



Vitamin D Supplementation in Northern European Winters: Evidence, Dose and the Gap Between Guidance and Practice

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Abstract

Two authoritative reviews of vitamin D status in Northern Europe disagree by a wide margin. One reports that 43 to 92 per cent of adults and 89 to 97 per cent of teenage girls have serum 25-hydroxyvitamin D below 50 nmol/L; another reports that deficiency at the same threshold occurs in under 20 per cent of the population in Northern Europe, against 30 to 60 per cent in Western, Southern and Eastern Europe. The discrepancy is not a simple error. Where fortification policy and a supplementation tradition exist, latitude runs inversely to serum concentration, so the countries with least winter sunlight are not reliably the worst affected. Dose guidance is similarly unsettled, ranging from a reference intake of 400 to 800 international units daily to expert consensus of 800 to 2,000, and up to 4,000 for defined groups. Across the European general population 13.0 per cent fall below 30 nmol/L and 40.4 per cent below 50.

Keywords: Vitamin D; 25-hydroxyvitamin D; Supplementation; Northern Europe; Fortification

Introduction

Vitamin D is obtained principally through synthesis in skin under ultraviolet-B radiation, with dietary intake traditionally playing a smaller part [1,2]. Above roughly 50 degrees of latitude, cutaneous synthesis ceases for several winter months, so the population depends on stores, diet and supplements through that period [3,4,33,34]. Whether the resulting picture amounts to a pandemic has been argued directly [10], and trends in status worldwide have been tracked over time [34].

Status is assessed by serum 25-hydroxyvitamin D, with target concentrations in current guidance ranging from at least 25 to at least 50 nmol/L [1,5]. That range alone produces different prevalence estimates from identical measurements [11,12,14]. Comparative analysis of nutritional guidelines documents how far the targets themselves diverge [14], and national guidance has been issued separately again [15].

This review examines what is known about winter status in Northern Europe, why published estimates for the same region differ so widely, what dose the evidence supports, and where guidance and practice diverge.

Objective

The purpose of this review is to set out three things from the published literature. First, the reported prevalence of low vitamin D status in Northern Europe and the reasons published figures conflict. Second, what daily dose has been shown to achieve a given serum concentration in winter conditions. And third, where recommendations diverge from one another and from what is delivered in practice.

Literature Review

Two estimates that do not agree: A review of vitamin D status in Northern Europe reports that around 43 to 92 per cent of adults and 89 to 97 per cent of teenage girls have plasma 25-hydroxyvitamin D below 50 nmol/L, attributing this to low sun exposure in winter at high latitude [3]. A review by the European Calcified Tissue Society reports that deficiency at the same threshold occurs in under 20 per cent of the population in Northern Europe, in 30 to 60 per cent in Western, Southern and Eastern Europe, and in up to 80 per cent in Middle Eastern countries (Figure 1) [1].

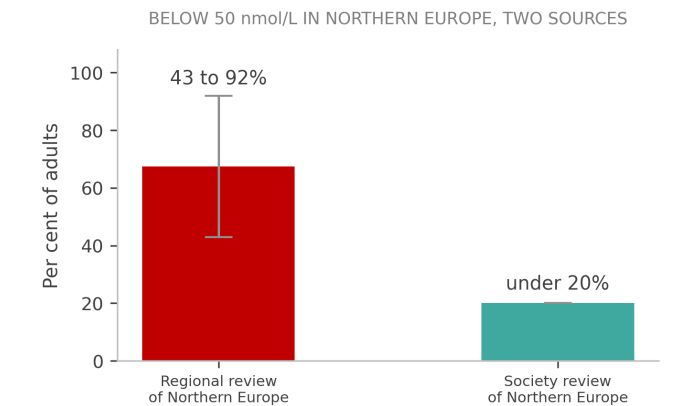


Figure 1: Reported prevalence below 50 nmol/L in Northern Europe, two sources [1,3]

Why the two can both be defensible: The same Northern European review notes that high dietary intake of fatty fish, cod liver and cod liver oil in Scandinavia and Iceland, together with frequent supplement use, mitigates the effect of reduced sun exposure [3]. It further observes that while latitude has a positive effect on average plasma concentrations across Europe as a whole, at the level of individual countries with a more common fortification policy and supplementation tradition the relationship is inverted (Figure 3) [3]. Deficiency in Northern Europe is therefore not simply a function of sunlight, and estimates depend on which populations and seasons are sampled.



Figure 3: Why northern populations are not reliably the worst affected [3]

Figures for Europe as a whole: Across the European general population, concentrations below 30 nmol/L are present in 13.0 per cent and below 50 nmol/L in 40.4 per cent (Figure 2) [5]. Severe deficiency below 30 nmol/L is reported in more than 10 per cent of Europeans, and identified risk groups include young

children, adolescents, pregnant women, older people particularly when institutionalised, and non-Western immigrants [1].

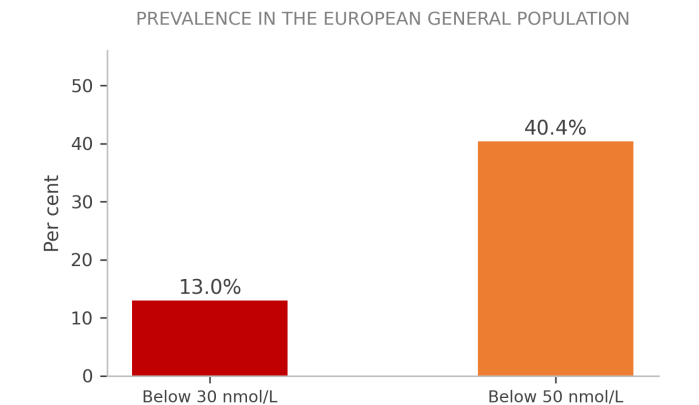


Figure 2: Prevalence in the European general population [5]

Table 1: Reported prevalence of low vitamin D status, as published by the original investigators

Population	Threshold	Reported prevalence
Northern Europe, adults	50 nmol/L	43% to 92% [3]
Northern Europe, teenage girls	50 nmol/L	89% to 97% [3]
Northern Europe, population	50 nmol/L	Under 20% [1]
Europe, general population	50 nmol/L	40.4% [5]
Europe, general population	30 nmol/L	13.0% [5]

What dose achieves what concentration: Dietary reference intakes generally correspond to 10 to 20 micrograms daily, that is 400 to 800 international units, aligned to target concentrations of at least 25 to at least 50 nmol/L [5]. Calculations of the intake required to replace daily metabolic clearance suggest 600 to 1,000 units daily should maintain concentrations above 50 nmol/L, and 800 units daily has been shown to reduce fracture and fall risk in older women [1]. Irish work found that 800 units daily during wintertime was sufficient to reach 50 nmol/L in about 90 to 95 per cent of the population studied (Figure 5) [6,7].

Body weight alters the response: Analysis of supplement use by body mass index found that participants with obesity and overweight taking more than 800 units daily had mean 25-hydroxyvitamin D concentrations 15.5 and 8.1 nmol/L lower respectively than normal-weight counterparts on the same intake (Figure 6) [9]. The same analysis reported lower prevalence of supplement use among participants with obesity, so the nutritional disparity compounds the physiological one [9].

Table 2: Daily intake recommended by each source, as published

REACHING 50 nmol/L ON 800 IU DAILY IN WINTER

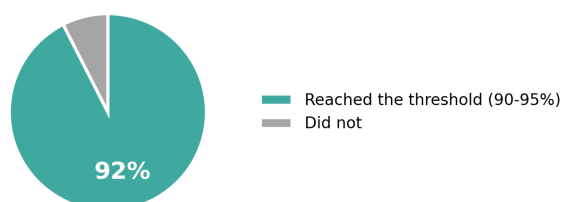


Figure 5: Reaching 50 nmol/L on 800 units daily in winter [6,7]

Where the recommendations diverge: A European expert panel using the Delphi method recommended 800 to 2,000 units daily for adults wishing to ensure sufficient status, with up to 4,000 units daily for particular groups including those with obesity, malabsorption syndromes and darker skin pigmentation, and higher doses such as 6,000 units daily for the first four to twelve weeks of treatment (Figure 4) [8]. The wide ranges are attributed to differences in the dose-response relationship, with higher requirements as body weight increases [8,13,30]. Society guidance issued separately recommends higher intakes again for at-risk groups [13], and individual participant data meta-regression has been used to refine dietary guidance on that basis [30]. The choice of preparation has been reviewed separately [31].

DAILY DOSE RECOMMENDED, BY SOURCE

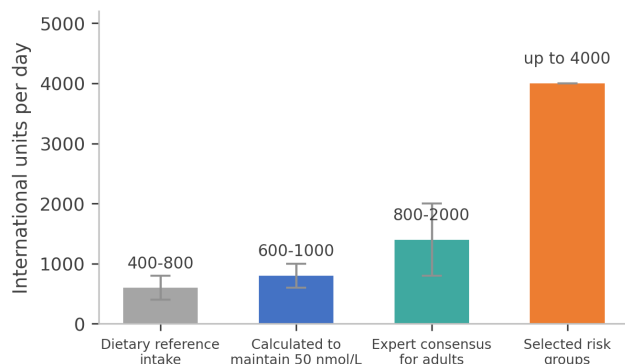


Figure 4: Daily dose recommended, by source [1,5,8]

LOWER 25-HYDROXYVITAMIN D DESPITE ABOVE 800 IU DAILY

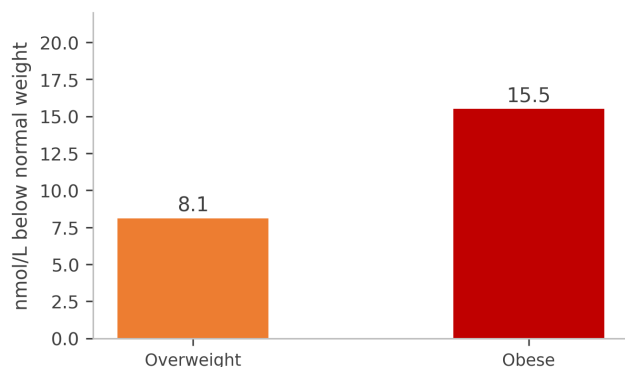


Figure 6: Lower concentrations despite intake above 800 units daily [9]

Source	Recommended daily intake
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Dietary reference intakes	400 to 800 units [5]
Calculated metabolic replacement	600 to 1,000 units [1]
European expert consensus, adults	800 to 2,000 units [8]
Consensus, defined risk groups	Up to 4,000 units [8]
Consensus, initial treatment	6,000 units for 4 to 12 weeks [8]

Screening is not recommended generally: The same expert panel argued against general population screening for vitamin D deficiency while suggesting 25-hydroxyvitamin D testing in defined risk groups [8]. Central European guidance additionally recommends assessment in patients with chronic autoimmune disease, cardiovascular disease, or admission with certain infections and chronic allergic disease, with treatment where concentration falls below 20 ng/mL [5,8].

Measurement itself is a variable: The European Calcified Tissue Society advises that measurement of serum 25-hydroxyvitamin D be standardised, for example through the Vitamin D Standardization Program [1]. Until assays are harmonised, part of the variation between published prevalence estimates is attributable to the laboratory rather than to the populations measured [1,5,17,18]. Assay standardisation has been described as the way out of the resulting confusion [18], and the definition of hypovitaminosis D was the subject of a dedicated international conference [17].

What supplementation achieves clinically: Dose-dependent reduction in non-vertebral fracture has been reported with oral vitamin D [23], while a systematic review with trial sequential analysis concluded that supplementation does not improve musculoskeletal health at a population level [24]. Large randomised trials found no reduction in cancer or cardiovascular disease [25], and individual participant data meta-analysis reported a protective effect against acute respiratory infection [26,27]. The skeletal case is therefore contested and the extra-skeletal case more so [1,24,25].

Dose in children and pregnancy: Work in northern Italian children found the commonly recommended 600 to 1,000 units daily insufficient to reach 75 nmol/L, and evaluated seasonal supplementation at 1,500 units daily from November to April [28]. In pregnancy, regular supplement intake was associated with higher maternal concentrations at delivery, with dietary intake contributing a smaller effect, and deficiency was most marked in autumn and winter [29,32].

Table 3: Why published prevalence estimates for the same region differ

Eligibility: Studies were included if they reported population prevalence of low vitamin D status in defined European populations, examined dose-response, or set out supplementation recommendations. Guidance and consensus documents are cited for the recommendations they contain and identified as such.

Consideration	Effect on the reported figure
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Threshold applied	30 against 50 nmol/L changes prevalence threefold [5]
Season sampled	Winter and summer differ within one population [3,4]
Assay used	Unstandardised methods are not comparable [17,18]
Fortification policy	Inverts the relationship with latitude [3,21,22]
Population selected	Risk groups differ markedly from the general population [1]

Consequences attributed to low status: The society review lists mineralisation defects and lower bone mineral density causing fracture as the skeletal consequences, with muscle weakness, falls and acute respiratory infection among the extra-skeletal ones [1]. The strength of evidence differs sharply between those two groups, and the effect of deficiency on long-term non-skeletal outcomes such as cancer is described in the same review as unresolved [1,25].

Method

Search strategy: PubMed and the archives of the major clinical nutrition, endocrinology and bone journals were searched for studies of vitamin D status and supplementation in European populations. Search terms combined vitamin D and 25-hydroxyvitamin D with Northern Europe, winter, prevalence, supplementation dose, fortification and guidelines. Reference lists of the society status review [1] and the expert consensus statement [8] were screened by hand for primary sources.

Data extraction and handling: Population, season, assay where reported, threshold and the reported estimate were extracted as published. The threshold is stated alongside every prevalence figure, because concentrations of 30 and 50 nmol/L produce estimates differing threefold in the same population, and that dependence is central to the argument here. This review reports published findings and the content of existing guidance. It makes no dietary, supplementation or dosing recommendation for any individual, all of which are matters for the treating clinician. No pooling or re-analysis was performed. Figures 1 to 6 and Tables 1 to 3 reproduce published values only. This is a narrative synthesis of published literature and was not registered as a systematic review.

Concluding Remarks

The most useful thing this literature offers is a caution about its own headline figures. Two reviews of the same region, both authoritative, report prevalence below 50 nmol/L as 43 to 92 per cent and as under 20 per cent [1,3]. A reader encountering either alone would form a confident and quite different impression of the problem.

The explanation is not that one is wrong. Northern European populations combine the least winter ultraviolet exposure in

Europe with the highest dietary intake of oily fish and among the most established supplementation habits, and where fortification policy exists the relationship between latitude and serum concentration inverts [3]. Prevalence therefore depends on which countries are grouped as northern, which season is sampled, which threshold is applied and which assay was used [1,5].

For dose, the picture is more tractable than the prevalence figures suggest. Eight hundred units daily achieved 50 nmol/L in about nine in ten people studied through an Irish winter, and calculations of metabolic replacement point to a similar figure [1,6,7]. The expert consensus range of 800 to 2,000 units sits above that, reflecting the wide individual variation in dose-response rather than disagreement about the target [8].

Body weight is the clearest modifier and the one with a practical consequence. Participants with obesity taking above 800 units daily still had concentrations 15.5 nmol/L below normal-weight counterparts, and were less likely to be taking supplements at all [9]. A single population-wide dose will therefore leave a predictable group short, and that group is identifiable without testing.

On the gap named in the title, the evidence supports a narrower statement than the phrase implies. Guidance is not uniform, so practice cannot straightforwardly be said to depart from it: reference intakes, metabolic calculations and expert consensus recommend 400 to 800, 600 to 1,000 and 800 to 2,000 units respectively [1,5,8]. What can be said is that most populations fail to meet even the lowest of those figures through diet alone, and that the authors of the dietary guidance describe the gap between recommended intake and observed status as requiring action [5,16]. Fortification has been proposed as the population-level response, and a national fortification policy was followed by improved status in a representative adult population [19,21,22], though fortifying dairy alone has been judged insufficient [19,20].

Two limitations belong with these conclusions. Prevalence estimates are drawn from studies using unstandardised assays across different seasons and age groups, which the society review identifies as a reason to standardise measurement before comparing populations [1]. And dose-response data come predominantly from lighter-skinned European populations, so requirements in groups with darker skin pigmentation are extrapolated rather than directly established [8,9].

A further reason the prevalence figures resist reconciliation concerns what is being counted. Deficiency, insufficiency and inadequacy are used differently between sources, and the same serum concentration can fall into any of them depending on the framework applied [11,12,14]. A comparative analysis of nutritional guidelines found the targets themselves diverge before any measurement is taken [14], which means the disagreement described in this review begins in the definitions rather than in the data.

Fortification offers the clearest illustration of why the northern picture is not simply a sunlight problem. Introduction of a general food fortification policy in one Nordic country was followed by improved status in a representative adult population [22], while analyses elsewhere concluded that fortifying dairy products alone would not close the gap [19,20]. A country at high latitude with fortification can therefore outperform one at lower latitude without it, which is precisely the inversion the regional review reported [3,21].

What would settle the question this review opens is standardisation rather than further surveys. Until assays are harmonised and thresholds agreed, additional prevalence studies will add estimates to a range that is already wide for methodological rather than biological reasons [1,17,18]. The measurement programme the society recommends is the prerequisite for comparing one population with another at all [1,18].

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Conflict of Interest

The authors declare no competing interests.

Ethics Statement

This article reviews previously published studies only. No new patient data were collected and no participants were recruited, so ethical approval was not required.

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