Title: A qualitative study to explore the knowledge and perceptions of vitamin D deficiency in women of Bengali origin living in the UK

Authors:

Penelope Belfield[1], Sofia Llahana[2]

1) MSc, RGN, Personalised Care Fellowship ACP, Derbyshire Community Health Services NHS Foundation Trust

2) DNSc, MSc, RGN, INP, NIHR ICA Postdoctoral Clinical Lecturer and Senior Lecturer in Advanced Clinical Practice, School of Health and Psychological Sciences, City, University of London; Hon Consultant Nurse in Endocrinology, University College London Hospitals NHS Foundation Trust

Abstract

Background: The prevalence of Vitamin D deficiency is widespread, particularly among South Asian women residing in temperate climates such as the United Kingdom. Contributory factors encompass dietary habits and conservative dressing practices.

Aims: This study aims to delineate the knowledge, perceptions, and determinants influencing Vitamin D supplementation among women of Bengali descent in the UK.

Methods: The study employed semi-structured interviews with women of Bengali origin at a general practice in London. A deductive thematic analysis was conducted utilizing the COM-B model to identify behavioural determinants. The study was approved by the Health Research Authority.

Findings: Key determinants to behaviours associated with Vitamin D supplementation encompassed awareness, cultural practices, healthcare advice, and personal convictions. Notwithstanding awareness of its criticality, actual intake was minimal due to factors like forgetfulness, cultural norms, and perceptions regarding the necessity of supplementation.

Conclusion: Although there is an overarching recognition of the significance of Vitamin D, adherence to supplementation regimens remains erratic. This study underscores the imperative for tailored health interventions that account for these elements to enhance Vitamin D supplementation among high-risk populations.

Keywords (5-6): Vitamin D deficiency, South Asian population, qualitative research, deductive analysis, Bangladeshi women, COM-B model.

Key Points

- Vitamin D deficiency is prevalent in the UK, especially among people with darker skin and other high-risk groups.
- Research into vitamin D deficiency in South Asian people fails to distinguish between large variations across people living within this large geographical area.
- This qualitative study of women of Bengali origin from one GP practice in West London shows high levels of knowledge regarding vitamin D, but that this insight does generally not change behaviour regarding regular vitamin D supplementation.
- Government consultation is welcome since more research and new methods are required to heighten vitamin D levels such as food fortification.

CPD reflective questions

- What are the protocols for vitamin D supplementation in your area of practice?
- Are patients at high risk for vitamin D deficiency identified in your area of practice?
- How can vitamin D knowledge be increased in your role?
- What do you think the Government could do to increase vitamin D intake/supplementation at a population level?

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Conflict of interest: None

1. Introduction

Vitamin D is critical for bone, teeth and muscle health (Pilz et al 2019); it also has an impact on immunity and the severity of Covid-19 (Deluca 2004; Burchell et al. 2020; Abdrabbo et al. 2021).

Vitamin D deficiency is highly prevalent worldwide (Lips & Van Schoor 2011; Pludowski et al. 2022) and the UK (Hirani et al. 2009; Lips et al. 2020). South Asians are known to have much lower vitamin D levels compared to the white population (Kift et al. 2013; Darling et al. 2018; Darling 2020), with women being at much higher risk (Kift et al. 2013; NICE 2014; Darling 2020).

Vitamin D is primarily produced from exposure to sunlight, and dietary intake can be inadequate (Burchell, et al. 2020; Butriss et al. 2021; Jin 2021).

Skin type affects the absorption of vitamin D as, the darker the skin, the higher the level of melatonin which inhibits the production of vitamin D (Burchell et al. 2020). This means that South Asian populations living in temperate regions such as the UK are at increased risk of vitamin D deficiency (Lowe & Bhojani 2017; Burchell et al. 2020). This is exacerbated if women dress modestly for religious or cultural reasons (Ojah & Welch 2012; Buyukuslu et al. 2014).

The South Asian population includes people of India, Pakistan, Bangladesh, Sri Lanka, Nepal and Bhutan. However, much of the research into these populations fails to take into account the significant differences within the South Asian population. For example, the Bengali population traditionally eat a fish-based diet which may be higher in vitamin D, whereas South Asian people of Indian origin mainly have a vegetarian diet (Darling 2020).

A further difference between the South Asian populations is socio-economic deprivation, with 28-31% of Bengali and Pakistani populations living in the poorest neighbourhoods in the UK compared with 8-9% of the Indian population (Ministry of Housing, Communities and Local government (2020). Socio-economic deprivation is associated with vitamin D deficiency (Lin et al 2021). Evidence also suggests that knowledge of vitamin D varies across participants from South Asian origin (Kotta et al. 2015; Webb et al. 2016; Clark et al. 2019; O'Connor et al. 2018; Burchill et al. 2020).

1.1 Background to the study

NICE (2021) recommends that people with dark skin of a South Asian origin, and those who usually dress modestly when outdoors, should supplement with 10 micrograms of vitamin D daily throughout the year, and this should be made available through outlets such as GP surgeries; health professionals should also promote vitamin D supplementation behaviours. Spending by GP practices on vitamin D supplements has risen from £28 million in 2004 to £76 million in 2011 (NICE 2020). However, in North West London where the first author is based, local prescribing guidance advises primary health practitioners to recommend that patients buy vitamin D supplements over the counter as part of national guidance to reduce costs (NHS England 2022).

1.2 Aim

The aim of the study was to provide an in depth understanding of the factors that influence vitamin D supplementation in women of Bengali origin.

1.3 Objectives

- To explore participants' knowledge and perceptions of vitamin D benefits.

- To identify potentially modifiable barriers that inhibit vitamin D intake.

2. Methods

2.1 Study design

We followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) Checklist (Tong et al, 2007) to design and report this qualitative study, aiming to provide an in-depth understanding of perceptions and experiences of vitamin D supplementation in women of Bengali origin attending a general practice in London. The methodological approach entailed one-to-one semi-structured interviews, which were instrumental in harvesting rich, qualitative data reflective of participants' lived experiences.

2.2 Theoretical Framework

The study adopted the COM-B framework (Michie et al. 2011) to provide a systematic and transparent approach to the investigation and understanding of the potentially modifiable barriers and enablers to behaviours that influence vitamin D-related behaviours. The COM-B framework explains how the interaction between one's capability (C), opportunity (O) and motivation (M) can produce or change behaviour (B), thus outlining all potential influences on the targeted behaviour (Michie et al. 2011).

2.3 Setting and participant selection

The study was conducted in a general practice in London where the first author worked as a Nurse Practitioner. The practice is in a deprived area of England and is very ethnically diverse. Internal practice data shows that of a practice population of around 2000 patients, the largest single ethnicity is people of Bengali origin at 35%. The data regarding speaking English is limited, however practice appointment data shows the highest proportion of

appointments over the last 5 years are for women of Bengali origin. The study sample was drawn from patients registered with the Practice.

Inclusion criteria

- Female patients registered at the general practice at the time of study and recorded as of Bengali origin, aged between 18-65 years.

Exclusion criteria

- Pregnancy or breastfeeding.
- Concurrent medical conditions that could affect vitamin D absorption (such as coeliac disease or Crohn's disease) or impair the activation of vitamin D (such as chronic kidney liver disease).

A convenience sampling approach was adopted aiming for 15-20 participants providing a balance between pragmatic considerations, including the time available to complete the study, the availability of the Bengali interpreter, and the aim to obtain a representative sample within the study population.

2.4 Data collection

Potential participants were sent a letter inviting them to take part in the study, written in English and Bengali and were asked to provide informed consent for participation in the study. Semi-structured telephone interviews were conducted by the first author; face-to-face interviews were not possible as COVID-19 pandemic restrictions were still in place. The Bengali interpreter facilitated the two-way translation for participants who were unable to communicate in English.

The interview guide was developed based on the COM-B behaviour change model (Michie et al. 2011) to address women's behaviour related to vitamin D supplementation. Interviews, each ranging from 30 to 45 minutes, were recorded using a digital Dictaphone and transcribed verbatim. All transcripts were de-identified and each participant was given a study identification number for reporting purposes.

2.5 Data analysis

Thematic analysis was conducted in accordance with the principles outlined by Braun and Clarke (2006). This entailed a rigorous process of data familiarization, generating initial codes, and searching for themes that describe similar underlying perspectives and experiences from respondents which reflect barriers and enablers to vitamin D intake. Data were analysed deductively using NVivo 12 software for qualitative analysis, and the generated themes were mapped onto the six COM-B components: physical capability; psychological capability; reflective motivation, automatic motivation; physical opportunity and social opportunity (Michie et al. 2011).

To minimise interpretive bias, 20% of transcripts were randomly selected and coded by the second author and cross-checked with those generated by the first author. Reliability was assessed by the concordance of themes and any conflict was resolved in discussion between the two authors.

2.6 Ethical considerations

The study was approved by the NHS Research Ethics Committee and received Health Research Authority approval (IRAS ID: 309401) in March 2022.

3.0 Findings

3.1 Participants

Interviews were conducted between April and July 2022 with 17 women of Bengali origin with an age range between 19 and 61 years (mean age = 37years , SD =9.9). For 4 women the interview was conducted in real-time translation by the Bengali interpreter. 13 of the women had vitamin D measured in the last12 months and 4 of them had vitamin D levels within the normal range; 3 women were being prescribed vitamin D by their Practice and taking regularly and 4 were obtaining this as an over the counter supplement.

3.2 Thematic analysis

Eleven themes across the six COM-B components were generated to describe factors (barriers and enablers) that influence behaviours associated with vitamin D supplementation (Table 1).

Table 1: Themes generated from thematic analysis

Insert Table 1 here

3.3 Capability

3.3.1. Knowledge of vitamin D

Only one participant reported having no knowledge of vitamin D; all the other participants reported varying levels of knowledge of vitamin D and its effects. Two participants mentioned an increased risk for the Bengali population due to their behaviour of dressing modestly due to cultural reasons and not spending time outside.

"I know that Bengali have a lot less because they stay indoors and they don't really stand out in the sun a lot." [P10]

The benefits of vitamin D to general health and the immune system were mentioned, with seven participants noting its effect on bone health.

"Well, all I know about it is, is good. I think it's good for you. Yeah, yeah. Or overall your health, vitamin and its good for your bones." [P11]

3.3.2. Knowledge of sources of vitamin D

Fifteen participants were aware that sunlight was a source of vitamin D. Knowledge of sunlight fed into knowledge that Asian women may have lower levels of vitamin D due to the practice of not exposing their skin to the sun.

"So I know you get it from the sun. I know Asian people have, I think, we have the less vitamin D and I think it's the lady because of the cover, because maybe, we cover skin…, I believe yeah, that's all I know." [P15]

There was a lack of awareness about foods that contain vitamin D, with five participants incorrectly believing it could be obtained from fruit and vegetables; others mentioned rice, curry and meat and three participants believed milk is a good source of vitamin D.

3.3.3. Awareness of population groups at risk

Knowledge that South Asians are a population group at risk for vitamin D deficiency was highlighted by four participants.

"Oh, I know that a lot of the Asian minorities we are told that we lack vitamin D…. But to be honest, I don't take any supplements for vitamin D or anything like that." [P2]

Three participants who worked in healthcare had a more detailed knowledge of at-risk population groups and this appeared to influence behaviour as they all regularly took vitamin D supplements.

3.3.4. Vitamin D intake

Forgetting to take tablets was identified as a barrier to taking vitamin D supplements by five participants. This was identified as 'being lazy' by two participants and not seen as important by another participant:

"But yes, I did forget, you know, but then I did take I think, I don't know why we forget vitamin D. I think no one doesn't really think it's very important." [P11]

One participant used a dossette box and this was an enabler for her to take regular vitamin D supplements.

3.4 Opportunity

3.4.1. Cultural influences

All participants dressed modestly as dictated by cultural norms, exposing only their hands and face to the sun when outside. One participant said that when sitting in her garden she would expose up to her elbows. Three participants identified this behaviour as a reason for vitamin D deficiency.

"I cover up so I don't think I get much sun, isn't it that's why it's always so low for a lot of people, like so many Asians." [P16]

Three participants who were born in Bangladesh followed a traditional diet including three or more times a week, which is a good source of vitamin D.

The cultural stigma of colourism, whereby lighter skin is considered preferential, was identified as a reason for avoiding sun exposure by one participant.

"I think the other thing, which might get me into trouble is, there's always that stigma attached to getting a tan and being dark." [P17]

Going outside for errands such as shopping and taking children to school was often cited as time spent outside. A number of participants reported struggling to spend time outside for a variety of reasons including migraines, Ramadan, housework, work and lack of time.

"To be honest, it's more when I'm collecting my daughter, shopping. It's not like all because I want to get vitamin D. You know, having a walk to get the sun is mainly because of my duties." [P16]

3.4.2. Named General Practitioner (GP)

The participants were all registered at a single-handed GP practice, where the same GP has been working for the past 30 years. He was spoken of as a positive influence, encouraging regular use of vitamin D supplements by five participants.

"I think even [name of GP] said I need to take it for life once he said." [P14]

Two participants had learnt about vitamin D supplements during pregnancy, but neither were taking regular supplements at the time of the study. Three participants expressed the belief that healthcare professionals would offer prescriptions of vitamin D if you were 'seriously low', which undermined the message of taking regular supplements.

3.4.3. Vitamin D formulation

A barrier to taking vitamin D supplements was the size of the supplements, as one participant, who was prescribed vitamin D supplements, described.

"Just I just think these tablets are too big…I find it so difficult to swallow these tablets and sometimes just puts me off from taking it." [P3]

One participant purchased her own vitamin D supplements as an oral spray formulation and took them regularly.

3.4.4. Availability of vitamin D

Five participants received vitamin D on repeat prescription,. This was an enabler to taking regular vitamin D supplementation as, of the four participants who had replete vitamin D in their latest blood tests, two of these were receiving regular repeat vitamin D prescriptions.

All but one participant had previously been prescribed vitamin D at some point in the past and the majority had taken this prescription, but then stopped supplementation.

"*I finished the course so he would usually prescribe me some I would maybe go on and off it on a weekly basis. And then and then it will just drop off slowly. And I would forget about it.*" *[P5]*

However, two participants reported that although they could afford purchasing vitamin D, this was not the case for all women of Bengali origin where buying the supplements would be a barrier to vitamin D supplementation.

"Well for me [it is ok to pay to for vitamin D] because I'm working and stuff but … I feel like if you're paying for prescription [it] might be an issue…" [P15]

3.5 Motivation

3.5.1. Government recommendations for vitamin D

Overall, there was a positive response to the idea of buying foods fortified with vitamin D but four participants were unsure and two were against the idea, largely due to concerns around perceived effects on the food or the use of preservatives.

"Probably not,..... I don't like things to be added in my food, I'd rather get it from the actual source." [P1]

"Sort of like radiation isn't it?" [P16]

Anger and a lack of institutional trust was highlighted by one participant who was adamant she would not change her behaviour regarding vitamin D supplements or take fortified food.

"No, that's it. They should just leave it as it is, if anyone wants to get it they can just buy it no need to keep adding it to everything you know?"

3.5.2. Beliefs about the consequences of vitamin D deficiency

Joint pains and impact on bone health were the main consequences of not taking vitamin D tablets identified by five participants, all of whom were motivated to take regular supplements. An improvement in mood when taking supplements was also identified by two participants.

Beliefs identified by participants that prevented them taking vitamin D were a lack of importance regarding vitamin D, concerns about side effects and a lack of physical effect if taken.

" ... I haven't been told oh this is really bad. You're lacking vitamin D. And you know, this will happen, that will happen." [P15]

4. Discussion

The aim of this study was to explore knowledge and perceptions of vitamin D supplementation among women of Bengali origin living in the UK, underpinned by the COM-B framework.

Almost all participants had some knowledge of vitamin D, which was most likely related to previously diagnosed vitamin D deficiency.

Knowledge regarding vitamin D, however, did not always translate into behaviour, with only seven participants taking supplements regularly. This is consistent with other research showing low uptake of vitamin D supplements in both the UK generally and within the UK South Asian population (Webb et al 2106; Sutherland et al. 2021; OHID 2022). The UK Biobank cohort found 17% of Bangladeshis reported taking a vitamin D supplement as opposed to 26% Indians and 21% Pakistanis (Darling et al. 2021)

Little differentiation is made between first and second generation South Asians in earlier studies (Darling 2020). The current study showed that being first generation immigrant (born in Bangladesh and speaking Bengali) was positively associated with regular vitamin D supplementation, as was working in healthcare.

Barriers to taking vitamin D supplements in this study were the unpalatability of the tablets, which is consistent with previous research (Kotta et al. 2015) and 'forgetfulness' which, although not specific to vitamin D, has previously been reported as a barrier to medication adherence (Foley et al. 2021).

A lack of physical effect if not taking the vitamin D supplement was a barrier and this is similar to research into other medication (Al-Noumani et al. 2019).

An enabler to taking regular supplements was the patients' GP and testing for vitamin D deficiency. NICE (2022) guidelines state that asymptomatic people of higher risk for vitamin D deficiency do not need routine testing, but nevertheless this remains common practice (Woodford et al. 2018; Kotta et al. 2015).

The participants' biochemistry investigations showed that three (19 %) were deficient in vitamin D. This is lower than expected as previous studies have found that between 54% (Engel et al. 2008) and >90% of South Asians (Kift et al. 2013) living in the UK were deficient in vitamin D.

One reason the Bengali population may have a higher vitamin D levels could be their higher intake of fish as part of their traditional diet (Rahman 2015; Darling 2020), with seven of the participants in the study eating fish twice a week or more (Darling 2021).

A way in which nutrition could increase the intake of vitamin D is through the fortification or biofortification of food. This has been used to successfully raise levels of vitamin D in the USA, Canada and Finland, but is currently only mandatory in the UK in infant formula (Butriss et al. 2021; OHID 2022).

The participants were generally positive towards fortification, but less so towards biofortification. Those against fortification had strong feelings regarding its unnaturalness or perceived government interference, which aligns with previous research (Kotta et al. 2015, O'Connor et al. 2018).

It is important that any food that may be fortified is appropriate for high-risk population groups. Foods like wheat flour (Butriss et al. 2021) or pork (Neill et al. 2021) have been

proposed for biofortification, but since the Bengali diet traditionally favours millet and rice flour (Leyvraz et al. 2015), this would not be beneficial for most people. Pork would also be unsuitable for anyone of Islamic faith, which includes the majority of Bangladeshis (Rahman 2014).

Participants were aware that sunlight was the main source of vitamin D and associated their skin covering with an increased risk of vitamin D deficiency. Overall, they appeared to spend limited time outside, similar to other studies (Darling 2021; Butriss et al. 2021; Kift et al. 2013). One participant identified 'colourism' as a reason not to spend time outside, a factor which was identified as the main barrier to being outside for Pakistani South Asians in the US (Shakir 2009).

4.1 Study strengths

This is the first study to provide an in-depth understanding of behaviours related to vitamin D supplementation in women of Bengali origin living in the UK. Adopting the COM-B theoretical framework to underpin the study provided a rigorous methodological strength with potential to replicate the study in other settings and populations.

4.2 Study limitations

A limitation of this study was the small geographical area from which the participants were recruited. The first author was a nurse practitioner in this practice which may be related with a degree of researcher-led bias to sample selection and interviewing.

5. Conclusion and implications for practice

Vitamin D deficiency is a worldwide problem which is especially pronounced for ethnic minorities in the UK.

The participants were knowledgeable regarding vitamin D but few were taking supplements regularly. Participants who were taking vitamin D supplementation regularly were more likely to have been born in Bangladesh, have vitamin D supplements on repeat prescription and be influenced by their GP. The Government's call for evidence (OHID 2022) to explore biofortification requires careful consideration to ensure modifications are culturally appropriate to population groups at high risk of vitamin D deficiency in the UK.

8. References

Abdrabbo, M., Birch, C.M., Brandt, M., Cicigoi, K.A., Coffey, S.J., Dolan, C.C., Dvorak, H., Gehrke, A.C., Gerzema, A.E.L., Hansen, A., Henseler, E.J., Huelsbeck, A.C., LaBerge, B., Leavens, C.M., Le, C.N., Lindquist, A.C., Ludwig, R.K., Reynolds, J.H., Severson, N.J., Sherman, B.A., Sillman, H.W., Smith, M.A., Smith, M.A., Snortheim, M.J., Svaren, L.M., Vanderpas, E.C., Wackett, M.J., Wozney, A.J., Bhattacharyya, S. & Hati, S. (2021) Vitamin D and COVID-19: A review on the role of vitamin D in preventing and reducing the severity of COVID-19 infection. *Protein Science*, 30, 2206–2220 [DOI: 10.1002/pro.4190] [PubMed: 34558135].

Al-Noumani, H., Wu, J.R., Barksdale, D., Sherwood, G., AlKhasawneh, E. & Knafl, G. (2019) Health beliefs and medication adherence in patients with hypertension: A systematic review of quantitative studies. *Patient Education and Counseling*, patient ednucation and Counselling, 102, 1045–1056 [DOI: 10.1016/j.pec.2019.02.022] [PubMed: 30846205].

Braun, V. & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77–101 [DOI: 10.1191/1478088706qp063oa].

Burchell, K., Rhodes, L.E. & Webb, A.R. (2020) Public awareness and behaviour in Great Britain in the context of sunlight exposure and vitamin D: Results from the first large-scale and representative survey. *International Journal of Environmental Research and Public Health*, 17, 6924 [DOI: 10.3390/ijerph17186924] [PubMed: 32971923].

Buttriss, J.L., Lanham-New, S.A., Steenson, S., Levy, L., Swan, G.E., Darling, A.L., Cashman, K.D., Allen, R.E., Durrant, L.R., Smith, C.P. et al. (2021) Implementation strategies for

improving vitamin D status and increasing vitamin D intake in the UK: Current controversies and future perspectives. *Proceedings of the 2nd Rank Prize Funds Forum on Vitamin D. British Journal of Nutrition*, 1–21 [DOI: 10.1017/S0007114521002555].

Buyukuslu, N., Esin, K., Hizli, H., Sunal, N., Yigit, P. & Garipagaoglu, M. (2014) Clothing preference affects vitamin D status of young women. *Nutrition Research*, 34, 688–693 [DOI: 10.1016/j.nutres.2014.07.012] [PubMed: 25156789].

Clark, B., Doyle, J., Bull, O., McClean, S. & Hill, T. (2019) Knowledge and attitudes towards vitamin D food fortification. *Nutrition and Food Science*, 49, 346–358 [DOI: 10.1108/NFS-04-2018-0121].

Darling, A.L. (2020) Vitamin D deficiency in western dwelling South Asian populations: An unrecognised epidemic. *Proceedings of the Nutrition Society*, 79, 259–271 [DOI: 10.1017/S0029665120000063] [PubMed: 32046797].

Darling, A.L., Blackbourn, D.J., Ahmadi, K.R. & Lanham-New, S.A. (2018) Vitamin D supplement use and associated demographic, dietary and lifestyle factors in 8024 South Asians aged 40–69 years: Analysis of the UK Biobank cohort. *Public Health Nutrition*, 21, 2678–2688 [DOI: 10.1017/S1368980018001404] [PubMed: 29936916].

Darling, A.L., Blackbourn, D.J., Ahmadi, K.R. & Lanham-New, S.A. (2021) Very high prevalence of 25-hydroxyvitamin D deficiency in 6433 UK South Asian adults: Analysis of the UK Biobank Cohort. *British Journal of Nutrition*, 125, 448–459 [DOI: 10.1017/S0007114520002779] [PubMed: 32693845].

DeLuca, H.F. (2004) Overview of general physiologic features and functions of vitamin D. *American Journal of Clinical Nutrition*, 80(6) (Supplement), 1689S–1696S [DOI: 10.1093/ajcn/80.6.1689S] [PubMed: 15585789].

Engel, B., Lee, P., Bottle, L., Cardew, P. & Lanham-New, S.A. (2008) Impact of ethnicity and season on body composition: Results from the vitamin D, Food Intake, Nutrition and Exposure to Sunlight in Southern England (D-FINES) Study. *Proceedings of the Nutrition Society*, 67, (OCE8) [DOI: 10.1017/S0029665108009956].

Foley, L., Larkin, J., Lombard-Vance, R., Murphy, A.W., Hynes, L., Galvin, E. & Molloy, G.J. (2021) Prevalence and predictors of medication non-adherence among people living with multimorbidity: A systematic review and meta-analysis. *BMJ Open*, 11, e044987 [DOI: 10.1136/bmjopen-2020-044987] [PubMed: 34475141].

Hirani, V., Mosdøl, A. & Mishra, G. (2009) Predictors of 25-hydroxyvitamin D status among adults in two British national surveys. *British Journal of Nutrition*, 101, 760–764 [DOI: 10.1017/S0007114508023416] [PubMed: 18631415].

Jin, J. (2021) Screening for vitamin D deficiency in adults. *JAMA*, 325, 1480 [DOI: 10.1001/jama.2021.4606] [PubMed: 33847716].

Kift, R., Berry, J.L., Vail, A., Durkin, M.T., Rhodes, L.E. & Webb, A.R. (2013) Lifestyle factors including less cutaneous sun exposure contribute to starkly lower vitamin D levels in U.K.

South Asians compared with the white population. *British Journal of Dermatology*, 169, 1272–1278 [DOI: 10.1111/bjd.12518] [PubMed: 23855783].

Kotta, S., Gadhvi, D., Jakeways, N., Saeed, M., Sohanpal, R., Hull, S., Famakin, O., Martineau, A. & Griffiths, C. (2015) "Test me and treat me"—Attitudes to vitamin D deficiency and supplementation: A qualitative study. *BMJ Open*, 5, e007401 [DOI: 10.1136/bmjopen-2014-007401] [PubMed: 26173717].

Leyvraz, M., Laillou, A., Rahman, S., Ahmed, T., Rahman, A.S., Alam, N., Ireen, S. & Panagides, D. (2015) An assessment of the potential impact of fortification of staples and condiments on micronutrient intake of young children and women of reproductive age in Bangladesh. *Nutrients*, 7, 9960–9971 [DOI: 10.3390/nu7125511] [PubMed: 26633483].

Lin L-Y, Smeeth L, Langan S, Warren-Gash C. Distribution of vitamin D status in the UK: a cross-sectional analysis of UK Biobank. BMJ Open. 2021 [accessed 2024 Jan 9];11(1):e038503. https://bmjopen.bmj.com/lookup/doi/10.1136/bmjopen-2020-038503. doi:10.1136/bmjopen-2020-038503

Lips, P., Bilezikian, J.P. & Bouillon, R. (2020) Vitamin D: Giveth to those who needeth. *JBMR Plus*, 4, e10232 [DOI: 10.1002/jbm4.10232] [PubMed: 31956848].

Lips, P. & van Schoor, N. (2011). Chapter 52 Worldwide vitamin D status. In: *Vitamin D*, 3rd edn (edited by D. Feldman, J. W. Pike & J. S. Adams). www.sciencedirect.com/science/article/pii/B9780123819789100526. accessed 12 April 2020. Academic Press: San Diego, USA, pp. 947–963.

Lowe, N.M. & Bhojani, I. (2017) Special considerations for vitamin D in the South Asian population in the UK. *Therapeutic Advances in Musculoskeletal Disease*, 9, 137–144 [DOI: 10.1177/1759720X17704430] [PubMed: 28620422].

Michie, S., van Stralen, M.M. & West, R. (2011) The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, 6, 42 [DOI: 10.1186/1748-5908-6-42] [PubMed: 21513547].

Ministry of Housing & Communities and Local Government (2020). *People Living in Deprived Neighbourhoods. People Living in Deprived Neighbourhoods – GOV.UK Ethnicity Facts and Figures*. (ethnicity-facts-figures.service.gov.uk).

Neill, H.R., Gill, C.I.R., McDonald, E.J., McRoberts, W.C. & Pourshahidi, L.K. (2021) Vitamin D biofortification of pork may offer a food-based strategy to increase vitamin D intakes in the UK population. *Frontiers in Nutrition*, 8. https://www.frontiersin.org/articles/10.3389/fnut.2021.777364. accessed 10 July 2022, 777364 [DOI: 10.3389/fnut.2021.777364] [PubMed: 34926552].

NHS England (2022) Guidance on conditions for which over the counter items should not routinely be prescribed in primary care. [accessed 2022v Jan 8]. https://www.england.nhs.uk/medicines-2/conditions-for-which-over-the-counter-items-should-not-routinely-be-prescribed/.

NICE (2022). *Management of Vitamin D Deficiency or Insufficiency*. National Institute for Health and Care Excellence: London.

NICE (2017). *Overview | Vitamin D: Supplement Use in Specific Population Groups | Guidance*. National Institute for Health and Care Excellence: London.

O'Connor, C., Glatt, D., White, L. & Revuelta Iniesta, R. (2018) Knowledge, attitudes and perceptions towards vitamin D in a UK adult population: A cross-sectional study. *International Journal of Environmental Research and Public Health*, 15, 2387 [DOI: 10.3390/ijerph15112387] [PubMed: 30373274].

OHID (2022). *Vitamin D: Call for Evidence*. Office for Health Improvement and Disparities: London.

Ojah, R.C.I. & Welch, J.M. (2012) Vitamin D and musculoskeletal status in Nova Scotian women who wear concealing clothing. *Nutrients*, 4, 399–412 [DOI: 10.3390/nu4050399] [PubMed: 22690323].

Pilz S, Zittermann A, Trummer C, Theiler-Schwetz V, Lerchbaum E, Keppel MH, Grübler MR, März W, Pandis M. Vitamin D testing and treatment: a narrative review of current evidence. Endocrine Connections. 2019;8(2):R27–R43. https://ec.bioscientifica.com/view/journals/ec/8/2/EC-18-0432.xml. doi:10.1530/EC-18-0432

Pludowski, P., Takacs, I., Boyanov, M., Belaya, Z., Diaconu, C.C., Mokhort, T., Zherdova, N., Rasa, I., Payer, J. & Pilz, S. (2022) Clinical practice in the prevention, diagnosis and treatment of vitamin D deficiency: A Central and Eastern European expert consensus statement. *Nutrients*, 14, 1483 [DOI: 10.3390/nu14071483] [PubMed: 35406098].

Rahman, U. (2015). *Bangladesh. London: Kuperard (Culture Smart!).*

ROS (2020). *Vitamin D and Bone Health in Adults*. Royal Osteoporosis Society: London.

Shakir, D.K. (2012) Vitamin D deficiency and cultural influences among Muslim women in Southern Illinois. *Vitamin D Deficiency and Cultural Influences Among Muslim Women in Sou* by Durar Kassim Shakir. (siu.edu).

Sutherland, J.P., Zhou, A., Leach, M.J. & Hyppönen, E. (2021) Differences and determinants of vitamin D deficiency among UK Biobank participants: A cross-ethnic and socioeconomic study. *Clinical Nutrition*, 40, 3436–3447 [DOI: 10.1016/j.clnu.2020.11.019] [PubMed: 33309415].

Tong, A., Sainsbury, P. & Craig, J. (2007) Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*, 19, 349–357 [DOI: 10.1093/intqhc/mzm042] [PubMed: 17872937].

Webb AR, Aseem S, Kift RC, Rhodes LE, Farrar MD. Target the message: a qualitative study exploring knowledge and cultural attitudes to sunlight and vitamin D in Greater Manchester, U.K. British Journal of Dermatology. 2016 [accessed 2023 Sep 1];175(6):1401–1403. https://doi.org/10.1111/bjd.14800. doi:10.1111/bjd.14800

Woodford, H.J., Barrett, S. & Pattman, S. (2018) Vitamin D: Too much testing and treating? *Clinical Medicine*, 18, 196–200 [DOI: 10.7861/clinmedicine.18-3-196] [PubMed: 29858427].

Table 1: Themes and their relationship with COM-B

COM-B	Component	Themes	Barriers	Enablers
Capability	Physical	Vitamin D intake	Forgetting to take tablets	Dossette box to aid medication intake
	Psychological	Knowledge of vitamin D	Lack of knowledge	Knowledge of vitamin D health benefits
		Knowledge sources of vitamin D	Incorrect beliefs regarding food sources	Awareness of sun as a source
		Awareness of population groups at risk	Lack of awareness that people of South Asian origin are at risk	Participant's work enables knowledge that people of South Asian origin are at risk
Opportunity	Social	Cultural Influences	Modest dressing as dictated by cultural norms	Investing in trips outside the UK for sun exposure
			Low fish intake	High fish intake
			Being born in the UK	Being born in Bangladesh and speaking Bengali
			Cultural stigma of colourism	Sun exposure is socially acceptable
		Named GP	Lack of support from HCPs to promote vitamin D intake	Positive influence of named GP
	Physical	Vitamin D formulation	Tablets unpalatable	Ability to take tablets
		Availability of vitamin D	Financial	Prescriptions
		Healthcare services	Blood tests for vitamin D levels with no action	Blood tests raise awareness
Motivation	Reflective	Government recommendations for vitamin D	Negative beliefs about food fortification	Fortification enables vitamin D intake
		Consequences of vitamin D deficiency	Lack of physical effect seen	Joint pains if do not take