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

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

Scientific recommendations for food-based dietary guidelines for older adults in Ireland

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List of Abbreviations

25(OH)D	25-hydroxyvitamin D
µg	microgram
ALA	alpha-linolenic acid
ALM	appendicular lean mass
AR	average requirement
ARTI	acute respiratory tract infection
ASM	appendicular skeletal muscle mass
BMI	body mass index
bw	body weight
CHD	coronary heart disease
CHI	Children's Health Ireland
cm	centimetre
COVID-19	coronavirus disease 2019
CSO	Central Statistics Office
CVD	cardiovascular disease
DFE	dietary folate equivalent
DHA	docosahexaenoic acid
DIAAS	digestible indispensable amino acid score
DNA	deoxyribonucleic acid
EAA	essential amino acid
EAR	estimated average requirement
EFSA	European Food Safety Authority
EGRac	erythrocyte glutathione reductase activation coefficient
EPA	eicosapentaenoic acid
ER	energy requirements

ESPEN	European Society for Clinical Nutrition and Metabolism
ESRI	Economic and Social Research Institute
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FBDG	food-based dietary guidelines
Fe^{2+}	ferrous ion
Fe^{3+}	ferric ion
FFMI	fat-free mass index
FSAI	Food Safety Authority of Ireland
g	gram
GI	glycaemic index
GL	glycaemic load
GP	general practitioner
HDL	high-density lipoprotein
HSE	Health Service Executive
IOM	Institute of Medicine
IQR	interquartile range
IU	international units
kcal	kilocalorie
kg	kilogram
kJ	kilojoule
L	litre
LC	long-chain
LDL	low-density lipoprotein
m^2	square metre
MaNuEL	MalNutrition in the ELderly

MAOI	monoamine oxidase inhibitor
mg	milligram
MJ	megajoule
mL	millilitre
mmHg	millimetres of mercury
mmol	millimole
MPS	muscle protein synthesis
MUFA	monounsaturated fatty acid
n-3	omega-3
n-6	omega-6
NANS	National Adult Nutrition Survey
ng	nanogram
NICE	National Institute for Health and Care Excellence
nmol	nanomole
NNR	Nordic Nutrition Recommendations
NSAID	non-steroidal anti-inflammatory drug
ONS	oral nutritional supplement
PAL	physical activity level
PDCAAS	protein digestibility-corrected amino acid score
PLP	pyridoxal phosphate
PRI	population reference intake
PUFA	polyunsaturated fatty acid
pmol	picomole
PPI	proton pump inhibitor
RCT	randomised controlled trial
RDA	recommended daily allowance

SACN	Scientific Advisory Committee on Nutrition
SARS-CoV-2	severe acute respiratory syndrome coronavirus 2
SD	standard deviation
SFA	saturated fatty acid
SPPB	short physical performance battery
T2D	type 2 diabetes
TAG	triacyl glycerol
TFA	trans fatty acids
TILDA	The Irish Longitudinal Study on Ageing
TUDA	The Trinity-Ulster and Department of Agriculture study
TUG(s)	timed up and go test(s)
UK	United Kingdom
UL	tolerable upper intake level
USA	United States of America
UVB	ultraviolet B
WHO	World Health Organization

Foreword

Successful ageing is dependent on many components, including genetics, health status, active living and social interaction. On retirement, people in good health can look forward to entering the 'golden years' of their third age, filled with many possibilities and interests. Healthy eating guidelines provide a blueprint for future-proofing optimal nutritional status and health into later life.

Average life expectancy has increased in Ireland since the 1980s in line with many other countries. Traditionally, retirement and a pension at 65 years of age were viewed as short-term economic solutions by national governments. However, there is a noticeable difference in the functional ability of older people alive today compared even with 30 years ago, and it is common to see many older people living healthy, productive lives.

The process of ageing is associated with an increase in age-related illnesses, often necessitating medications; decreased muscle mass; a decline in physical activity; and accumulation of body fat associated with obesity and/or frailty. Individuals within the older age group can differ widely in terms of functional ability at a given age and may be more appropriately classified in relation to their health status – ranging from healthy, free-living people to those with comorbidities and/or decreased mobility, to people living semi-independently and those in residential care. The preservation of muscle mass and skeletal strength are both critical to maintaining functional autonomy and independence and there are important nutritional considerations in this population group.

This report, aimed at policy-makers and healthcare professionals, identifies the scientific basis for increased requirements of specific nutrients in the older population and examines dietary intake data from three contemporary Irish studies of this age cohort in order to produce food-based recommendations to complement *The Food Pyramid* (Department of Health, 2016). The year 2020 was defined by COVID-19, and older people have been identified as a vulnerable population. Certain nutrients have been linked with health outcomes in response to the virus and these are addressed in this report, as relevant.

The coming years will see an increasing number of older adults in the population. However, it is important to recognise that older people are a diverse group with different abilities, backgrounds, needs and experiences, which may change over time. Healthy eating as part of an overall healthy lifestyle enables older citizens to live life, and live it to the full.

Ita Saul

Chair, Public Health Nutrition Subcommittee **April 2021**

Executive summary

Background

Ageing is not just a chronological process, it is also a biological process that can be referred to as senescence, i.e. the biological process of deterioration with age. Chronological age is measured in years, whereas biological age is measured by assessing physical and mental function. For some people, biological age can be older or younger than their chronological age. Ageing is associated with particular nutritional issues which are summarised here and explored in more detail within the main body of this report.

The nutritional needs of older adults (i.e. those aged 65 years or older) are particularly varied as a result of health, physiological function and susceptibility to disease. Older adults are a diverse group. Some older adults are healthy and fit, with a good capacity for physical activity and good dentition. While dietary requirements for these older adults may be similar to those of the younger adult population, the ageing process should be considered. Other older adults may have chronic conditions and diseases which compromise activity levels and mobility. All of these factors can impact on nutritional requirements and the type of diet that is optimal.

In Ireland, older adults are the fastest-growing age group, having increased by 19% since 2011 according to the most recent census in 2016. In 2016, there were 629,800 older people living in Ireland and this is expected to increase to 1.6 million older people by 2051.

In 2000, the Food Safety Authority of Ireland (FSAI) published the *Recommendations for a national food and nutrition policy for older people* report (Food Safety Authority of Ireland, 2000). Since then, there have been considerable advances in scientific knowledge in nutrition and on optimal dietary intakes to enhance the well-being of older adults. As older adults constitute a significant and growing proportion of the Irish population, there is a need for updated food-based dietary guidelines for optimal health in this population subgroup.

Ireland is fortunate to have rich nutritional data on this older adult age group, as three relevant cohort studies have been completed in Ireland, or are currently ongoing, with a focus on (or including data for) older adults living in Ireland. These are:

1. The *National Adult Nutrition Survey* (NANS) (Irish Universities Nutrition Alliance, 2011)
2. The Trinity-Ulster and Department of Agriculture (TUDA) Study (Trinity College Dublin and Ulster University, 2016–2018)
3. The Irish Longitudinal Study on Ageing (TILDA) (Trinity College Dublin, 2019).

There is a high incidence of overweight and obesity among older adults living in Ireland, where, according to these cohort studies, between 61% and 78% of older adults are classified as overweight or obese. Older adults with overweight or obesity are at increased risk of type 2 diabetes (T2D) and cardiovascular disease (CVD). Although the prevalence of underweight in older Irish adults is reported to be low (<2%), this may be underestimated, as the aforementioned cohort studies do not include individuals who are in residential care, where a much higher prevalence of underweight and frailty would be expected.

Purpose

The Department of Health has requested that the Scientific Committee of the Food Safety Authority of Ireland provide an evidence-based report to underpin food-based dietary guidelines (FBDG) for older adults living in Ireland, outlining the nutritional issues related to ageing (Appendix 1). Older adults living in Ireland are defined as those aged 65 years and older and have been divided into four subgroups by the Department of Health. These are as follows:

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

The recommendations outlined in each section of this report apply to all four of the Department of Health subgroups of older adults, unless otherwise stated.

Methods

Dietary intakes of older adults in Ireland were explored using data from the three cohort studies available, and macro- and micronutrients of public health concern for this age group were identified. These nutrients included protein, carbohydrate, fibre, fat, B vitamins (folate, vitamin B12, vitamin B6 and riboflavin), vitamin C, vitamin D, calcium, iron and zinc. These macro- and micronutrients were then further examined in order to identify where nutrient goals or food-based dietary advice differ for older adults in comparison to the general adult population.

Key reports from international bodies, such as the European Food Safety Authority (EFSA), the Institute of Medicine (IOM) and the Nordic Council of Ministers' Nordic Nutrition Recommendations (NNR), were examined to identify goals for these nutrients for older adults. The goals were reviewed with reference to the dietary intakes of this age group as described in the three cohort studies. Factors impacting on the dietary intakes of the four subgroups of older adults, as defined by the Department of Health, were explored. Key issues were identified, and recommendations were developed.

Results and recommendations

For the majority of nutrients examined, nutrient intake goals for older adults are the same as those for the general adult population. Nonetheless, many issues associated with ageing were identified – such as socioeconomic status, dependence on residential care, mobility, comorbidities, etc. – which need to be addressed by specific food-based dietary guidance. The key issues and recommendations for relevant macro- and micronutrients are outlined below.

Introduction

Key issues

1. The healthy eating guidelines for the general adult population can be used as a basis for guidelines for older adults. However, there are additional nutritional issues specific to the older adult population, even in those who are heathy, which require more specific food-based dietary guidelines.
2. Recent evidence and information about dietary intake for those aged ≥65 years enables the nutritional issues of older adults to be examined in detail and specific food-based dietary advice to be provided in addition to the advice given for the general population.
3. Older adults, unlike other age groups, are best described according to functional capacity rather than chronological age due to the considerable variations in the ageing process, e.g. some older adults are still very physically active and living independently, whereas others may have compromised mobility and/or comorbidities and be dependent on residential care.

Nutrition-related issues for older adults living in Ireland

High levels of overweight and obesity

Key issues

1. Older adults living in Ireland are more affected by overweight and obesity than any other age group.
2. Only about 2% of older adults living in Ireland are described as being underweight. However, the true prevalence of underweight may be underestimated, as the three nutritional studies of older adults living in Ireland exclude residents in long-term care facilities.

Recommendations

1. Older adults who are overweight, particularly those with an abdominal body fat distribution, should:

    a. Be encouraged to combine a balanced, nutrient-rich diet with physical activity to avoid further weight gain and maintain lean body tissue
    b. Be advised to avoid weight-loss diets in order to prevent loss of muscle mass.
2. Older adults who are obese with weight-related health problems should be individually assessed (including functional resources, metabolic risk, comorbidities, the individual's perspective and priorities, and estimated effects on his or her quality of life) to consider the potential impact of a weight-loss diet. Where a weight-loss diet is deemed to be beneficial:
    a. Energy restriction should be moderate in order to achieve slow weight loss and preserve muscle mass.
    b. Diets with very low energy intakes (<1000 kcal/day) are strongly discouraged due to the risk of developing malnutrition and promoting functional decline.
    c. Dietary interventions should be combined with physical activity where possible in order to preserve muscle mass.

Dental health

Key issues

1. Oral health and the presence of natural teeth are important, as these factors can influence dietary intake and nutritional status.
2. Older adults are susceptible to chronic dental diseases.

Recommendations

1. Appropriate dietary advice, such as the reduction in intake frequency of sugars and refined carbohydrates, must be given in order to avoid the development of chronic dental diseases in older adults.
2. Edentate older adults need specific dietary advice in order to ensure adequate nutrient intakes.

Hydration and advice on beverages

Key issues

1. Due to a wide range of age-related physiological changes, dehydration is widespread among older adults, who, as a population subgroup, should be considered to be at high risk of low fluid intake.
2. Consideration of types of beverages is important, as caffeine can disturb sleep and tolerance for alcohol decreases with age.

Recommendations

1. Older adults who may be at risk of 'low intake' dehydration should be encouraged and reminded to consume adequate amounts of drinks. Women need at least 1.6 L of *drinks*

each day and men need at least 2.0 L of *drinks* each day, unless they have a clinical condition that requires fluid restriction.

2. Water is the best drink, especially for those who are overweight, but milk, tea, coffee and unsweetened fruit juice will all contribute towards meeting the overall recommended fluid intake. For underweight, frail older adults, milky drinks are a useful source of calories and protein as well as fluid. Strong tea (as opposed to herbal teas) should be consumed between meals, and not at meals, as it interferes with the absorption of iron and zinc.
3. Drinks containing caffeine should be avoided close to bedtime as they can increase the time it takes to go to sleep and reduce the time spent asleep.
4. Alcohol intake should be kept to a minimum, as tolerance decreases with age and because it increases the risk of comorbidities.
5. Older adults in residential care need to be offered drinks on a frequent basis in order to ensure that they maintain adequate fluid intakes.

Salt

Key issues

1. More than one-half of older adults in Ireland have hypertension.
2. Hypertension increases with age due to a range of factors, such as atherosclerosis, increasing arterial stiffness, increasing obesity and abdominal body fat distribution, and reduced tolerance for alcohol.
3. Sense of taste diminishes with age, which leads to increased salt intake.

Recommendations

1. The recommended salt target for the older adult population in Ireland is the same as that for the general adult population, i.e. 2.4 g/100 mmol sodium (6 g salt) per day.
2. Consumption of salty foods (cured and processed meats, savoury snacks, soups, sauces, some cheeses, anchovies, olives, etc.) and the addition of salt to foods during cooking and at the table should be limited.
3. Alternatives to salt, such as herbs and spices, should be used to increase flavour and palatability.
4. Use of salt substitutes at the table should be discouraged because of the:
    - Very high potassium content, which is contraindicated in older adults with kidney disease (this is common, as it is associated with ageing)
    - Sodium content.
5. Those at risk of renal impairment, diabetes, heart failure or hypertension should avoid taking salt substitute products, i.e. products containing potassium chloride.

Macronutrients of public health concern

Protein – Part A. General older adult population

Key issues

1. Older adults need a more protein-dense diet than the general adult population.
2. High-quality protein foods assessed using protein digestibility-corrected amino acid scores (PDCAAS) or digestible indispensable amino acid scores (DIAAS) (defined by the digestibility and quantity of essential amino acids (EAAs)) should be consumed in order to stimulate muscle protein synthesis.
3. The combination of a dietary pattern that provides adequate protein and physical activity is required from middle age in order to prevent sarcopenia and frailty in older adulthood.

Recommendations

1. Healthy older adults should consume a more protein-dense diet than the general adult population.
2. Sufficient high-quality protein foods assessed using PDCAAS or DIAAS (defined by digestibility and quantity of EAAs) should be included in the diet and consumed at a minimum of two meals per day. Such foods include meat, poultry, fish, dairy products, and eggs, and, to a lesser extent, beans, peas, lentils and nuts.
3. Older adults should aim to be physically active on a daily basis so that each meal is consumed while the muscles are in a ‘sensitised’ state. This is relevant even when capacity for physical activity is low.

Protein – Part B. Frailty, sarcopenia and undernutrition

Key issues

1. Frailty, sarcopenia and undernutrition are often associated with ageing, have negative consequences for health and quality of life, and can usually be avoided, delayed or reversed with timely and appropriate interventions.
2. To prevent frailty, sarcopenia and undernutrition, high-quality protein foods assessed using PDCAAS or DIAAS (defined by digestibility and quantity of EAAs) should be consumed at a minimum of two meals per day in order to stimulate muscle protein synthesis.
3. Older adults who are frail, sarcopenic or undernourished need a protein-dense diet that provides adequate energy and should engage in resistance exercise.

Recommendations

1. Frailty, sarcopenia and undernutrition should be identified in adults aged 65 years and older, as these conditions increase the risk of morbidity and mortality and reduce quality of life.

2. Older adults should consume adequate energy (kilocalories) to prevent the development of frailty, sarcopenia and undernutrition.
3. Older adults at risk of frailty, sarcopenia and undernutrition are recommended to eat a minimum of 1.0–1.2 g/kg body weight (bw) of protein per day to preserve muscle mass.
4. Sufficient high-quality protein foods assessed using PDCAAS or DIAAS (defined by digestibility and quantity of EAAs) should be included in the diet and consumed at a minimum of two meals per day. Such foods include meat, poultry, fish, dairy products, and eggs, and, to a lesser extent, beans, peas, lentils and nuts.
5. Older adults should aim to complete physical activity daily and resistance exercise 2–3 times/week in order to maintain or improve physical function.

Dietary carbohydrate and fibre – Part A. Dietary carbohydrate

Key issues

1. The average intake of carbohydrate among older adults living in Ireland is at the lower end of the recommended range, but almost one-third (31%) of older adults have free sugars intakes exceeding recommended limits and inadequate fibre intakes (fibre is specifically addressed in Section 3.2 Part B).
2. Anthropometric data show that high proportions of older adults living in Ireland are overweight with an abdominal body fat distribution, indicating a high risk of T2D. Controlling the amount and type of carbohydrate consumed may help weight control and delay or prevent the onset of T2D and subsequent macro- and microvascular complications.
3. Frail, underweight older adults with poor food intakes and limited appetites may benefit from higher intakes of refined carbohydrates and free sugars. Underweight among free-living older adults in Ireland is estimated to affect about 2% (see Table 1).

Recommendations

1. In general, older adults, similar to the younger adult population, require carbohydrate foods that are high in fibre and low in free sugars. Such foods include wholemeal breads, cereals, pasta and rice, as well as vegetables, salads and fruit.
2. Older adults should limit intakes of free sugars. Food sources of free sugars include confectionery, biscuits, cakes, preserves, honey and syrup.
3. Older adults with impaired blood glucose or T2D should be advised to minimise the glycaemic effect of carbohydrate foods by:
    a. Eating whole rather than mashed carbohydrate foods
    b. Avoiding overcooking carbohydrate foods

   c. Choosing meals and snacks with low to moderate amounts of carbohydrate foods mixed with protein foods, vegetables and salads, rather than choosing high amounts of carbohydrate foods only.

4. Older adults who are frail and underweight should be individually assessed (including functional resources, metabolic risk, comorbidities, the individual's perspective and priorities, and estimated effects on his or her quality of life), and foods provided should be acceptable in order to ensure that energy and protein requirements are achieved at the expense, if necessary, of achieving requirements for fibre and exceeding the limits for free sugars.

Dietary carbohydrate and fibre – Part B. Dietary fibre

Key issues

1. Achieving adequate fibre intake in older adults is important for the maintenance of normal bowel function and prevention of constipation. Dietary fibre also helps protect against CVD, colorectal cancer and T2D, as well as having a role in weight maintenance.
2. Inadequate hydration, physical inactivity and use of medications that affect gut motility or hydration status can all compound the problem of constipation in this age group, particularly for those who are semi-dependent or dependent on residential care.
3. Dietary fibre intakes are dependent on total energy intakes. Older adults may have lower energy intakes due to decreased energy requirements, physical inactivity, or other factors associated with ageing, such as poor appetite or poor dentition. Therefore, it could be challenging for older adults to achieve an absolute target level of intake for dietary fibre (25 g/day), and it may be more realistic to consider goals for dietary fibre in relation to energy requirements (g/MJ/day).

Recommendations

1. Dietary recommendations for fibre should be related to energy requirements for those aged ≥65 years and should be set at ≥3 g of fibre per MJ per day. This should include a combination of soluble fibre (mainly vegetables, salads, fruits and some cereals, e.g. oats) and insoluble fibre (bran and outer husk of cereals, e.g. wheat bran).
2. Fibre intake should be achieved by:
   a. Encouraging consumption of foods such as wholemeal bread, potatoes with skins, wholegrain cereals, porridge oats, fruit, vegetables and pulses (peas, beans, lentils)
   b. Ensuring adequate hydration (see Section 2.3).
3. Adding bran to foods at home or in residential care settings should be avoided, as this reduces absorption of iron in the gut and can exacerbate the risk of constipation. However, this does not apply to the addition of bran during baking (e.g. bread).

Fat

Key issues

1. A reduction in intake of saturated fats to ≤10% of energy intake will reduce the risk of developing CVD and other chronic inflammatory conditions associated with ageing. This is particularly important for older adults, as data from the NANS cohort suggest that people in this age group exceed the recommendations for consumption of saturated fats.
2. Saturated fatty acids (SFA) should be replaced with polyunsaturated fatty acids (PUFAs) or monounsaturated fatty acids (MUFAs).
3. Intake of 250 mg/day long-chain (LC) omega-3 (n-3) PUFAs (e.g. eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)) should be achieved for health benefits and to support the immune system.

Recommendations

1. Older adults should be advised to reduce total intake of saturated fat and substitute saturated fat with MUFAs and PUFAs, which will help reduce total cholesterol and low-density lipoprotein (LDL) cholesterol, and thereby reduce risk of CVD.
2. Older adults should be encouraged to increase their dietary intake of alpha-linolenic acid (ALA), and in particular, the LC n-3 PUFAs EPA and DHA, in order to achieve benefits to immune function and the amelioration of chronic inflammatory diseases. Eating fish (including one portion of oily fish per week) as part of a balanced diet can help protect against heart disease and other inflammatory-related conditions.

Micronutrients of public health concern

B vitamins

Key issues

1. A low status of folate and the related B vitamins (i.e. vitamin B12, vitamin B6 and riboflavin) commonly occurs in older adults and is associated with a higher risk of diseases of ageing (including CVD, cognitive dysfunction and osteoporosis). Improved B vitamin status is associated with better health outcomes in older adults.
2. Causes of B vitamin deficiency in this population are different for each vitamin, but can include inadequate intake, malabsorption, increased requirements, and/or adverse drug-nutrient interactions.
3. Low status of vitamin B12 is of particular concern in older adults as it is associated with age-related atrophic gastritis and/or use of proton pump inhibitor (PPI) drugs.
4. Vitamin B6 status is typically lower in older adults compared to younger adults and is associated with a decline in immune function with advancing age.

Recommendations

1. Rigorous assessment of folate and vitamin B12 status in older adults, through blood sampling by general practitioners (GPs) or hospital doctors, is essential and should be based on measurement of reliable biomarkers (serum or red blood cell folate; serum B12), rather than relying on dietary data alone. Assessment of folate status should be carried out if dietary inadequacy is suspected. For vitamin B12, annual monitoring of serum concentrations will identify those with deficiency and enable intervention to correct status.
2. B group vitamin status should be optimised in older populations in order to ensure that any adverse health consequences of deficient or low status are prevented.
3. Fortified foods provide a good and particularly bioavailable source of folate and related B vitamins (B12, B6 and riboflavin). Fortified breakfast cereals offer a practical and highly effective means of improving B vitamin status in older adults and can potentially lead to better health outcomes in older people. In the case of vitamin B12, however, consideration should be given to increasing current levels of fortification in order to optimise status.
4. Apart from fortified foods, vitamin B12 needs are best met through meat intake, whereas riboflavin intakes are best provided by milk and dairy foods. Good sources of folate in the diet are limited to green leafy vegetables, legumes and liver. However, all natural folate sources are poorly bioavailable compared with folic acid (as found in fortified foods and supplements), which is readily converted to natural folates after its ingestion. Vitamin B6 is ubiquitous in foods, although protein foods (e.g. meat, milk) provide particularly good sources.

Vitamin C

Key issues

1. Vitamin C (ascorbic acid) is a key antioxidant and reducing agent in the aqueous media of the body and is required for correct immune function.
2. It is likely that significant numbers of older adults, particularly those from lower socioeconomic status groups, consume insufficient dietary vitamin C and/or have a higher requirement due to lifestyle or ill health.
3. While there is some limited evidence that vitamin C ameliorates the symptoms of viral infections such as the common cold and influenza, and is being administered to patients with COVID-19, there is as yet little published clinical data as to its effectiveness.

Recommendations

1. To provide sufficient dietary vitamin C, at least five portions of vegetables, salads and fruit are needed each day. Fresh potatoes will also contribute vitamin C to the diet. One 150 mL portion of orange juice per day would contribute significantly to vitamin C intakes; this is

particularly important for frail older adults and those who are dependent on residential care, who could be offered this at every meal.

2. Foods containing vitamin C are best consumed in the same meal as foods containing iron from plant sources in order to improve the absorption of iron in the gut.
3. In older adults likely to have low vitamin C status due to poor diet or increased need due to ill health, a supplement providing the EFSA population reference intake (PRI) of 95 mg/day for women and 110 mg/day for men could be advised by a GP; however, supplements should provide less than the IOM/FSAI tolerable upper intake level (UL) of 2000 mg/day in order to avoid causing gastrointestinal upset.
4. Well-designed clinical trials are required in order to study the use of vitamin C as an adjunctive therapy in serious infections due to influenza and other common viral illnesses, including establishing the effective dose.

Vitamin D

Key issues

1. Vitamin D is essential in older adults for bone health, and its deficiency increases the risk of fractures.
2. There is a putative link between vitamin D deficiency and non-skeletal health, such as CVDs; diabetes; inflammatory, infectious and immune disorders (including COVID-19); certain cancers; and a higher mortality, but causal evidence is lacking.
3. Vitamin D deficiency is common in older adults, particularly nursing home residents.
4. Vitamin D is obtained from the diet (natural foods, fortified foods, and supplements) and skin exposure to extended summer sunlight (during the months April through October).
5. While natural food 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.
6. High-dose vitamin D supplements on the market should be avoided so that the UL of 100 µg is not exceeded.

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 international units (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 or 15 µg may be considered safe for older adults in Ireland.

Calcium

Key issues

1. The principal source of calcium intake in older adults is dairy products.
2. Intake of dairy products in older adults is lower than in younger adults; most older adults do not achieve the recommended intake of three portions daily.
3. There is no biomarker available to assess calcium status.

Recommendations

1. As a food-based dietary guideline, daily consumption of three portions of calcium-rich foods (such as milk, yogurt and cheese) is recommended in order to meet the requirement for older adults. In addition to providing calcium, these foods are rich in other valuable nutrients for older adults, such as protein, and are easy for frail older adults to consume (e.g. nursing home residents).
2. In those older adults who consume less than one portion of dairy products daily, a daily 500 mg calcium supplement is recommended. It should be noted that supplemental calcium products usually contain vitamin D (see Section 4.3).

Iron

Key issues

1. The prevalence of iron deficiency increases with age, particularly among older adults who are dependent on residential care and those aged over 80 years. Even mild deficiency causes increased ill health and mortality.
2. In older adults, iron deficiency is caused by blood loss, chronic medical conditions, poor diet and malabsorption.
3. Iron status is readily assessed by measuring serum iron, iron-binding capacity and ferritin. The best measure is ferritin, but it may be spuriously elevated as a result of many illnesses.

Recommendations

1. Older adults should be advised to consume food providing iron (meat, poultry, fish, eggs and beans) and vitamin C (potatoes, vegetables, salads and fruit) in the same meal as far as possible. This is important for enhancing iron absorption from plant sources in particular.
2. Iron status in all older adults should be monitored. Iron stores are readily measured by automated laboratory tests (serum iron, iron-binding capacity and ferritin). This is particularly important:
   a. For older adults who are dependent on residential care and for people aged >80 years, in order to identify those with poor iron status and hence avoid its consequent adverse effects on health
   b. To identify and exclude from supplementation those with haemochromatosis.
3. If iron supplements are necessary, these should provide at least the EFSA PRI of 11 mg/day elemental iron; 15 mg/day is recommended as an effective dose. However, supplements should not exceed the IOM/FSAI UL of 45 mg/day in order to avoid unpleasant gastrointestinal side-effects and to prevent interference with the absorption of other essential minerals such as zinc in the gut.
4. Research is needed into the effects of ageing on iron absorption in the gut since poor absorption in the gut may be a more important factor affecting iron status than the amount of iron in the diet.

Zinc

Key issues

1. Zinc deficiency is likely to be common in older adults, particularly older adults who are dependent on residential care.
2. The best dietary sources of zinc are high-protein foods such as dark meats. Due to the cost, these high-protein foods are relatively less accessible to many older adults than refined foods, which are low in zinc.
3. Zinc deficiency is associated with low socioeconomic status, problems with chewing food and poor absorption in the gut. Even marginal zinc status causes impaired biochemical and immune function.
4. Zinc is required for immune function.

Recommendations

1. Older adults require high-protein foods providing zinc: dark meat, which includes tuna, red meat and dark poultry meat (e.g. leg meat as distinct from breast meat); cheese; eggs; and nuts. Ensuring sufficient dietary intakes of high-protein foods is important in order to ensure sufficient dietary zinc.

2. If the diet is low in high-protein foods, as may be the case in frail older adults and those dependent on residential care, a zinc supplement may be required. This should provide the EFSA PRI of 12.7 mg/day elemental zinc for women and 16.3 mg/day for men; a dose of 15 mg/day would be suitable for both men and women. The total dietary intake should not exceed the EFSA/FSAI UL of 25 mg/day in order to avoid interference with the absorption of other essential minerals such as copper in the gut, leading to anaemia.
3. Research is needed into the incidence and effects of zinc deficiency in older adults since little is known about these, and they will be important in a population known to be at greater risk of adverse outcomes from viral infections.
4. The most effective means and potential benefits of supplementation should also be investigated; the most effective supplements need to be identified in order to improve zinc status in this population, with potential benefits for the immune response to infection and disease, and consequent improvement of the overall health of this group.

COVID-19 pandemic and older adults

Key issues

1. Older adults are the most at-risk population group from the COVID-19 pandemic.
2. Frailty, malnutrition/undernutrition and sarcopenia are associated with higher risk of infection and poorer outcomes from COVID-19.
3. While many nutrients play a beneficial role in immune function, as yet there is not enough scientific evidence to establish a link with COVID-19 outcomes.

Recommendations

1. Older adults should be screened (using a validated malnutrition screening tool) to identify those at risk of malnutrition/undernutrition, and a full nutritional assessment undertaken for all those identified as being at risk. Nutritional issues identified should be specifically addressed by dietary counselling from a registered dietitian using an individualised, comprehensive food-first approach in combination with oral nutritional supplements and/or vitamin and mineral supplementation as necessary.
2. For older adults who are cocooning, regular physical activity in the form of daily aerobic, dynamic and flexible exercise to whatever capacity possible will greatly enhance the impact of nutrition on immune competence.

1. Introduction

1.1 Key issues

1. The healthy eating guidelines for the general adult population can be used as a basis for guidelines for older adults. However, there are additional nutritional issues specific to the older adult population, even in those who are heathy, which require more specific food-based dietary guidelines.
2. Recent evidence and information about dietary intake for those aged ≥65 years enables the nutritional issues of older adults to be examined in detail and specific food-based dietary advice to be provided in addition to the advice given for the general population.
3. Older adults, unlike other age groups, are best described according to functional capacity rather than chronological age due to the considerable variations in the ageing process, e.g. some older adults are still very physically active and living independently, whereas others may have compromised mobility and/or comorbidities and be dependent on residential care.

1.2 Purpose of this report

The purpose of this report is to provide an addendum to the food-based dietary guidelines (FBDG) for the general adult population. This report will outline any additional or modified guidelines required by older adults living in Ireland, following a review of relevant evidence in this area.

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's categorisation into the following four subgroups:

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

The recommendations outlined in each section of this report apply to all four of the Department of Health subgroups of older adults, unless otherwise stated.

1.3 Food-based dietary guidelines for the general population in Ireland to date, and how these cover the needs of older adults

In 2011, at the request of the Department of Health, and using the food pyramid as the graphic model, the Food Safety Authority of Ireland (FSAI) published a report on the evaluation and revision of the *Scientific Recommendations for Healthy Eating Guidelines in Ireland* for the population aged 5 years and older (Food Safety Authority of Ireland, 2011). Given the wide age ranges that these healthy eating guidelines needed to cover, it was not possible to examine or address the specific nutritional needs of older adults in detail.

1.3.1 Dietary intake data on older adults (≥65 years) living in Ireland

In Ireland, the current life expectancy is 78.4 years and 82.8 years for men and women, respectively (Central Statistics Office, n.d.). According to the Central Statistics Office (CSO), the older adult (≥65 years) population increased by 19% in 2016, making it the fastest-growing age group in Ireland (Central Statistics Office, 2017). The CSO has stated that the older adult population is projected to increase from 629,800 people in 2016 to 1.6 million in 2051. It has also stated that the number of young people (0–14 years; 1,005,500) was higher than the number of older adults (≥65 years; 629,800) in 2016, but that this will be reversed by 2031 (Central Statistics Office, 2018). It is projected that by 2051 there will be between 496,600 and 691,800 more older people than younger people in Ireland (Central Statistics Office, 2018). A report published by the Economic and Social Research Institute (ESRI) in 2017 projected that the demand for health and social care will see the greatest increase among services for older adults, with up to a 54% increase in the demand for home help and residential places in nursing homes (Wren *et al*., 2017). According to the 2018 Health Service Executive (HSE) annual report, the gross expenditure on disability and older persons support services in 2018 was €3.3 billion (Health Service Executive, 2019a). Therefore, assessing the nutritional issues and needs of this population group and providing specific food-based dietary advice to address these needs and issues is of great importance.

To reflect variations in nutritional requirements due to age and gender, the 2011 FSAI *Scientific Recommendations for Healthy Eating Guidelines in Ireland* report provided FBDG, for both genders, for four different age groups: 5–13 years, 14–18 years, 19–50 years and 51+ years. Therefore, the only FBDG for the older adult population are those for the general adult population aged 51+ years. This is because the FBDG were developed based on dietary intake data from the North/South Ireland Food Consumption Survey (Irish Universities Nutrition Alliance, 2001) which only included participants up to the age of 64 years.

Since the publication of the 2011 FSAI *Scientific Recommendations for Healthy Eating Guidelines in Ireland* report, three relevant cohort studies have been completed in Ireland, or are currently ongoing, with a focus on (or including data for) older adults living in Ireland. These are:

1. The *National Adult Nutrition Survey* (NANS) (Irish Universities Nutrition Alliance, 2011)
   This survey was carried out from 2008 to 2010 and collected dietary intake and biochemical data from free-living adults residing in the Republic of Ireland. The survey included 226

adults over the age of 65 years, with the oldest participant being 90 years of age. Food and beverage intake data were collected using a 4-day semi-weighed food record. For all participants, the study period included at least one weekend day. Nutrient intakes were estimated using United Kingdom (UK) and Irish food composition tables. During the survey, modifications were made to include recipes of composite dishes, nutritional supplements, fortified foods, generic Irish foods that were commonly consumed, and new foods on the market. A blood sample was provided by 64% of respondents, of whom 79% were fasting. The blood samples were used to measure biochemical status for nutrients such as B vitamins, vitamin D and iron. A first-void morning urine sample was provided by 67% of respondents to estimate sodium and potassium intakes.

2. The Trinity-Ulster and Department of Agriculture (TUDA) Study (Trinity College Dublin and Ulster University, 2016–2018)
   The TUDA cohort provides detailed nutrition and health data, along with related lifestyle, clinical, and biochemical details, on a total of 5,186 community-dwelling older adults aged 60–102 years, making this cohort one of the most comprehensively characterised cohorts of its kind for ageing research internationally. With an overall goal to address the prevention of age-related disease, the TUDA Cohort Study is aimed at investigating nutrition and related factors in the development of common diseases of ageing. TUDA study participants were recruited between 2008 and 2012 from hospital outpatient or general practice clinics in the Republic of Ireland and in Northern Ireland via standardised protocols for participant sampling, assessment and data recording and with centralised laboratory analysis. In brief, the inclusion criteria for the TUDA study were being born on the island of Ireland, aged 60 years or older, and without an existing diagnosis of dementia. Non-fasting blood samples were collected from all participants and a wide range of parameters, including routine biochemistry and haematological profiles, along with biomarkers of micronutrient status, were measured. A comprehensive health and lifestyle questionnaire was administered as part of the 90-minute interview to capture medical and demographic details, along with comprehensive information on medication and vitamin supplement usage. Physiological function tests, blood pressure, bone health (dual-energy X-ray absorptiometry scans) and cognitive function tests were also measured. The TUDA 5+ study involved re-investigation of 1,000 TUDA study participants 5 years after initial sampling for the full range of biomarkers and health measures and including more comprehensive dietary analysis.

3. The Irish Longitudinal Study on Ageing (TILDA) (Trinity College Dublin, 2019)
   This study, which is representative of the older Irish population that began in 2009, collects information on all aspects of health, economic and social circumstances from people aged 50 years and over in a series of data collection waves once every 2 years. Participants are interviewed using computer-aided personal interviewing techniques and a self-completion questionnaire. Detailed information on all aspects of the respondents' lives is collected by the computer-aided personal interviewing techniques and a self-completion questionnaire, including details in relation to: pensions, employment, living standards, physical and mental health, formal and informal care, social participation, relationship quality, sexuality, loneliness, stressful life events, worry, and alcohol intake. A detailed 52-item food frequency questionnaire has also been recorded at multiple waves. At health waves, participants also complete a health assessment, which is carried out by qualified and trained research nurses. Cognitive, cardiovascular, bone health, gait and balance, and vision measurements/tests are taken in the health assessment, along with blood samples which are either biobanked or used to measure blood lipids, HbA1c, 25-hydroxyvitamin D, B12 and folate, and to take detailed measures of inflammation along with a genetic profile.

More details of each study are outlined in Table 1. The nutritional status of older Irish adults using information from these surveys is described in more detail in Chapter 3 and Chapter 4. Therefore, the current report provides the opportunity to look at the older adult population group in more detail and build upon the FBDG currently in place for the general adult population.

Table 1 Characteristics of the three national studies of older adults in Ireland

	NANS	TUDA; TUDA 5+	TILDA
Year of study	2008–2010	2008–2012; 2016–2018	2009–2011
Sample size (n)	226*	5186; 1000 resampled	5356**
Age range (years)	18–90	>60	>50
BMI (kg/m^2)	27.7 (4.1)	27.9 (5.4)	Not available
% normal weight	39	24	21
% underweight	0	2	<1
% overweight	37	40	42
% obese	24	34	36
Study design	Cross-sectional survey	Observational	Prospective cohort
Inclusion criteria	Not pregnant/lactating, no disability that impeded ability to fill in survey form	Born on the island of Ireland, aged >60 years, without an existing diagnosis of dementia and not residing in nursing home	Aged ≥50 years, have an Irish residential address, without diagnosis of dementia or not residing in nursing home
Nationally representative (Y/N)	Y	N	Y
Dietary intake assessment type	4-day semi-weighed food record	Food frequency questionnaire/food record	Food frequency questionnaire

*The NANS surveyed adults aged >18 to <90 years; 226 were aged >65 years.

**Blood samples only available for n=5356; total cohort n=8504.

Abbreviations - BMI: body mass index; NANS, National Adult Nutrition Survey; TUDA, Trinity-Ulster and Department of Agriculture study; TUDA 5+, resampling 5 years after initial investigation; TILDA, The Irish Longitudinal Study on Ageing.

1.3.2 Nutrient goals and food-based dietary guidelines for older adults

The FBDG for adults living in Ireland were developed to cover the general adult population and are not specific to older adults. When developing the FBDG for the general adult population, relevant nutrients were examined by creating and analysing food intake patterns (Flynn *et al.*, 2011). Some of the macronutrient and micronutrient goals used for the general adult population need to be revised for the older adult population. This is outlined in Chapter 3 and Chapter 4. The subsequent development of specific FBDG for older adults living in Ireland is described throughout this report.

2. Nutrition-related issues for older adults living in Ireland

2.1 High levels of overweight and obesity

2.1.1 Key issues

1. Older adults living in Ireland are more affected by overweight and obesity than any other age group.
2. Only about 2% of older adults living in Ireland are described as being underweight. However, the true prevalence of underweight may be underestimated, as the three nutritional studies of older adults living in Ireland exclude residents in long-term care facilities.

2.1.2 Background

Older adults living in Ireland are more affected than any other age group by overweight and obesity, with between 61% and 78% of older adults affected, according to direct anthropometric assessment (as shown in Table 1). Obesity in older adults may be accompanied by underlying nutritional deficiencies, creating a double burden of malnutrition in an obese world (World Health Organization, n.d.). The physical effects of ageing alter body composition and body shape so that the percentage of fat increases at the expense of lean tissue and body fat becomes distributed more abdominally. Overweight combined with these effects of ageing increases the risk of metabolic syndrome, type 2 diabetes (T2D), cardiovascular disease (CVD) and cancer. The prevalence of risk factors for metabolic syndrome, a predictor of T2D, is outlined in Table 2.

Table 2 Risk factors for metabolic syndrome in older adults living in Ireland

Risk factors*	% older adults affected	
	Males	Females
Abdominal obesity		
Increased risk waist >94 cm ♂, >80 cm♀	79†	83†
High risk waist >102 cm ♂, >88 cm♀	50†	57†
Blood pressure >140/90 mmHg	Not available	Not available
Impaired fasting glucose >5.5 mmol/L	Not available	Not available
HDL-C <1 mmol/L	Not available	Not available
TAGs >1.7 mmol/L	Not available	Not available

*Presence of three risk factors is diagnostic of metabolic syndrome.
†Irish Universities Nutrition Alliance (2011)
Abbreviations – HDL-C: high density lipoprotein cholesterol; TAGs: triacylglycerols

Body fat distribution was measured by waist circumference in the NANS, and this assessment revealed that high proportions of older adults (83% of women and 79% of men) were abdominally obese (waist circumference exceeding 94 cm for men and 80 cm for women). It is notable that over 50% of these abdominally obese older adults were categorised as being at high risk on the basis of their waist circumference measurements (>102 cm for men and >88 cm for women (Table 2)). These anthropometric data show that high proportions of older adults living in Ireland are overweight with an abdominal body fat distribution, which indicates high risk of T2D.

A very low proportion (<2%) of older adults living in Ireland are described as being underweight. However, the true prevalence of underweight may be underestimated, as the three nutritional studies of older adults living in Ireland exclude residents in long-term care facilities (Table 1). A higher prevalence of underweight and frailty with a low capacity for physical activity can be expected among this subgroup.

Some research has shown that weight loss can prevent or delay the onset of T2D (see Section 3.2 Part A for more details on preventing and delaying the onset of T2D). However, careful assessment of the potential impacts of weight-loss diets in older adults are needed and should include consideration of functional resources, metabolic risk, comorbidities, the individual's perspective and priorities, and estimated effects on his or her quality of life (Volkert *et al*., 2019b).

While losing weight may prevent or delay the onset of T2D, based on current evidence (Volkert *et al*., 2019b), it is recommended that:

- For older adults who are overweight:
  - Weight-loss diets should be avoided in order to prevent loss of muscle mass.
  - A combination of a balanced, nutrient-rich diet and physical activity is recommended to keep weight stable in older adults who are overweight.
- For older adults who are obese:
  - The benefits and risks of weight-loss diets need to be carefully considered.
  - Where a weight-loss diet is deemed to be beneficial, energy restriction should be moderate in order to achieve slow weight loss and preserve muscle mass.
  - Diets with very low energy intakes (<1000 kcal/day) are strongly discouraged due to the risk of developing malnutrition and promoting functional decline.
  - Dietary interventions should be combined with physical activity where possible in order to preserve muscle mass.

2.1.3 Recommendations

1. Older adults who are overweight, particularly those with an abdominal body fat distribution, should:

   a. Be encouraged to combine a balanced, nutrient-rich diet with physical activity to avoid further weight gain and maintain lean body tissue
   b. Be advised to avoid weight-loss diets in order to prevent loss of muscle mass.
2. Older adults who are obese with weight-related health problems should be individually assessed (including functional resources, metabolic risk, comorbidities, the individual's perspective and priorities, and estimated effects on his or her quality of life) to consider the potential impact of a weight-loss diet. Where a weight-loss diet is deemed to be beneficial:
   a. Energy restriction should be moderate in order to achieve slow weight loss and preserve muscle mass.
   b. Diets with very low energy intakes (<1000 kcal/day) are strongly discouraged due to the risk of developing malnutrition and promoting functional decline.
   c. Dietary interventions should be combined with physical activity where possible in order to preserve muscle mass.

2.2 Dental health

2.2.1 Key issues

1. Oral health and the presence of natural teeth are important, as these factors can influence dietary intake and nutritional status.
2. Older adults are susceptible to chronic dental diseases.

2.2.2 Background

While dietary intake and nutritional status are influenced by an array of factors, oral health and the presence of natural teeth are important components. Positive changes in the oral health status of older adults have resulted in an increasingly partially dentate older population (Steele and O'Sullivan, 2011). In the NANS, 87% of older adults either had all of their own teeth or were partially dentate with or without dentures (Irish Universities Nutrition Alliance, 2011). However, maintenance of retained natural teeth in older adults is challenging, as this population is very susceptible to chronic dental diseases. In addition to reduced manual cleaning, dietary intakes high in sugars and refined carbohydrates are causative factors in the development of caries, especially in the presence of xerostomia (dry mouth) (Hayes *et al*., 2016). Therefore, effective prevention of chronic dental diseases in older adults must include appropriate dietary advice (Department of Health, 2019).

Older adults remain susceptible to natural tooth loss throughout the life-course and a significant proportion are edentate (no teeth) (Steele and O'Sullivan, 2011). A complete lack of natural teeth negatively impacts on masticatory ability and function. Older adults with fewer natural teeth tend to choose foods which are softer and easier to chew; however, these are often low in nutrients and fibre, and high in calories and complex carbohydrates. Evidence clearly demonstrates that edentate older adults have lower dietary intakes of important nutrients – including omega-3 fatty acids, non-starch polysaccharides, folate and vitamin C – compared with dentate patients (Watson *et al*., 2019).

2.2.3 Recommendations

1. Appropriate dietary advice, such as the reduction in intake frequency of sugars and refined carbohydrates, must be given in order to avoid the development of chronic dental diseases in older adults.
2. Edentate older adults need specific dietary advice in order to ensure adequate nutrient intakes.

2.3 Hydration and advice on beverages

2.3.1 Key issues

1. Due to a wide range of age-related physiological changes, dehydration is widespread among older adults, who, as a population subgroup, should be considered to be at high risk of low fluid intake.
2. Consideration of types of beverages is important, as caffeine can disturb sleep and tolerance for alcohol decreases with age.

2.3.2 Background

Dehydration is a shortage of water (fluid) in the body. Older adults are at increased risk of dehydration for a variety of reasons (Volkert *et al*., 2019b). The ageing process dampens two key physiological responses to not drinking enough fluids, which increases dehydration risk: first, the feeling of thirst, and second, increased primary urine concentration by the kidneys. Additionally, the use of medications such as diuretics and laxatives, which is common among older adults, can increase fluid losses. Other factors which can increase the risk of dehydration in older adults include memory problems, whereby older adults forget to drink; social isolation resulting in a loss of drinking routines; swallowing problems and dysphagia, leading to not drinking enough fluids; and fear of incontinence and not getting to the toilet in time (Volkert *et al*., 2019b).

2.3.3 Fluid requirements

The European Food Safety Authority (EFSA) recommends that adequate intakes of fluid from all sources (including food) should be 2 L per day for women and 2.5 L per day for men (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010d). This equates to at least 1.6 L of *drinks* per day for women and 2 L of *drink*s per day for men (Volkert *et al*., 2019b), unless there is a clinical condition that requires fluid restriction.

2.3.4 Advice on beverages

For healthy older adults water is the best drink, but milk, tea, coffee and unsweetened fruit juice will all contribute towards meeting the overall recommended fluid intake. However, it is important to note that black tea, with or without milk (as opposed to herbal teas), should be consumed between meals and not at meals, as the tannins found in tea can interfere with iron and zinc absorption.

It is worth noting that caffeine close to bedtime should be avoided, as it can increase the time it takes to go to sleep and reduce the time spent asleep (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2015d). Therefore, the timing of consumption of caffeine-rich drinks, such as coffee and tea, should be planned.

It should be noted that, for those in residential care, offering drinks frequently improves maintenance of adequate fluid intakes (Volkert *et al*., 2019b). For those who are frail and/or underweight, fortification of drinks with calories and/or protein should be considered.

2.3.5 Advice on alcohol

The body's tolerance for alcohol decreases with increasing age, thus making older adults more vulnerable to the effects of alcohol than younger adults (Lal and Pattanayak, 2017; Barry and Blow, 2016). Excess alcohol consumption in older adults increases the risk of accidents, including falls as a result of balance problems (National Institute on Aging, 2017; World Health Organization, 2007).

2.3.6 Recommendations

1. Older adults who may be at risk of 'low intake' dehydration should be encouraged and reminded to consume adequate amounts of drinks. Women need at least 1.6 L of *drinks* each day and men need at least 2.0 L of *drinks* each day, unless they have a clinical condition that requires fluid restriction.
2. Water is the best drink, especially for those who are overweight, but milk, tea, coffee and unsweetened fruit juice will all contribute towards meeting the overall recommended fluid intake. For underweight, frail older adults, milky drinks are a useful source of calories and protein as well as fluid. Strong tea (as opposed to herbal teas) should be consumed between meals, and not at meals, as it interferes with the absorption of iron and zinc.
3. Drinks containing caffeine should be avoided close to bedtime as they can increase the time it takes to go to sleep and reduce the time spent asleep.

4. Alcohol intake should be kept to a minimum, as tolerance decreases with age and because it increases the risk of comorbidities.
5. Older adults in residential care need to be offered drinks on a frequent basis in order to ensure that they maintain adequate fluid intakes.

2.4 Salt

2.4.1 Key issues

1. More than one-half of older adults in Ireland have hypertension.
2. Hypertension increases with age due to a range of factors, such as atherosclerosis, increasing arterial stiffness, increasing obesity and abdominal body fat distribution, and reduced tolerance for alcohol.
3. Sense of taste diminishes with age, which leads to increased salt intake.

2.4.2 Background

As people age, their sense of taste decreases. This can be due to physiological changes affecting the taste buds and saliva production, oral diseases, or medication use (Sergi *et al*., 2017; Imoscopi *et al*., 2012). As a result, many foods can taste bland, leading to older adults using additional salt on foods in order to increase palatability (Sergi *et al*., 2017). Consequently, as previously outlined in the FSAI *Salt and Health: Review of the Scientific Evidence and Recommendations for Public Policy in Ireland (Revision 1)* (2016) report, this high dietary salt intake represents an important causal factor in the rise in blood pressure with age and in the development of hypertension.

Hypertension, defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg, is a major modifiable risk factor in the development of CVD and is responsible for at least 45% of deaths due to CVD and 51% of deaths due to stroke (World Health Organization, 2013). The prevalence of hypertension increases with age due to a variety of factors, such as atherosclerosis, increasing arterial stiffness, increasing obesity – particularly abdominal body fat distribution – and reduced tolerance for alcohol (National Institute on Aging, 2018; Pinto, 2007). In 2016, data from TILDA found that 64% of adults in Ireland over the age of 50 years are hypertensive (Murphy *et al.*, 2016). Evidence suggests that relatively modest reductions in salt intake have the potential to produce a significant fall in average blood pressure at a population level, with a concomitant substantial impact on the burden of morbidity and mortality from CVD (Food Safety Authority of Ireland, 2016).

The 2008–2010 NANS assessed salt intake from foods, but did not measure intentional addition of salt in cooking and at the table. In this survey, older adults had a mean daily salt intake of 6.3 g (men: 7.3 g; women: 5.4 g) from foods alone, with the main sources of salt in the diet being breads, and cured and processed meats (Irish Universities Nutrition Alliance, 2011). This highlights the need for clear advice to avoid adding salt at the table and in cooking, and to minimise intake of salty foods (cured and processed meats, savoury snacks, soups, sauces, some cheeses, anchovies, olives, etc.).

It is important to note that since 2004, salt reformulation has led to significant reductions in the salt content of many staple foods on the Irish market consumed regularly by older adults (e.g. breads, breakfast cereals, etc.). This emphasises the importance of continued reformulation to reduce salt content of processed foods and the continued monitoring under the FSAI's salt reduction programme.

The FSAI Scientific Committee currently advises against the use of low-sodium salt substitutes. This is due to concerns about the possible vulnerability of certain population subgroups (including those with type 1 diabetes, chronic renal insufficiency, end-stage renal disease, severe heart failure, and adrenal insufficiency) to a high potassium load from these salt substitutes (Food Safety Authority of Ireland, 2016).

More detailed information can be found in the FSAI *Salt and Health: Review of the Scientific Evidence and Recommendations for Public Policy in Ireland (Revision 1)* (2016) report, available at www.fsai.ie (information about the FSAI's salt reduction programme can also be found here).

2.4.3 Recommendations

1. The recommended salt target for the older adult population in Ireland is the same as that for the general adult population, i.e. 2.4 g/100 mmol sodium (6 g salt) per day.
2. Consumption of salty foods (cured and processed meats, savoury snacks, soups, sauces, some cheeses, anchovies, olives, etc.) and the addition of salt to foods during cooking and at the table should be limited.
3. Alternatives to salt, such as herbs and spices, should be used to increase flavour and palatability.
4. Use of salt substitutes at the table should be discouraged because of the:
    - Very high potassium content, which is contraindicated in older adults with kidney disease (this is common, as it is associated with ageing)
    - Sodium content.
5. Those at risk of renal impairment, diabetes, heart failure or hypertension should avoid taking salt substitute products, i.e. products containing potassium chloride.

3. Macronutrients of public health concern

3.1 Protein

Part A. General older adult population

3.1.1 Key issues

1. Older adults need a more protein-dense diet than the general adult population.
2. High-quality protein foods assessed using protein digestibility-corrected amino acid scores (PDCAAS) or digestible indispensable amino acid scores (DIAAS) (defined by the digestibility and quantity of essential amino acids (EAAs)) should be consumed in order to stimulate muscle protein synthesis.
3. The combination of a dietary pattern that provides adequate protein and physical activity is required from middle age in order to prevent sarcopenia and frailty in older adulthood.

3.1.2 Background

Adequate protein is essential for health and reproduction, as proteins are the building blocks within the body, responsible for the maintenance and repair of body tissue (EFSA Panel on Dietetic Products, Nutrition and Allergies 2012a; Institute of Medicine, 2006). Sufficient dietary protein is critical to prevent protein-energy malnutrition, also referred to as undernutrition, which can frequently occur in older adults, with a pooled prevalence rate of 3% in European community-dwelling older people, rising to 11.2% in those receiving home care (Crichton *et al.,* 2019). Furthermore, 8.5% of European community-dwelling older adults are at high risk of undernutrition (Crichton *et al*., 2019; Leij-Halfwerk *et al*., 2019). Protein deficiency can detrimentally affect the body's organ systems, including the immune system, which can result in increased risk of infection (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2012a). Protein is composed of amino acids which act as precursors for nucleic acids, hormones, vitamins and other important molecules. There are 20 different amino acids in proteins. These are classified as either essential (indispensable), meaning they cannot be synthesised in the body, or non-essential (dispensable). There are nine EAAs: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. The remainder are non-essential: alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine and tyrosine (Institute of Medicine, 2006).

Protein quality is determined by digestibility and the quantity of EAAs necessary for growth, maintenance and repair (Institute of Medicine, 2006). Protein quality can be assessed using the PDCAAS or the DIAAS. These methods relate the EAA content of a foodstuff to a reference amino acid profile, after applying a correction term for protein digestibility (FAO, 2018). A PDCAAS or

DIAAS below 100 indicates that at least one amino acid is limiting in the food or diet, whereas a score of 100 indicates that there is no limiting amino acid in the food or diet (FAO, 2018). Protein can be obtained in the diet from animal or plant sources. Plant protein sources, such as grain-based foods, vegetables, and nuts, are considered lower-quality protein due to less balanced EAA content and lower digestibility (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2012a). Protein from animal sources such as meat, poultry, fish, eggs and milk-based products provide all nine EAAs and generally have a higher content of leucine, an EAA that appears to be of critical importance for the postprandial stimulation of muscle protein synthesis (MPS) (van Vliet *et al*., 2015). Although the consumption of plant-based foods is associated with numerous health benefits, how best to selectively combine multiple plant-based protein sources to allow for the ingestion of a ‘complete’ EAA profile to maintain muscle mass and function within a single meal remains to be determined (Reidy *et al*., 2013). The protein and leucine content, along with the relevant PDCAAS and DIAAS, of common foods are outlined in Table 3.

Table 3 Commonly eaten protein-rich food sources (protein g/100 g), ranked according to protein and leucine content per gram of typical food portion sizes with corresponding DIAAS and PDCAAS

Food	Protein (g per 100 g)	Adult portion size (household measure)	Protein (g per portion size)	Leucine (g per portion size)	DIAAS	PDCAAS
Tuna, canned in sunflower oil, drained	25.4	150 g (1 portion cooked fish)	38.1	3.2	NA	100[1]
Beef, sirloin steak, grilled well-done, lean	33.9	100 g (1 palm of hand size)	33.9	2.9	91[2]	95[3]
Chicken, breast, grilled without skin, meat only	32.0	100 g (1 palm of hand size)	32.0	2.2	108[4,a]	100[3]
Sardines, canned in sunflower oil, drained	23.3	85 g (3 sardines)	19.8	1.7	NA	100[1]
Eggs, chicken, whole, boiled	14.1	100 g (2 eggs)	14.1	1.2	116[4,a]	100[3]
Lentils, red, split, boiled	7.6	144 g (¾ cup)	10.9	0.9	50[5]	54[5]
Beans, red kidney, dried, boiled in unsalted water	8.6	120 g (½ standard tin)	10.3	0.7	59[6]	65[6]
Peanuts, dry roasted	25.7	40 g (30 kernels)	10.3	0.7	43[6]	51[6]
Milk, whole, pasteurised, average	3.4	200 mL (1 cup)	6.8	0.6	120[7,b]	100[7]
Milk, soya, non-dairy alternative to milk, unsweetened, fortified	2.4	200 mL (1 cup)	4.8	0.4	84[7,c]	100[6,c]
Rice, brown, wholegrain, boiled in unsalted water	3.6	146 g (1 cup cooked rice)	5.3	0.4	42[8]	NA
Beans, chickpeas, canned, reheated, drained	8.4	86 g (¾ cup)	7.2	0.4	NA	66[3]
Bread, wholemeal, average	9.4	60 g (2 slices)	5.6	0.4	20[8]	32[9,d]
Rice, white, basmati, boiled in unsalted water	2.8	116 g (1 cup cooked rice)	3.2	0.3	37[8]	62[6]
Porridge, made with water	1.4	30 (1 cup)	0.4	0.3	54[6]	67[6]
Peas, boiled in unsalted water	6.7	50 g (½ cup)	3.4	0.3	58[6]	60[6]
Ready-to-eat breakfast cereal	7.1	30 g (1 cup)	2.1	0.3	1[6]	8[6]
Potatoes, old, boiled in unsalted water, flesh only	1.8	180 g (1 medium potato)	3.2	0.2	NA	85[3]

A PDCAAS or DIAAS below 100 indicates that at least one amino acid is limiting in the food or diet, whereas a score of 100 indicates that there is no limiting amino acid in the food or diet.

Protein content derived from McCance and Widdowson's The Composition of Foods Integrated Dataset 2019, available at https://www.gov.uk/government/publications/composition-of-foods-integrated-dataset-cofid.

Amino acid content of foods derived from Nutritics (2019) Research Edition (v5.09) using GB15 database.
[1]Usydus *et al*. (2009)
[2]Hodgkinson *et al*. (2018)
[3]Boye *et al*. (2012)
[4]Ertl *et al*. (2016)
[5]Nosworthy *et al*. (2017)
[6]Rutherfurd *et al*. (2015)
[7]Mathai *et al*. (2017)
[8]Han *et al*. (2018)
[9]Acevedo-Pacheco and Serna-Saldívar (2016)
[a]Not directly measured
[b]Based on milk protein concentrate
[c]Based on soy protein isolate
[d]Based on wheat tortillas
Abbreviations – PDCAAS: protein digestibility-corrected amino acid score; DIAAS: digestible indispensable amino acid score; NA: not available.

EFSA (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2012a) has used nitrogen balance (the difference between nitrogen intake and loss in urine, faeces and skin) studies and a reference body weight (bw) of 70 kg to determine the population reference intake (PRI) for protein of 0.83 g/kg bw/day, applicable to both high-quality protein and protein in mixed diets. The Institute of Medicine (IOM) (Institute of Medicine, 2002) has set a recommended daily allowance (RDA) of 0.8 g/kg bw/day of good-quality protein, also based on nitrogen balance studies. Neither the IOM nor EFSA has made recommendations on protein intake specifically for older adults (i.e. aged ≥65 years) (Table 4).

A number of international working groups have recently recommended higher protein requirements for older adults. These range from 1 g/kg bw/day up to 2 g/kg bw/day for those with severe illness or injury, or with marked undernutrition (Dorrington *et al*., 2020; German Nutrition Society, 2016; Deutz *et al*., 2014; Bauer *et al*., 2013). The Nordic countries have subsequently increased the protein requirements for older adults to 1.1–1.3 g/kg bw/day, corresponding to 15–20% energy intake from protein (Nordic Council of Ministers, 2014b) (Table 4). However, recent randomised controlled trials (RCTs) found mixed results in terms of beneficial effects of increased protein intake on muscle mass and strength (ten Haaf *et al*., 2019; Bhasin *et al*., 2018; Park *et al*., 2018; Beelen *et al*., 2017).

Table 4 International recommendations on protein intake

Report	Country/region	Recommended intake (g/kg bw/day)
EFSA (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2012a)	Europe	0.83
IOM (Institute of Medicine, 2002)	United States of America (USA) and Canada	0.80
Nordic Council of Ministers (Nordic Council of Ministers, 2014b)	Nordic countries	1.10–1.30

In Ireland, the NANS reported that the mean protein intake in older adults is 76.8 g/day (17.9% of total energy) (Irish Universities Nutrition Alliance, 2011) and that one-third of older adults had protein intakes below the EFSA estimated average requirement (EAR) of 0.66 g/kg bw/day (Kehoe, 2018). Such low intakes will not maintain muscle mass and function, which decline due to the ageing process. This indicates that ensuring adequate protein intake is critical for optimal health in older adults in Ireland. The main contributors to protein intakes in the older adult age group are: meats (40%), dairy (15%) and breads (12%) (Hone *et al*., 2020). Table 5 outlines the average protein and energy intakes of older adults as reported in the NANS. Hone *et al*. (2020), using the NANS data, reported that average protein intakes relative to bw for older adults are 1.15 g/kg bw/day, thus exceeding the EFSA reference intake for protein. Also outlined in Table 5 are intakes of total protein (g/day), energy (kcal/day) and protein (g/kg actual bw) according to actual height at the 5th, 50th and 95th percentiles for both genders of older adults in the NANS. The calculation of protein intake in g/kg actual bw/day is confounded by the high level of overweight and obesity among the older adults included in this survey.

Table 5 Protein (g/day) and energy (kcal/day) intakes of older adults (aged ≥65 years) from the 2008–2010 NANS

	Males (≥65 years)				Females (≥65 years)			
	Mean	SD	Median	IQR	Mean	SD	Median	IQR
Height (m)	1.71	0.70	NA	NA	1.58	0.06	NA	NA
Weight (kg)	82.4	13.3	NA	NA	68.1	10.7	NA	NA
Energy intake (kcal/day)	1983	630	1905	1531–2401	1554	381	1508	1284–1856
Protein intake (g/day)	85.2	24.1	85.2	66.4–100.6	69.4	17.8	68.7	56.1–81.4

	Males (≥65 years)			Females (≥65 years)		
	5th percentile	50th percentile	95th percentile	5th percentile	50th percentile	95th percentile
Height (m)	1.61	1.71	1.81	1.50	1.58	1.68
Weight (kg)	63.2	80.6	109.1	53.2	69.1	89.3
Energy intake (kcal/day)	1029	1905	2999	984	1508	2209
Protein intake (g/day)	45.7	85.2	126.3	43.0	68.7	100.0
Protein intake (g/kg bw/day)	0.7	1.1	1.2	0.8	1.0	1.1

Source: Kehoe (2018)
Abbreviations – IQR: interquartile range; NA: not available; SD: standard deviation

To account for the confounding effect of overweight and obesity in older adults included in the NANS, the ideal body weight of older adults at the 5th, 50th and 95th percentiles of actual height was estimated. This is outlined in Table 6, along with predicted energy requirements at various physical activity levels (PALs). Also shown in this table are total daily protein intakes based on ideal body weight calculated at 0.8 g/kg ideal bw/day, at 1.0 g/kg ideal bw/day and at 1.2 g/kg ideal bw/day. This shows that recommending protein intakes at 1.0–1.2 g/kg ideal bw/day provides a range of protein intakes that are higher than the lowest actual intake levels, but are lower than the highest actual intake levels (58–89 g for males and 48–73 g for females, versus 46–126 g for males and 43–100 g for females (actual intakes outlined in Table 5)). Increasing the lowest levels of protein intake among older adults addresses those at greatest risk of protein inadequacy. In addition, data outlined in Table 6 show that providing protein at 1.2 g/kg ideal bw/day yields a range of energy intake from protein of 11–18%, which is low compared with the 15–20% energy from protein recommended by the Nordic Council of Ministers. It is concluded from this analysis that older adults in Ireland need more protein-dense diets.

Table 6 Protein requirements (g/kg bw and total g/day) based on estimated ideal body weight according to the actual height of older adults (≥65 years) included in the 2008–2010 NANS at 5th, 50th and 95th percentiles

	Males (≥65 years)			Females (≥65 years)		
	5th percentile	50th percentile	95th percentile	5th percentile	50th percentile	95th percentile
Actual height (m)	1.61	1.71	1.81	1.50	1.58	1.68
Ideal body weight (kg)*	58	66	74	48	54	61
Energy requirements (kcal/day)**						
PAL 1.2	1603	1906	2360	1315	1518	1775
PAL 1.4	1870	2223	2754	1534	1770	2070
PAL 1.6	2137	2541	3147	1753	2023	2366
Daily protein requirement (g) at 0.8 g/kg bw/day	47	53	59	39	43	48
% energy from protein at 0.8 g/kg bw/day						
PAL 1.2	12	11	10	12	11	11
PAL 1.4	10	10	9	10	10	9
PAL 1.6	9	8	7	9	9	8
Daily protein requirement (g) at 1 g/kg bw/day	58	66	74	48	54	61
% energy from protein at 1 g/kg bw/day						
PAL 1.2	14	14	13	15	14	14
PAL 1.4	12	12	11	13	12	12
PAL 1.6	11	10	9	11	11	10
Daily protein requirement (g) at 1.2 g/kg bw/day	70	79	89	58	64	73
% energy from protein at 1.2 g/kg bw/day						
PAL 1.2	17	17	15	18	17	16
PAL 1.4	15	14	13	15	14	14
PAL 1.6	13	12	11	13	13	12

*Calculated using the actual height from the NANS (Irish Universities Nutrition Alliance, 2011) and the IOM (Institute of Medicine, 2002) reference BMI for males (22.5 kg/m^2) and females (21.5 kg/m^2).

**Calculated using the Henry equation (Henry, 2005)

PALs are defined by the IOM (Institute of Medicine, 2002) as follows: sedentary (PAL ≥1.0 to <1.4); low-active (PAL ≥1.4 to <1.6) (a low-active lifestyle for an adult weighing 70 kg includes exertion equivalent to walking 2.2 miles per day at a rate of 3–4 miles per hour or the equivalent energy expenditure in other activities, in addition to the activities that are part of independent living); and active (PAL ≥1.6 to <1.9) (an active lifestyle for an adult weighing 70 kg includes exertion equivalent to walking 7 miles per day at the rate of 3–4 miles per hour or the equivalent energy expenditure in other activities, in addition to the activities that are part of independent living).

3.1.3 Key issues outlined in more detail and how these can be addressed through diet

The links between ageing, morbidity and functionality are outlined in Figure 1. Skeletal muscles play a crucial role within the body by maintaining posture, stabilising bones and joints, and controlling movement. MPS is the main process responsible for regulating the maintenance or gain in skeletal muscle mass. Consumption of dietary protein and physical activity both stimulate MPS. Dietary protein-derived EAAs act both as signalling molecules to induce MPS, and as building blocks for the new muscle tissue (van Vliet *et al*., 2015). Muscle mass decreases by 8% per decade between the ages of 40 and 70 years, and decreases by 15% per decade after the age of 70 years (Flakoll *et al*., 2004). A decrease in MPS and physical activity, as well as illness and undernutrition can all result in the loss of muscle mass in older adults (Cruz-Jentoft *et al*., 2010). This decline in muscle mass and function, which can begin as early as age 40, is known as sarcopenia (see Section 3.1 Part B for more details). Loss of muscle mass has been associated with negative health outcomes in chronic obstructive pulmonary disease, cancer and CVD, and is associated with an increased risk of falls and fractures (Deutz *et al*., 2014; Cruz-Jentoft *et al*., 2010).

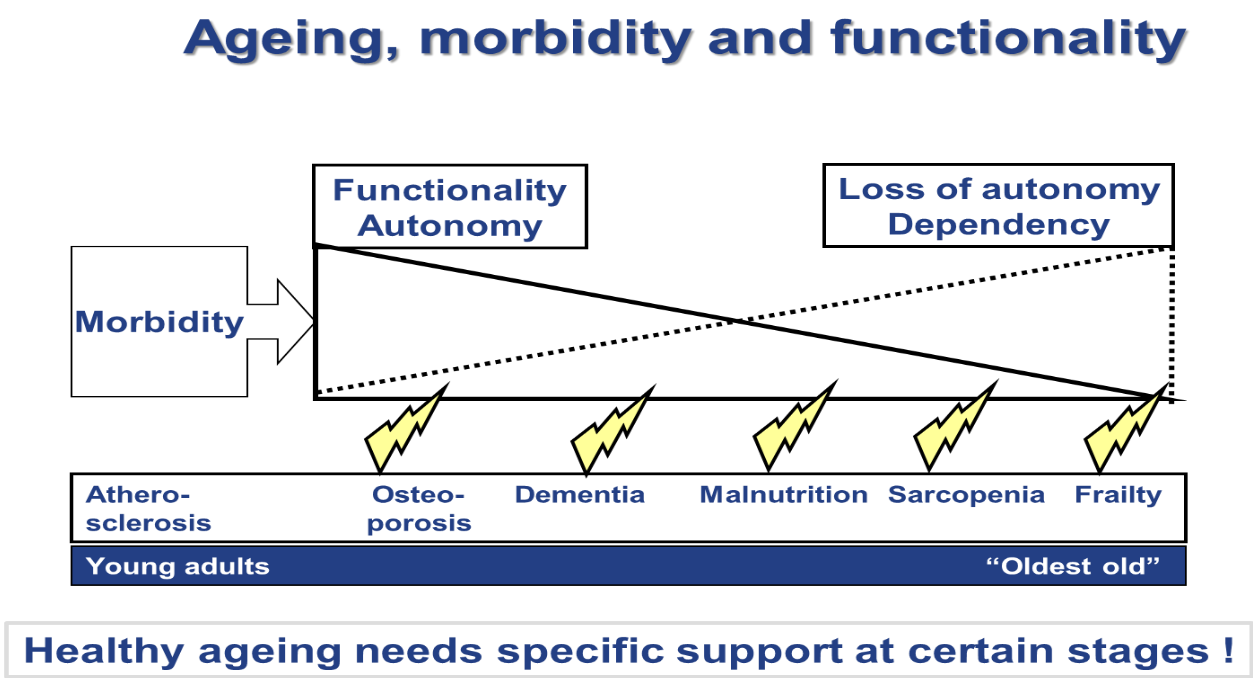

Figure 1 Ageing, morbidity and functionality

Source: Professor J Bauer, personal communication, 18 September 2020.

Recent research has suggested that spreading protein intake across the day at a rate of ingestion of approximately 0.4 g/kg bw/meal (equating to roughly 20 or 28 g of protein per meal for a 50 kg or 70 kg person, respectively) maximises MPS (Loenneke *et al*., 2016; Moore *et al*., 2014; Volpi *et al*., 2013; Symons *et al*., 2009). National food survey data indicate that older adults living in Ireland consume the majority of their daily protein at one meal – usually the evening dinner meal (~40–50% of total protein intake) – with smaller amounts typically consumed at breakfast (~15%), the midday meal (~28%) and as snacks (Hone *et al*., 2020). This translates into lower protein intakes at breakfast (~10–15 g) and lunch (~16–22 g) that are likely to be suboptimal for the stimulation of MPS. Achieving protein intake recommendations may prove challenging for older adults. A number of recent cross-sectional studies have reported positive associations between the number of daily meals containing optimal per-meal protein and muscle mass and/or strength in older adults (Loenneke *et al*., 2016; Bollwein *et al*., 2013); breakfast or lunch therefore provide good meal opportunities to improve protein intake distribution. In addition to high-quality protein foods commonly consumed at dinner (e.g. meat, fish, poultry, beans, legumes), older adults should be encouraged to consume greater amounts of high-quality protein foods at breakfast (e.g. milk or yogurt with fortified breakfast cereals or eggs) and/or lunch (e.g. beans on toast, cheese, eggs, meat, poultry, fish) in place of the bread-based meals that older adults frequently consume at these times (Tieland *et al*., 2012). Eating a hot meal can increase protein intake to ~35–40 g per meal (Tieland *et al*., 2012). Given that hot meals generally include a serving of protein-rich meat, poultry or fish, recommending consumption of a hot meal at both lunch and dinner may represent an effective strategy to improve daily per-meal protein intake. A more recent RCT in older adults concluded that 'peak' protein (i.e. consuming one very high-protein (35–45 g) meal per day) and evenly distributing protein throughout the remainder of the day (equal amount of protein (≤20 g) during each meal and snacks) is equally effective and feasible in increasing protein intakes in this age group (Reinders *et al*., 2020). In addition, in order to enhance MPS, leucine-rich whey protein supplementation may be warranted in some situations where age-related issues arise, such as poor appetite, poor dentition, dysphagia or functional disabilities (Deutz *et al*., 2014; Bauer *et al*., 2013). For older adults with severe chronic kidney disease, caution should be taken when consuming high levels of protein, and individuals should seek and follow appropriate medical advice with regard to individual protein intake recommendations (Bauer *et al*., 2013).

Therefore, determining which strategy to use for increasing protein intakes should consider the circumstances of the individual; for example, health status, appetite, depression, loneliness and socioeconomic status may make one strategy more feasible and effective than another. See Table 7 for examples of commonly eaten high-quality protein foods (PDCAAS 66–100) outlined according to typical meal and snack consumption patterns among older adults living in Ireland.

Table 7 A range of commonly eaten foods with a high-quality protein (PDCAAS of 66–100) content, outlined according to typical consumption patterns (meals and snacks)

Food sources (typical portion sizes; g and household measure)	Amount of protein (g) provided by typical portion size
Breakfast foods	
Eggs (50 g; 1 egg)	7
Milk (200 g; 1 cup)	7
Cheese (30 g; 2 thumbs width and depth)	7
Yogurt (150 g; ¾ cup)	7
Light meal foods	
Cod/haddock/salmon (75 g; ½ cooked portion)	18
Chicken (50 g; ½ palm of hand size)	16
Beef (50 g; ½ palm of hand size)	17
Eggs (50 g; 1 egg)	7
Cooked lentils (88 g; ¾ cup)	7
Baked beans (146 g; ¾ cup)	7
Main meal foods	
Cod/haddock/salmon (75 g; ½ cooked portion)	18
Chicken (50 g; ½ palm of hand size)	16
Beef (50 g; ½ palm of hand size)	17
Eggs (50 g; 1 egg)	7
Lentils (88 g; ¾ cup)	7
Baked beans (146 g; ¾ cup)	7
Snack foods	
Cheese (30 g; 2 thumbs width and depth)	7
Yogurt (150 g; ¾ cup)	7
Peanut butter (12 g; 1 tablespoon)	7
Hummus (50 g; ¼ cup)	3

The current literature indicates that preservation of lean body mass and strength is not possible with higher protein intake alone (Backx *et al*., 2016; Wycherley *et al*., 2012; Houston *et al*., 2008) and studies that have included exercise (particularly resistance exercise) generally show a greater effect of higher protein intake on lean body mass and strength preservation (Macdonald *et al*., 2020; Kim *et al*., 2012). Resistance exercise is considered the most effective and safe treatment for improving muscle mass, strength and function in older adults (Travers *et al*., 2019). Aerobic exercise improves cardiorespiratory fitness, an independent predictor of all-cause mortality (Blair *et al*., 1996), and may also improve protein feeding-induced muscle anabolism (Timmerman *et al*., 2012). This emphasises that older adults should aim to perform physical activity on a daily basis so that each meal is consumed with the muscles in a 'sensitised' state. In situations in which opportunities for physical activity are limited (e.g. bed rest), any activity that loads the skeletal muscle is likely to have a beneficial effect (i.e. short walks, pressing feet against the foot of the bed) and should be encouraged. The addition of carbohydrate and/or fat to a protein beverage does not affect the MPS response in older adults (Gorissen *et al*., 2017; Kramer *et al*., 2015; Gorissen *et al*., 2014), although emerging evidence suggests a potential role for long-chain (LC) omega-3 (n-3) polyunsaturated fatty acids (PUFAs) to support muscle health in older adults (Smith *et al*., 2015) and should be considered as the evidence develops.

3.1.4 Recommendations

1. Healthy older adults should consume a more protein-dense diet than the general adult population.
2. Sufficient high-quality protein foods assessed using PDCAAS or DIAAS (defined by digestibility and quantity of EAAs) should be included in the diet and consumed at a minimum of two meals per day. Such foods include meat, poultry, fish, dairy products, and eggs, and, to a lesser extent, beans, peas, lentils and nuts.
3. Older adults should aim to be physically active on a daily basis so that each meal is consumed while the muscles are in a 'sensitised' state. This is relevant even when capacity for physical activity is low.

Part B. Frailty, sarcopenia and undernutrition

3.1.5 Key issues

1. Frailty, sarcopenia and undernutrition are often associated with ageing, have negative consequences for health and quality of life, and can usually be avoided, delayed or reversed with timely and appropriate interventions.
2. To prevent frailty, sarcopenia and undernutrition, high-quality protein foods assessed using PDCAAS or DIAAS (defined by digestibility and quantity of EAAs) should be consumed at a minimum of two meals per day in order to stimulate muscle protein synthesis.
3. Older adults who are frail, sarcopenic or undernourished need a protein-dense diet that provides adequate energy and should engage in resistance exercise.

3.1.6 Background

Frailty, sarcopenia and undernutrition (Appendix 2) are related conditions associated with ageing but are not normal components of the ageing process. The aetiology of each condition is multifactorial, but all have negative consequences, including functional impairment, falls, adverse health outcomes, hospitalisation, reduced quality of life and mortality (Volkert *et al*., 2019a; Bianchi *et al*., 2016; Trombetti *et al*., 2016; Landi *et al*., 2013; Tom *et al*., 2013). Older adults, and those who are frail, sarcopenic or at risk of undernutrition, also have a higher incidence of acute respiratory complications, including severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Barazzoni *et al*., 2020).

In Ireland, frailty occurs in 15% of those aged 65 years and older living in the community where older age, female gender and lower socioeconomic status are recognised predisposing factors (O'Halloran, 2020). European data indicate that frailty prevalence increases to 76% among older adults in long-term care (O'Caoimh *et al*., 2018). Pre-frailty describes older adults who have one or two frailty characteristics. The prevalence of pre-frailty internationally is estimated to be 31% in the community setting (Ofori-Asenso *et al*., 2019). These older people are at high risk of progressing to frailty (Xue, 2011).

Sarcopenia has been identified in between 10% and 40% of community-dwelling older adults depending on the definition used (Mayhew *et al*., 2019). The development of sarcopenia is related to ageing, disease, inactivity and malnutrition/undernutrition (Cruz-Jentoft *et al*., 2019). The high prevalence of obesity in Irish older adults can complicate the identification of sarcopenia (Leahy *et al*., 2014). Being both obese and sarcopenic is associated with poorer health status and functional capacity than that associated with either one of the conditions alone (Baumgartner *et al*., 2004).

Undernutrition in older adults can be attributed to many interrelated factors that can increase the requirements for, while simultaneously impairing the bioavailability and reducing the intake of, energy, dietary protein and specific micronutrients (Volkert *et al*., 2019c). Community-dwelling older adults who require home care services are particularly vulnerable (Crichton *et al*., 2019). Risk of undernutrition increases with age among those who are unmarried, divorced or separated, and is particularly high in those who have been recently hospitalised or have mobility difficulties (Streicher *et al*., 2018). In Ireland, older men who have fallen in the previous 2 years and older women who are cognitively impaired or require help purchasing groceries, completing household chores or making meals are also at increased risk (Bardon *et al*., 2020).

Nutrition can play an important role in delaying or reversing these three conditions; nutritional intervention and muscle strengthening exercise are regarded as the most effective intervention to delay or reverse frailty and sarcopenia (Travers *et al*., 2019; Dent *et al*., 2018; Pennings *et al*., 2011). Ensuring energy balance by consuming adequate calories is crucial to maintaining muscle mass and preventing the development of frailty, sarcopenia and undernutrition (Hector *et al*., 2015; Murphy *et al*., 2015). As animal protein sources contain more EAAs, which are needed for MPS, these sources of protein are thought to be associated with a lower risk of frailty in comparison to plant protein sources, but evidence for this is limited. Nevertheless, a recent study by Isanejad *et al*. (2020) observed a stronger association between animal protein and frailty (as opposed to plant protein and frailty), concluding that a higher protein intake focusing on animal protein in particular may be effective in preventing frailty. Consumption of protein at a minimum of two meals per day over a number of years may delay the progression of sarcopenia and reduce the likelihood of developing frailty (Bollwein *et al*., 2013; Paddon-Jones and Rasmussen, 2009).

Screening recommendations for frailty, sarcopenia and undernutrition in the community setting vary depending on the condition and setting (Dwyer *et al*., 2020; Cruz-Jentoft *et al*., 2019; Walston *et al*., 2018; Kondrup *et al*., 2003), and any approach to screening should be evidence based. Comprehensive assessment and appropriate intervention should be provided if any one of these conditions is identified.

3.1.7 Key issues outlined in more detail and how these can be addressed through diet

Ageing is associated with a decrease in muscle mass, a decline in physical activity and an increase in both total and central accumulation of body fat. Frailty, sarcopenia and undernutrition are dynamic processes and contribute to increased morbidity and mortality in older adults. None of these conditions is inevitable and they can be avoided, delayed or reversed with timely and appropriate interventions (Reinders *et al*., 2019; Travers *et al*., 2019; Hector *et al*., 2015; Murphy *et al*., 2015; Pennings *et al*., 2011).

International working groups (as outlined in Section 2.1 Part A) recommend that protein intakes, in the presence of acute or chronic disease, be increased to 1.2–1.5 g/kg bw/day (Volkert *et al*., 2019a).

3.1.8 Recommendations

1. Frailty, sarcopenia and undernutrition should be identified in adults aged 65 years and older, as these conditions increase the risk of morbidity and mortality and reduce quality of life.
2. Older adults should consume adequate energy (kilocalories) to prevent the development of frailty, sarcopenia and undernutrition.
3. Older adults at risk of frailty, sarcopenia and undernutrition are recommended to eat a minimum of 1.0–1.2 g/kg body weight (bw) of protein per day to preserve muscle mass.
4. Sufficient high-quality protein foods assessed using PDCAAS or DIAAS (defined by digestibility and quantity of EAAs) should be included in the diet and consumed at a minimum of two meals per day. Such foods include meat, poultry, fish, dairy products, and eggs, and, to a lesser extent, beans, peas, lentils and nuts.
5. Older adults should aim to complete physical activity daily and resistance exercise 2–3 times/week in order to maintain or improve physical function.

3.2 Dietary carbohydrate and fibre

Part A. Dietary carbohydrate

3.2.1 Key issues

1. The average intake of carbohydrate among older adults living in Ireland is at the lower end of the recommended range, but almost one-third (31%) of older adults have free sugars intakes exceeding recommended limits and inadequate fibre intakes (fibre is specifically addressed in Section 3.2 Part B).
2. Anthropometric data show that high proportions of older adults living in Ireland are overweight with an abdominal body fat distribution, indicating a high risk of T2D. Controlling the amount and type of carbohydrate consumed may help weight control and delay or prevent the onset of T2D and subsequent macro- and microvascular complications.
3. Frail, underweight older adults with poor food intakes and limited appetites may benefit from higher intakes of refined carbohydrates and free sugars. Underweight among free-living older adults in Ireland is estimated to affect about 2% (see Table 1).

3.2.2 Background

Carbohydrate can be divided into sugars (monosaccharides and disaccharides), polyols, oligosaccharides (malto-oligosaccharides and non-digestible oligosaccharides) and polysaccharides (starch and non-starch polysaccharides). However, this chemical classification does not allow for categorisation of nutritional effects because these classes of carbohydrate overlap, both in terms of physiological properties and effects on health (Scientific Advisory Committee on Nutrition, 2015).

For nutritional purposes, classifying dietary carbohydrate according to digestion and absorption in the human small intestine differentiates two broad categories of carbohydrates:

a) Carbohydrate that is digested and absorbed in the human small intestine
b) Dietary fibre, which includes non-digestible carbohydrate plus lignin, that passes into the large intestine (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010b).

This section describes total dietary carbohydrates in terms of health effects on older adults living in Ireland, but mainly focuses on the types of carbohydrates that are digested and absorbed in the human small intestine. While these carbohydrates may include polyols and malto-oligosaccharides, they are mainly composed of starch and free sugars (Box 1).

Box 1
Free sugars include monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates (World Health Organization, 2015).

The main role of dietary carbohydrate is energy provision – a role that is shared and balanced by dietary fat intakes so that higher carbohydrate diets are characterised by lower fat intakes and higher fat diets are characterised by lower carbohydrate intakes. Therefore, consideration of the health effects of various levels of carbohydrate intake must account for the confounding effects of altered fat intakes. While protein also provides dietary energy (kcal), protein should not have a major role in energy provision for older adults. Section 3.1 describes the importance of dietary protein (especially EAAs) for older adults, including how this may influence the progressive loss of muscle mass, strength and function associated with ageing.

The specific role of dietary fibre for older adults is addressed in more detail in Section 3.2 Part B.

Dietary carbohydrate intakes of older adults living in Ireland in relation to recommendations

International recommendations on adult carbohydrate requirements by EFSA and the IOM are outlined in Table 8. There are no specific recommendations for older adults. EFSA has established a reference intake range for carbohydrates of 45–60% of total energy, which is applicable to all adults (EFSA Panel on Dietetic Products, Nutrition and Allegies, 2010b). The IOM has established an acceptable macronutrient distribution range[1] for carbohydrates of 45–65% of total energy for both adults and children (Institute of Medicine, 2006). The World Health Organization (WHO) has established the most recent guidelines for free sugars intake, which were subsequently supported by the UK Scientific Advisory Committee on Nutrition (SACN) (Scientific Advisory Committee on Nutrition, 2015; World Health Organization, 2015). As shown in Table 8, these free sugars intake guidelines recommend an upper limit for both adults and children of <10% of energy, with a further reduction to <5% of energy (Scientific Advisory Committee on Nutrition, 2015; World Health Organization, 2015). Recommendations on fibre intakes from these international bodies are described in detail and considered separately in Section 3.2 Part B.

[1] A range of intakes for a particular energy source that is associated with reduced risk of chronic diseases while providing adequate intakes of essential nutrients.

Table 8 International recommendations on carbohydrate requirements

Report	Country/region	Types of carbohydrates		
		Total carbohydrate (% energy)	Free sugars (% energy)*	Total fibre (g/day)
WHO (World Health Organization, 2015)	Global		<10 <5	
SACN (Scientific Advisory Committee on Nutrition, 2015)	UK		<10 <5	
EFSA (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010b)	Europe	45–60		25
IOM (Institute of Medicine, 2006)	USA and Canada	45–65		Males 30 Females 21

*Free sugars intakes are recommended to be <10% of total energy, with a further recommendation of <5% of total energy, if possible.

Abbreviations – EFSA: European Food Safety Authority; IOM: Institute of Medicine; SACN: Scientific Advisory Committee on Nutrition; WHO: World Health Organization.

In relation to international dietary carbohydrate recommendations outlined in Table 8, average daily intakes of total carbohydrate by older adults are within the recommended range, but at the lower end. Detailed data on carbohydrate intakes in older adults in Ireland are outlined in Table 9. This shows that a significant proportion of older adults have low total carbohydrate intakes (<40% of total energy). While average intakes of free sugars are below the recommended upper limit of <10% energy, almost one-third (31%) of older adults exceed this limit. The main sources of carbohydrate in this age group are breads (27%), potatoes (12%), fruit and fruit juices (10%), breakfast cereals (9%) and confectionery (8%). Average daily intakes of dietary fibre are significantly below recommended intakes, and this is addressed in Section 3.2 Part B.

Table 9 Carbohydrate intakes (g/day) of older adults (≥65 years) from the 2008–2010 NANS

	Total	5th percentile	95th percentile	Males	Females
Total carbohydrate (% energy)	44.0	31.9	55.7	42.8	44.5
Total sugar (% energy)	18.0	7.7	28.2	16.3	18.9
Free sugars (% energy)	8.3 (4.4)	-	-	7.8 (4.2)	8.8 (4.5)
Total fibre (g/day)	17.9	8.3	33.8	18.4	17.3

Total data for males and females are median values; all free sugars data are means (SD).

3.2.3 Key issues outlined in more detail and how these can be addressed through diet

In this report, older adults are categorised into four subgroups according to comorbidities and capacity for physical activity (see Chapter 1). Optimal dietary carbohydrate intakes for older adults will vary according to these factors and weight status (see Section 2.1 for more details on weight status). Therefore, this section explores the key issues for each of these subgroups in more detail.

Dietary carbohydrate and all older adults who are overweight or obesity within the four subgroups

Box 2
Metabolic syndrome is having any three of the following:
- Abdominal obesity: waist >94 cm (♂) or >80 cm (♀)
- Blood pressure >140/90 mmHg
- Impaired fasting glucose (>5.5 mmol/L)
- HDL-C <1 mmol/L
- TAGs >1.7 mmol/L.

Older adults who are overweight with abdominal obesity are at increased risk of T2D and CVD because, in addition to abdominal obesity, older adults having just two other highly prevalent risk factors can be described as having metabolic syndrome (see Box 2) (Shin *et al*., 2013). Metabolic syndrome is a strong predictor of T2D and CVD (Shin *et al*., 2013).

For more than 20 years, evidence has been steadily accumulating to show that dietary interventions can ameliorate these risks. Since 1997, RCTs in many different parts of the world have shown that the onset of T2D can be prevented or delayed through diet and weight loss (Lean, 2019; Lindström *et al*., 2013; Ramachandran *et al*., 2006; Kosaka *et al*., 2005; Diabetes Prevention Program Research Group, 2002; Tuomilehto *et al*., 2001; Pan *et al*., 1997). Weight reduction and reduced carbohydrate intakes are the hallmarks of these dietary interventions and the independent effects of both are explored in a recent draft UK Government report, *Lower carbohydrate diets for adults with type 2 diabetes: draft report* (Scientific Advisory Committee on Nutrition, 2020c). While the conclusions of this report have yet to be completed, the scientific evidence shows that weight loss is a crucial factor in preventing T2D and that over the long term (>6 months), very low carbohydrate intakes are not more effective than moderate carbohydrate restriction, i.e. usual range of carbohydrate intake in Ireland (~45% energy) as part of a weight-loss diet. While weight reduction among overweight and obese older adults has been shown to prevent or delay the onset of T2D, with the best outcomes apparent among those losing the most weight (Lean, 2019), a recent European Society for Clinical Nutrition and Metabolism (ESPEN) review concludes that weight-reducing diets should only be considered in obese older adults with weight-related health problems and that this should be combined with physical exercise in order to prevent loss of muscle mass and accompanying functional decline (Volkert *et al*., 2019b) (see Section 2.1 for more details).

It is important to also consider the disadvantages of low-carbohydrate diets (<40% energy) for older adults, which include:

- Inadequate dietary fibre (see Section 3.2 Part B)
- High intakes of fat, which can lead to passive overconsumption of energy (see Section 3.3)
- Excessive intakes of saturated fat, which increases CVD risk (see Section 3.3).

Moderate intakes of fibre-rich carbohydrates and low free sugars consumption, eaten as mixed meals (with protein and fat) throughout the day, reduces the glycaemic effect of carbohydrates, i.e. effects on blood glucose. This is likely to represent the best approach for older adults in Ireland to address risk of T2D due to high incidence of overweight and obesity and tendency for abdominal body fat distribution (see Table 1). Older adults should choose carbohydrate foods that are high in dietary fibre and low in free sugars. In food-based terms, this involves always choosing wholemeal breads, cereals, pastas, etc. and whole fresh fruits, and minimising intakes of foods containing free sugars (cakes, biscuits, confectionery, sugar-sweetened beverages, etc.).

Carbohydrates higher in fibre and lower in free sugars are digested, absorbed and metabolised more slowly, resulting in a lower and slower rise in blood glucose (and insulin). Such carbohydrates may protect against T2D, obesity, CVD and cancer – common causes of morbidity and mortality among older adults living in Ireland (Scientific Advisory Committee on Nutrition, 2020c; Scientific Advisory Committee on Nutrition, 2015). The WHO recommends that free sugars intakes be reduced throughout the life-course (World Health Organization, 2015). High intakes of free sugars increase overall energy intake but may reduce the intake of foods providing more nutrient-dense calories, resulting in an unhealthy diet and in increased body weight and risk of non-communicable diseases. Free sugars intake is associated with an increase in dental caries. Therefore, the WHO has recommended that free sugars intake, in both adults and children, be reduced to less than 10% of total energy, with a further reduction to less than 5% of total energy if possible (World Health Organization, 2015).

Older adults with impaired blood glucose control or diabetes

In older adults who have impaired blood glucose control (pre-diabetes) or diabetes, controlling the glycaemic effect (how quickly a food raises blood glucose) of carbohydrate foods can ameliorate post-prandial hyperglycaemia and associated complications (Scientific Advisory Committee on Nutrition, 2020c; Scientific Advisory Committee on Nutrition, 2015). While glycaemic index (GI; see Box 3) values are available globally for a wide range of carbohydrate food sources and can be used to estimate glycaemic load (GL; see Box 3), this is too complex to be of practical use. Nonetheless, general guidelines for lowering the GI and GL of meals outlined in Table 10 can be used to improve dietary carbohydrate quality for this group of older adults.

Box 3
Glycaemic index (GI) and glycaemic load (GL) are two measures of the glycaemic characteristic of foods and are defined as follows:

Glycaemic index
GI is a relative measure of the capillary blood glucose response to a specific ingredient, food or portion of a meal, as compared with the response to a reference food having the same amount of available carbohydrate (usually 50 g). The reference food is commonly pure glucose, but white bread has also been used.

Glycaemic load
GL refers to a portion of food consumed and is estimated by multiplying the GI of the food by the carbohydrate content. This accounts for both the quality of the carbohydrate food in terms of raising blood glucose, and the amount of available carbohydrate it contains.

Physical activity, which is vital for preventing loss of lean tissue in favour of fat issue, is particularly important for this group of older adults. Physical activity also helps maintain blood glucose control and should be encouraged on a daily basis to whatever capacity possible.

Dietary carbohydrate and older adults who are frail and underweight

Given that low nutrient intake and sedentary behaviour (O'Connell *et al*., 2020) are key contributors to frailty and that one of the main underlying aetiological factors in underweight individuals is poor appetite (Landi *et al*., 2016), older adults who are frail and underweight are advised to avoid restrictive diets (Volkert *et al*., 2019a; Volkert *et al*., 2019b,). In such cases, acceptable forms of dietary carbohydrate that encourage eating and provide energy can be provided as a component of a personalised approach that can include dietary counselling; adjustment to the nutritional content of meals; meal enrichment, modification and assistance; offering snacks; and/or provision of oral nutritional supplements (Volkert *et al*., 2019a).

Table 10 Minimising the glycaemic effect of carbohydrate foods for older adults with impaired blood glucose control or diabetes

Carbohydrate foods to eat more of	Carbohydrate foods to eat less of
Vegetables Carrots, broccoli, celery, leeks, peppers, mushrooms, asparagus, mangetouts, cabbage, kale, Brussels sprouts, peas, courgettes, aubergines	Vegetables – none, because these foods provide fibre, and most provide minimal carbohydrate
Salad Lettuce, tomatoes, cucumber, scallions, onions, beetroot, radishes, peppers, bean sprouts, watercress	Salad – none, because these foods provide fibre and have minimal carbohydrate content
Fruit Apples, oranges, pears, peaches, nectarines, bananas, melons, pineapples, mandarins, apricots, kiwis, grapes, strawberries, blueberries, raspberries, mangoes, grapefruit, prunes	Fruit – none, because these foods provide fibre
Wholemeal breads, rice, pasta	White breads, rice, pasta, etc.
High-fibre breakfast cereals low in added sugar	Breakfast cereals low in fibre and high in added sugar
	Confectionery, preserves, honey and syrups
Best cooking methods	**Cooking methods to limit**
Whole foods – chunks of potatoes and root vegetables	Mashed or pureed potatoes and root vegetables
Al dente vegetables, rice and pasta	Overcooked vegetables, rice and pasta
Best meal options	**Meal options to limit**
Eat carbohydrate foods mixed with other types of foods	Meals and snacks of carbohydrate foods only
Eat low to moderate amounts of carbohydrate foods with protein foods and vegetables/salad	High amounts of carbohydrate foods at one eating occasion

3.2.4 Recommendations

1. In general, older adults, similar to the younger adult population, require carbohydrate foods that are high in fibre and low in free sugars. Such foods include wholemeal breads, cereals, pasta and rice, as well as vegetables, salads and fruit.
2. Older adults should limit intakes of free sugars. Food sources of free sugars include confectionery, biscuits, cakes, preserves, honey and syrup.
3. Older adults with impaired blood glucose or T2D should be advised to minimise the glycaemic effect of carbohydrate foods by:
    a. Eating whole rather than mashed carbohydrate foods
    b. Avoiding overcooking carbohydrate foods
    c. Choosing meals and snacks with low to moderate amounts of carbohydrate foods mixed with protein foods, vegetables and salads, rather than choosing high amounts of carbohydrate foods only.
4. Older adults who are frail and underweight should be individually assessed (including functional resources, metabolic risk, comorbidities, the individual's perspective and priorities, and estimated effects on his or her quality of life), and foods provided should be acceptable in order to ensure that energy and protein requirements are achieved at the expense, if necessary, of achieving requirements for fibre and exceeding the limits for free sugars.

Part B. Dietary fibre

3.2.5 Key issues

1. Achieving adequate fibre intake in older adults is important for the maintenance of normal bowel function and prevention of constipation. Dietary fibre also helps protect against CVD, colorectal cancer and T2D, as well as having a role in weight maintenance.
2. Inadequate hydration, physical inactivity and use of medications that affect gut motility or hydration status can all compound the problem of constipation in this age group, particularly for those who are semi-dependent or dependent on residential care.
3. Dietary fibre intakes are dependent on total energy intakes. Older adults may have lower energy intakes due to decreased energy requirements, physical inactivity, or other factors associated with ageing, such as poor appetite or poor dentition. Therefore, it could be challenging for older adults to achieve an absolute target level of intake for dietary fibre (25 g/day), and it may be more realistic to consider goals for dietary fibre in relation to energy requirements (g/MJ/day).

3.2.6 Background

The role of fibre in health

Dietary fibre includes the edible parts of a plant that cannot be digested or absorbed in the small intestine, and instead pass into the large intestine intact. Dietary fibre plays an important role in maintaining bowel health and helps prevent constipation by increasing stool weight and decreasing gut transit time.

Constipation can be described as the passage of faeces less frequently than normal for a particular individual, or hard and dry stools accompanied by difficulty passing a bowel motion (Tvistholm *et al*., 2017). It is estimated that chronic constipation affects 30–40% of people aged over 60 years (Emmanuel *et al*., 2017), which can decrease quality of life (Tvistholm *et al*., 2017). Apart from inadequate intake of dietary fibre, insufficient hydration, reduced physical activity and reduced gut motility can all increase the risk of constipation. Furthermore, certain medications that reduce gut motility or decrease hydration status can also cause constipation. Polypharmacy (taking multiple medications) is more common in older adults than in younger adults (Maher *et al*., 2014). Prescribed medications that may cause constipation include opioid painkillers such as codeine and synthetic opioids; antacids; antispasmodics (e.g. dicyclomine); anticonvulsants (e.g. phenytoin); antipsychotics; calcium channel blockers; diuretics; and tricyclic antidepressants (Brundrett, 2014). Iron and calcium supplements may also contribute to constipation (Brundrett, 2014).

There is strong evidence that diets rich in fibre are associated with a lower incidence of coronary heart disease, T2D (Scientific Advisory Committee on Nutrition, 2015; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010b) and colorectal cancers (Scientific Advisory Committee on Nutrition, 2015), as well as improved weight maintenance (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010b). Soluble fibre, found in oats, fruit, vegetables and pulses, may slow the digestion and absorption of carbohydrates and can help people with diabetes improve control of their blood glucose levels (Leclère *et al*., 1994).

Dietary fibre positively influences the gut microbiome and produces the anti-inflammatory short-chain fatty acids acetate, butyrate and propionate (Vaughan *et al*., 2019). There is an emerging hypothesis that these anti-inflammatory effects may extend beyond the gut to include the lungs (Vaughan *et al*., 2019; Young *et al*., 2016). In line with this “gut-lung axis” hypothesis, a small number of prospective studies have found high fibre intakes to be associated with a reduced risk of chronic obstructive pulmonary disease (Szmidt *et al*., 2019; Varraso *et al*., 2010), which commonly occurs in older adults .This is an area of research that should be kept under review.

Intakes and sources of dietary fibre

The NANS (Irish Universities Nutrition Alliance, 2011) shows that 80% of those aged ≥65 years (106 men and 120 women) do not meet the EFSA recommendation of 25 g of fibre per day. For men, mean energy intakes were 8.3 MJ per day and mean fibre intakes were 19.6 g per day. This is equivalent to 2.4 g of fibre per MJ (total energy). For women, mean energy intakes were 6.5 MJ per day with a mean intake of 18.4 g of fibre per day (equivalent to 2.8 g of fibre per MJ (total energy)). The main five sources of fibre were breads (contributing 29%), vegetables (18%), fruit and fruit juices (15%), potatoes (12%) and breakfast cereals (10%). Rice, pasta and grains only contributed 2% total fibre. The ELDERMET study, comprising 208 community-dwelling elderly people (94 men and 114 women aged 64–93 years), used a different method to estimate fibre intakes[2] and found that the men achieved the equivalent intake of 25 g of fibre per day, whereas the women fell slightly short at 22.7 g of fibre per day (Power, 2013). However, the most recent and larger survey of 953 people in Ireland aged over 60 years (mean age of 75.8 years) has shown mean intakes of 7.3 MJ (1745 kcal) per day, with an average daily fibre intake of just 20 g (H McNulty, personal communication, 2020).

Irish surveys of older people also show that fruit and vegetable intakes fall short of recommendations (O'Connor *et al*., 2017; Power, 2013; Irish Universities Nutrition Alliance, 2011). The NANS found that only 15% of those aged over 65 years reached the WHO recommended target of 400 g of fruit and vegetables daily (Irish Universities Nutrition Alliance, 2011). Data from TILDA (O'Connor *et al*., 2017) compared dietary intakes in 5,279 people aged ≥54 years with the 2012 Department of Health Food Pyramid (Department of Health, 2016) and found that just 24% of older people achieved 5+ servings per day of fruit and vegetables, with those aged ≥75 years having fewer servings than those aged 54–75 years. Those with moderate to high levels of physical activity were more likely to achieve the recommended servings of fruit and vegetables compared with those who were inactive. This may have particular relevance for people aged ≥65 years who are semi-dependent or immobile.

Fibre recommendations

Recommendations for dietary fibre range from 25 g (EFSA) (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010b) to 30 g per day in the UK (Scientific Advisory Committee on Nutrition, 2015). However, a modelling exercise (Hooper *et al*., 2015) showed that consuming 30 g of fibre per day would require an increase in fibre intakes of 50% in men and 75% in women. Fibre intakes are highly dependent on an individual's total energy (kcal) intake. Ireland's FBDG (Flynn *et*

[2] Fibre intake was estimated by the Englyst method, which measures the non-starch polysaccharides fraction of fibre, i.e. the plant cell wall components, but not the lignin and resistant starches.

al., 2012) were derived by developing food patterns which were adjusted to meet target nutrient goals (25 g/day for fibre) (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010b). Due to the lower energy requirements for women aged ≥51 years of 1600 kcal per day (6.7 MJ) for sedentary individuals and 1800 kcal per day (7.5 MJ) for moderately active individuals (Institute of Medicine, 2002), the food patterns provided only 64% and 68%, respectively, of the fibre goal.

Based on this finding and the available dietary intakes of older people in Ireland, the Nordic Nutrition Recommendations of approximately 3 g of fibre per MJ (Nordic Council of Ministers, 2014b) per day would allow for variation in energy requirements. For an individual requiring 8.4 MJ per day (2000 kcal), 3 g of fibre per MJ would equate to 25 g of fibre.

Foods to be recommended

Regular meals and snacks providing a variety of fibre types are important. Consumption of wholemeal/wholegrain breads and potatoes (preferably with skin) should be encouraged. Porridge oats provide an excellent source of soluble fibre and, for those who enjoy ready-to-eat breakfast cereals, wholegrain varieties should be chosen (fortified if possible). Pulses (peas, beans and lentils) added to soups, stews or casseroles, or baked beans on wholemeal toast or a baked potato are also good choices.

Fruit and vegetable intakes are generally low among those aged 65 years and over, and so these foods need to be encouraged. Easier-to-prepare fruit such as bananas, satsumas or seedless grapes may be useful, particularly for those who are semi-dependent. A 200 mL glass of unsweetened fruit juice can also count as one serving – taken with a fortified, wholegrain ready-to-eat breakfast cereal, this will also enhance absorption of non-haem iron. Tinned fruit in its own juice as well as frozen or tinned vegetables are all practical and economical sources of fibre.

For those who have very low intakes of fibre, high-fibre foods should be added gradually, as bowel discomfort, flatulence and distension may occur if the amount of fibre eaten is increased too quickly. Ensuring adequate fluid intake is also important as fibre intakes increase. Those at risk of ‘low-intake dehydration’ should be encouraged to consume regular drinks (see Section 2.3).

Adding raw bran to foods as a method of increasing fibre intake or preventing constipation should be avoided as it reduces absorption of nutrients such as iron in the gut (Hallberg *et al*., 1987) (see Section 4.5), and may also exacerbate the risk of constipation.

Foods, both natural and fortified, and the amount of fibre provided are outlined in Table 11.

Additional factors to consider

For those who are semi-dependent or in residential care, poor hydration, physical inactivity and polypharmacy are common. Any one of these factors will compound low energy and fibre intakes and increase the risk of constipation and faecal impaction. Faecal impaction is a severe bowel condition where a hard, dry mass of stool becomes lodged in the colon or rectum and cannot be passed, and which may cause a bowel obstruction if not treated. It is particularly common in residential settings (Obokhare, 2012), but older people living at home, especially those who are semi-dependent, can also be at risk.

Among community-dwelling elderly people, there is evidence that determinants of malnutrition include having a poor appetite (strong evidence) and being edentulous (moderate evidence) (Corish and Bardon, 2019). Whether community-dwelling or in residential care, older people with a poor appetite, limited access to food, decreased ability to prepare and consume food, and poor dentition should be referred to a CORU-registered dietitian who will advise on the most appropriate foods and/or oral nutritional supplements (ONS), and level of dietary fibre intake. Those with reduced ability to swallow (dysphagia) should be referred to a CORU-registered dietitian and speech and language therapist.

3.2.7 Recommendations

1. Dietary recommendations for fibre should be related to energy requirements for those aged ≥65 years and should be set at ≥3 g of fibre per MJ per day. This should include a combination of soluble fibre (mainly vegetables, salads, fruits and some cereals, e.g. oats) and insoluble fibre (bran and outer husk of cereals, e.g. wheat bran).
2. Fibre intake should be achieved by:
    a. Encouraging consumption of foods such as wholemeal bread, potatoes with skins, wholegrain cereals, porridge oats, fruit, vegetables and pulses (peas, beans, lentils)
    b. Ensuring adequate hydration (see Section 2.3).
3. Adding bran to foods at home or in residential care settings should be avoided, as this reduces absorption of iron in the gut and can exacerbate the risk of constipation. However, this does not apply to the addition of bran during baking (e.g. bread).

Table 11 Natural and fortified foods and the amount of fibre provided

Food	Amount of fibre (g per 100 g)	Adult portion size	Amount of fibre (g per portion size)
Natural foods			
Porridge (made with low-fat milk)	7.2	30 g (1 cup)	2.2
Jacket potato	1.4	180 g (1 medium potato)	2.5
Wholemeal/wholegrain bread (pan)	5.0	60 g (2 slices)	3
Wholemeal soda bread	2.3	50 g (1 slice)	1.2
Cooked brown spaghetti/pasta	4.4	140 g (1 cup)	1.3
Cooked brown rice	0.9	146 g (1 cup)	1.3
Baked beans	3.8	146 g (¾ cup)	5.6
Nuts*	6.2	40 g (¼ cup)	2.5
Peas			
Frozen green peas	3.9	50 g (½ cup)	2
Tinned chickpeas	4.3	86 g (¾ cup)	3.7
Tinned kidney beans or other beans (e.g. broad beans)	6.7	120 g	8
Lentils			
Red split lentils	1.9	144 g (¾ cup)	2.7
Green and brown lentils	3.8	119 g (¾ cup)	4.5
Bananas	0.8	112 g (1 medium banana)	0.9
Apples (with skin)	1.3	100 g (1 medium apple)	1.3
Mandarins	1.5	120 g (2 mandarins)	1.8
Berries			
Strawberries	1	100 g (6 strawberries)	1
Blueberries	1.5	54 g (17 blueberries/½ cup)	0.8
Grapes (seedless)	0.7	64 g (10 grapes)	0.4
Broccoli	2.6	80 g (½ cup)	2.1
Carrots	2.1	80 g (½ cup)	1.7
Cabbage	2	40 g	0.8
Fortified foods**			
Two wholewheat breakfast cereal biscuits (e.g. Weetabix)	7.3	40 g (2 wheat biscuits)	2.9
Wholewheat cereal flakes (e.g. branflakes)	12.8	30 g (1 cup)	3.8

*Provided there is no poor dentition, difficulty swallowing, or choking risk
**Nutrition labelling must be checked, as the types of foods fortified and the amounts of fibre added to such foods are continually changing.

3.3 Fat

3.3.1 Key issues

1. A reduction in intake of saturated fats to ≤10% of energy intake will reduce the risk of developing CVD and other chronic inflammatory conditions associated with ageing. This is particularly important for older adults, as data from the NANS cohort suggest that people in this age group exceed the recommendations for consumption of saturated fats.
2. Saturated fatty acids (SFA) should be replaced with polyunsaturated fatty acids (PUFAs) or monounsaturated fatty acids (MUFAs).
3. Intake of 250 mg/day long-chain (LC) omega-3 (n-3) PUFAs (e.g. eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)) should be achieved for health benefits and to support the immune system.

3.3.2 Background

Fats are one of the three macronutrients in our food, a major source of dietary energy and, for most people, the largest store of energy in the body. Dietary fats, sometimes referred to as dietary lipids, have many important roles in the body, including structural roles within cell membranes, as well as being necessary for enzyme activities, immune function and in the regulation of gene expression. One gram of dietary fat has a physiological fuel value of approximately 37 kJ (9 kcal) of energy. Fats can be stored in adipose tissue in the body.

The term dietary fat is a broad umbrella term encompassing many individual fatty acids. These are typically grouped according to chemical structure and the presence or absence of double bonds.

Saturated fats have no carbon–carbon double bonds and are solid at room temperature. Saturated fats raise blood cholesterol and increase risk of heart disease (Scientific Advisory Committee on Nutrition, 2019; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Saturated fats are found in butter; hard margarine; lard; cream and cream-based sauces; fatty meat; and many processed meats, and in products cooked with butter or hard margarine, e.g. biscuits, cakes or battered foods. It is recommended that everyone needs to reduce their intake of saturated fat from food sources such as animal fats (e.g. meat fat, poultry skin, cream, butter, spreading fats, and cakes, biscuits or pastries made with such animal fats) (Food Safety Authority of Ireland, 2019; Flynn *et al.*, 2011). It is also important to remember that tropical oils such as coconut oil and palm oil contain saturated fat.

MUFAs have one carbon–carbon double bond in their chemical structure and are liquid to semi-solid at room temperature. MUFAs have a low smoke point, so they burn at lower temperatures and are best used sparingly in dressings, dips and cold dishes. MUFAs do not raise blood cholesterol (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Examples include rapeseed (canola) oil, olive oil, sesame seed oil, almond oil and peanut oil.

PUFAs contain at least two carbon–carbon double bonds in their chemical structure. PUFAs are always liquid at room temperature, and spreads made from these fats and oils are always very soft (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). A balance of the two types of PUFA – omega-6 (n-6) PUFA and n-3 PUFA – is needed for health. n-6 PUFA lowers blood cholesterol and can be used sparingly to replace saturated fats and oils to protect heart health (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). The LC n-3 PUFAs can be obtained from plant sources – for example, alpha-linolenic acid (ALA) is found in flaxseed, chia seeds, rapeseed oil and soya bean oil. Oily fish is a rich source of the LC n-3 PUFAs EPA and DHA (e.g. salmon, mackerel, herring). People in Ireland should try to include some LC n-3 PUFAs – especially EPA and DHA in the diet. These LC n-3 PUFAs are associated with lowering blood pressure as well as having roles in regulating inflammation and blood clotting (Abdulrazaq *et al*., 2017; Sanders *et al*., 2011; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010e; Kris-Etherton *et al*., 2003). Including small amounts of n-3 PUFAs in the diet will help to maintain normal heart health (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010e).

A final class of fatty acids is *trans*-fatty acids (TFAs), so called due to the positioning of hydrogen atoms around the carbon atoms at a double bond. These are hard fats which have been processed (hydrogenated) so that liquid oils become solid at room temperature. They were traditionally used in processed foods because they improved texture and increased shelf life. TFAs increase heart disease risk because they increase harmful low-density lipoprotein (LDL) cholesterol and reduce protective high-density lipoprotein (HDL) cholesterol (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Intake of TFAs should be kept as low as possible (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). The biggest food sources of TFAs are processed foods such as crackers, pies, pastries, biscuits, cakes and confectionery. Small amounts of TFAs naturally occur in meat and dairy products. It is easy to keep intake of TFAs from these sources low by simply choosing low-fat dairy products and lean cuts of meat. Many countries impose a legal limit on the amount of TFAs permitted in processed food. A 2% legal limit on TFAs in processed foods was defined by the European Union (EU) in 2019 (Commission Regulation (EU) 2019/649). In Ireland, very little TFA has been used in processed foods since the late 1990s (Food Safety Authority of Ireland, 2008a; Food Safety Authority of Ireland, 2008b).

As we age, there is an increased risk of developing conditions such as high blood pressure, heart disease, diabetes and arthritis, risk factors for which may be influenced by the amounts and types of dietary fat we consume (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Although there is some evidence that high-fat diets may have negative effects on metabolic health (e.g. insulin sensitivity) and may increase cardiovascular risk, a precise dose-response relationship has not been defined (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Hence, EFSA proposed a reference intake range for fat of 20–35% based on evidence that moderate fat intake may be compatible with good health and normal body weight depending on dietary patterns and level of physical activity (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). According to the NANS, total dietary fat contributed 35% to energy intakes in Irish adults. The key dietary sources of total fat intake in older adults were fresh meat; spreading fats and oil; biscuits, cakes and confectionery; and butter, which together contributed ~28% to total fat intakes (Li *et al*., 2016). To optimise healthy ageing and help reduce disease risk, it is important to ensure a healthy dietary pattern containing moderate dietary fat intake, inclusive of MUFAs and PUFAs, and with the aim of maintaining a healthy body weight.

3.3.3 Key issues outlined in more detail and how these can be addressed through diet

In Ireland, dietary recommendations for fat are the same for healthy older adults as for the rest of the population, and similar healthy eating guidelines apply. Nevertheless, there are a few key considerations for optimising dietary fat intake in older adults.

CVD, including coronary heart disease (CHD) and stroke, is the main cause of morbidity and mortality in older adults. The main risk factors for CVD include obesity and a high intake of saturated fat. People aged over 65 years are more likely than younger adults to suffer from CVDs, so managing intakes of saturated fat is important. For saturated fat, there is strong evidence of a dose-dependent relationship between saturated fat dietary intakes and blood LDL cholesterol. As raised LDL cholesterol is a risk factor for CVD and CHD, reducing dietary saturated fat may reduce the risk of these chronic conditions (Scientific Advisory Committee on Nutrition, 2019; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Furthermore, reducing dietary intake of saturated fat is associated with lower total LDL cholesterol, higher HDL cholesterol and improved markers of glycaemic control (Scientific Advisory Committee on Nutrition, 2019; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). As saturated fats are not essential in our diet, EFSA concludes that saturated fat intake should be as low as is possible within the context of a nutritionally adequate diet (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Analysis of the NANS identified that, on average, older Irish adults consumed 14.3% energy from saturated fat (exceeding the upper recommendation of 10%) with key dietary sources of saturated fat in older adults being meat products; confectionery; biscuits, cakes and pastries; and whole milk (Li *et al*., 2016).

Although no reference intakes for MUFAs or PUFAs have been established by EFSA (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c), the balance of intakes for older adults is important, particularly when used as dietary substitute fats for saturated fat (Scientific Advisory Committee on Nutrition, 2019; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). When consumed instead of saturated fat, MUFAs and PUFAs have been shown to improve blood lipid profiles (e.g. total and LDL cholesterol), with other possible benefits of PUFAs relating to aspects of glycaemic control (Scientific Advisory Committee on Nutrition, 2019). Data from the NANS indicate that older adults in Ireland obtained 12.2% of energy from MUFAs and 5.9% energy from PUFAs (Li *et al*., 2016).

Food sources of MUFAs include olive oil and certain nuts. Food sources of n-6 PUFAs include sunflower oil, safflower oil, sesame seed oil and almonds, and spreads made from these. There are two forms of n-3 PUFAs: plant sources found in foods such as flaxseed, chia seeds, rapeseed (canola) oil and soya bean oil, and the n-3 PUFAs (EPA and DHA) found in oily fish (e.g. salmon, mackerel, herring). The EPA and DHA content of some sources of n-3 PUFAs are listed in Table 12.

Table 12 n-3 PUFA content of natural and fortified foods

Food	n-3 PUFA content (g per 100 g food)	Adult portion size (g, unless otherwise indicated)	n-3 PUFA content (g per portion)
Natural foods			
n-3 PUFA marine sources (EPA+DHA)			
Mackerel, flesh only, grilled	3.0	150	4.5
Salmon, farmed, flesh only, baked	2.1	150	3.2
Trout, rainbow, flesh only, baked	1.3	150	2.0
Salmon, red, canned in brine, drained	1.3	150	2.0
n-3 PUFA plant sources (ALA)			
Flaxseed oil	57.0	1 tablespoon	9.0
Flaxseed	23.0	10	2.3
Chia seeds	17.8	20	3.6
Canola oil	9.3	1 tablespoon	1.3
Walnuts	2.0	28 (4–6 walnuts)	0.6
Fortified foods*			
Omega-3 eggs	1.3	100 (2 eggs)	1.3
Supplements containing LC PUFAs			
Standard supplement	3 (1 EPA plus DHA capsule/day)		
Vegetarian supplement**	4–6 (1 ALA*** capsule/day)		

*Nutrition labelling must be checked, as the types of foods fortified and the blends of fatty acids added to such foods are continually changing.

**Supplements containing 450 mg of EPA + DHA per daily adult dose will provide the same amount of EPA and DHA as eating one to two portions of fish per week (one of which should be an oily fish). Check the labels for DHA and EPA content and stick to the daily amount that would be provided by eating one to two portions of fish per week (British Dietetic Association, 2020).

***ALA has to be converted to EPA/DHA by the body. However, the amount needed has not been accurately determined.

Abbreviations – ALA: alpha-linolenic acid; DHA: docosahexaenoic acid; EPA: eicosapentaenoic acid; PUFA: polyunsaturated fatty acid.

Of particular note for older adults are the n-3 PUFAs EPA and DHA, for which guidance suggests a combined intake of approximately 0.25 g per day (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). There is strong evidence to support a beneficial role for these n-3 PUFAs for cardiac health in older adults (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c). Furthermore, there is emerging evidence relating to these n-3 PUFAs and benefits to inflammatory conditions and musculoskeletal health, in cancer prevention, and in the prevention of dementia and frailty (Gutiérrez *et al*., 2019; McGlory *et al*., 2019; Burckhardt *et al*., 2016; Calder, 2013; Orchard *et al*., 2010). Current dietary guidance for these n-3 PUFAs relates to the primary prevention of cardiac events (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2010c).

At present, the combined intake of EPA and DHA by older Irish adults is reported to be 0.43 g/day; however, these intakes were generally boosted by the contribution of supplements, which contributed up to 55% of total EPA + DHA intake (Li *et al*., 2016). While the body can synthesise some EPA and DHA from ALA, this ability is limited, and therefore it is important to include dietary sources of EPA and DHA. Oily fish and oily fish products represent key dietary sources of EPA and DHA, with supplements (e.g. fish oil supplements) providing another option for those who do not eat fish. It has been suggested that two portions of oil-rich fish per week equates to between 0.4 and 0.5 g of EPA + DHA per day (Harris *et al*., 2008). The UK SACN suggests that two 140 g portions of fish per week, including one portion of oil-rich fish, will provide approximately 0.45 g of EPA + DHA per day (Scientific Advisory Committee on Nutrition, 2004). The SACN also states that this represents a minimal and achievable average population goal, albeit this does not correspond to the level of fish consumption required for maximum nutritional benefit (Scientific Advisory Committee on Nutrition, 2004). Some benefits may occur following fish oil supplementation. For example, fish oil supplements, providing 3–4 g/day of EPA + DHA, have been associated with a reduction in symptoms of rheumatoid arthritis, having beneficial effects on swollen and tender joints, grip strength and mobility (Abdulrazaq *et al*., 2017). EFSA considers that supplemental intakes of EPA and DHA combined at doses of up to 5 g/day, and supplemental intakes of EPA alone of up to 1.8 g/day, do not raise safety concerns for the adult population. The USA Food and Drug Administration recommends that consumers should not exceed more than a total of 3 g/day of EPA + DHA, with no more than 2 g/day from a dietary supplement. Taking supplements containing n-3 PUFAs which provide an amount of EPA + DHA that would be achieved by eating one or two portions of fish per week (~0.4–0.5 g of EPA + DHA per day) is generally safe (Harris *et al*., 2008). There is no evidence to suggest that taking n-3 PUFA supplements at the recommended dose is related to increased bleeding (Carr, 2018; Jeansen *et al*., 2018; Begtrup *et al*., 2017). Nevertheless, it is important that individuals seek guidance on supplement use from a healthcare professional if they are taking anticoagulant medications such as aspirin, warfarin (Coumadin®), rivaroxaban (Xarelto®), dabigatran (Pradaxa®), apixaban (Eliquis®) and edoxaban (Lixiana®), which may interact with n-3 PUFAs (Carr, 2018; Institute for Safe Medication Practicies, 2018a; Institute of Safe Medication Practices, 2018b; British Heart Foundation, n.d.).

Examples of some food-based strategies to achieve dietary guidelines for fat are illustrated in Table 13.

Table 13 Examples of food-based strategies to achieve dietary guidelines for fat intake

Dietary guideline	Suggested strategies
Reduce intake of saturated fat	Older adults could replace sources of saturated fat – such as butter, hard margarines, and cooking fats – with soft margarines and spreading fats, liquid cooking fats and vegetable oils which are higher in MUFAs and PUFAs. Choose reduced-fat, unsaturated spreads when possible. One portion pack of reduced-fat poly- or monounsaturated spread is more than enough for one slice of bread – try to make it do for two. Choose cooking methods such as grilling or baking more often.
Increase intake of n-3 PUFAs	Include two portions of fish per week, one of which should be oily, to provide 0.25 g per day of EPA plus DHA for the primary prevention of CVD and CHD in healthy individuals. Examples of oily fish include salmon, trout, sardines, mackerel and herring.
Incorporate more ALA in your diet	Include plant sources of ALA in your diet through consuming seeds and nuts which are good sources (e.g. flaxseed, walnuts, chia and hemp) and some common vegetable oils.
Limit foods high in fat, sugar and salt	Foods which are high in fat can also be high in calories, sugar and salt, and need to be limited – you can enjoy healthy eating without them. These foods (cakes, biscuits, savoury snacks and confectionery) may contain saturated fat and possibly TFAs and should be limited to consumption occasionally, but not every day.
n-3 PUFA supplements	Adults who do not eat oil-rich fish may consider a supplement. There are many n-3 PUFA supplements on the market. These vary widely, so it is important to check product labels to determine the types and amounts of n-3 PUFAs in these products. The content of both DHA and EPA need to be added together to get the total n-3 PUFA content. Some people may need larger amounts under the supervision of a medical professional. Flaxseed supplements are available for vegetarians; such supplements supply ALA that the body can convert to EPA and DHA, albeit this process is inefficient.

Abbreviations – ALA: alpha-linolenic acid; CHD: coronary heart disease; CVD: cardiovascular disease; DHA: docosahexaenoic acid; EPA: eicosapentaenoic acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid.

3.3.4 Recommendations

1. Older adults should be advised to reduce total intake of saturated fat and substitute saturated fat with MUFAs and PUFAs, which will help reduce total cholesterol and low-density lipoprotein (LDL) cholesterol, and thereby reduce risk of CVD.

2. Older adults should be encouraged to increase their dietary intake of alpha-linolenic acid (ALA), and in particular, the LC n-3 PUFAs EPA and DHA, in order to achieve benefits to immune function and the amelioration of chronic inflammatory diseases. Eating fish (including one portion of oily fish per week) as part of a balanced diet can help protect against heart disease and other inflammatory-related conditions.

4. Micronutrients of public health concern

4.1 B vitamins

4.1.1 Key issues

1. A low status of folate and the related B vitamins (i.e. vitamin B12, vitamin B6 and riboflavin) commonly occurs in older adults and is associated with a higher risk of diseases of ageing (including CVD, cognitive dysfunction and osteoporosis). Improved B vitamin status is associated with better health outcomes in older adults.
2. Causes of B vitamin deficiency in this population are different for each vitamin, but can include inadequate intake, malabsorption, increased requirements, and/or adverse drug-nutrient interactions.
3. Low status of vitamin B12 is of particular concern in older adults as it is associated with age-related atrophic gastritis and/or use of proton pump inhibitor (PPI) drugs.
4. Vitamin B6 status is typically lower in older adults compared to younger adults and is associated with a decline in immune function with advancing age.

4.1.2 Background

Folate is essential for one-carbon metabolism, a network of biological pathways required for deoxyribonucleic acid (DNA) synthesis and repair, homocysteine metabolism, methylation reactions and the synthesis of neurotransmitters. For folate to function effectively within this network, it interacts closely with vitamin B12, vitamin B6 and riboflavin. Therefore, suboptimal status of one or more of these B vitamins or polymorphisms in folate metabolism-related genes can impair these biological processes, even if folate intakes and status are adequate. Apart from its role in folate metabolism, vitamin B6 has a number of other biological roles, including important immunomodulating effects, and in clinical and population-based studies, blood B6 concentrations are found to be inversely associated with inflammatory conditions (Ueland *et al*., 2017).

Given these key metabolic and biological roles, not surprisingly, low or deficient B vitamin status is linked with a number of adverse health outcomes in older adults, including an increased risk of CVD, cognitive dysfunction and osteoporosis. These can arise in the absence of the more classical symptoms of B vitamin deficiency and can occur within the B vitamin status biomarker range of what may be classed as normal within the clinical setting (Porter *et al*., 2016).

4.1.3 Key issues outlined in more detail and how these can be addressed through diet

Evidence is accumulating to support the beneficial roles of folate and related B vitamins in maintaining healthy ageing, with those most at risk benefitting from optimising one or more B vitamins.

The role of B vitamins in CVD has been widely investigated, with strong evidence linking poor folate status with an increased risk of stroke (McNulty *et al*., 2012). In particular, RCTs show that folic acid intervention can decrease the risk of stroke by as much as 18%, and higher (more than 25%) in those with a treatment duration of >36 months, where individuals had a poorer baseline folate status and no previous history of stroke (Lee *et al*., 2010; Wang *et al*., 2007). In support of these findings, population data from the USA and Canada show an improvement in stroke mortality corresponding to the time that mandatory folic acid food fortification was introduced in those countries; in contrast, no similar improvement was found over the same time period in England and Wales (with similar standards of healthcare) where no mandatory fortification policy exists (Yang *et al*., 2006). Thus, optimisation of folate and the related B vitamins might be beneficial for lowering CVD risk, particularly stroke, and most convincingly in primary prevention. Of note, in relation to hypertension (the leading risk factor for CVD), riboflavin, administered at the dietary level of 1.6 mg/day, was shown in three RCTs to significantly lower blood pressure – independently of antihypertensive medication concurrently being prescribed – specifically in adults with a common variant in a folate gene (affecting approximately 12% of the Irish population) leading to elevated blood pressure (McNulty *et al*., 2020).

There is a growing body of evidence to indicate that folate and related B vitamins may be important for maintaining cognitive health in ageing. As extensively reviewed elsewhere, a lower status of folate and a lower vitamin B12 and vitamin B6 status are associated with cognitive deficit in ageing (Porter *et al*., 2016). Intervention studies in older adults that include high-dose folic acid, vitamin B12 and vitamin B6 over 2 years or more have shown improved cognitive performance in this group (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2015b; de Jager *et al*., 2012) and reduced rate of brain atrophy, assessed using magnetic resonance imaging (Douaud *et al*., 2013). Again, the greatest benefits were observed in those with the poorest B vitamin status, while participants with generally high B vitamin status were less likely to benefit. A significant relationship between low folate status and risk of depression (Gilbody *et al*., 2007) has also been observed with low dietary intake, and a low vitamin B12 status is associated with an increased risk of depression (Sánchez-Villegas *et al*., 2009; Kim *et al*., 2008; Reynolds, 2006). In 2019, evidence from the TUDA cohort indicated that lower biomarker status of folate, vitamin B6 and riboflavin was associated with an increased risk of depression in Irish adults aged >60 years, while deficient vitamin B6 status was associated with increased anxiety. Of particular note, regular consumption of B vitamin-fortified foods not only increased intakes of all B vitamins and substantially improved corresponding biomarker status, but importantly was found to reduce the risk of depression (by 54%) in those who consumed fortified foods on a daily basis (Moore *et al*., 2019).

Poor bone health has been associated with suboptimal status or low dietary intakes of folate (Gjesdal *et al*., 2007; Cagnacci *et al*., 2003) and vitamin B12 (Morris *et al*., 2005; Tucker *et al*., 2005). Likewise, studies have also found an increased fracture risk in older people with suboptimal status/intake of folate (Gjesdal *et al*., 2007), vitamin B12 (Dhonukshe-Rutten *et al*., 2009), vitamin B6 (McLean *et al*., 2008) and riboflavin (Yazdanpanah *et al*., 2007). The evidence is not entirely consistent, however, as some observational studies have shown no relationships with B vitamin biomarkers and bone mineral density (Rumbak *et al*., 2012); thus, the benefit of interventions with B vitamins may be greatest in at-risk groups such as those with suboptimal status of one or more B vitamins.

These B vitamins (especially vitamin B6) also have roles in supporting the human immune system and reducing risk of infections. Plasma concentrations of pyridoxal phosphate (PLP; the active form of vitamin B6) are lower in those who have inflammatory conditions, and high proportions of older adults in population-based surveys from Europe, as in the USA, are reported to have deficient or low PLP status (Bates *et al*., 1999a). Plasma PLP predicts the risk of CVD and certain cancers, and is inversely associated with neurodegenerative diseases and depression in clinical and population-based studies (Ueland *et al*., 2017). A possible mechanism underlying these observations is the mobilisation of vitamin B6 to sites of inflammation where it may serve as a cofactor in pathways producing metabolites with immunomodulating effects.

The availability of population-based data from the NANS along with data from the TUDA cohort study of older Irish adults provides not only dietary intakes of folate and related B vitamins, but also corresponding biomarker measurements. This greatly facilitates a more thorough investigation of nutritional status of these B vitamins than is generally available in other countries worldwide. The most common cause of folate and riboflavin deficiencies in older people appears to be low dietary intake, whereas low vitamin B12 status is primarily associated with food-bound malabsorption, and suboptimal vitamin B6 status is attributed to increased requirements in ageing (Porter *et al*., 2016). Thus, improving B vitamin status through improved diet requires consideration of each B vitamin, as the food sources (apart from fortified foods; see below) differ from one nutrient to the next (Table 15).

Folate

The PRIs of folate for adults set by EFSA are 330 dietary folate equivalents (DFEs)[3] per day (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2014a). Median intakes of DFEs for Irish adults aged >65 years are reported to be 356 µg/day for men and 269 µg/day for women, with a significant contribution from folic acid-fortified foods in both men (18%) and women (17%) (Hopkins *et al*., 2015). Data from the NANS indicate that 13% of women aged >65 years have inadequate folate intakes, while folate deficiency (red blood cell folate) <340 nmol/L) is reported in 2.3% of TUDA study participants (Moore *et al*., 2019) who report intakes of 309 µg/day in males and 301 µg/day in females. TILDA found that 15% of older adults investigated had a low or deficient folate status, with the poorest status observed in adults aged >80 years. In TILDA, obesity, smoking and lower mean asset wealth were associated with significantly lower biomarker status and higher rates of deficiency (Laird *et al*., 2018b). In the most recent national survey of Irish adults, the greatest dietary contributors to total folate intake were bread (16%), milk and yogurts (11%), vegetables (11%), potatoes (9%), and breakfast cereals (9%) (Irish Universities Nutrition Alliance, 2011).

In relation to fortified food consumption, the majority of older Irish adults (81% of men and 74% of women) are consumers of fortified foods, whereas only 8% of older men and 14% of older women are reported to consume supplements on a regular basis (Hopkins *et al*., 2015). These findings are supported by a 2019 report from the TUDA study which found that 71% of the cohort consumed fortified foods, while only 10% of men and 11% of women were regular consumers of B vitamin supplements (Moore *et al*., 2019). The most commonly consumed foods fortified with folic acid (and vitamin B12) were breakfast cereals (65%), spreads (55%) and fortified drinks (20%). Moreover, folate biomarker status was shown to increase in a stepwise manner in response to low, medium and high consumption of fortified foods in TUDA study participants (see Table 16), with the highest biomarker status observed in those who reported the highest intakes of fortified foods (i.e. at least once daily) and in those taking a B vitamin supplement (Moore *et al*., 2019). On the contrary, non-consumers of fortified foods (21% of Irish adults) were found to be at higher risk of suboptimal status of folate and related B vitamins (Hopkins *et al*., 2015).

Vitamin B12

Current dietary recommendations for vitamin B12 range between 2.4 µg/day in the USA (Institute of Medicine, 1998) and 4.0 µg/day, which is the PRI set by EFSA in Europe (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2015b). However, the EFSA recommendations do not

[3] Natural food folates have a lower bioavailability than folic acid. DFEs have been introduced to account for these differences. For combined intakes of food folate and folic acid, DFEs can be computed as follows: µg DFE = µg natural food folate + (1.7 × µg folic acid from fortified food).

account for the high prevalence of food-bound malabsorption in older people, whereas people aged ≥50 years in the USA are recommended to consume most of their vitamin B12 from crystalline sources (i.e. fortified food and supplements) in order to overcome food-bound B12 malabsorption (Institute of Medicine, 1998). The synthetic form of vitamin B12, found in fortified foods and supplements, is freely available and thus has no gastric acid requirement (Hughes *et al*., 2013). Furthermore, there was a previous safety concern that high folic acid intake may potentially mask the anaemia of vitamin B12 deficiency and thus delay diagnosis, resulting in irreversible nerve damage (Porter *et al*., 2016). However, mandatory food fortification in the USA has not led to these adverse events (Qi *et al*., 2014). Therefore, from a public health perspective, there are significant challenges in relation to maintaining optimal vitamin B12 status in older people, and vitamin B12 food fortification could help address some of these challenges.

Vitamin B12 deficiency is common in older people despite the average intakes of 4.1 µg/day (men) and 4.8 µg/day (women) reported in the NANS (Hopkins *et al*., 2015) and of 5.7 µg/day (men) and 5.3 µg/day (women) reported in TUDA (Table 14). Natural food sources (including meat; chicken; fish; and eggs, milk and milk products) make the greatest contribution to total mean intake, contributing an estimated 87%, while vitamin B12 from fortified foods contributes only 8% of total intake (Hopkins *et al*., 2015). In the NANS, the three main food groups contributing to total vitamin B12 intake were fresh meat and meat dishes (22%), milk and milk-based drinks (19%), and fish, fish dishes and fish products (13%) (Irish Universities Nutrition Alliance, 2011). In TUDA, despite mean biomarker concentrations within the normal range, an 11.6% deficiency rate was reported (based on biomarker status and using a cut-off of serum total B12 <148 pmol/L), which is similar to estimates in the UK (5–20% deficient) and the USA (6% deficient, >20% marginal status) (Porter *et al*., 2016). Comparison between populations is problematic, however, due to different studies using different biomarkers and cut-off points and the lack of consensus as to the best biomarker to use (Hughes and McNulty, 2018). In TILDA, a similar 12% vitamin B12 deficiency rate was reported, which again was most pronounced in adults aged >80 years (Laird *et al*., 2018b).

Vitamin B12 deficiency causes megaloblastic anaemia and irreversible neurological disease, leading to death if untreated; early detection and treatment (with vitamin B12 injections) are therefore essential. Severe deficiency of vitamin B12 arises with pernicious anaemia, an autoimmune gastritis characterised by B12 malabsorption due to loss of intrinsic factor (Stabler, 2013). Much more commonly, however, a subtle depletion of vitamin B12 status can arise from mild atrophic gastritis, leading to reduced gastric acid production (hypochlorhydria), thereby diminishing vitamin B12 absorption from food because of the essential role of gastric acid in the release of vitamin B12 from food proteins (Hughes *et al*., 2013). Food-bound vitamin B12 malabsorption commonly occurs in older adults (it is reported to affect up to 20%) (Stabler, 2013) and leads to subclinical deficiency, with metabolic evidence of deficient status but without the classical haematological or neurological signs of deficiency (Carmel, 2011). Of note, low vitamin B12 status found in older adults is rarely attributable to dietary insufficiency and is typically the result of malabsorption related to atrophic gastritis or use of PPI drugs. These medications are commonly prescribed to older people (for conditions such as reflux and peptic ulcers), resulting in gastric acid suppression. There is evidence to suggest that these medications have been associated with up to a 4.5 times higher risk of vitamin B12 deficiency in case control studies (Masclee *et al*., 2014; Valuck and Ruscin, 2004). In 2013 in the USA, a large community survey (25,956 cases and 184,199 controls) found that the long-term use (>2 years) of H2 receptor antagonists (H2RAs) and PPIs was associated with a 25–65% greater risk of vitamin B12 deficiency (Lam *et al*., 2013). In addition, metformin usage in those with T2D can also result in vitamin B12 deficiency (Porter *et al*., 2019; Aroda *et al*., 2016). In the TUDA cohort, use of metformin was associated with a 45% increased risk of vitamin B12 deficiency, a 48% increased risk of vitamin B6 deficiency, and poorer cognitive function, using two independent measures of cognitive performance. Optimising B vitamin status may thus be beneficial for maintaining better cognitive outcomes in older people with diabetes, and particularly those on metformin treatment (Porter *et al*., 2019).

Given the significant health consequences, diagnosis and treatment of clinical vitamin B12 deficiency in older adults is essential, albeit accurate assessment of vitamin B12 status is problematic (Hughes and McNulty, 2018). From a wider public health perspective, vitamin B12 status needs to be optimised in older populations generally in order to ensure that any adverse health effects of deficient/low vitamin B12 status are prevented.

Vitamin B6 and riboflavin

There is an important metabolic interaction between vitamin B6 and riboflavin in that optimal riboflavin is required in order to generate the active form of vitamin B6 in tissues (Jungert *et al*., 2020; McNulty *et al*., 2019).

High proportions of older adults are found to have deficient or low vitamin B6 status in population-based surveys from Ireland, the UK, the USA and Europe. The EFSA PRI for vitamin B6 is 1.6 mg/day for females and 1.7 mg/day for males (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016b). A high prevalence of vitamin B6 deficiency is commonly reported in older people, as evident in large population-based surveys in Europe (23%) (Haller, 1999), the UK (11–27% among free living individuals, 30–65% among institutionalised individuals) (Bates *et al*., 1999b) and the USA (15–23% of males, 14–49% of females) (Morris *et al*., 2008). This deficiency in older age has been primarily attributed to increased requirements as a result of reduced absorption, as opposed to inadequate dietary intake (van den Berg, 1999; Ribaya-Mercado *et al*., 1991). In Ireland, intakes are estimated from the NANS to be 3.1 mg/day and 5.4 mg/day in males and females, respectively, with fresh meat and meat dishes (16%) and potato and potato products (15%) found to be the two main contributors to total vitamin B6 intakes. Estimated intakes in the TUDA cohort are 2.1 mg/day (males) and 1.8 mg/day (females) (Table 14). A deficiency rate of 12.2% in older Irish adults was reported in a 2015 TUDA study based on the vitamin B6 biomarker cut-off of <30.0 nmol PLP. In this cohort, the consumption of fortified foods significantly improved biomarker status (Hopkins *et al*., 2015).

The PRI for riboflavin set by EFSA is 1.6 mg/day (EFSA Panel on Dietetic Products, Nutrition and Allergies *et al.*, 2017). The NANS reported mean riboflavin intakes to be 2.0 mg/day in men and 3.7 mg/day in women aged >65 years, while 25.1% of men and 19.4% of women were reported to have intakes below the EAR of 1.3 mg/day. In TUDA, estimated intakes are 1.9 mg/day (males) and 1.8 mg/day (females) (Table 14). The main dietary contributors to riboflavin intake in older Irish adults are milks (22%), meat and meat products (16%), and fortified breakfast cereals (8%) (Kehoe *et al*., 2018), with supplements estimated to contribute only 8% of total riboflavin intake. Riboflavin deficiency is thought to arise mainly from inadequate dietary intake, particularly in those who do not consume dairy products or fortified foods (Troesch *et al*., 2012), and in a recent systematic review in community-dwelling older adults in developed Western countries, riboflavin was identified among six nutrients of potential public health concern (ter Borg *et al*., 2015). To date, most population-based surveys only report dietary intake data, and relatively few include biomarker data. Despite mean dietary intakes being reported to be sufficient in the NANS, more than 50% of older adults (aged >65 years) were reported to have suboptimal riboflavin status using the riboflavin biomarker cut-off of erythrocyte glutathione reductase activation coefficient (EGRac) 1.3. A similar level of deficiency was reported in TUDA, where 48.6% of the cohort were found to have low riboflavin biomarker status. Regular consumption of fortified foods (>5 times/week) and supplement use was shown to improve riboflavin biomarker status in this cohort (Moore *et al*., 2019).

Table 14 B vitamin intake* in older adults in Ireland

	NANS (>65 years)		TUDA 5+ (>60 years)**	
	Men (n=106)	Women (n=120)	Men (n=287)	Women (n=565)
Folate (DFE)†	430	363	309	301
Vitamin B12 (µg)	5.6	4.4	5.7	5.3
Vitamin B6 (mg)	2.8	2.3	2.1	1.8
Riboflavin (mg)	1.8	1.7	1.9	1.8

*Mean daily intake. Data presented relate to dietary intake from food sources only (nutrient intakes from supplements not included).

**TUDA 5+: The Trinity-Ulster and Department of Agriculture (TUDA) Study – 5-year follow-up of a subset of original TUDA study participants.

†DFE, dietary folate equivalents. Natural food folates have a lower bioavailability than folic acid. DFEs have been introduced to account for these differences. For combined intakes of food folate and folic acid, DFEs can be computed as follows: µg DFE = µg natural food folate + (1.7 × µg folic acid from fortified food).

Fortified foods as a source of folate and related B vitamins

Folic acid refers to the synthetic form of the B vitamin known as folate, while the natural folate forms are found in plant, animal and human tissues. Food folates occur naturally in the richest supplies in green leafy vegetables, asparagus, beans, legumes, liver and yeast, whereas folic acid is found in the human diet only in fortified foods and supplements but is readily converted to the natural cofactor forms of folate after its ingestion. Because of their chemical structure, natural food folates are inherently unstable outside living cells and tend to have poor bioavailability (McNulty *et al*., 2019). In addition to their limited bioavailability, food folates (particularly green vegetables) can be unstable during cooking, and this will substantially reduce the folate content of the food before it is even ingested. As a result of the poor stability and limited bioavailability of folate from natural food sources, achieving optimal folate status can be challenging in practice (McNulty *et al*., 2019). Folic acid is, however, much more stable and more bioavailable compared to an equivalent amount of the vitamin eaten as naturally occurring food folates. Thus, consumers of fortified foods (providing the vitamin in the folic acid form) are typically found to have much better folate status at all stages of the life cycle, including in older age (Moore *et al*., 2019; Porter *et al*., 2019).

Fortified foods are known to improve dietary and biomarker status of folate (and the related B vitamins) (Moore *et al*., 2019; Hoey *et al*., 2007), with potential benefits particularly for mental health in older Irish adults (Moore *et al*., 2019), and should be promoted. A mandatory food fortification programme with folic acid (considered to reduce the prevalence of neural tube defects) may also have additional benefits for the ageing population. As a result of mandatory fortification with folic acid, currently introduced in more than 80 countries worldwide (but not yet in Ireland or other European countries), folate deficiency in the USA and Canada is practically non-existent

(Bailey *et al*., 2015) and there appear to be significant benefits arising from this public health measure with respect to reducing mortality from stroke (Yang *et al*., 2006).

4.1.3 Recommendations

1. Rigorous assessment of folate and vitamin B12 status in older adults, through blood sampling by general practitioners (GPs) or hospital doctors, is essential and should be based on measurement of reliable biomarkers (serum or red blood cell folate; serum B12), rather than relying on dietary data alone. Assessment of folate status should be carried out if dietary inadequacy is suspected. For vitamin B12, annual monitoring of serum concentrations will identify those with deficiency and enable intervention to correct status.
2. B group vitamin status should be optimised in older populations in order to ensure that any adverse health consequences of deficient or low status are prevented.
3. Fortified foods provide a good and particularly bioavailable source of folate and related B vitamins (B12, B6 and riboflavin). Fortified breakfast cereals offer a practical and highly effective means of improving B vitamin status in older adults and can potentially lead to better health outcomes in older people. In the case of vitamin B12, however, consideration should be given to increasing current levels of fortification in order to optimise status.
4. Apart from fortified foods, vitamin B12 needs are best met through meat intake, whereas riboflavin intakes are best provided by milk and dairy foods. Good sources of folate in the diet are limited to green leafy vegetables, legumes and liver. However, all natural folate sources are poorly bioavailable compared with folic acid (as found in fortified foods and supplements), which is readily converted to natural folates after its ingestion. Vitamin B6 is ubiquitous in foods, although protein foods (e.g. meat, milk) provide particularly good sources.

Table 15 Main contributors to B vitamin intakes in older Irish adults

B vitamins	Food group	Contribution to intakes of the listed nutrient (%)
Folate	Bread and rolls[a]	14
	Fortified breakfast cereals	12
	Milk and dairy products[b]	10
	Potatoes and potato products	10
	Vegetables and vegetable dishes	10
	Meat and meat products	7
	Vitamin supplement	7
	Other	30
Vitamin B12	Meat and meat products	31
	Milk and dairy products[b]	25
	Fish, fish dishes and fish products	13
	Fortified breakfast cereals	6
	Eggs and egg dishes	6
	Vitamin supplement	6
	Other	13
Vitamin B6	Meat and meat products	23
	Potatoes and potato products	15
	Fortified breakfast cereals	10
	Vitamin supplement	8
	Milk and dairy products[b]	7
	Vegetables and vegetable dishes	5
	Other	32
Riboflavin	Milk and dairy products[b]	28
	Meat and meat products	16
	Fortified breakfast cereals	14
	Vitamin supplement	8
	Other	34

[a]Includes brown and white breads, brown and white rolls, and fortified products.
[b]Includes cheese and yogurt.

Table 16 B vitamin intakes from fortified foods and corresponding biomarker status among older Irish adults[1]

		Fortified food consumer[2]		
	Non-consumer	**Low consumer**	**Medium consumer**	**High consumer**
Servings of fortified food/week	0	1–4	5–7	7+
TUDA 5+ total **n** (%)	214 (30)	166 (23)	168 (23)	175 (24)
B vitamins				
Folate (DFEs, µg/day)	**212 (66)**	**246 (69)**	**292 (66)**	**471 (157)**
RBC folate (nmol/L)	*907 (368)*	*940 (440)*	*1009 (458)*	*1168 (452)*
Vitamin B12 (µg/day)	**4.8 (2.0)**	**4.9 (1.6)**	**5.3 (1.9)**	**5.4 (1.7)**
Serum total vitamin B12 (pmol/L)	*268 (109)*	*270 (108)*	*286 (115)*	*305 (129)*
Vitamin B6 (mg/day)	**1.7 (0.6)**	**1.7 (0.6)**	**1.9 (0.6)**	**2.2 (0.7)**
Plasma vitamin B6, PLP (nmol/L)	*65.6 (29.6)*	*67.4 (26.7)*	*73.4 (37.7)*	*83.7 (42.9)*
Riboflavin (mg/day)	**1.5 (0.7)**	**1.6 (0.4)**	**1.8 (0.5)**	**2.2 (0.7)**
EGRac[3] (ratio)	*1.36 (0.19)*	*1.31 (0.15)*	*1.32 (0.20)*	*1.28 (0.13)*

Data presented as mean (SD)
[1]TUDA study participants, non-supplement users. A small number of participants (n=87) were missing dietary data and therefore excluded.
[2]The main contributor to fortified food intake is fortified breakfast cereals (63%).
[3]Biomarker status of riboflavin is determined by the functional assay EGRac ; higher EGRac values indicate lower riboflavin status.

Table 17 B vitamin supplement advice for older adult population subgroups

Older adult subgroup	**Supplement advice**
Healthy older persons; older persons with compromised mobility and/or with comorbidities and living independently; semi-independent older persons; older persons dependent on residential care.	Supplemental levels of B vitamins (folic acid, vitamin B12, vitamin B6 and riboflavin) are recommended as part of a multivitamin supplement (typically providing 100% of the RDA). For older adults taking PPIs or metformin, supplementation with vitamin B12 is particularly recommended at a level of between 2 and 10 mg/day. If clinical deficiency of folate or vitamin B12 has been diagnosed, however, then supplementation will be at the prescribed dose (in the case of vitamin B12, this will be administered by injection).

4.2 Vitamin C

4.2.1 Key issues

1. Vitamin C (ascorbic acid) is a key antioxidant and reducing agent in the aqueous media of the body and is required for correct immune function.
2. It is likely that significant numbers of older adults, particularly those from lower socioeconomic status groups, consume insufficient dietary vitamin C and/or have a higher requirement due to lifestyle or ill health.
3. While there is some limited evidence that vitamin C ameliorates the symptoms of viral infections such as the common cold and influenza, and is being administered to patients with COVID-19, there is as yet little published clinical data as to its effectiveness.

4.2.2 Background

The NANS (Irish Universities Nutrition Alliance, 2011) reported average intakes of vitamin C in males and females aged 65 years or older to be 102 mg/day (SD: 146) and 132 mg/day (SD: 333), respectively. The 5% of individuals with the lowest intakes consumed only 14 mg/day (males) and 23 mg/day (females) from both food sources and all other sources. Thus, although average dietary intakes for older adults are above the EFSA recommended average requirement (AR) of 90 mg/day for males and 80 mg/day for females, the very high SDs show that there is a very wide range of intakes, therefore indicating that some in this group have low intakes; the NANS notes that 17% of males in this age group had inadequate intakes while 1% of older adults had intakes less than the UK lower reference nutrient intake of 10 mg/day (Panel on Dietary Reference Values of the Committee on Medical Aspects of Food Policy, 1991).

The primary sources of vitamin C reported in the NANS were fruit and fruit juices, vegetables, and potatoes, followed by supplements, milk and yogurts, and meat. Vitamin C is present in all fresh food, with the richest sources being blackcurrants and citrus fruits. Significant losses occur due to oxidation and leaching during storage and cooking. Because vitamin C is not stored in the body as such, it should be consumed every day. As a water-soluble vitamin, it is not toxic in excess, although doses over 1000 mg/day can cause gastrointestinal upset, i.e. stomach pain, diarrhoea or flatulence.

Older adults, particularly those from lower socioeconomic status groups and those who are dependent on residential care, are at risk of low vitamin C status. This is caused by low dietary intake due to low intakes of fresh food, especially fruit and vegetables, and hence low body stores, coupled with increased needs caused by smoking, infections, and diseases with oxidative and inflammatory components such as T2D (Carr and Maggini, 2017).

Vitamin C has important antioxidant functions throughout the aqueous media in the body. In the gut, it reduces the iron from plant sources (non-haem iron) from the ferric ion (Fe^{3+}) to the more soluble ferrous ion (Fe^{2+}), which is better absorbed. This could be crucial for those with marginally iron sufficient or vegetarian diets. Vitamin C is required as a reducing agent for some important hydroxylation reactions, including in the cross-linking of collagen in connective tissue, and in the formation of catecholamines (e.g. epinephrine) and the immune protein complement C1q.

The immune system, particularly immune cell function, requires vitamin C (Carr and Maggini, 2017). Thus, it has been suggested that it could be effective against diseases such as cancer and CVD; however, intervention studies have generally not supported this theory.

Megadosing (i.e. ≥1 g/day) with vitamin C has long been used to attempt to reduce the incidence and/or duration of the common cold and influenza. However, studies have not supported a role for vitamin C in reduced incidence of colds, although slight reductions in duration have been reported (Hemilä and Chalker, 2013). While experimental models (*Gulo(–/–)* knockout mice) demonstrate a beneficial effect of vitamin C in influenza infections, there is limited clinical evidence that it is effective in patients (Colunga Biancatelli *et al.*, 2020). Nevertheless, this has inevitably led to the suggestion that vitamin C might be effective against COVID-19, and clinical trials are investigating this (Peng, 2020). Older adults are particularly vulnerable to infections due to their reduced immune function, so viral infections are more likely to lead to complications such as pneumonia; thus, low vitamin C status in this group could be a potentially correctable contributing factor to morbidity and mortality (Carr and Maggini, 2017).

4.2.3 Recommendations

1. To provide sufficient dietary vitamin C, at least five portions of vegetables, salads and fruit are needed each day. Fresh potatoes will also contribute vitamin C to the diet. One 150 mL portion of orange juice per day would contribute significantly to vitamin C intakes; this is particularly important for frail older adults and those who are dependent on residential care, who could be offered this at every meal.
2. Foods containing vitamin C are best consumed in the same meal as foods containing iron from plant sources in order to improve the absorption of iron in the gut.
3. In older adults likely to have low vitamin C status due to poor diet or increased need due to ill health, a supplement providing the EFSA population reference intake (PRI) of 95 mg/day for women and 110 mg/day for men could be advised by a GP; however, supplements should provide less than the IOM/FSAI tolerable upper intake level (UL) of 2000 mg/day in order to avoid causing gastrointestinal upset.

4. Well-designed clinical trials are required in order to study the use of vitamin C as an adjunctive therapy in serious infections due to influenza and other common viral illnesses, including establishing the effective dose.

Table 18 Food-based dietary guidelines for older adults on how to meet vitamin C requirements

A Natural and fortified foods and the amount of vitamin C provided

Food[a]	Amount of vitamin C[b] (mg per 100 g)	Adult portion size (household measure)	Amount of vitamin C (mg per portion)
Natural foods			
Fruit juice (orange/apple)	31/26	150 mL (¾ cup)	47/39
Citrus fruit, easy-peeler/oranges	42/52	120 g (2 mandarins)	50/62
Kiwi fruit	71	60 g (2 kiwis)	43
Strawberries	57	100 g (6 strawberries)	57
Green, red, yellow peppers	120/126/121	50 g (1 cup)	60/63/61
Broccoli (steamed)	60	80 g (½ cup)	48
Cabbage/cauliflower (boiled)	45/30	74/86 g	33/26
Potatoes, new with skin/old (boiled)	7/9	180 g (1 medium potato)	13/16
Green salad	35	40 g (1 cup)	14
Tomatoes (raw)	22	67 g (1 tomato)	15
Apples/pears	6/3	100/150 g (1 medium apple/pear)	6/5
Bananas	9	112 g (1 medium banana)	10
Fortified foods[c]			
Ready-to-eat breakfast cereals	67–134	30 g (1 cup)	20–40
Fortified skim milk[d]	12	200 mL (1 cup)	24
Fortified mixed fruit and vegetable juice	6	150 mL (¾ cup)	9

[a]Foods contributing vitamin C to the diet identified by Irish Universities Nutrition Alliance (2011)

[b]McCance and Widdowson's The Composition of Foods Integrated Dataset 2019, available at https://www.gov.uk/government/publications/composition-of-foods-integrated-dataset-cofid

[c] Nutrition labelling must be checked, as the types of foods fortified and the amounts of vitamin C added to such foods are continually changing.

[d]https://www.avonmore.ie/products/slimline-milk

B Vitamin C supplement advice for older adult population subgroups

Older adult subgroup	Supplement advice
Healthy older persons; older persons with compromised mobility and/or with comorbidities and living independently; semi-independent older persons; older persons dependent on residential care	A vitamin C supplement providing the EFSA PRI of 95 mg/day for women and 110 mg/day for men may be needed by those with low vitamin C status due to a poor diet, or increased need due to illness. The supplement dose should not exceed 2000 mg/day in order to avoid gastrointestinal upset (Health Service Executive n.d.).

4.3 Vitamin D

Note: The Department of Health requested that the vitamin D section of this report be fast-tracked, and this section has also been published as a separate report (Food Safety Authority of Ireland, 2020).

4.3.1 Key issues

1. Vitamin D is essential in older adults for bone health, and its deficiency increases the risk of fractures.
2. There is a putative link between vitamin D deficiency and non-skeletal health, such as CVDs; diabetes; inflammatory, infectious and immune disorders (including COVID-19); certain cancers; and a higher mortality, but causal evidence is lacking.
3. Vitamin D deficiency is common in older adults, particularly nursing home residents.
4. Vitamin D is obtained from the diet (natural foods, fortified foods, and supplements) and skin exposure to extended summer sunlight (during the months April through October).
5. While natural food 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.
6. High-dose vitamin D supplements on the market should be avoided so that the UL of 100 µg is not exceeded.

4.3.2 Background and scope

Adequate vitamin D intake is essential in older adults for bone health (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016a; Scientific Advisory Committee on Nutrition, 2016; Nordic Council of Ministers, 2014a; 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 CVDs; 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 older adults, while the supply of vitamin D from sunlight exposure may be greatly reduced, adequate vitamin D intake may be ensured through augmented oral intake.

4.3.2 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 NANS, the TUDA Cohort Study, and TILDA. They all showed a high frequency of vitamin D deficiency in older adults, which was defined using the USA IOM threshold of serum 25-hydroxyvitamin D (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 19) (Laird *et al*., 2018a; 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*., 2018a). 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*., 2018a; 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 people in more disadvantaged 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 the NANS and TILDA, respectively, had serum 25(OH)D <30 nmol/L during the summer months (Table 19). The participants in the two studies were free-living individuals. Vitamin D deficiency is common in nursing home residents in the Galway region based on laboratory samples collected from 2011 to 2015 (n=273) 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 (with 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 19 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 ± SD.

Abbreviations – NANS: National Adult Nutrition Survey (≥65 years cohort); TUDA: 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 2). 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). In 2019, an 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).

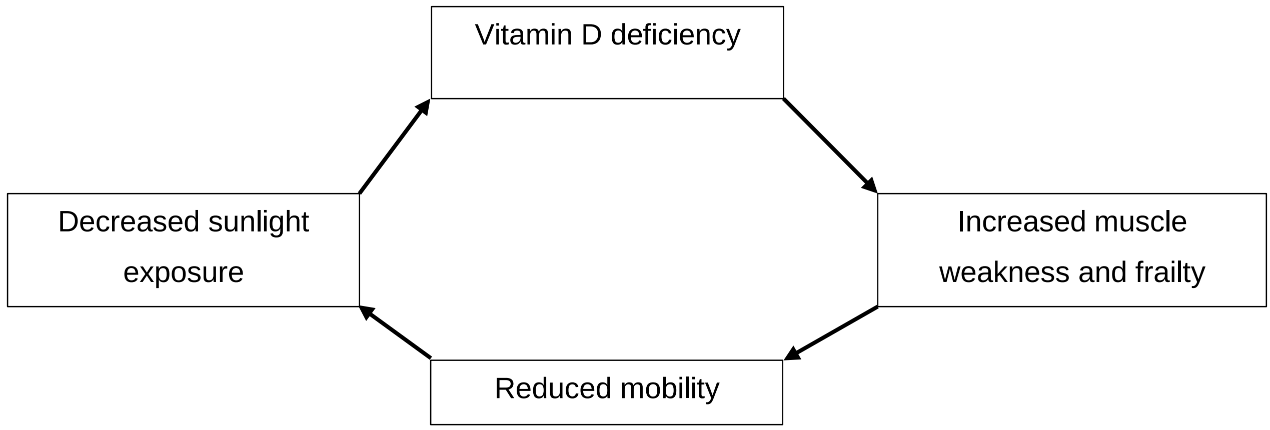

Figure 2 Self-perpetuating cycle of vitamin D deficiency in frail older adults

Source: 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, 2020a; Rhodes *et al*., 2020; Scientific Advisory Committee on Nutrition, 2020a). 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 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 (published in June 2020) summarised the best available scientific evidence on vitamin D and risk of COVID-19 (NICE, 2020a) and acute respiratory tract infections (Scientific Advisory Committee on Nutrition, 2020a). 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 SACN concluded that the evidence on vitamin D supplementation and acute respiratory tract infection (ARTI) risk was inconsistent and generally did not show a beneficial effect of vitamin D supplementation on infectious disease risk. Two updates on these rapid reviews, which considered any further evidence since June, were issued in December 2020. NICE's conclusion in relation to vitamin D and COVID-19 was unchanged (NICE, 2020b). The SACN concluded that there may be some benefit from daily, low-dose vitamin D supplementation in reducing the risk of ARTI, although the size of any potential benefit may be small (Scientific Advisory Committee on Nutrition, 2020b). The SACN recommended that a vitamin D intake of 10 µg/day, as it currently recommends on the basis of protection of musculoskeletal health, may provide some additional benefit in reducing the risk of ARTI (Scientific Advisory Committee on Nutrition, 2020b). 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).

4.3.3 Vitamin D dietary requirements for older adults in Ireland

Health authorities in the EU through EFSA (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016a), 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, 2014a), and in North America through the IOM (Institute of Medicine Committee to Review Dietary Reference Intakes for Vitamin D Calcium, 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 20. 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 and 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, 2014a).

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 is 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 the 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, 2016a; 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 (Section 4.4). It should be noted that vitamin D supplements usually contain calcium, and vice versa.

Table 20 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, 2016b (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2016a)	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 international units (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 level of 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 requirements 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 will also allow a majority to attain serum 25(OH)D concentrations linked with adequacy.

4.3.4 Current dietary vitamin D intakes in older adults in Ireland

The 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 EAR is taken as an estimate of the percentage of the population with probable inadequate intakes (EFSA Panel on Dietetic Products, Nutrition, and Allergies, 2010a). Using 10 µg per day, set by the IOM as the EAR 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.

4.3.5 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 21); however, foods fortified with vitamin D can significantly increase vitamin D intakes and improve vitamin D status. In the 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, since the mid-2000s, the emergence of a few vitamin D-fortified breads and processed cheeses (Table 21) – can contribute towards meeting the intake requirement of 15 µg vitamin D daily. However, data from the 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 that this 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 in the USA (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 with 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 this population.

Table 21 Natural and vitamin D-fortified foods and the amount provided per serving

Food	Typical serving size (household measure)	Amount of vitamin D (µg)
Natural foods		
Salmon	150 g	4.4–27.8*
Trout	150 g	15
Mackerel	150 g	12.9
Tuna	150 g	4.5
Sardines	85 g (3 sardines)	4.3
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/100 g) is higher than that of farmed salmon (2.9–9.5 µg/100 g) (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, are continually changing.

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 (aged >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 (aged >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 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 20 and discussed above.

4.3.6 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 22), 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 22 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.

4.3.7 Safety of vitamin D supplement use

The 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, 2016a; EFSA Panel on Dietetic Products, Nutrition and Allergies, 2012b; Institute of Medicine, 2011; Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment, 2014). Both the UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment and 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, 2012b). The EFSA (2012b) 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 hypercalcaemia, 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 of vitamin D per day (Smith *et al*., 2017) and lower bone mineral density in those consuming 100 µg or 250 µg of 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, 2020a). 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).

4.3.8 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 or 15 µg may be considered safe for older adults in Ireland.

4.4 Calcium

4.4.1 Key issues

1. The principal source of calcium intake in older adults is dairy products.
2. Intake of dairy products in older adults is lower than in younger adults; most older adults do not achieve the recommended intake of three portions daily.
3. There is no biomarker available to assess calcium status.

4.4.2 Background

An adequate intake of calcium is needed for optimal bone health in older adults. There is a strong nutrient–nutrient interdependence between calcium intake and vitamin D intake, such that a higher intake of calcium is better at compensating for low vitamin D intake than the converse (Institute of Medicine, 2011). Unlike vitamin D, there is no simple measure of adequacy of calcium intake, but the body can manage across a range of calcium intakes (Institute of Medicine, 2011). There is agreement on the optimal calcium intake for younger adults according to different authorities, but there are differences in recommendations for older adults (Table 23) (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2015a; Nordic Council of Ministers, 2014a; Institute of Medicine, 2011). Higher intakes are recommended for older adults in North America compared with in Europe (Institute of Medicine, 2011). EFSA does not recommend higher calcium intake for older adults, because its modelling analysis excluded an effect of age or gender on calcium intake requirements (Table 23).

Table 23 Recommendations on calcium intake requirements for older adults

Report	Country/region	Calcium intake daily requirement (mg)		
		Lower limit	**AR**	**PRI**
IOM 2011 (Institute of Medicine, 2011)	USA and Canada	600	1000	1200
NNR 2012 (Nordic Council of Ministers, 2014a)	Nordic countries	400	500	800
EFSA 2016 (EFSA Panel on Dietetic Products, Nutrition and Allergies 2015a)	EU	Not stated	750	950

EFSA: European Food Safety Authority; IOM: Institute of Medicine; NNR: Nordic Nutritional Recommendations

The predominant source of dietary calcium is dairy products (Table 24), but it is also available from fish and plant sources such as wholegrain cereals, pulses, nuts, seeds and dark-green leaves. Calcium from plant sources is generally less bioavailable than that from animal sources. It is estimated that the average intake in those who avoid dairy products is about 250 mg daily (Cosman *et al*., 2014).

Table 24 Natural and fortified foods and the amount of calcium provided

Food	Amount of calcium (mg per 100 g)	Adult portion size (household measurement)	Amount of calcium (mg per portion size)
Natural foods			
Low-fat milk	120	200 mL (1 cup)	240
Full-fat milk	130	200 mL (1 cup)	260
Skimmed milk	120	200 mL (1 cup)	240
Flavoured milk	120	200 mL (1 cup)	240
Natural or fruit yogurt	160	150 g (¾ cup)	240
Natural yogurt drink	120	200 mL (1 cup)	240
Fruit yogurt drink	120	200 mL (1 cup)	240
Flavoured yogurt drink	120	200 mL (1 cup)	240
Natural pouring yogurt	133	150 g (¾ cup)	200
Flavoured pouring yogurt	133	150 g (¾ cup)	200
Diet yogurt	140	150 g (¾ cup)	210
Cottage cheese	120	200 mL (1 cup)	240
Hard cheese	334–800	30 g (width and depth of 2 thumbs)	100–240 (depending on thumb size)
Soft cheese	267–734	30 g (width and depth of 2 thumbs)	80–220 (depending on thumb size)
Fortified foods*			
Low-fat fortified milk	160	200 mL (1 cup)	320
Fortified soya drink**	120	200 mL (1 cup)	240
Fortified almond drink**	120	200 mL (1 cup)	240
Fortified oat drink**	120	200 mL (1 cup)	240

Dietary guidelines recommend consuming three portions of these dairy foods per day.
*Nutrition labelling must be checked, as the types of foods fortified and the amounts of nutrients added to such foods are continually changing.
**https://www.alpro.com/uk/products/drinks/

4.4.3 Key issues outlined in more detail and how these can be addressed through diet

Comparing adults worldwide, Ireland ranks among the highest calcium intakes in the world due to individuals' higher intake of dairy products (Balk *et al*., 2017). The NANS recorded an average calcium intake of 1080 mg daily (Feeney *et al*., 2016). The NANS estimated that milk and cheese accounted for 48% of calcium intake (Feeney *et al*., 2016). In those aged over 65 years (n=226), the NANS reported a mean daily calcium intake of 908 mg daily for men and 985 mg daily for women, including supplemental intake (Irish Universities Nutrition Alliance, 2011). The percent contributions of various types of foods to calcium intake was as follows: milk/yogurt: 30%; bread:

22%; cheese: 7%; and supplemental intake: 7% (Table 25) (Irish Universities Nutrition Alliance, 2011). A subsequent survey (the ELDERMET study) of community-dwelling older adults in Cork, ranging in age from 64 to 93 years (n=208), recorded higher calcium intake because 32% of women and 13% of men took mineral supplements (Table 25) (Power *et al*., 2014).

While older adults may disclose eating dairy, few consume sufficient portions (Table 25). The recommended daily intake of dairy is three portions. The NANS reported an intake of 1.98 portions per day, while other surveys have shown an even lower intake. Evidence from TUDA shows that around 96% of older adults do not get three portions of dairy per day; the average intake was around 1.16 portions (Laird *et al*., 2017). Women also ate a lot more dairy than men. In TILDA, 70% of all older Irish adults did not consume three portions of dairy foods per day (O'Connor *et al*., 2017).

Table 25 Studies of calcium intake in Irish older adult cohorts

Study	Sample size	Age (years)	Average calcium intake (mg/day)		Average daily dairy portions	% consuming <3 dairy portions daily
			Women	Men		
NANS	226	>65	985	908	1.98	-
ELDERMET	208	>64	1272	1056	1.4	-
TUDA	4444	>60	-	-	1.16	96
TILDA	5356	≥50	-	-	2.10	70

Abbreviations – ELDERMET: Enhancing gut health in the Irish elderly through an improved understanding of intestinal bacteria; NANS: National Adult Nutrition Survey; TUDA: The Trinity-Ulster and Department of Agriculture study; TILDA: The Irish Longitudinal Study on Ageing.

4.4.4 Recommendations

1. As a food-based dietary guideline, daily consumption of three portions of calcium-rich foods (such as milk, yogurt and cheese) is recommended in order to meet the requirement for older adults. In addition to providing calcium, these foods are rich in other valuable nutrients for older adults, such as protein, and are easy for frail older adults to consume (e.g. nursing home residents).
2. In those older adults who consume less than one portion of dairy products daily, a daily 500 mg calcium supplement is recommended. It should be noted that supplemental calcium products usually contain vitamin D (see Section 4.3).

4.5 Iron

4.5.1 Key issues

1. The prevalence of iron deficiency increases with age, particularly among older adults who are dependent on residential care and those aged over 80 years. Even mild deficiency causes increased ill health and mortality.
2. In older adults, iron deficiency is caused by blood loss, chronic medical conditions, poor diet and malabsorption.
3. Iron status is readily assessed by measuring serum iron, iron-binding capacity and ferritin. The best measure is ferritin, but it may be spuriously elevated as a result of many illnesses.

4.5.2 Background

The NANS (Irish Universities Nutrition Alliance, 2011) shows that average iron intakes in the ≥65 year age group are 15.8 mg/day (while the 5% of people with the lowest intakes consumed 5.3 mg/day) from all sources, and 10.8 mg/day from food (intakes of the lowest 5% of consumers were 4.3 mg/day). Thus, most older adults have dietary intakes above the EFSA recommended AR of 6 mg/day for men and postmenopausal women. The principal dietary sources of iron were breads, meats and breakfast cereals. However, the absorption of iron from plant sources (termed 'non-haem' iron) is reduced by dietary phytate (the fibre in wholegrain cereals and legumes), polyphenols (the naturally occurring coloured compounds in tea, coffee, red wine and some vegetables) and foods high in calcium (Scientific Advisory Committee on Nutrition, 2010). It would be very difficult to develop iron deficiency due to food interference, but this may contribute to iron deficiency if an individual experiences blood loss. The absorption of iron from plant sources in the gut is enhanced by consuming vitamin C (ascorbic acid) and meat in the same meal. Iron supplements greater than 25 mg per day have been shown to decrease zinc absorption from supplements (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2015c).

The prevalence of iron deficiency anaemia increases with age, particularly among older adults who are dependent on residential care (up to 50%), and is generally caused by several factors (Bach *et al*., 2014). These causative factors include occult blood loss, poor diet, renal insufficiency, and malabsorption of iron in the gut due to common conditions in older adults, such as atrophic gastritis*, H. pylori* infection and coeliac disease (Bach *et al*., 2014).

Iron deficiency is characterised by reduced iron stores. Iron status is readily and easily tested by automated measurement of serum iron, iron-binding capacity and ferritin. Ferritin, a storage protein, is the best single measure of iron status; ferritin <30 ng/mL is diagnostic of iron deficiency. Ferritin is also an acute phase reactant that may be increased in disease states which are common in older adults, such as inflammation, infections, liver disease, renal insufficiency, heart failure, and malignancy (Namaste *et al*., 2020). In those circumstances, the combination of serum iron and iron-binding capacity have diagnostic value. Thus, poor iron status in older frail adults must be identified in order to prevent ill health and higher mortality (Girelli *et al*., 2018; Fairweather-Tait *et al*., 2014; Scientific Advisory Committee on Nutrition, 2010).

Iron-deficiency anaemia can be treated by supplementation; 15 mg/day elemental iron has been shown to increase haemoglobin and iron stores in anaemic adults aged >65 years, with minimal adverse effects (while having no effect on iron status in those with adequate iron stores), whereas high-dose supplements (>45 mg/day) may not be tolerated due to side-effects including abdominal discomfort, nausea and constipation (Rimon *et al*., 2005). Furthermore, the prevalence of elevated iron stores may be relatively high among free-living older adults consuming a Western diet; therefore, high-dose supplements would be both unnecessary and potentially toxic in this population (Fleming *et al*., 2001). This is a particular problem in those with haemochromatosis (affecting approximately 1 in 83 people in Ireland (Health Service Executive, 2011)). Intravenous iron delivered directly into the bloodstream can also be prescribed, with the dose being based on the patient’s iron deficit (Auerbach and Deloughery, 2016).

4.5.3 Recommendations

1. Older adults should be advised to consume food providing iron (meat, poultry, fish, eggs and beans) and vitamin C (potatoes, vegetables, salads and fruit) in the same meal as far as possible. This is important for enhancing iron absorption from plant sources in particular.
2. Iron status in all older adults should be monitored. Iron stores are readily measured by automated laboratory tests (serum iron, iron-binding capacity and ferritin). This is particularly important:
    a. For older adults who are dependent on residential care and for people aged >80 years, in order to identify those with poor iron status and hence avoid its consequent adverse effects on health
    b. To identify and exclude from supplementation those with haemochromatosis.
3. If iron supplements are necessary, these should provide at least the EFSA PRI of 11 mg/day elemental iron; 15 mg/day is recommended as an effective dose. However, supplements should not exceed the IOM/FSAI UL of 45 mg/day in order to avoid unpleasant gastrointestinal side-effects and to prevent interference with the absorption of other essential minerals such as zinc in the gut.
4. Research is needed into the effects of ageing on iron absorption in the gut since poor absorption in the gut may be a more important factor affecting iron status than the amount of iron in the diet.

Table 26 Food-based dietary guidelines for older adults on how to meet iron requirements

A Natural and fortified foods and the amount of iron[a] provided

Food[b]	Amount of iron[c] (mg per 100 g)	Adult portion size (household measure)	Amount of iron (mg per portion size)
Natural foods			
Liver (fried, calf/lamb)[d]	12.2/7.7	30 g	3.7/2.3
Beef (roast/minced stewed)[d]	2.0/2.7	100 g (1 palm of hand size)	2.0/2.7
Black (blood) sausage	12.3	55 g	6.8
Eggs[d]	2.0	100 g (2 eggs)	2.0
Baked beans[d]	1.4	146 g (¾ cup)	2.0
Wholemeal bread	2.4	60 g (2 slices)	1.4
Nuts (roasted peanuts)[d]	2.1	40 g (¼ cup)	0.8
Dried fruit (apricots/raisins and sultanas)	4.1/2.2	30 g (½ cup)	1.2/0.7
Fortified foods[e]			
Ready-to-eat breakfast cereals	8–13.5	30 g (1 cup)	2.4–4.1
Fortified skim milk[f]	2.1	200 mL (1 cup)	4.2

[a]Iron from plant-based sources is less bioavailable than iron from animal-derived sources. Vitamin C consumed in the same meal will enhance absorption in the gut of iron from plant-based sources.

[b]Foods contributing iron to the diet were identified by Irish Universities Nutrition Alliance (2011)

[c]McCance and Widdowson's The Composition of Foods Integrated Dataset 2019, available at https://www.gov.uk/government/publications/composition-of-foods-integrated-dataset-cofid

[d]Also a good source of zinc.

[e]Nutrition labelling must be checked, as the types of foods fortified and the amounts of iron added to such foods are continually changing.

[f]https://www.avonmore.ie/products/slimline-milk

B Iron supplement advice for older adult population subgroups

Older adult subgroup	Supplement advice
Healthy older persons; older persons with compromised mobility and/or with comorbidities and living independently; semi-independent older persons; older persons dependent on residential care.	Depending on consumption of the iron-rich foods listed above and/or iron status as clinically tested, an iron supplement providing 15 mg/day elemental iron can be recommended. A higher dose may be advised by a GP, but should not exceed 45 mg/day in order to avoid toxic effects (Health Service Executive n.d.).

4.6 Zinc

4.6.1 Key issues

1. Zinc deficiency is likely to be common in older adults, particularly older adults who are dependent on residential care.
2. The best dietary sources of zinc are high-protein foods such as dark meats. Due to the cost, these high-protein foods are relatively less accessible to many older adults than refined foods, which are low in zinc.
3. Zinc deficiency is associated with low socioeconomic status, problems with chewing food and poor absorption in the gut. Even marginal zinc status causes impaired biochemical and immune function.
4. Zinc is required for immune function.

4.6.2 Background

The NANS (Irish Universities Nutrition Alliance, 2011) shows that average zinc intakes in the ≥65 age group are 10.4 mg/day from all sources (the 5% of people with the lowest intakes consumed 4.7 mg/day), and 8.7 mg/day from food sources (the 5% of people with the lowest intakes consumed 4.5 mg/day). The EFSA ARs (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2014b) take into account the inhibitory effects of a range of intakes of dietary phytate (from dietary fibre) on zinc absorption; these ARs for zinc range from 6.2 to 10.2 mg/day for women with a reference weight of 58.5 kg, and from 7.5 to 12.7 mg/day for men with a reference weight of 68.1 kg. Based on this, EFSA set the PRI of elemental zinc at 12.7 mg/day for women and 16.3 mg/day for men.

The best dietary sources of zinc are dark-coloured meats – including tuna, red meat and dark poultry meat (e.g. leg meat as distinct from breast meat) – and some shellfish and crustaceans. Wholegrain products and other meats are also good sources, whereas refined cereals are not; however, the bioavailability of zinc from plant-based diets can be low due to phytate (present in wholegrain cereals and legumes) (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2014b). Iron supplements greater than 25 mg per day elemental iron may decrease zinc absorption from supplements (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2015c). Chronic high zinc intakes can interfere with the absorption of essential dietary copper, causing copper deficiency and consequent anaemia (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2014b).

Zinc deficiency is a problem among older adults, particularly older adults dependent on residential care (Barnett *et al*., 2016). Low socioeconomic status and hence a poor diet; inadequate chewing of food; and impaired absorption in the gut will lead to lowered zinc status, and even marginal zinc status adversely affects biochemical and immunological function (which normally declines with age) because zinc is required for many diverse functions in the body (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2014b). Furthermore, a few studies have shown that supplementation with zinc improves immune function, reducing the incidence and severity of infections, including viral infections (Cabrera, 2015; Prasad *et al*., 2007), whereas excess zinc impairs immune function (Haase and Rink, 2009) and can also interfere with the action of medications such as some antibiotics (Health Service Executive, 2018). Supplements of 15 mg/day elemental zinc have been shown to maintain immune function in older adults with adequate or marginal zinc status while avoiding the negative side-effects (including nausea and vomiting) of higher-dose supplements (30 mg/day), which can elevate intakes above the UL (Hodkinson *et al*., 2007). For those with low zinc status, a supplement of 45 mg/day is likely to restore immune function that has been impaired by zinc deficiency (Prasad *et al*., 2007); however, this should only be taken if recommended by a clinician, and recipients should be monitored in order to prevent adverse effects.

4.6.3 Recommendations

1. Older adults require high-protein foods providing zinc: dark meat, which includes tuna, red meat and dark poultry meat (e.g. leg meat as distinct from breast meat); cheese; eggs; and nuts. Ensuring sufficient dietary intakes of high-protein foods is important in order to ensure sufficient dietary zinc.
2. If the diet is low in high-protein foods, as may be the case in frail older adults and those dependent on residential care, a zinc supplement may be required. This should provide the EFSA PRI of 12.7 mg/day elemental zinc for women and 16.3 mg/day for men; a dose of 15 mg/day would be suitable for both men and women. The total dietary intake should not exceed the EFSA/FSAI UL of 25 mg/day in order to avoid interference with the absorption of other essential minerals such as copper in the gut, leading to anaemia.
3. Research is needed into the incidence and effects of zinc deficiency in older adults since little is known about these, and they will be important in a population known to be at greater risk of adverse outcomes from viral infections.
4. The most effective means and potential benefits of supplementation should also be investigated; the most effective supplements need to be identified in order to improve zinc status in this population, with potential benefits for the immune response to infection and disease, and consequent improvement of the overall health of this group.

Table 27 Food-based dietary guidelines for older adults on how to meet zinc requirements

A Natural and fortified foods and the amount of zinc[a] provided

Food[b]	Amount of zinc[c] (mg per 100 g)	Adult portion size (household measure)	Amount of zinc (mg per portion size)
Natural foods			
Liver (fried, calf/lamb)[d]	15.9/5.9	30 g	4.8/1.8
Beef (roast/minced stewed)[d]	5.7/5.6	100 g (1 palm of hand size)	5.7/5.6
Lamb (roast)	5.2	100 g (1 palm of hand size)	5.2
Pork (roast)	2.8	100 g (1 palm of hand size)	2.8
Chicken (dark/light meat, roasted)	2.2/0.8	100 g (1 palm of hand size)	2.2/0.8
Crab (cooked)	6.6	30 g	2.0
Cheese (cheddar)	4.1	30 g (2 thumbs width and depth)	1.2
Eggs[d]	1.3	100 g (2 eggs)	1.3
Wholemeal bread	1.6	60 g (2 slices)	1.0
Nuts (roasted peanuts)	3.3	40 g (¼ cup)	1.3
Baked beans[d]	0.6	146 g (¾ cup)	0.9
Fortified foods[e]			
Ready-to-eat breakfast cereals	1.8–8.4	30 g (1 cup)	0.5–2.5

[a]Zinc absorption in the gut is inhibited by the presence of phytate (from wholegrain cereals and legumes) in the same meal.

[b]Foods contributing zinc to the diet were identified by Irish Universities Nutrition Alliance (2011)

[c]McCance and Widdowson's The Composition of Foods Integrated Dataset 2019, available at https://www.gov.uk/government/publications/composition-of-foods-integrated-dataset-cofid

[d]Also a good source of iron.

[e]Nutrition labelling must be checked, as the types of foods fortified and the amounts of nutrients added to such foods are continually changing.

B Zinc supplement advice for older adult population subgroups

Older adult subgroup	Supplement advice
Healthy older persons; older persons with compromised mobility and/or with comorbidities and living independently; semi-independent older persons; older persons dependent on residential care.	When the diet is low in protein, a supplement (12.7 mg/day elemental zinc for women and 16.3 mg/day for men, or 15 mg/day for both men and women) may be advised by a GP but should not exceed 25 mg/day in order not to compromise copper absorption in the gut, which can lead to anaemia.

5. COVID-19 pandemic and older adults living in Ireland

5.1 Key issues

1. Older adults are the most at-risk population group from the COVID-19 pandemic.
2. Frailty, malnutrition/undernutrition and sarcopenia are associated with higher risk of infection and poorer outcomes from COVID-19.
3. While many nutrients play a beneficial role in immune function, as yet there is not enough scientific evidence to establish a link with COVID-19 outcomes.

5.2 Background

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the virus responsible for coronavirus disease 2019 (COVID-19). The first cases of COVID-19 were identified in Wuhan, China in December 2019, reaching Ireland in February 2020. The spread of COVID-19 was recognised as a pandemic by the WHO on 11 March 2020 (World Health Organization, 2020).

Older adults – particularly those who are frail, sarcopenic and/or undernourished – and people living with obesity are at higher risk of severe illness, poorer outcomes and higher mortality rates from COVID-19. Ageing is associated with a loss of immune competence and increased concentrations of blood inflammatory mediators (Calder, 2020; Calder *et al*., 2017; Ventura *et al*., 2017; Pera *et al*., 2015). This increase in inflammatory mediators may, in part, explain the increased vulnerability of older adults to COVID-19 (Calder, 2020; Calder *et al*., 2020). Older adults are also more at risk due to having a higher prevalence of comorbidities and age-associated changes in body composition. As outlined in Table 1, 61–78% of older adults in Ireland are affected by overweight or obesity. Older adults who are obese and have chronic diseases are at risk of reduced skeletal muscle mass and function. COVID-19 patients with obesity are more likely to be hospitalised and require treatment in an intensive care unit (ICU). Malnutrition/undernutrition is known to occur in individuals in an ICU, with older age, diabetes and CVD also associated with increased risk of malnutrition/undernutrition. Therefore, ESPEN has recommended that "prevention, diagnosis and treatment of mal/undernutrition should be considered in the management of COVID-19 patients to improve both short- and long-term prognosis" (Barazzoni *et al*., 2020).

Some specific nutrients, such as vitamin D, have been suggested as being potentially protective against inflammatory, infectious and immune disorders, and may therefore be pertinent during the COVID-19 pandemic, but causal evidence is lacking. Vitamin D is an unusual nutrient in that status can be affected not only through diet but also through sunlight exposure. There is a seasonal aspect to this crucial source of vitamin D because sunlight in Ireland from October to March is insufficient to stimulate skin synthesis of vitamin D, and therefore vitamin D status is solely dependent on dietary sources during these months. For these reasons, the vitamin D section of this report, including recommendations, was provided to the Department of Health in advance of the rest of the report in order to enable any policy actions to be implemented without delay before winter 2020.

5.3 Key issues outlined in more detail and how these can be addressed through diet

ESPEN has recently produced expert statements and practical guidance for nutritional management of individuals with SARS-CoV-2 infection (Barazzoni *et al*., 2020). Five of these expert statements are relevant to older adults living in Ireland, and are outlined below.

Statement 1

All adults should be screened on admission to hospital with a validated malnutrition screening tool (Department of Health, 2020). The Malnutrition Screening Tool or the Malnutrition Universal Screening Tool are the two malnutrition screening tools recommended for use in Ireland (Department of Health, 2020). Patients at risk of malnutrition/undernutrition should be treated without delay and referred to a dietitian for nutritional assessment (Department of Health, 2020). Particular attention should be paid to those at risk of severe COVID-19 (i.e. older adults and individuals with comorbidities such as obesity, diabetes and CVD). Maintaining good nutritional status and preventing or treating malnutrition/undernutrition can potentially reduce complications and adverse outcomes associated with COVID-19.

Statement 2

Registered dietitians should use diet counselling and a food-first approach to optimise the nutritional status of individuals with malnutrition/undernutrition. Any restrictions or limitations in terms of dietary intakes should be avoided.

Statement 3

Sufficient supplementation with vitamins and minerals of individuals with malnutrition/undernutrition should be ensured. The general nutrition approach for viral infection prevention is supplementation and/or adequate provision of vitamins to potentially reduce the disease's negative impact.

Vitamin D and C were referred to by ESPEN as specific examples of relevant nutrients with respect to reducing the impact of COVID-19. Deficiency of both of these nutrients, particularly vitamin D, is not uncommon among older adults in Ireland, as outlined in Section 4.2 and Section 4.3. Recommendations to address these nutritional inadequacies are included in this report. Well-designed trials are needed in order to establish the effectiveness of vitamin C supplementation as an adjunctive therapy in viral illnesses such as COVID-19.

Statement 4

For those who are cocooning, regular physical activity should continue. Cocooning can lead to increased sedentary behaviours, thus leading to an increased risk for, and potential worsening of, chronic health conditions, weight gain, sarcopenia and a loss of immune competence. While capacity for physical activity varies greatly among older adults living in Ireland, daily programmes including aerobic, dynamic and flexible exercise to whatever capacity possible greatly enhance the impact of nutrition on body composition and CVD risk factors.

Statement 5

Oral nutritional supplements (ONS) providing at least 400 kcal/day, including 30 g or more of protein/day, should be used for 1 month when diet counselling and food fortification are not sufficient to increase dietary intake or meet nutritional goals (Health Service Executive, 2020). Follow-up is essential and the use and efficacy of the ONS should be assessed after 1 month. In the community setting, the Prescribing Pathway for the Initiation and Renewal of Standard Oral Nutritional Supplements (ONS) for Adults Living in the Community should be used (Health Service Executive, 2019b).

Other nutrients and their implications in COVID-19

Many other nutrients play a beneficial role in immune function. However, due to COVID-19 being a very recent disease, there is not enough scientific evidence to implicate these nutrients in COVID-19 outcomes.

Protein, as well as fats such as DHA and EPA, play a role in maintaining immune function.

There is emerging evidence to support an important role for vitamin B6 in maintaining a healthier immune function. On this basis, correcting low vitamin B6 status (which commonly occurs in older adults) may contribute to maintaining immune function.

Zinc is required for immune function and research is needed into the incidence and effects of zinc deficiency in older adults.

In summary, while these macro- and micronutrients are important for immune function, there is no scientific evidence to support a specific protective role for them in relation to COVID-19.

5.4 Recommendations

1. Older adults should be screened (using a validated malnutrition screening tool) to identify those at risk of malnutrition/undernutrition, and a full nutritional assessment undertaken for

all those identified as being at risk. Nutritional issues identified should be specifically addressed by dietary counselling from a registered dietitian using an individualised, comprehensive food-first approach in combination with oral nutritional supplements and/or vitamin and mineral supplementation as necessary.

2. For older adults who are cocooning, regular physical activity in the form of daily aerobic, dynamic and flexible exercise to whatever capacity possible will greatly enhance the impact of nutrition on immune competence.

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Appendix 1 Request for Advice from the Scientific Committee

Topic title: Scientific recommendations for healthy eating guidelines for older adults
Date requested: 9 April 2019
Date accepted: 26 September 2019
Target deadline for advice: September 2020
Form of advice required: Report with recommendations

Background/Context

The nutritional requirements of individuals change over time, with the needs of older adults (i.e. those aged over 65 years) being particularly varied as a result of health, physiological function and susceptibility to disease. Older adults are a diverse group. Some older adults are healthy and fit, with a good capacity for activity and good dentition. While dietary requirements for these older adults may be similar to those of the younger adult population, the ageing process has to be taken into account, e.g. vitamin D, where ageing reduces the capacity to synthesise vitamin D through the skin. Other older adults may have poor detention or may suffer from chronic conditions and diseases which may compromise activity levels and mobility. All of these factors impact on nutritional requirements and the type of diet that best meets their needs.

The population group of older adults may be described in terms of the following 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.

In 2000, the Food Safety Authority of Ireland (FSAI) published the report *Recommendations for a national food and nutrition policy for older people.* Since then, there have been considerable advances in scientific knowledge on optimal nutritional intakes to enhance the well-being of older adults. As older adults constitute a significant and growing proportion of the Irish population, there is a need for updated optimal food-based dietary guidelines for this population subgroup.

The National Adult Nutrition Survey (2008–2010) investigated the macronutrient and micronutrient intakes of adults in Ireland, including those aged over 65 years. This survey found that:

- Fat provided 37% of food energy, with 63% of the population exceeding the recommended upper limit for total fat of 35%.
- Carbohydrate provided 45% of food energy.

- Mean daily intakes of salt were 6.3 g (men: 7.3 g; women: 5.4 g), which exceeded the FSAI target of 6 g/day.
- Average daily intakes of dietary fibre were 18.9 g, with 80% of this age group not meeting the European Food Safety Authority (EFSA) recommendation of 25 g/day.
- More than one-half of those aged over 65 years (men: 59%; women: 58%) had mean daily vitamin D intakes of less than 5 µg, with 87% of men and 77% of women having daily intakes of less than 10 µg.
- Forty-nine per cent of women and 59% of men were overweight.
- Twenty-four per cent of women and 25% of men were obese.

In light of the new Department of Health's *Food Pyramid* published in 2016, healthy eating guidelines for older adults need to be developed. These should take into account more recent scientific research and literature, such as that outlined above from the National Adult Nutrition Survey.

Questions to be addressed by the Scientific Committee

The Scientific Committee is requested to:

Develop scientific recommendations for food-based dietary guidelines for older adults, particularly where they differ from current national dietary guidelines for the younger adult population.

This report will:

1. Identify factors impacting on dietary intakes of older adults in Ireland (e.g. socioeconomic, family, etc.)
2. Identify which macronutrients and micronutrients need to be considered for developing food-based dietary guidelines
3. Examine, using survey data, where intakes are in relation to these goals and then develop the scientific recommendations for food-based dietary guidelines that enable this age group to meet these goals.

This report will not consider the specialised dietary needs of older adults under clinical care for specific conditions.

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Appendix 2 Frailty, sarcopenia and undernutrition definitions

Table 29 Definitions of frailty, malnutrition/undernutrition and sarcopenia

Syndrome	Definition
Frailty*	A medical syndrome with multiple causes and contributors that is characterised by diminished strength and endurance, as well as reduced physiological function that increases an individual's vulnerability for developing increased dependency and/or death.
Malnutrition/undernutrition	A state resulting from lack of uptake or intake of nutrition, leading to altered body composition (decreased fat-free mass) and body cell mass, thus leading to diminished physical and mental function and impaired clinical outcomes from disease.
Sarcopenia	A muscle disease characterised by declines in muscle mass and strength that accumulate across a lifetime. Sarcopenia is common among adults of older age but can also occur earlier in life.

*Both malnutrition/undernutrition and sarcopenia can contribute to the development of frailty.

Table 30 Characteristics of sarcopenia, frailty and undernutrition

Summary	Sarcopenia = Low muscle strength + low muscle quantity (Cruz-Jentoft *et al*., 2019)	Frailty = ≥3 of 5 criteria (Fried *et al*., 2001)	Undernutrition = risk (using validated screening tool) + (≥1 phenotypic + 1 aetiologic criterion) (Cederholm *et al*., 2019)
			Phenotypic criteria
Weight loss	–	≥4.5 kg unintentional in previous year	≥5% over 6 months >10% over indefinite period
BMI (kg/m^2)	–	–	<20 if <70 years <22 if ≥70 years
ALM (kg)	–	–	<21.4 (M) <14.1 (F)
FFMI (kg/m^2)	–	–	<17 (M) <15 (F)
Low muscle strength: **Handgrip strength (kg)** **Chair stand**	<27 (M) <16 (F) >15 s for 5 rises (M)	≤29–32 (M) ≤17–21 (F)	–
Low muscle quantity: **ASM (kg)** **ASM/height^2 (kg/m^2)**	<20 (M) <15 (F) <7.0 (M) <5.5 (F)	–	–
Low performance: **Usual gait speed (m/s)** **SPPB (point score)** **TUG(s)** **400 m walk test (min)**	In severe sarcopenia: <0.8 ≤8 ≥20 Non-completion/ ≥6 min	<0.65 or <0.76	–
Fatigue/exhaustion	–	Self-reported exhaustion	–
Physical activity (kcal/week)	–	<383 (M) <270 (F)	–
			Aetiologic criteria
Inflammation	–	–	From acute disease/injury/chronic disease
Reduced food intake/absorption	–	–	<50% ER >1 w Reduced intake >2 w Any chronic gastrointestinal condition impacting on absorption

Abbreviations – BMI: body mass index; ALM: appendicular lean mass; FFMI: fat-free mass index; ASM: appendicular skeletal muscle mass; SPPB: short physical performance battery; TUG(s): timed up and go test(s); ER: energy requirements

Appendix 3 Drug-nutrient interactions

Table 31 Commonly used medications and how they interact with various nutrients

Medication	Nutrient(s) affected	Effect(s) of interaction
Opioid painkillers, codeine, calcium channel blockers, cyclic antidepressants, MAOIs, NSAIDs, diuretics	Fibre	Constipation
Aspirin	Iron	Causes gastric bleeding, hence loss of iron from the body and iron deficiency
Proton pump inhibitors (PPIs), H2-receptor antagonists (H2RAs)	Vitamin B12 Iron	Gastric acid suppression, leading to food-bound vitamin B12 malabsorption and iron malabsorption Vitamin B12 deficiency, iron deficiency
Metformin	Vitamin B12 Vitamin B6	Vitamin B12 deficiency Vitamin B6 deficiency
Anti-convulsant and sulfasalazine	Folate Vitamin B12 Vitamin B6	Negative impact on nutrient status

Abbreviations – MAOIs: monoamine oxidase inhibitors; NSAIDs: non-steroidal anti-inflammatory drugs

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