
28  
29 348 in more depth, with more representative samples.  
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32  
33 349 Results from both studies indicated no preference for products to be voluntarily fortified with  
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35 350 vitamin D, with there also being no consensus over the influence of mandatory fortification in  
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37 351 purchasing staple products such cow's milk or bread, other than for the British Caucasian  
38  
39 352 group, who were not in favour.  
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42 353 The lack of preference for fortification of certain products, and for mandatory fortification in  
43  
44 354 general, may be partially explained by concerns raised during the qualitative research, in  
45  
46 355 relation to toxicity, consumer choice and naturalness. This reflects findings by Tedstone *et*  
47  
48 356 *al.*, (2008) who found mandatory fortification of folic acid was generally accepted amongst  
49  
50 357 participants, although concerns regarding consumer safety and choice were raised. This  
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52 358 highlights a need for effective communication in relation to the safety of fortified products,  
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## Knowledge of vitamin D

359 and clear labelling, especially for voluntary fortification, to ensure consumer freedom of  
360 choice is maintained.

361 *Recommendations*

362 Further research could include other groups at risk of deficiency such as pregnant women,  
363 obese individuals, and care providers for those in institutionalised care. It would also be  
364 interesting to increase the sample size so as to make inferences about whether a particular  
365 factor influences the level of vitamin D awareness among these different at risk groups, and  
366 to conduct more research into which foods would be the most appropriate and acceptable to  
367 fortify to target those most at risk of vitamin D deficiency. Future research should also look  
368 to establish the effect of conveying information on the health benefits of vitamin on  
369 willingness-to-purchase and preferences for fortified products.

370 *Conclusion*

371 Food fortification with vitamin D is a promising approach to increase vitamin D intake in  
372 countries and groups susceptible to vitamin D deficiency. Both these pilot studies identified a  
373 distinct lack of awareness of vitamin D and fortified foods among at risk groups of the UK  
374 population, although favourable attitudes towards fortification, particularly voluntary  
375 fortification, were displayed. Further research, on a larger scale, is needed in this area to  
376 enable a better understanding of the knowledge and attitudes of vitamin D and fortified foods  
377 among these at risk groups so that the most effective public health policies can be introduced.

378  
379 *Research Considerations*

380 Both studies are limited by small sample sizes, a result of the difficulties experienced whilst  
381 trying to recruit participants from the specific groups of the population within a limited time  
382 frame. Subsequently, future research should look to ensure larger, stratified samples to  
383 improve the results generalisability. In addition, years of residence in a country could be  
384 added to further explore any variations in attitudes and preferences this may bring. The

## Knowledge of vitamin D

385 sequence of questions could have been improved to reduce potential bias, in that questions on  
 386 awareness and knowledge precede that of behaviour and attitudes. Therefore, participants  
 387 may become more favourable towards fortification after answering questions on awareness  
 388 and knowledge of vitamin D, after realising they may not get adequate vitamin D themselves.  
 389 For the qualitative study a more representative sample of the South Asian population could  
 390 have been used, to encompass a wider range of ages and a mix of genders, thus enabling a  
 391 more representative view of the populations' knowledge and attitudes to be obtained.  
 392 However, both pieces of research present novel studies, into an area where there is limited  
 393 research. The quantitative study design enabled a direct comparison between different  
 394 ethnicities and the control group, with the qualitative study enabling more in-depth  
 395 information to be obtained to further explore consumers' knowledge and attitudes.

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Knowledge of vitamin D

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Nutrition and Food Science

**Table 1: Demographic and sample size information for each group of survey participants**

Question	South Asian (n=25)	Black (n=22)	Over 65 years (n=20)	Arabic and Middle East (n=21)	Far Eastern (n=11)	Control (n=21)
<b>a.) Gender</b>						
Male	14 (54%)	16 (73%)	2 (10%)	12 (60%)	4 (36%)	6 (29%)
Female	10 (38%)*	6 (27%)	18 (90%)	8 (40%)	7 (64%)	15 (71%)
$p = 0.001$						
<b>b.) Age group</b>						
18 – 34 years old	23 (88%)	10 (45%)	0 (0%)	17 (85%)	6 (55%)	7 (34%)
35 – 49 years old	2 (8%)	11 (50%)	0 (0%)	2 (10%)	4 (36%)	3 (14%)
50 – 64 years old	0 (0%)	1 (5%)	0 (0%)	1 (5%)	1 (9%)	11 (52%)
Over 65 years old	1 (4%)	0 (0%)	20 (100%)	0 (0%)	0 (0%)	0 (0%)
$p = <0.001$						
<b>c.) How long have you been resident in the UK?</b>						
All my life	11 (42%)	2 (9%)	16 (80%)	2 (10%)	0 (0%)	18 (86%)
Less than a year	5 (19%)	2 (9%)	0 (0%)	4 (20%)	3 (27%)	0 (0%)
Between 1-3 years	4 (15%)	2 (9%)	0 (0%)	5 (25%)	0 (0%)	0 (0%)
Between 3-5 years	2 (8%)	3 (14%)	1 (5%)	4 (20%)	0 (0%)	0 (0%)
More than 5 years	3 (12%)*	12 (55%)*	1 (5%)*	5 (25%)	8 (73%)	3 (14%)
$p = <0.001$						
<b>e.) What is your highest qualification?</b>						
GCSE / GNVQ or equivalent	3 (11%)	3 (14%)	3 (15%)	1 (5%)	0 (0%)	5 (24%)
AS / A Level or equivalent	11 (42%)	1 (5%)	1 (5%)	1 (5%)	1 (9%)	1 (5%)
Diploma	0 (0%)	4 (18%)	2 (10%)	2 (10%)	1 (9%)	2 (10%)
Foundation Degree	0 (0%)	1 (5%)	0 (0%)	2 (10%)	0 (0%)	0 (0%)
Degree	7 (27%)	4 (18%)	3 (15%)	4 (20%)	4 (36%)	7 (33%)
Postgraduate Degree	3 (11%)	6 (27%)	0 (0%)	9 (45%)	2 (18%)	4 (19%)
Other professional qualification	0 (0%)	1 (5%)	4 (20%)	0 (0%)	0 (0%)	0 (0%)
Other qualification	1 (4%)*	1 (5%)*	1 (5%)*	1 (5%)	3 (27%)	0 (0%)*
$p = <0.001$						

\*Responses for some questions do not add up to 100% due to participants declining to provide this information.

GCSE - General Certificate of Secondary Education; GNVQ - General National Vocational Qualification;

AS/A levels -Advanced Subsidiary/ Advanced level

Data across groups was compared with a Chi-Square test

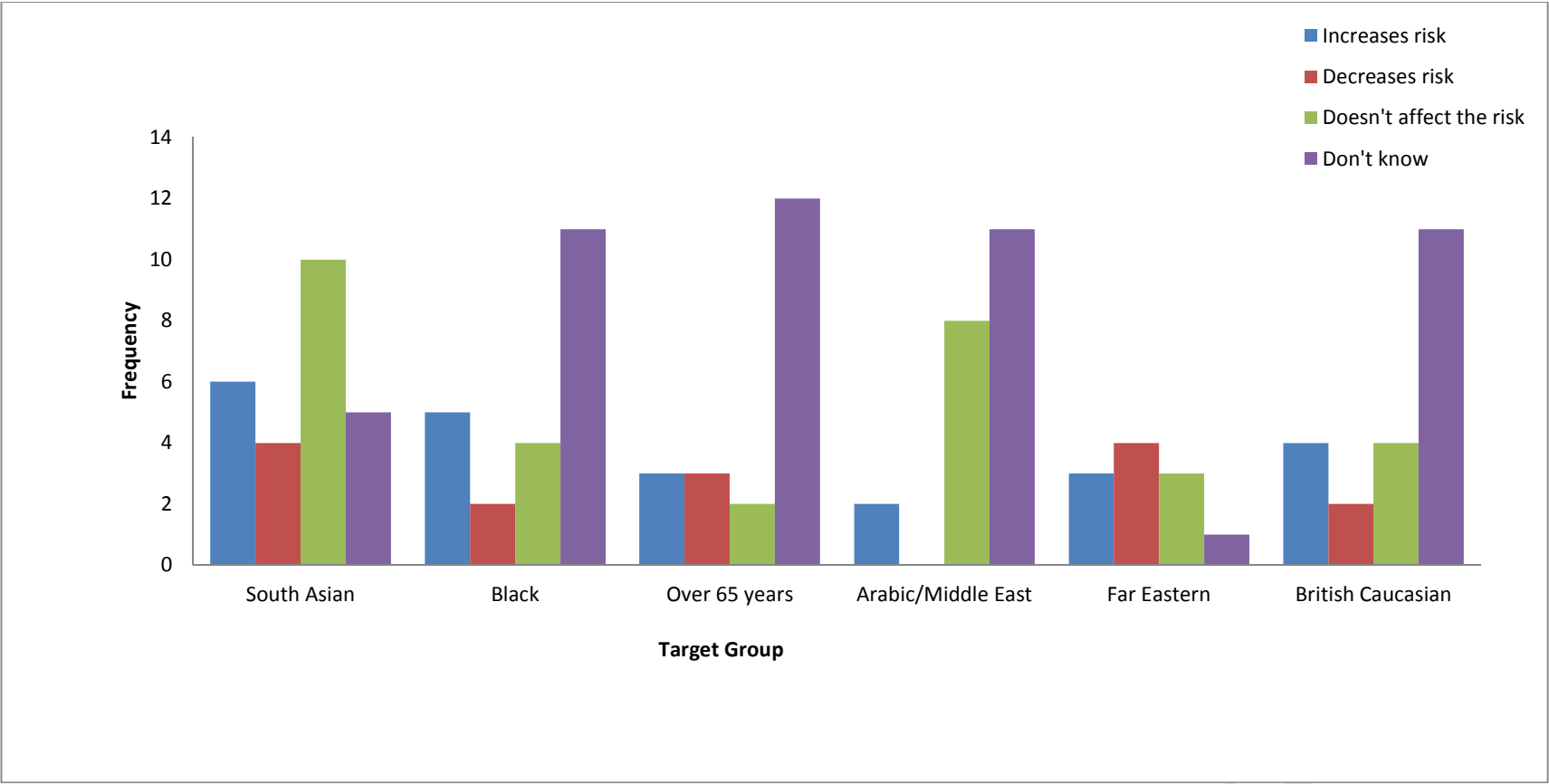
**Table 2: Health benefits associated with vitamin D as listed by survey participants**

What health benefits do you associate with vitamin D?	Number participants citing the benefit (n=120)	Percentage of participants citing the benefit (%)
Bone Health	44	37%
Healthy skin	21	18%
General health/fitness	13	11%
Mental health/cognition/improves mood	10	8%
Absorption of calcium	8	7%
Hair and nails	8	7%
Strong teeth	7	6%
Energy	5	4%
Healthy immune system	4	3%
Joints	3	3%
Eyesight	3	3%
Prevent cancer	3	3%
Regulates blood pressure	3	3%
Muscle strength	2	2%
Normal neurological function	2	2%
Well-balanced diet	1	1%
Storage of calcium	1	1%
Normal liver function	1	1%
Protection from sunburn	1	1%
Helps reduce weight	1	1%
Melanin synthesis	1	1%
Thin legs and big belly if lack of vitamin D	1	1%

All responses were provided as free text entries in the survey, and grouped together based on the type of benefit mentioned.

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**Figure 1: The number of survey participants who believe that darker skin pigmentation is a risk factor for vitamin D deficiency (  $p=0.023$  )**



Comparison across groups was made using a Chi-Square test

**Table 3: Acceptance rates for the mandatory fortification of foods with vitamin D by survey participants, as indicated by the percentage responding yes to each statement.**

	South Asians	Blacks	Over 65 years	Arabic/ Middle Eastern	Far Eastern	Caucasian British	Chi square result
<b>If the government introduced law to fortify some foods with vitamin D, would this influence your choice of purchasing these foods?*</b>	48%	68%	50%	67%	73%	29%	$p= 0.004$
<b>If the government introduced law to fortify all cow's milk with vitamin D, would this influence your choice of purchasing this food?</b>	36%	55%	50%	57%	73%	29%	$p= 0.004$
<b>If the government introduced law to fortify all UK varieties of bread with vitamin D, would this influence your choice of purchasing this food?</b>	40%	55%	30%	52%	73%	33%	$p= 0.003$

Comparisons across groups was made using a Chi-Square test