Tripartite Industry Association Briefing Document

An update on the UK industry upper level for vitamin D in food supplements for adults, pregnant and breast-feeding women and children aged 11-18

November 2023

Summary

The three industry trade associations - the Council for Responsible Nutrition (CRN UK), the Health Food Manufacturer's Association (HFMA) and the PAGB, the Consumer Healthcare Association, which represent the vast majority of companies marketing food supplements in the UK - have revised the industry's daily upper level in food supplements for vitamin D to 100 µg (microgram; 4000 IU) for adults, including pregnant and breast-feeding women, and children aged 11-18 years old. This is an increase from the previous industry maximum of 75 µg per day (3000 IU) agreed in 2019. By working together, a consistent approach across the industry will continue to be ensured.

The revised industry level is based on examination of new data from randomised controlled clinical trials (RCTs) drawn on by the European Food Safety Authority (EFSA) to reassess the European safe upper level (UL) for vitamin D. This clearly shows a wide safety margin of supplemental intakes of vitamin D up to 100 µg/day (4000 IU) in addition to habitual dietary intakes, including the supply of vitamin D from fortified foods.

This revised tripartite advice also takes into account the evolving body of evidence that reveals significant population cohorts may not be achieving sufficient blood vitamin D status, as well as the continuing trend documented by the UK National Dietary and Nutrition Surveys that demonstrate low mean vitamin D dietary intakes, compared with the Department of Health and Social Care's recommended intakes.

Background

In 2003, a Guidance Level of 25 µg/day for long-term vitamin D supplementation was set by the UK Expert Group on Vitamins and Minerals (EVM)[1], which the industry initially worked to. The EVM Guidance Level has since been superseded by risk assessments undertaken by EFSA and the Institute of Medicine (IOM) in the US. A UL of 100 µg/day from all sources was set by the IOM in 2010[2] and by EFSA in 2012[3]. Following publication of these reports, the UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) reviewed the safety data and agreed that a UL of 100 µg/day for adults and children aged 11-18 years was appropriate[4].

Significantly, the Scientific Advisory Committee on Nutrition (SACN) in 2016 (UK)[5] agreed with COT that this upper limit for safe long-term use of vitamin D did not distinguish between total intakes (diet and food supplements) as opposed to solely food supplementary vitamin D intake, since '*dietary intakes of vitamin D make only a small contribution to total exposures at the UL'*. It should be noted that 'dietary intakes' includes foods fortified with vitamin D. Additionally, advice on the current NHS website under the heading 'What happens if I take too much vitamin D?' is to not take more than 100 micrograms (4000 IU) of vitamin D a day as it could be harmful, which is given in the context of supplementation[†]. This advice applies to adults, including pregnant and lactating women, the elderly, and to children aged 11 to 17 years.

[†] https://www.nhs.uk/conditions/vitamins-and-minerals/vitamin-d/#:~:text=Do%20not%20take%20more%20than,(2%2C000%20IU)%20a%20day

EFSA has recently undertaken a further risk assessment in 2023[6] and has reasserted the UL for vitamin D at 100 µg/day. EFSA has made specific reference to the large body of randomised placebo-controlled clinical trial (RCT) evidence that now supports a UL of 100 µg/day, which includes long-term evidence of vitamin D supplement use of more than 12 months, across various population groups. Examination of this data clearly shows that the doses of vitamin D tested and reported on in the trials were in addition to usual, background dietary intakes of the nutrient (Table 1, Appendix)[7-41].

On evaluation of this data, the Tripartite Industry Association group has concluded that a maximum intake of 100 µg/day or 4000 IU vitamin D from food supplements can safely be taken by adults, pregnant and lactating women and children aged 11-18 years, in addition to usual dietary intake. This parallels the approach taken for magnesium, where the UL is set for food supplements only. To reach the UL for vitamin D from food sources alone is virtually impossible and would result in a significantly unbalanced diet. Current UK dietary vitamin D intakes, including that from fortified foods, range from an average intake of 2.1 µg to 10.2 µg at the 97.5 percentile (Table 2, Appendix)[42]. Hence there is no possibility that intakes from food and vitamin D fortified food might result in adverse effects.

In view of the large uncertainty factor applied to the lowest observed adverse effect level (LOAEL) by EFSA, and the documented safe use of supplemental intakes of vitamin D alongside dietary intake, including vitamin D from fortified foods, in the RCTs, it can be concluded that applying the UL exclusively to food supplements is safe for adults, including pregnant or breast-feeding women, and for children aged 11-18 years.

Taken together with evidence that significant UK population cohorts may not be sufficiently provided for (e.g., black, Asian and minority ethnic populations[43], as well as those who by occupation or institutionalisation receive less sunlight exposure[44] and overweight/obese individuals[45-46]) and evidence for the safe use of the nutrient in adults, including pregnant or breast-feeding women and children aged 11-18 years [47-64], the Tripartite Industry Association's new position for the UL is strengthened.

Rationale for the revised level

The rationale for the revised 100 µg/day level takes into account:

- The EFSA and IOM UL of 100 µg/day for vitamin D [2,6,47]
- The COT review of the UL[4], as reported in the SACN report (2016)[5]
- European industry models for deriving maximum levels of vitamins and minerals in food supplements[49,50]
- Safety data including long-term randomised controlled trials across various population groups [7-41]
- Specific UK cohorts that were not sufficiently provided for previously [43-46]

Appendix

Table 1. Vitamin D supplementary doses tested and compliance, in addition to usual intake from the diet in randomised controlled trials assessed by EFSA to propose the European UL for vitamin D

Randomised controlled trials included by EFSA for derivation of the adult UL	Vit D dose/μg day (analysed dose)	Dietary intake/μg day	Compliance (pill count) %
General Adult Population			
Aloia et al, 2013[7]	100	4.5 ± 4.1	78
Aloia et al, 2018[8]	15 (18.88) 250 (317.5)	N/R assumed intake 5	87 85
Billington et al, 2020[9]	10 100 250	4.2 ± 2.2 4.5 ± 2.3 4.7 ± 3.0	99.6 99.7 99.1
Brohult et al, 1973[10]	2500	N/R	NR
Burnett-Bowie et al, 2012[11]	178.6	3.8 (1.9-5.8)	85-100
Ceglia et al, 2013[12]	100	NR	High
Diamond et al, 2013[13]	50 125	NR	NR
Drincic et al, 2013[14]	25 (22.8) 125 (143.7) 250 (287.4)	5.2 ± 6.9 5.1 ± 5.8 7.0 ± 7.8	94-97
Gallagher et al, 2012[15]; 2014[16]	10 (12.6) 20 (22.8) 40 (38.3) 60 (64.8) 80 (73.8) 100 (105.2) 120 (123.4)	2.5 ± 1.5 3.4 ± 1.8 3.1 ± 1.8 2.5 ± 1.4 2.7 ± 1.6 2.7 ± 2.1 3.4 ± 2.2	94
Gallagher et al, 2013[17]	10 (12.6) 20 (22.8) 40 (38.3) 60 (64.8) 80 (73.8) 100 (105.2) 120 (123.4)	NR	81-91
Grimnes et al, 2012[18]	20 162.5	8.1 ± 6.0 9.1 ± 6.2	92
Heaney et al, 2003[19]	25 (20.9) 125 (137.5) 250 (275.0)	NR	NR
Hin et al, 2017[20]	50 100	NR	92-93 90-93
Johnson et al, 2022[21]	100	7.8 ± 10.0	84.1
Jorde et al, 2008[22]; Sneve et al, 2008[23]	71.43 142.86	9.1 ± 7.0 9.0 ± 6.7	95
Mastaglia et al, 2006[24]	125 (131)	NR	89 ± 11

	250 (262)		92 ± 10
Ponda et al, 2012[25]	178.6	NR	NR
Rafii et al, 2019[26]	50 75 178.6 357.1	NR	78.6 72.8 89.5 87.7
Rorie et al, 2014[27]	15 100	NR	>80
Schwartz et al, 2016[28]	20 (21.5) 50 (62.0) 100 (120.2) 178.6 (1708 to 1439)	NR	96 ± 7
Shirvani et al, 2020[29]	15 100 250	NR	NR
Vieth et al, 2001[30]	25 100	NR	NR
Wagner et al, 2016[31]	107.1	NR	NR
Wamberg et al, 2013[32]	175	1.5-4.0	95 ± 6
Pregnant/Lactating Women			
Enkhmaa et al, 2019[33]	15 50 100	NR	88 89 87
Hollis & Wagner, 2004[34]	50 100	NR	87.0-89.7 89.0-91.6 89.6-92.4
Hollis et al, 2011[35]	10 50 100	4.5 ± 2.7 4.9 ± 3.4 5.1 ± 3.7	69 68 69
Roth et al, 2018[36]	15 60 100 100	NR	88.2 86.9 84.3 90.9
Wagner et al, 2006[37]	10 160	6.8 ± 6.9 6.8 ± 2.9	≥80
Adolescents 11-17 years			
Belenchia, 2013[38]	100	NR	81
Lewis et al, 2013[39]	10 (12.15) 25 (28.5) 50 (47) 100 (117.75)	5 ± 3.5 3.6 ± 2.8 4.6 ± 4 4.4 ± 2.5	52.3
Maalouf et al, 2008[40]	5 (within 10%) 50 (within 10%)	NR	98 ± 3 97 ± 3
Rajakumar et al, 2020[41]	15 (18.85) 25 (27.15) 50 (53.55)	3.1-7.2 3.0-7.1 3.1-8.3	73 68-73 77-73

NR: Not recorded

Table 2. National Diet and Nutrition Survey (NDNS) Results: Years 9-11 (2016/17-2018/19)[42]

Vitamin D intake µg /day	Girls 11-18 yrs	Women 19-64 yrs	Women 65+ yrs	Boys 11-18 yrs	Men 19-64 yrs	Men 65+ yrs	Adults 19-64 yrs	Adults 65+ yrs
Mean	2.1	2.6	2.8	2.4	3.2	3.7	2.9	3.2
Median	1.8	2.2	2.6	1.9	2.5	3.3	2.4	2.9
SD (+/-)	1.5	1.0	1.9	1.7	2.7	2.4	2.3	2.2
Upper 2.5 percentile	5.9	7.7	6.9	7.1	10.2	8.9	8.4	8.4
Lower 2.5 percentile	0.2	0.3	0.3	0.2	0.4	0.4	0.3	0.4

µg: microgram; SD: standard deviation; yrs: years old

Dietary intake data from the latest UK National Diet and Nutrition Survey (NDNS) show that the adult mean intake of vitamin D from food sources only is less than 3 µg /day, while that for 65+ year old adults is slightly higher at 3.2 µg/day[42].

Intake at the upper 2.5 percentile (97.5%ile) is highest for boys aged 11-18 and adult men and is also higher for 65+ year old adult males. This is therefore approximated at 9.5 µg/day. These results show reduced dietary intakes compared with the previous NDNS survey[65].

The threshold for serum vitamin D sufficiency is currently under scrutiny [66,67] and could be revised upwards. This, combined with SACN's statement[5], agreed by COT[4], that the upper limit for safe long-term use of vitamin D should not distinguish between total and supplementary vitamin D intake, since '*dietary intakes of vitamin D make only a small contribution to total exposures at the UL'*, means that an industry UL of 100 µg /day is justified.

References

1. Expert Vitamins and Minerals Group (EVM). Safe Upper Levels for Vitamins and Minerals. May 2003.
2. Institutes of Medicine. Dietary reference Intakes for Calcium and Vitamin D. November 2010.
3. European Food Safety Authority. Scientific Opinion on the Tolerable Upper Intake Level of Vitamin D. June, 2012.
4. Committee on Toxicity of Chemicals in Food, Consumer Products and The Environment (COT). Statement on adverse effects of high levels of vitamin D (2014). https://webarchive.nationalarchives.gov.uk/ukgwa/20200808011447/https://cot.food.gov.uk/cotstatements/cotstatementsyrs/cotstatements2014/cot-statement-on-vitamin-d
5. Scientific Advisory Committee on Nutrition. Vitamin D and Health Report. 21 July 2016
6. European Food Safety Authority (EFSA). Scientific opinion on the tolerable upper intake level for vitamin D, including the derivation of a conversion factor for calcidiol monohydrate. EFSA Journal 2023 21(8), 1–219 pp. http://doi.org/10.2903/j.efsa.2023.8145.
7. Aloia JF, Dhaliwal R, Shieh A et al., Calcium and vitamin d supplementation in postmenopausal women. J Clin Endocrinol Metab. 2013 Nov;98(11):E1702-9. doi: 10.1210/jc.2013-2121. Epub 2013 Sep 24. PMID: 24064695.
8. Aloia JF, Katumuluwa S, Stolberg A et al., Safety of calcium and vitamin D supplements, a randomized controlled trial. Clin Endocrinol (Oxf). 2018 Dec;89(6):742-749. doi: 10.1111/cen.13848. Epub 2018 Oct 1. PMID: 30180273.
9. Billington EO, Burt LA, Rose MS et al., Safety of High-Dose Vitamin D Supplementation: Secondary Analysis of a Randomized Controlled Trial. J Clin Endocrinol Metab. 2020 Apr 1;105(4):dgz212. doi: 10.1210/clinem/dgz212. Erratum in: J Clin Endocrinol Metab. 2021 Mar 25;106(4):e1932. PMID: 31746327.
10. Brohult J, Jonson B. Effects of large doses of calciferol on patients with rheumatoid arthritis. A double-blind clinical trial. Scand J Rheumatol. 1973;2(4):173-6. doi: 10.3109/03009747309097085. PMID: 4129296.
11. Burnett-Bowie SA, Leder BZ, Henao MP et al., Randomized trial assessing the effects of ergocalciferol administration on circulating FGF23. Clin J Am Soc Nephrol. 2012 Apr;7(4):624-31. doi: 10.2215/CJN.10030911. Epub 2012 Feb 2. PMID: 22300739; PMCID: PMC3315336.
12. Ceglia L, Niramitmahapanya S, da Silva Morais M et al., A randomized study on the effect of vitamin D_3 supplementation on skeletal muscle morphology and vitamin D receptor concentration in older women. J Clin Endocrinol Metab. 2013 Dec;98(12):E1927-35. doi: 10.1210/jc.2013-2820. Epub 2013 Oct 9. PMID: 24108316; PMCID: PMC3849671.
13. Diamond T, Wong YK, Golombick T. Effect of oral cholecalciferol 2,000 versus 5,000 IU on serum vitamin D, PTH, bone and muscle strength in patients with vitamin D deficiency. Osteoporos Int. 2013 Mar;24(3):1101-5. doi: 10.1007/s00198-012-1944-7. Epub 2012 Mar 16. PMID: 22422304.
14. Drincic A, Fuller E, Heaney RP et al., 25-Hydroxyvitamin D response to graded vitamin D_3 supplementation among obese adults. J Clin Endocrinol Metab. 2013 Dec;98(12):4845-51. doi: 10.1210/jc.2012-4103. Epub 2013 Sep 13. PMID: 24037880.
15. Gallagher JC, Sai A, Templin T et al., Dose response to vitamin D supplementation in postmenopausal women: a randomized trial. Ann Intern Med. 2012 Mar 20;156(6):425-37. doi: 10.7326/0003-4819-156-6-201203200-00005. Erratum in: Ann Intern Med. 2012 May 1;156(9):672. PMID: 22431675.

16. Gallagher JC, Smith LM, Yalamanchili V. Incidence of hypercalciuria and hypercalcemia during vitamin D and calcium supplementation in older women. Menopause. 2014 Nov;21(11):1173-80. doi: 10.1097/GME.0000000000000270. PMID: 24937025; PMCID: PMC4209182.
17. Gallagher JC, Peacock M, Yalamanchili V et al., Effects of vitamin D supplementation in older African American women. J Clin Endocrinol Metab. 2013 Mar;98(3):1137-46. doi: 10.1210/jc.2012-3106. Epub 2013 Feb 5. PMID: 23386641; PMCID: PMC3590472.
18. Grimnes G, Joakimsen R, Figenschau Y et al., The effect of high-dose vitamin D on bone mineral density and bone turnover markers in postmenopausal women with low bone mass--a randomized controlled 1-year trial. Osteoporos Int. 2012 Jan;23(1):201-11. doi: 10.1007/s00198-011-1752-5. Epub 2011 Sep 10. PMID: 21909730.
19. Heaney RP, Davies KM, Chen TC et al., Human serum 25-hydroxycholecalciferol response to extended oral dosing with cholecalciferol. Am J Clin Nutr. 2003 Jan;77(1):204-10. doi: 10.1093/ajcn/77.1.204. Erratum in: Am J Clin Nutr. 2003 Nov;78(5):1047. PMID: 12499343.
20. Hin H, Tomson J, Newman C et al., Optimum dose of vitamin D for disease prevention in older people: BEST-D trial of vitamin D in primary care. Osteoporos Int. 2017 Mar;28(3):841-851. doi: 10.1007/s00198-016-3833-y. Epub 2016 Dec 16. PMID: 27986983; PMCID: PMC5306173.
21. Johnson KC, Pittas AG, Margolis KL et al., Safety and tolerability of high-dose daily vitamin D_3supplementation in the vitamin D and type 2 diabetes (D2d) study-a randomized trial in persons with prediabetes. Eur J Clin Nutr. 2022 Aug;76(8):1117-1124. doi: 10.1038/s41430-022-01068-8. Epub 2022 Feb 9. Erratum in: Eur J Clin Nutr. 2022 Apr 13; PMID: 35140313; PMCID: PMC9352576.
22. Jorde R, Sneve M, Figenschau Y et al., Effects of vitamin D supplementation on symptoms of depression in overweight and obese subjects: randomized double-blind trial. J Intern Med. 2008 Dec;264(6):599-609. doi: 10.1111/j.1365-2796.2008.02008.x. Epub 2008 Sep 10. PMID: 18793245.
23. Sneve M, Figenschau Y, Jorde R. Supplementation with cholecalciferol does not result in weight reduction in overweight and obese subjects. Eur J Endocrinol. 2008 Dec;159(6):675-84. doi: 10.1530/EJE-08-0339. PMID: 19056900.
24. Mastaglia SR, Mautalen CA, Parisi MS et al., Vitamin D2 dose required to rapidly increase 25OHD levels in osteoporotic women. Eur J Clin Nutr. 2006 May ;60(5):681-7. doi: 10.1038/sj.ejcn.1602369. PMID: 16391587.
25. Ponda MP, Dowd K, Finkielstein D et al., The short-term effects of vitamin D repletion on cholesterol: a randomized, placebo-controlled trial. Arterioscler Thromb Vasc Biol. 2012 Oct;32(10):2510-5. doi: 10.1161/ATVBAHA.112.254110. Epub 2012 Sep 4. PMID: 22947589; PMCID: PMC3633472.
26. Rafii DC, Ali F, Farag A et al., A prospective study of commonly utilized regimens of vitamin d replacement and maintenance therapy in adults. Endocr Pract. 2019 Jan;25(1):6-15. doi: 10.4158/EP-2018-0219. Epub 2018 Nov 1. PMID: 30383486.
27. Rorie A, Goldner WS, Lyden E et al., Beneficial role for supplemental vitamin D3 treatment in chronic urticaria: a randomized study. Ann Allergy Asthma Immunol. 2014 Apr;112(4):376-82. doi: 10.1016/j.anai.2014.01.010. Epub 2014 Feb 5. PMID: 24507460.
28. Schwartz JB, Kane L, Bikle D. Response of Vitamin D Concentration to Vitamin D3 Administration in Older Adults without Sun Exposure: A Randomized Double-Blind Trial. J Am Geriatr Soc. 2016 Jan;64(1):65-72. doi: 10.1111/jgs.13774. PMID: 26782853; PMCID: PMC4724876.
29. Shirvani A, Kalajian TA, Song A et al., Variable Genomic and Metabolomic Responses to Varying Doses of Vitamin D Supplementation. Anticancer Res. 2020 Jan;40(1):535-543. doi: 10.21873/anticanres.13982. PMID: 31892609.

30. Vieth R, Chan PC, MacFarlane GD. Efficacy and safety of vitamin D3 intake exceeding the lowest observed adverse effect level. Am J Clin Nutr. 2001 Feb;73(2):288-94. doi: 10.1093/ajcn/73.2.288. PMID: 11157326.
31. Wagner H, Alvarsson M, Mannheimer B et al., No Effect of High-Dose Vitamin D Treatment on β-Cell Function, Insulin Sensitivity, or Glucose Homeostasis in Subjects With Abnormal Glucose Tolerance: A Randomized Clinical Trial. Diabetes Care. 2016 Mar;39(3):345-52. doi: 10.2337/dc15-1057. Epub 2016 Jan 19. PMID: 26786573.
32. Wamberg L, Pedersen SB, Richelsen B et al., The effect of high-dose vitamin D supplementation on calciotropic hormones and bone mineral density in obese subjects with low levels of circulating 25-hydroxyvitamin d: results from a randomized controlled study. Calcif Tissue Int. 2013 Jul;93(1):69-77. doi: 10.1007/s00223-013-9729-3. Epub 2013 Apr 17. PMID: 23591713.
33. Enkhmaa D, Tanz L, Ganmaa D et al., Randomized trial of three doses of vitamin D to reduce deficiency in pregnant Mongolian women. EBioMedicine. 2019 Jan;39:510-519. doi: 10.1016/j.ebiom.2018.11.060. PMID: 30552064; PMCID: PMC6354654.
34. Hollis BW, Wagner CL. 2004. Vitamin D requirements during lactation: high dose maternal supplementation as therapy to prevent hypovitaminosis D for both the mother and the nursing infant Am J Clin Nutr 80: 1752S-1758S
35. Hollis BW, Wagner CL. Vitamin D requirements and supplementation during pregnancy. Curr Opin Endocrinol Diabetes Obes. 2011 Dec;18(6):371-5. doi: 10.1097/MED.0b013e32834b0040. PMID: 21857221; PMCID: PMC7905986.
36. Roth DE, Morris SK, Zlotkin S, Gernand AD, Ahmed T, Shanta SS, Papp E, Korsiak J, Shi J, Islam MM, Jahan I, Keya FK, Willan AR, Weksberg R, Mohsin M, Rahman QS, Shah PS, Murphy KE, Stimec J, Pell LG, Qamar H, Al Mahmud A. Vitamin D Supplementation in Pregnancy and Lactation and Infant Growth. N Engl J Med. 2018 Aug 9;379(6):535-546. doi: 10.1056/NEJMoa1800927. Erratum in: N Engl J Med. 2021 Oct 28;385(18):1728. PMID: 30089075; PMCID: PMC6004541.
37. Wagner CL, Hulsey TC, Fanning D, Ebeling M, Hollis BW. High-dose vitamin D3 supplementation in a cohort of breastfeeding mothers and their infants: a 6-month follow-up pilot study. Breastfeed Med. 2006 Summer;1(2):59-70. doi: 10.1089/bfm.2006.1.59. PMID: 17661565.
38. Belenchia AM, Tosh AK, Hillman LS, Peterson CA. Correcting vitamin D insufficiency improves insulin sensitivity in obese adolescents: a randomized controlled trial. Am J Clin Nutr. 2013 Apr;97(4):774-81. doi: 10.3945/ajcn.112.050013. Epub 2013 Feb 13. PMID: 23407306.
39. Lewis RD, Laing EM, Hill Gallant KM, Hall DB, McCabe GP, Hausman DB, Martin BR, Warden SJ, Peacock M, Weaver CM. A randomized trial of vitamin D_3 supplementation in children: dose-response effects on vitamin D metabolites and calcium absorption. J Clin Endocrinol Metab. 2013 Dec;98(12):4816-25. doi: 10.1210/jc.2013-2728. Epub 2013 Oct 3. PMID: 24092833; PMCID: PMC3849678.
40. Maalouf J, Nabulsi M, Vieth R, Kimball S, El-Rassi R, Mahfoud Z, El-Hajj Fuleihan G. Short- and long-term safety of weekly high-dose vitamin D3 supplementation in school children. J Clin Endocrinol Metab. 2008 Jul;93(7):2693-701. doi: 10.1210/jc.2007-2530. Epub 2008 Apr 29. PMID: 18445674; PMCID: PMC2729206.
41. Rajakumar K, Moore CG, Khalid AT et al., Effect of vitamin D3 supplementation on vascular and metabolic health of vitamin D-deficient overweight and obese children: a randomized clinical trial. Am J Clin Nutr. 2020 Apr 1;111(4):757-768. doi: 10.1093/ajcn/nqz340. PMID: 31950134; PMCID: PMC7138671.
42. Public Health England. National Diet and Nutrition Survey: Results from Years (9 to 11) of the Rolling Programme (2016/17-2018/19).

43. Darling AL, Blackbourn DJ, Ahmadi KR, Lanham-New SA. Very high prevalence of 25-hydroxyvitamin D deficiency in 6433 UK South Asian adults: analysis of the UK Biobank Cohort. Br J Nutr 2021. Feb 28;125(4):448-459. doi: 10.1017/S0007114520002779.
44. Cashman KD, Dowling KG, Škrabáková Z, et al., Vitamin D deficiency in Europe: pandemic? Am J Clin Nutr. 2016 Apr;103(4):1033-44. doi: 10.3945/ajcn.115.120873. PMID: 26864360; PMCID: PMC5527850.
45. Bassatne A, Chakhtoura M, Saad R, Fuleihan GE. Vitamin D supplementation in obesity and during weight loss: A review of randomized controlled trials. Metabolism. 2019 Mar; 92:193-205. doi: 10.1016/j.metabol.2018.12.010.PMID: 30615949.
46. Zittermann A, Ernst JB, Gummert JF, Börgermann J. Vitamin D supplementation, body weight and human serum 25-hydroxyvitamin D response: a systematic review. Eur J Nutr. 2014;53(2):367-74. doi: 10.1007/s00394-013-0634-3. PMID: 24292820.
47. Scientific Committee on Food/Scientific Panel on Dietetic Products, Nutrition and Allergies. Tolerable Upper Intake Levels for Vitamins and Minerals. February 2006.
48. Institutes of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D and Fluoride. 1997.
49. Food Supplements Europe. Risk management approaches to the setting of maximum levels of vitamins and minerals in food supplements for adults and for children aged 4-10 years. July 2014.
50. EHPM proposal for maximum and minimum levels for vitamins and minerals in food supplements for adults and children sold in Europe (2021) European Federation of Associations of Health Produce Manufacturers (EHPM), Brussels. https://ehpm.org/wp-content/uploads/2022/03/2021_02_EHPM_Max_Min_Levels_for_Vit_and_Min.pdf
51. Hollis BW, Wagner CL. Assessment of dietary vitamin D requirements during pregnancy and lactation. Am J Clin Nutr. 2004 May;79(5):717-26. doi: 10.1093/ajcn/79.5.717. PMID: 15113709.
52. Hollis BW, Wagner CL. Vitamin D requirements during lactation: high-dose maternal supplementation as therapy to prevent hypovitaminosis D for both the mother and the nursing infant. Am J Clin Nutr. 2004 Dec;80(6 Suppl):1752S-8S. doi: 10.1093/ajcn/80.6.1752S. PMID: 15585800.
53. Wagner CL, Hulsey TC, Fanning D et al., High-dose vitamin D3 supplementation in a cohort of breastfeeding mothers and their infants: a 6-month follow-up pilot study. Breastfeed Med. 2006 Summer;1(2):59-70. doi: 10.1089/bfm.2006.1.59. PMID: 17661565.
54. Dawodu A, Saadi HF, Bekdache G et al., Randomized controlled trial (RCT) of vitamin D supplementation in pregnancy in a population with endemic vitamin D deficiency. J Clin Endocrinol Metab. 2013 Jun;98(6):2337-46. doi: 10.1210/jc.2013-1154. PMID: 23559082.
55. Litonjua AA, Carey VJ, Laranjo N et al., Effect of Prenatal Supplementation With Vitamin D on Asthma or Recurrent Wheezing in Offspring by Age 3 Years: The VDAART Randomized Clinical Trial. JAMA. 2016 Jan 26;315(4):362-70. doi: 10.1001/jama.2015.18589. PMID: 26813209; PMCID: PMC7479967.
56. Enkhmaa D, Tanz L, Ganmaa D et al., Randomized trial of three doses of vitamin D to reduce deficiency in pregnant Mongolian women. EBioMedicine. 2019 Jan;39:510-519. doi: 10.1016/j.ebiom.2018.11.060. PMID: 30552064; PMCID: PMC6354654.
57. Dawodu A, Salameh KM, Al-Janahi NS et al., The Effect of High-Dose Postpartum Maternal Vitamin D Supplementation Alone Compared with Maternal Plus Infant Vitamin D Supplementation in Breastfeeding Infants in a High-Risk Population. A Randomized Controlled Trial. Nutrients. 2019 Jul 17;11(7):1632. doi: 10.3390/nu11071632. PMID: 31319554; PMCID: PMC6682993.

58. Wagner CL, Hulsey TC, Ebeling M et al., Safety Aspects of a Randomized Clinical Trial of Maternal and Infant Vitamin D Supplementation by Feeding Type Through 7 Months Postpartum. Breastfeed Med. 2020 Dec;15(12):765-775. doi: 10.1089/bfm.2020.0056. PMID: 32915638; PMCID: PMC7757584.
59. Chawes BL, Bønnelykke K, Stokholm J et al., Effect of Vitamin D3 Supplementation During Pregnancy on Risk of Persistent Wheeze in the Offspring: A Randomized Clinical Trial. JAMA. 2016 Jan 26;315(4):353-61. doi: 10.1001/jama.2015.18318. PMID: 26813208.
60. Hossain N, Kanani FH, Ramzan S et al., Obstetric and neonatal outcomes of maternal vitamin D supplementation: results of an open-label, randomized controlled trial of antenatal vitamin D supplementation in Pakistani women. J Clin Endocrinol Metab. 2014 Jul;99(7):2448-55. doi: 10.1210/jc.2013-3491. PMID: 24646102.
61. Sablok A, Batra A, Thariani K et al., Supplementation of vitamin D in pregnancy and its correlation with feto-maternal outcome. Clin Endocrinol (Oxf). 2015 Oct;83(4):536-41. doi: 10.1111/cen.12751. PMID: 25683660.
62. Litonjua AA, Carey VJ, Laranjo N et al., Six-Year Follow-up of a Trial of Antenatal Vitamin D for Asthma Reduction. N Engl J Med. 2020 Feb 6;382(6):525-533. doi: 10.1056/NEJMoa1906137. PMID: 32023372; PMCID: PMC7444088.
63. Rostami M, Tehrani FR, Simbar M et al., Effectiveness of Prenatal Vitamin D Deficiency Screening and Treatment Program: A Stratified Randomized Field Trial. J Clin Endocrinol Metab. 2018 Aug 1;103(8):2936-2948. doi: 10.1210/jc.2018-00109. PMID: 29788364.
64. Roth DE, Gernand AD, Al Mahmud A. Vitamin D Supplementation in Pregnancy and Lactation and Infant Growth. N Engl J Med. 2018 Nov 8;379(19):1881. doi: 10.1056/NEJMc1812157. PMID: 30403950.
65. Public Health England. National Diet and Nutrition Survey: Results from years 1,2,3 and 4 (combined) of the rolling Programme (2008/2009-2011/2012).
66. Giustina A, Adler RA, Binkley N et al., Consensus statement from 2nd International Conference on Controversies in Vitamin D. Rev Endocr Metab Disord. 2020 Mar;21(1):89-116. doi: 10.1007/s11154-019-09532-w. PMID: 32180081; PMCID: PMC7113202.
67. Griffin G, Hewison M, Hopkin J et al., Preventing vitamin D deficiency during the COVID-19 pandemic: UK definitions of vitamin D sufficiency and recommended supplement dose are set too low. Clin Med (Lond). 2021 Jan;21(1): e48-e51. doi: 10.7861/clinmed.2020-0858. PMID: 33158957; PMCID: PMC7850219.