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Report of the Scientific Committee
of the Food Safety Authority of Ireland

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Vitamin D
Scientific Recommendations for Food-Based Dietary Guidelines for Older Adults in Ireland

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Glossary

Term	Definition
25(OH)D	serum 25-hydroxyvitamin D
µg	microgram
EFSA	European Food Safety Authority
EU	European Union
FBDG	food-based dietary guidelines
IOM	Institute of Medicine
IU	international units
NANS	National Adult Nutrition Survey
NICE	National Institute for Health and Care Excellence
nmol/L	nanomole per litre
NNR	Nordic Nutrition Recommendations
PRI	population reference intake
RCT	randomised controlled trial
SACN	Scientific Advisory Committee on Nutrition
TILDA	The Irish Longitudinal Study on Ageing
TUDA	The Trinity-Ulster and Department of Agriculture Study
UK	United Kingdom
UL	tolerable upper intake level
UVB	ultraviolet B
WHO	World Health Organization

Vitamin D

1. Summary

This report was developed by the Scientific Committee of the Food Safety Authority of Ireland in response to a request from the Department of Health to provide an evidence base to underpin public health policy for vitamin D supplementation in people aged 65 years and older.

Adequate vitamin D intake is essential in older adults for bone health. Although causation has not been proven, some studies suggest associations between vitamin D deficiency and non-skeletal health, such as: cardiovascular diseases; diabetes; inflammatory, infectious and immune disorders; certain cancers; and higher mortality. Recent reviews concluded that there is no evidence to support taking vitamin D supplements to specifically prevent or treat COVID-19 and that the evidence on vitamin D supplementation and acute respiratory tract infection risk was inconsistent and generally did not show a beneficial effect of vitamin D supplementation on infectious disease risk.

Vitamin D is obtained from diet (natural foods, fortified foods, and supplements) and (during the months April through October in the Northern hemisphere) skin exposure to sunlight. A review of the available evidence, including studies in Ireland, shows that the daily dietary vitamin D requirement to maintain serum 25-hydroxyvitamin D (25(OH)D) ≥30 nmol/L (the threshold below which risk of vitamin D deficiency is increased) in older adults in Ireland is 15 µg for those who are generally healthy and living independently, and 20 µg for those who are housebound with limited or no sunlight exposure.

Studies in Ireland have shown a high frequency of vitamin D deficiency (serum 25(OH)D <30 nmol/L) in older free-living adults, varying from 10% to 44% of the population, which was more pronounced in the winter months. One study showed that vitamin D deficiency is common in nursing home residents (42% with serum 25(OH)D <25 nmol/L). United Kingdom (UK) data show that in older adults from ethnic minority groups with dark skin, the prevalence of vitamin D deficiency (serum 25(OH)D <25 nmol/L) is much higher (36–57%) than in the Caucasian population (12%).

In Ireland, the Irish National Adult Nutrition Survey (2008–2010) showed that the mean daily intakes of vitamin D from diet and supplements was 5.2 µg for men and 8.5 µg for women (≥65 years), and 27% of both men and women regularly consumed a nutritional supplement containing vitamin D (males: 21%; females: 32%). Mean daily intake of vitamin D from natural foods was 3.6 µg and increased to 4.7 µg when the contribution of fortified foods was included. Fish, meats, eggs, and vitamin D-fortified foods contributed 23%, 19%, 7% and 17%, respectively, to the mean

daily intake of vitamin D. Vitamin D-fortified foods include some fat spreads, milks, yogurts, and ready-to-eat breakfast cereals. Thus, while natural vitamin D sources and vitamin D-fortified foods make important dietary contributions, these sources alone are not sufficient to ensure that vitamin D dietary requirements are achieved in older adults in Ireland, and vitamin D supplements are also needed. Taking the average daily vitamin D intake in older adults in Ireland not consuming vitamin D-containing supplements as around 5 µg, daily supplements containing 10 µg or 15 µg are needed in order to achieve a total intake of 15 µg and 20 µg, respectively.

A daily vitamin D supplement of 10 µg or 15 µg may be considered safe for older adults in Ireland. Such a supplement would increase the daily vitamin D intake of high consumers (from foods) to about 20 µg or 25 µg, which is not higher than the current intake of high consumers (from foods and supplements) and is well below the tolerable upper intake level (UL) of vitamin D (100 µg). It should be noted that many supplemental vitamin D products also contain calcium. Many frail older adults require calcium as well as vitamin D supplements.

Recommendations

The recommended daily intake of vitamin D in older adults in Ireland is 15 µg for those who are generally healthy and living independently, and 20 µg for those who are housebound with limited or no sunlight exposure.

Diets of older adults in Ireland should include regular intakes of natural sources of vitamin D, such as oily fish, eggs, meats, and vitamin D-fortified foods.

Older adults in Ireland are advised to consider taking a daily supplement of vitamin D as follows:

- For healthy older adults living independently and who get sunlight exposure during summer, a daily vitamin D supplement containing 10 µg (400 IU) should be taken during the extended winter months (end of October to March); and for those of darker-skinned ethnicity, this daily vitamin D supplement containing 10 µg (400 IU) should be taken throughout the full year.
- For housebound older adults in Ireland with minimal or no sunlight exposure, a daily vitamin D supplement containing 15 µg (600 IU) should be taken throughout the full year.

A daily vitamin D supplement of 10 µg or 15 µg may be considered safe for older adults in Ireland.

2. Background and scope

Adequate vitamin D intake is essential in older adults for bone health (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016; Scientific Advisory Committee on Nutrition, 2016; Nordic

Council of Ministers, 2014; Institute of Medicine, 2011). Although causation has not been proven, association studies suggest a link between vitamin D deficiency and non-skeletal health, such as: cardiovascular diseases; diabetes; inflammatory, infectious and immune disorders; certain cancers; and higher mortality (Lips *et al*., 2019).

Two separate sources contribute to vitamin D supply in Ireland: unprotected skin exposure to ambient ultraviolet B (UVB) radiation from sunlight during the months April through October; and oral intake of vitamin D from natural foods, fortified foods, and supplements. For the older adult, while the supply of vitamin D from sunlight exposure may be greatly reduced, adequate vitamin D intake may be ensured through augmented oral intake.

The Scientific Committee of the Food Safety Authority of Ireland is in the process of developing a report which will be an addendum to the food-based dietary guidelines (FBDG) for the general adult population, outlining additional or modified guidelines for older adults living in Ireland, following a review of relevant research in this area. The Department of Health has requested that the vitamin D section of the report be fast-tracked. Therefore, the purpose of this current report is to provide additional or modified guidelines on vitamin D for older adults living in Ireland (see Appendix 1).

This report outlines information on vitamin D status in older adults in Ireland, possible health consequences of low status, dietary vitamin D requirements and whether these are being met by older adults in Ireland, and if not, how this might be addressed through dietary means. Finally, it presents a number of key scientific recommendations for FBDG for older adults in Ireland. For the purposes of this report, older adults are defined as those aged 65 years and older and are grouped according to the Department of Health categorisation into the following four subgroups:

- Healthy older person living independently
- Older person with compromised mobility and/or with comorbidities and living independently
- Semi-independent older person
- Older person dependent on residential care.

3. Vitamin D status and deficiency in older adults in Ireland, its determinants and health consequences

Several recent studies in Ireland have evaluated vitamin D status and explored its determinants: the National Adult Nutrition Survey (NANS); the Trinity-Ulster and Department of Agriculture (TUDA) Study; and The Irish Longitudinal Study on Ageing (TILDA). They all showed a high

frequency of vitamin D deficiency in older adults, which was defined using the United States Institute of Medicine (IOM) threshold of serum 25(OH)D <30 nmol/L (Institute of Medicine, 2011), varying from 10% to 44% of the population cohort, which was more pronounced in the winter months (Table 2) (Laird *et al*., 2018; O'Sullivan *et al*., 2017; McCarroll *et al*., 2015). Vitamin D supplement use, together with sunnier season, sun exposure preference, and dietary vitamin D intake, were significant positive determinants of serum 25(OH)D_3 concentrations in the entire NANS sample (18–84 years) (Cashman, 2015). TILDA showed that the frequency of vitamin D deficiency was lower in those on supplements, but less than 10% were taking supplements (Laird *et al*., 2018). Vitamin D status was also better in those who consumed fortified milk, ate eggs or oily fish, and preferred going outdoors in the sun or on sun holidays (Laird *et al*., 2018; O'Sullivan *et al.*, 2017; McCarroll *et al.*, 2015). TILDA showed that vitamin D status was worse based on: geographic location (with the lowest vitamin D status being in Donegal); smoking; obesity; and physical inactivity. Socioeconomic status has a bearing on vitamin D status as shown by a geo-mapping study in the Dublin region, with more deprived districts being more likely to be vitamin D deficient (Scully *et al*., 2020). It should also be noted that between 7% and 13% of older adults in NANS and TILDA, respectively, had serum 25(OH)D <30 nmol/L during summer months (Table 1). The participants in the two studies were free-living individuals. Vitamin D deficiency is common in nursing home residents (n=273) in the Galway region based on laboratory samples collected from 2011 to 2015 that recorded 42% of residents with 25(OH)D <25 nmol/L (Griffin *et al*., 2020). Older adults from ethnic minority groups with dark skin are also at particular risk of having a low vitamin D status, but there are no Irish studies in older adult minority groups. Recent data from the UK Biobank (348,598 participants, aged 37–73 years) show that the prevalence of serum 25(OH)D <25 nmol/L in South Asian and black participants was much higher than in Caucasian participants (57.3% and 36.3%, respectively, versus 11.7%) (Hastie *et al*., 2020).

Table 1 Frequency of vitamin D deficiency and inadequacy in older adults in Ireland cohorts*

Study	Year of study	Sample size	Age (years)	% with 25(OH)D <30 nmol/L		% with 25(OH)D <50 nmol/L	
NANS	2008–2010	147	>65	10 [7 summer, 12 winter]		Summer 35	Winter 50
TUDA	2008–2012		>60				
*Sub-cohorts***							
Bone		1233	70.1 ± 6.3	14		43	
Hypertensive		1895	71.0 ± 7.3	27		66	
Cognitive		1316	80.4 ± 6.7	44		75	
TILDA	2009–2011	5356	>50	Summer 13	Winter 37	Summer 27	Winter 59

*Serum 25(OH)D of <30 and <50 nmol/L, representing vitamin D deficiency and inadequacy, respectively.

**On the basis of recruitment, the TUDA Cohort Study consists of three sub-cohorts: Bone, Hypertensive and Cognitive. The Bone and Cognitive sub-cohorts were recruited from outpatient clinics at St James's Hospital, Dublin for investigation of bone and memory, respectively. Those in the Hypertensive cohort had a diagnosis of hypertension and were recruited from Western and Northern Health and Social Care Trusts in Northern Ireland. Regardless of location of recruitment, all participants were sampled using a common protocol, and biomarker analysis, including vitamin D, was conducted centrally. Age is given as mean ± standard deviation.

Abbreviations: NANS, National Adult Nutrition Survey (≥65 years cohort); TUDA, The Trinity-Ulster and Department of Agriculture study; TILDA, The Irish Longitudinal Study on Ageing

There is a strong association between frailty and low vitamin D status in older adults. A self-perpetuating cycle may develop in older adults whereby vitamin D deficiency results in muscle weakness and frailty, thus leading to reduced mobility and the unlikelihood of going outdoors, which in turn reduces the supply of vitamin D from sunshine exposure (Figure 1). TILDA showed that three measures of frailty (Frailty Phenotype, Frailty Index, and the Frail Scale) were all associated with vitamin D deficiency (O'Halloran *et al*., 2019). A similar study in England showed a link between both impaired muscle strength and physical performance with vitamin D deficiency (Aspell *et al*., 2019). In a meta-analysis, vitamin D supplementation was found to have a small, but significant positive effect on global muscle strength but no effect on muscle mass and muscle power (Beaudart *et al*., 2014). The effects on muscle strength were substantially greater for those with a lower baseline 25(OH)D (<30 nmol/L), suggesting that the benefits of vitamin D supplementation on skeletal muscle outcomes may be confined to those with lower vitamin D status (Beaudart *et al*., 2014). A recent randomised controlled trial (RCT) of vitamin D 30 µg daily for 12 months in participants aged 60–80 years showed no benefit with respect to depressive symptoms or functional limitations, but the initial baseline average 25(OH)D before supplementation was 46 nmol/L, which is substantially higher than the threshold for risk of vitamin D deficiency (de Koning *et al*., 2019).

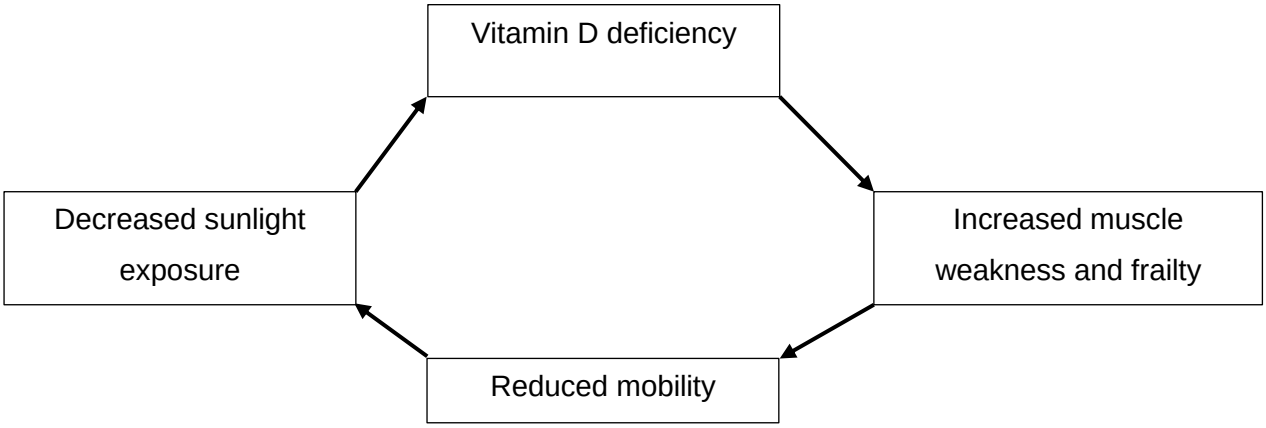

Figure 1 Self-perpetuating cycle of vitamin D deficiency in frail older adults (adapted from McKenna *et al*. (1981))

There is concern in Ireland about vitamin D status during the SARS-CoV-2 virus pandemic and the associated disease, COVID-19 (Laird and Kenny, 2020; McKenna and Flynn, 2020; NICE, 2020; Rhodes *et al*., 2020; Scientific Advisory Committee on Nutrition, 2020). Since activated vitamin D regulates more than 200 genes, and especially since vitamin D receptors and metabolic enzymes are evident in immune cells, it is generally accepted that vitamin D has a role in immune homeostasis (Lanham-New *et al*., 2020). There is an association between vitamin D status and influenza, but it is not clear whether this is a causal link (Lanham-New *et al*., 2020; Martineau *et al*., 2017; Rejnmark *et al*., 2017). A systematic review of RCTs on vitamin D for the prevention of respiratory infections concluded that the benefit was most evident in those with 25(OH)D below 25 nmol/L (Martineau *et al*., 2017). The World Health Organization (WHO) has indicated that older adults and people with underlying health conditions are at higher risk of developing severe forms of COVID-19. Two recent rapid evidence reviews conducted in the UK summarised the best available scientific evidence on vitamin D and risk of COVID-19 (NICE, 2020) and acute respiratory tract infections (Scientific Advisory Committee on Nutrition, 2020). After reviewing the acknowledged limited evidence base and lack of RCT data, the National Institute for Health and Care Excellence (NICE) concluded that there is no evidence to support taking vitamin D supplements to specifically prevent or treat COVID-19. The Scientific Advisory Committee on Nutrition (SACN) concluded that the evidence on vitamin D supplementation and acute respiratory tract infection risk was inconsistent and generally did not show a beneficial effect of vitamin D supplementation on infectious disease risk. Regardless of whether vitamin D deficiency is a risk for poor outcome due to COVID-19, the practice of cocooning is a risk factor for vitamin D deficiency because it curtails skin production of vitamin D by minimising exposure to natural sunlight (McKenna and Flynn, 2020).

4. Vitamin D dietary requirements for older adults in Ireland

Health authorities in the European Union (EU) through the European Food Safety Authority (EFSA) (EFS Panel on Dietetic Products, Nutrition and Allergies, 2016), in the UK through the SACN (Scientific Advisory Committee on Nutrition, 2016), in Nordic countries through the Nordic Nutrition Recommendations (NNR) (Nordic Council of Ministers, 2014), and in North America through the IOM (Institute of Medicine, 2011) have all established dietary vitamin D requirements at all ages, including older adults. These dietary requirements are based on specified health outcomes and the associated serum 25(OH)D concentration, an index of vitamin D status. These defined target serum 25(OH)D thresholds are then translated into vitamin D intake requirements using data from RCTs with vitamin D to relate serum 25(OH)D to vitamin D intake. The RCTs are typically winter based so as to allow for the assumed absence of UVB-derived vitamin D supply in deriving the dietary requirement estimates. These recommendations for older adults are summarised in Table 2. All agencies which have established these dietary requirements for vitamin D in older adults have based them on bone/musculoskeletal health, with some including additional health outcomes such as total mortality and/or the risk of falling. Three of the four sets of recommendations (IOM, NNR and EFSA) aimed to achieve adequacy of vitamin D status to support these bone health outcomes and thus based their recommendations on a serum 25(OH)D target of 50 nmol/L. The IOM and EFSA established a dietary requirement of 10–15 µg per day for older adults, while the NNR set a requirement of 10 µg per day for adults aged 61–74 years. This recommendation considers some contribution of vitamin D from outdoor activities during the summer season (late spring to early autumn), and this is compatible with normal, everyday life and is also in line with recommendations on physical activity. For people with little or no sun exposure, an intake of 20 µg per day is recommended. In addition, two bodies (IOM, NNR) set a higher vitamin D intake requirement of 20 µg per day for those aged 70–75 years and older. This was on the basis that people aged over 70 years are a very diverse group undergoing a number of physiological changes as a result of ageing that could have an impact on, and increase the variability around, the vitamin D requirement (Institute of Medicine, 2011). In addition, it could account for the more limited solar-induced vitamin D synthesis and the evidence for the protective effect of such an intake against mortality, fractures, and falls (Nordic Council of Ministers, 2014).

The UK recommendations for older adults of vitamin D intakes of 10 µg per day aimed to provide protection to nearly all (97.5%) individuals in the population against serum 25(OH)D concentrations falling below 25 nmol/L, in order to protect musculoskeletal health (Scientific Advisory Committee on Nutrition, 2016).

For this report, the primary focus of the recommendations will be on prevention of vitamin D deficiency (serum 25(OH)D <30 nmol/L) in older adults in Ireland as a population protective

approach, since recommendations in relation to achievement of vitamin D adequacy are very mixed and are still being debated internationally.

It is important to note that by convention, dietary vitamin D requirement values are set assuming that intakes of interacting nutrients, such as calcium, are adequate (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016; Institute of Medicine, 2011). There are older adults in Ireland who do not have adequate intakes of calcium (Kehoe, 2018); this is further described in the section on calcium in the *Scientific recommendations for food-based dietary guidelines for older adults in Ireland* report (in preparation). It should be noted that vitamin D supplements usually contain calcium and vice versa.

Table 2 International specifications on vitamin D status and recommendations for oral intake requirements in older adults with minimal or no sunlight exposure

Report/publication	Country/ region	Serum 25(OH)D (nmol/L)		Population Reference Intake (PRI) vitamin D (µg per pay) *[Basis of recommendation]**
		Deficiency	Adequacy	
IOM 2011 (Institute of Medicine, 2011)	USA and Canada	<30	≥50	15 (1–70 years) 20 (>70 years) *[Health outcome: bone health; target serum 25(OH)D: ≥50 nmol/L]*
NNR 2014 (Nordic Council of Ministers, 2014)	Nordic countries	<25/30	≥50	10 (61–74 years) [20 if little/no sun exposure] 20 (≥74 years) *[Health outcomes: bone health, total mortality, risk of falling; target serum 25(OH)D: ≥50 nmol/L]*
SACN 2016 (Scientific Advisory Committee on Nutrition, 2016)	UK	<25	not stated	10 *[Health outcomes: musculoskeletal health, falls; target serum 25(OH)D: ≥25 nmol/L]*
EFSA 2016 (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016)	EU	Not stated	≥50	15 *[Health outcomes: musculoskeletal health; target serum 25(OH)D: ≥50 nmol/L]*

*In each report, the recommended intake is that covering the needs of 97.5% of individuals at the specified serum 25(OH)D target concentration based on a defined health outcome(s); note that EFSA's recommendation is an adequate intake and thus covers the needs of the majority (97.5%) of individuals.

Vitamin D equivalents: 10 µg (400 IU), 15 µg (600 IU), 20 µg (800 IU).

Abbreviations: EFSA, European Food Safety Authority; IOM, Institute of Medicine; NNR, Nordic Nutrition Recommendations; PRI, population recommended oral intake of vitamin D for those with little or no sunlight exposure; SACN, Scientific Advisory Committee on Nutrition.

In relation to data on the vitamin D requirements of older adults in Ireland, a specifically designed RCT to establish this requirement in adults aged 64 years and older showed that an intake of 9 µg per day would keep winter-time serum 25(OH)D >25 nmol/L in nearly all (97.5%) individuals (Cashman *et al*., 2009), with no significant difference between those aged older than or younger than 70 years. In order to achieve 25(OH)D >30 nmol/L, the estimated vitamin D intake would be 13.7 µg per day (Cashman *et al*., 2014b). The intake of vitamin D needed to keep 97.5% of individuals with serum 25(OH)D above 50 nmol/L would be 25 µg per day (Cashman *et al*., 2009).

These estimates are also supported by two Irish-led meta-analyses using individual participant data from several RCTs with vitamin D supplements (Cashman *et al*., 2017) and vitamin D-fortified foods (Cashman *et al*., 2020). Based on these studies collectively, the estimated vitamin D intake needed to keep 97.5% of individuals with serum 25(OH)D above 30 nmol/L is in the range of 12–16 µg per day.

As mentioned above, while there is debate on the serum 25(OH)D which ensures adequacy of vitamin D status in terms of bone health, there is strong agreement that maintaining serum 25(OH)D above 30 nmol/L is important in order to prevent increased risk of poor bone health. **The dietary vitamin D requirement to maintain serum 25(OH)D ≥30 nmol/L during winter in healthy older adults in Ireland living independently is 15 µg per day.** This requirement was established using apparently healthy, free-living adults, the majority of whom had sun exposure the previous summer. Since housebound older adults have limited or no sunlight exposure, their requirement for vitamin D may be higher. While there is a lack of a sufficient vitamin D intake-status relationship dataset upon which to base a higher recommendation, an addition of 5 µg to the requirement may be justified, as per the IOM's increased recommendation for those aged 70 years and older. This increase in estimate by 5 µg per day is supported by a lower estimate (by 3.5 µg per day) in winter dietary vitamin D requirement in order to achieve the 25 nmol/L serum 25(OH)D threshold for older adults in Ireland who were exposed to a minimum of 15 minutes per day of summer sunshine versus those who did not have such exposure (Cashman *et al*., 2009). However, the small sample size of the subgroup not exposed to summer sunshine did not allow for high confidence in the estimates. **Therefore, the dietary vitamin D requirement to maintain serum 25(OH)D ≥30 nmol/L in housebound older adults in Ireland with limited or no sunlight exposure is estimated to be 20 µg per day.** It should be noted that these are requirement estimates of total vitamin D intake needed, not just supplemental vitamin D.

In relation to the 50 nmol/L serum 25(OH)D threshold suggested by some authorities in relation to vitamin D adequacy, an intake of 18 µg per day has been estimated in order to allow 90% of free-living older adults in Ireland to maintain a serum 25(OH)D above this threshold during winter (Cashman *et al*., 2009). Thus, the recommended vitamin D intakes of 15 µg and 20 µg per day will not only protect nearly all older adults in Ireland against vitamin D deficiency, but it will also allow a majority to attain serum 25(OH)D concentrations linked with adequacy.

5. Current dietary vitamin D intakes in older adults in Ireland

NANS reported mean daily intakes of vitamin D from all sources (diet and supplements) of 5.2 µg for men and 8.5 µg for women (≥65 years) (Irish Universities Nutrition Alliance, 2011). Twenty-

seven percent of adults aged ≥65 years took a nutritional supplement containing vitamin D (males: 21%; females: 32%) (Kehoe, 2018). From a public health nutrition perspective, the percentage of the population/population group with a habitual daily nutrient intake lower than the estimated average requirement is taken as an estimate of the percentage of the population with probable inadequate intakes (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010). Using 10 µg per day, set by the IOM as the estimated average requirement for vitamin D, it can be estimated that 78% of NANS adults aged ≥65 years (95% for non-vitamin D supplement users) have inadequate vitamin D intakes.

6. Approaches to addressing low vitamin D intakes

Any intervention that is aimed at improving vitamin D intake must incorporate the concept of total vitamin D intake, not just supplemental intake (Lanham-New *et al*., 2020; Scientific Advisory Committee on Nutrition, 2016; Institute of Medicine, 2011). The WHO and the Food and Agriculture Organization of the United Nations (FAO) have suggested that there are a number of strategies that can be considered in terms of addressing inadequacy of micronutrient intake (Allen *et al*., 2006). These include: i) increasing the diversity of foods consumed, ii) food fortification, and iii) supplementation. The range of foods naturally rich in vitamin D is very limited (oily fish and eggs – see Table 3); however, foods fortified with vitamin D can significantly increase vitamin D intakes and improve vitamin D status. In NANS 2008–2012, fish, meats, eggs, and vitamin D-fortified foods contributed 23%, 19%, 7% and 17%, respectively, to the mean daily intake of vitamin D among adults aged ≥65 years. Vitamin D-fortified foods include some fat spreads, milks, yogurts, and ready-to-eat breakfast cereals. A community-based study of older adults in Ireland in the 1990s showed that consumption of fortified milk ameliorated the problem of vitamin D deficiency (Keane *et al*., 1998). Ireland, unlike other countries (e.g. Canada), does not have a mandatory vitamin D food fortification programme in place. This means there is no staple food (a food eaten by almost everyone) that is fortified with vitamin D. Nonetheless, under EU legislation (Regulation (EC) No 1925/2006), voluntary addition of vitamin D to foods can be undertaken by the food industry. This has resulted in an increasing range of foods fortified with vitamin D on the market in Ireland. All vitamin D-fortified foods are clearly labelled with information to indicate this to consumers. Regular intake of these vitamin D-fortified foodstuffs, which include most ready-to-eat breakfast cereals, *some* milks and *some* yogurts, and, more recently, the emergence of a few vitamin D-fortified breads and processed cheeses (Table 3), can contribute towards meeting the intake requirement of 15 µg vitamin D daily. However, data from NANS in 2008–2012 showed that the mean intake of vitamin D from natural foods was 3.6 µg per day among adults aged ≥65 years, and increased to 4.7 µg per day when the contribution of fortified foods was accounted for (Kehoe, 2018). This is

similar to findings in the National Health and Nutrition Examination Survey (NHANES) in the United States (which has voluntary, although almost universal, milk fortification with vitamin D) where mean vitamin D intake from naturally occurring foods was 1.6 µg per day, and when fortified foods were included it increased to 5.4 µg per day (Newman *et al*., 2019). Black *et al*. (2015) reported only small increases in vitamin D intakes among Irish adults participating in the NANS in 2008–2012 compared to the equivalent nutrition survey a decade before, despite major scientific and public interest around vitamin D during that period.

Clearly, natural vitamin D sources do not provide adequate vitamin D for older adults in Ireland, and current voluntary fortification practices, while helpful, are ineffective on their own in terms of achieving adequate intakes in the population.

Table 3 Natural and vitamin D-fortified foods and the amount provided per serving

Food	Serving size (household measure)	Vitamin D (µg)
Natural foods		
Salmon	100 g (palm of hand size)	2.9–18.5*
Trout	100 g (palm of hand size)	10
Mackerel	100 g (palm of hand size)	8.6
Tuna	100 g (palm of hand size)	3
Sardines	100 g (palm of hand size)	5
Eggs	2 eggs	4
Vitamin D-fortified foods**		
Milk with added vitamin D	200 mL (a glass)	2–4
Cereal with added vitamin D	30–40 g (a bowl)	1.5–2.9
Yogurt with added vitamin D	125 g (a pot)	0.8–5.0
Cheese with added vitamin D	One cheese string	1.3

*The vitamin D content of wild salmon (9.4–18.5 µg)) is higher than that of farmed salmon (2.9–9.5 µg) (Jakobsen *et al*., 2019); most of the salmon consumed in Ireland is farmed salmon.

**Nutrition labelling must be checked, as the types of foods fortified, and the amounts of vitamin D added to such foods, change continuously.

Regarding the role of vitamin D supplementation in older adults in Ireland, a study in the early 1980s in nursing home residents showed that administration of an oral daily vitamin D supplement of 20 µg for 16 months corrected and prevented vitamin D deficiency (McKenna *et al*., 1985). A more recent winter-based RCT of vitamin D supplementation in older adults in Ireland (>50 years) in 2012 showed that 20 µg of supplemental vitamin D daily over 10 weeks during winter achieved an average serum 25(OH)D of 69 nmol/L (Cashman *et al*., 2012). In addition, another winter-based RCT of vitamin D supplementation in older adults in Ireland (>50 years), stratified by high and

moderate to low calcium intake, showed that 20 µg of supplemental vitamin D daily over 15 weeks during winter achieved average serum 25(OH)D concentrations of 74 and 80 nmol/L, respectively (Cashman *et al*., 2014a). Moreover, in both RCTs, none of the participants in groups receiving the 20 µg of supplemental vitamin D, when combined with mean habitual dietary intake of 4–7 µg per day, had serum 25(OH)D concentrations <30 nmol/L; and only 2.9% had serum 25(OH)D concentrations <50 nmol/L (Cashman, 2015). This aligns well with the requirement estimates outlined in Table 2 and discussed above.

7. Conclusions on vitamin D supplementation in older adults in Ireland

While natural vitamin D food sources as well as vitamin D-fortified foods will continue to play a role in meeting the vitamin D dietary requirements mentioned above, at least in part, vitamin D supplements will be needed by older adults in order to achieve these intake requirements. The average vitamin D intake in older adults in Ireland not consuming vitamin D-containing supplements is around 5 µg per day. Therefore, in order to achieve a total intake requirement of 15 µg and 20 µg per day, supplements containing 10 µg and 15 µg per day, respectively (Table 4), could be recommended depending on the individual's sunlight exposure potential and/or dermal capacity for vitamin D synthesis:

- **For healthy older adults in Ireland living independently and who get sunlight exposure during summer, a daily vitamin D supplement containing 10 µg (400 IU) should be taken during the extended winter months (end of October to March); and for those of darker-skinned ethnicity, this daily vitamin D supplement containing 10 µg (400 IU) should be taken throughout the full year.**

- **For housebound older adults in Ireland with minimal or no sunlight exposure, a daily vitamin D supplement containing 15 µg (600 IU) should be taken throughout the full year.**

There are many reasons why older adults may get only minimal or no sunlight exposure, but low/limited sunlight exposure may be more likely in the following subgroups: older persons with compromised mobility and/or with comorbidities and living independently; semi-independent older persons; and older persons dependent on residential care. Public health advice for older adults in Ireland to practise cocooning during the COVID-19 pandemic will also limit sunlight exposure.

Vitamin D supplements in the dose range of 10–20 µg are available over the counter or by prescription. It should be noted that many of the prescription formulations of vitamin D also contain calcium, and that many older adults need calcium supplementation as well.

Table 4 Vitamin D supplement advice for older adult population subgroups

Older adult subgroup	Supplement advice
Generally healthy older adults who can be outdoors and get sunlight exposure	A daily supplement providing 10 µg vitamin D is needed during the extended winter months (end of October to March), as sunlight in Ireland cannot stimulate human skin to make any vitamin D during this period; and for those of darker-skinned ethnicity, a daily supplement providing 10 µg vitamin D is needed throughout the full year.
Older adults with minimal or no sunlight exposure* and those of a dark-skinned ethnicity	A daily vitamin D supplement of 15 µg is needed throughout the full year**

*This is commonly due to being housebound due to frailty, or to compromised health or mobility.

**Other medicinal sources of vitamin D need to be considered in order to avoid providing excessive amounts because many frail older adults are already prescribed combined calcium and vitamin D supplements.

8. Safety of vitamin D supplement use

The tolerable upper intake level (UL) is the maximum total intake that can be consumed every day over a lifetime without appreciable risk to health. The UL for vitamin D is 100 µg (4000 IU) daily for adults, as set by governmental agencies (Food Safety Authority of Ireland, 2018; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016; Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment, 2014; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2012; Institute of Medicine, 2011). The UK Committee on Toxicity and the UK SACN took into account the reviews by EFSA and the IOM, along with other relevant research that had been published subsequently and endorsed the vitamin D UL of 100 µg per day for adults, including older adults (Scientific Advisory Committee on Nutrition, 2016; Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment, 2014). The most well-recognised adverse effect of high vitamin D intakes is hypercalcaemia, and this endpoint should be the critical outcome on which to base ULs for vitamin D; evidence for other potential adverse effects, which might occur at lower exposures, is considered to be inconsistent (Scientific Advisory Committee on Nutrition, 2016; Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment, 2014; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2012). The EFSA Panel on Dietetic Products, Nutrition and Allergies (2012) concluded that the 25(OH)D

concentration in serum or plasma cannot be considered a suitable predictor of hypercalcaemia. The vitamin D UL of 100 µg per day for adults is supported by recent studies that observed either no hypercalcaemia (50 µg vitamin D per day for 5 years in adults aged >50 years) (Manson *et al*., 2018), or only rare, mild, transient hypercalcemia, with all cases resolved on repeat testing (100 or 250 µg vitamin D per day for 3 years in adults aged 55–70 years) (Billington *et al*., 2019; Burt *et al*., 2019).

Recent trials using high daily doses of vitamin D over 1 to 3 years in older adults have reported an increased number of falls in those consuming 100–120 µg vitamin D per day (Smith *et al*., 2017) and lower bone mineral density in those consuming 100 µg or 250 µg vitamin D per day (Burt *et al*., 2019). However, in each study, the authors have considered these findings as preliminary and needing confirmation by further research. The findings are not supported by other studies in older adults, which found no adverse effect on falls in older adults consuming vitamin D at daily intakes of 100 µg or 250 µg (compared to 10 µg) for 3 years (Burt *et al*. 2019) and no adverse effect on bone mineral density in older adults consuming vitamin D at daily intakes of up to 120–162 µg for 1 year (Smith *et al*., 2018, Grimnes *et al*., 2012). Overall, the evidence of adverse effects provided by these recent trials is inconsistent and does not provide a basis for reconsideration of the vitamin D UL of 100 µg per day for adults. However, further research is needed on possible adverse effects of vitamin D at daily doses greater than 100 µg.

Daily intake of vitamin D in higher consumers (95th percentile of the population; P95) among older adults in Ireland is estimated from the NANS study as 24.2 µg from all sources, including supplements, and 9.4 µg from food sources only, including fortified foods (Food Safety Authority of Ireland, 2018; Irish Universities Nutrition Alliance, 2011). Daily consumption of a 10 µg or 15 µg vitamin D supplement in addition to diet would increase daily vitamin D intake of high consumers (from foods) to about 20 µg or 25 µg, which is not higher than the current intake of high consumers and is well below the vitamin D UL of 100 µg. Thus, a daily vitamin D supplement of 10 µg or 15 µg may be considered safe for older adults in Ireland. Daily supplementation is preferred because in some studies, bolus doses at intermittent intervals have been associated with increased risk of fracture (Sanders *et al*., 2010; Smith *et al*., 2007) or falls (Smith *et al*., 2007).

In conclusion, as outlined above, for most older people, 10 µg or 15 µg of supplemental vitamin D per day will be enough. People should not take more than 100 µg per day because it could be harmful. If people take higher therapeutic doses of vitamin D, monitoring is recommended (NICE, 2020). Supplementation of institutionalised elderly people should not be random and without cause, because excess intakes of vitamin D (and calcium) may have adverse consequences for this frail subpopulation (Institute of Medicine, 2011).

9. Recommendations

The recommended daily intake of vitamin D in older adults in Ireland is 15 µg for those who are generally healthy and living independently, and 20 µg for those who are housebound with limited or no sunlight exposure.

Diets of older adults in Ireland should include regular intakes of natural sources of vitamin D, such as oily fish, eggs, meats, and vitamin D-fortified foods.

Older adults in Ireland are advised to consider taking a daily supplement of vitamin D as follows:

- For healthy older adults living independently and who get sunlight exposure during summer, a daily vitamin D supplement containing 10 µg (400 IU) should be taken during the extended winter months (end of October to March); and for those of darker-skinned ethnicity, this daily vitamin D supplement containing 10 µg (400 IU) should be taken throughout the full year.
- For housebound older adults in Ireland with minimal or no sunlight exposure, a daily vitamin D supplement containing 15 µg (600 IU) should be taken throughout the full year.

A daily vitamin D supplement of 10 µg or 15 µg may be considered safe for older adults in Ireland.

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Appendix 1 Request for Advice from the Scientific Committee

Topic title: Scientific recommendations for Vitamin D supplementation in older adults
Date requested: 4 June 2020
Date accepted: 12 June 2020
Target deadline for advice: September 2020
Form of advice required: Short paper

Background/Context

In the context of the COVID-19 pandemic, there have been several scientific papers from Irish research teams published recently regarding the role of Vitamin D in immunity and optimal intakes (Laird, 2020; Lanham-New *et al.*, 2020; McCartney and Byrne, 2020; McKenna and Flynn, 2020). Other papers on vitamin D and the elderly, including commentary and response regarding the McCartney paper cited above, appeared in an edition of the *Irish Medical Journal* and links are included in the References list. Elderly people have been identified as one population group where vitamin D intakes may be suboptimal and supplementation may be necessary. The Scientific Committee has been requested by the Department of Health to fast-track the current work on Vitamin D and older people in order to provide an evidence base to the Department of Health to underpin public health policy for vitamin D supplementation in older people aged 65 years or over.

Questions to be addressed by the Scientific Committee

The Scientific Committee is requested to:

1. Look at the vitamin D requirements for older adults and their current vitamin D intake status.
2. Consider how best to achieve vitamin D requirements, taking total vitamin D intake into consideration.
3. Determine the older population subgroups that need vitamin D supplementation.
4. Determine the level of supplementation required within these subgroups and the appropriate vitamin D supplement.
5. Consider any special circumstances.
6. Deliver scientific advice for population-based guidance to the Department of Health.

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http://imj.ie/mccartney-et-al-comment-on-covid-19-cocooning-and-vitamin-d-requirements-response-report/

http://imj.ie/vitamin-d-and-covid-19-a-note-of-caution/

http://imj.ie/mccartney-et-al-comment-on-vitamin-d-and-covid-19-a-note-of-caution-response-letter/

http://imj.ie/vitamin-d-deficiency-and-ards-after-sars-cov-2-infection/

http://imj.ie/vitamin-d-and-inflammation-potential-implications-for-severity-of-covid-19/

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- Dr Laura Kehoe, School of Food and Nutritional Sciences, University College Cork; Vitamin D data from the National Adult Nutrition Survey ≥65 years cohort.

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