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Scientific Recommendations for Food-Based Dietary Guidelines for 1 to 5 Year-Olds in Ireland

SCIENTIFIC RECOMMENDATIONS FOR FOOD-BASED DIETARY GUIDELINES FOR 1 TO 5 YEAR-OLDS IN IRELAND

Scientific Committee of the Food Safety Authority of Ireland, 2020

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ABBREVIATIONS

µg	microgram
AI	adequate intake
ALA	alpha-linoleic acid
AMDR	acceptable macronutrient distribution range
AR	average requirement
ASD	autism spectrum disorder
BMI	body mass index
CP	cerebral palsy
DHA	docosahexaenoic acid
DRV	dietary reference value
DS	Down syndrome
EAR	estimated average requirement
EFSA	European Food Safety Authority
EPA	eicosapentaenoic acid
ESPGHAN	European society for paediatric, gastroenterology, hepatology and nutrition
FSAI	Food Safety Authority of Ireland
g	gram
HDL	high-density lipoprotein
ID	intellectual disability
IDD	iodine deficiency disorder
IgE	immunoglobulin E
IOM	Institute of Medicine
IU	international units
kg	kilogram
L	litre
LDL	low-density lipoprotein
LRNI	lower reference nutrient intake
mg	milligram
mL	millilitre
nm	nanometer

nmol	nanomole
NPNS	National Pre-School Nutrition Survey
PAL	physical activity level
PRI	population reference intake
RDA	recommended dietary allowance
RE	retinol equivalent
RI	reference intake
RNI	recommended nutrient intake
SACN	Scientific Advisory Committee on Nutrition
SD	standard deviation
SPF	sun protection factor
UIC	urinary iodine concentration
UK	United Kingdom
UL	Tolerable Upper Intake Level
USA	United States of America
UVB	ultraviolet B
WHO	World Health Organization

FOREWORD

In early childhood, food provides nutrients, promotes growth and development, fosters nurturing and caring, demonstrates love, and affirms parental ability. The period from 1 to 5 years of age is an exciting and challenging time of transition from a predominantly milk-based diet at the end of infancy, to a fully mixed diet by the time of starting school. Development of physical skills and increasing autonomy are intrinsically linked with food intake. An innovative approach was adopted in the development of these recommendations due to the dearth of information on healthy eating for this age group.

Young children have significantly higher nutritional requirements relative to their size, necessitating a focus on quality over quantity. As children come in different sizes, with the needs of the smallest differing from the needs of those growing along the higher percentiles, these food-based dietary guidelines were devised using a modelling approach that accounted for such differences. International micronutrient intake recommendations cover the needs of young children according to age range, which does not consider the challenge smaller children face in meeting such requirements due to their low food intake. The report aims to address such anomalies and uses a 'food-first' approach.

Children with special needs comprise an important proportion of the population, and the guidelines apply equally to them, sometimes with minor adjustments which are included in this report.

Early childhood is a well-recognised critical period, impacting lifelong health. Dietary habits formed in the early years persist into later life, and scientific research increasingly demonstrates how early feeding practices are linked with many non-communicable diseases in adulthood, including obesity, type 2 diabetes, hypertension, and other cardiovascular conditions. The early establishment and fostering of good nutritional habits in a nurturing, caring society, together with play-based physical activity, will provide an excellent foundation for the future health of our nation's children.

This report completes the suite of dietary guidelines for all ages from pregnancy and infancy to older adulthood.

Ita Saul
Chair, Public Health Nutrition Subcommittee

June 2020

EXECUTIVE SUMMARY

Background

Globally, food-based dietary guidance for children under the age of 5 years is poorly developed. Where such guidance is available, only children aged 2 years and older are considered. In these cases, 2–5 year-olds are grouped with significantly older children, which prevents targeted dietary guidance. In Ireland, guidelines are available on infant feeding (covering birth to 12 months) and healthy eating for all ages over 5 years. There are no Irish guidelines available for children aged 1–5 years. This period involves the transition from a predominantly milk-based diet to one which includes foods from all five food groups in order to ensure optimal nutrition and acceptance of foods required for lifelong health.

Objective

The purpose of the current report is to develop scientific, food-based dietary guideline recommendations for children aged 1–5 years in Ireland.

Methods

Individual foods consumed by ≥10% of children aged 1–5 years were identified by secondary analysis of the Irish National Pre-School Nutrition Survey (NPNS). This analysis also identified typical meal patterns. Data from a questionnaire and from a focused discussion involving paediatric and community dietitians working specifically with this age group provided additional information, such as common adjustments advised for improving the dietary intakes of this age group (e.g. reducing processed meat, using wholemeal instead of white bread, etc.).

Dietary intake targets were identified for energy, macronutrients (protein, carbohydrate, sugar, dietary fibre, fat, saturated fat, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA)) and six key micronutrients (vitamin A, vitamin D, calcium, iron, iodine and zinc).

Dietary modelling, informed by healthy eating principles, was conducted on boys (*n*30) and girls (*n*30) at five percentiles based on World Health Organization (WHO) growth charts (0.4th, 25th, 50th, 75th and 99.6th) for six age groups (1 year, 1.5 years, 2 years, 3 years, 4 years and 5 years).

Food intake patterns were iteratively changed in order to meet the energy requirements as precisely as possible, as this is the critical determinant of total food intake. Further iterations were made in order to address the inadequacies in iron and vitamin D intakes identified in the dietary modelling.

Each daily food intake pattern included an intake of 550 mL of milk, some of which was provided as yogurt or cheese. Different types of milk (*n*7) were modelled in order to ensure that the wide range of different milk feeding for this age group in Ireland was represented.

Based on scientific evidence for best practice in the Irish context, members of Healthy Eating Guidelines for Toddlers and Pre-schoolers Working Group with expertise in physical development and activity, behavioural and cognitive development, diet and dental health, and clinical dietetics developed additional relevant recommendations.

Results

A total of 640 4-day food intake patterns, representing 2,560 days, were developed and analysed in order to establish the food-based dietary guidelines for 1–5 year-olds in Ireland.

The food intake patterns developed provided an adequate intake of most nutrients, except for DHA, EPA, iron and vitamin D.

All children aged 1–3 were found to be at risk of inadequate iron intakes. A combination of red meat approximately 3 days a week and an iron-fortified breakfast cereal 5 days a week addressed this issue, except for children aged 1–3 years growing at ≤25th percentile level on the WHO growth charts. For these children, a daily additional 4 mg of iron was required. Dietary modelling demonstrated that this can be provided as a low-dose iron supplement (providing the Recommended Dietary Allowance (RDA) of 7 mg of iron) given 4 days a week, or, alternatively, through the use of an iron-fortified milk (≥1 mg of iron/100 mL).

Most 1–5 year-olds were found to have inadequate vitamin D intakes in relation to the dietary goal, which assumes no vitamin D synthesis from sunlight. Consideration of evidence from studies that have examined vitamin D status (blood levels) in this age group in Ireland has shown that the prevalence of vitamin D deficiency and inadequacy varies seasonally. The evidence indicates that, during the summer, most young children in Ireland get enough vitamin D through diet and through the effect of sunlight on the skin. However, during the winter, dietary sources are inadequate to maintain blood levels of 25-hydroxyvitamin D (25(OH)D, the biomarker of vitamin D status) above 50 nmol/L (the level needed in order to ensure adequate vitamin D for good bone health) in a considerable proportion of young children (between 40% and 45%). This evidence was considered with the results of the dietary modelling when developing recommendations for vitamin D.

Recommendations

The recommendations outlined below should be considered in their totality, i.e. the recommendations are not independent from each other.

i. Food-based dietary recommendations

- A **wide variety of foods** should be included in order to increase acceptability of, and familiarisation with, foods that are part of a lifelong healthy diet.
- **Milk** is a key food in the diets of 1–5 year-old children. Milk is an important source of a range of nutrients, including protein, and is a critical source of calcium.
  1. A daily intake of 550 mL of milk, or equivalent amounts of yogurt or cheese, should be provided (where 200 mL of milk is equivalent to 150 mL of yogurt or 30 g of cheese).
  2. Low-fat (1% to 2%) cow's milk can be used from the age of 2 years where there is no concern about the adequacy of calorie intake.
  3. Plant-based milk replacement beverages (e.g. soya 'milk') can be used to replace cow's milk, provided they are fortified with the same level of nutrients, particularly calcium. Use of plant-based milk replacement beverages such as almond 'milk', coconut 'milk' and rice 'milk', is not recommended, as they are nutritionally inadequate.
  4. While not necessary for this age group, fortified full-fat milk, follow-up formula and young child formula will contribute to the intake of three key nutrients (iron, vitamin D and n-3 polyunsaturated fatty acids) in 1–3 year-olds (see additional comments under the Supplements recommendation).
  5. It is important that children aged 1–5 years are not given more than the recommended amount of milk as a drink, as this reduces intake of solid food

and of some nutrients, such as fibre, and may result in iron deficiency anaemia.

6. It is important that very young children are not given milks in an infant feeding bottle with a teat, as this will delay the development of the child's oral motor and fine motor skills.

- **Breads, cereals, potatoes, pastas and rice** are an important source of calories and fibre.
  1. A combination of both white and wholemeal breads, cereals, potatoes, pastas and rice will provide adequate fibre. For children prone to constipation, an increased proportion of these foods can be given as wholemeal varieties.
  2. Breakfast cereals fortified with iron (containing ≥12 mg of iron/100 g) and vitamin D help to ensure adequate intake of these nutrients. Vitamin C-containing fruit or vegetables, or a small amount of very well-diluted fruit juice, should also be consumed along with the iron-fortified cereal in order to increase iron absorption.
- **Meat, poultry, fish, eggs, beans, lentils and smooth nut butters** are important sources of protein, iron, DHA and EPA.
  1. Red meat is a rich bioavailable source of iron in the diet of 1–5 year-olds. Including 30 g of red meat approximately three times a week helps ensure adequate iron intake. However, smaller children (i.e. 1–3 year-olds growing at ≤25th percentile level) will require an additional 4 mg of iron/day.
  2. Unprocessed meats (e.g. lean red meat, chicken, fish, etc.) are preferable to processed meats (e.g. ham, sausages, deli meat, etc.), which have high salt and fat content.
  3. Fish should be included at least once a week in the diet of 1–5 year-olds. As important sources of DHA, EPA and vitamin D, oily fish can be included up to once a week, or white fish can be eaten twice a week.
  4. Eggs, beans and lentils are important sources of non-haem iron and, in the case of beans and lentils, provide soluble fibre. These foods may be used as alternatives to meat, fish and poultry. It is important to include these foods during these early years in order to increase acceptability and

familiarisation. Vitamin C-containing fruit or vegetables, or a small amount of very well-diluted fruit juice, consumed along with such foods will increase iron absorption from these non-haem sources.

- **Fruit, salad and vegetables** are important sources of vitamins and fibre.
    1. A portion[i] of vegetables should always be included at the main meal. In addition, a number of small pieces of fruit, salad or vegetables should be included to match the age in years of the child, as follows:
        - One small piece of fruit, salad or vegetables for 1 year-olds
        - Two small pieces of fruit, salad or vegetables for 2 year-olds
        - Three small pieces of fruit, salad or vegetables for 3 year-olds
        - Four small pieces of fruit, salad or vegetables for 4 year-olds
        - Five small pieces of fruit, salad or vegetables for 5 year-olds
    2. Small amounts of fruit and vegetables given at different times of the day minimise the risk of overwhelming the child's capacity to consume other foods required for critical nutrients such as iron.
- **Fats, spreads and oils** should be used minimally.
    1. A small amount of fat spreads can be added to foods such as bread in order to increase palatability and acceptability.
    2. Frying of foods should be avoided as far as possible, and foods should instead be baked, steamed or grilled.
    3. Roast potatoes or thick-cut oven chips can be used very occasionally (once a week).
- **Foods high in fat, sugar or salt** should be limited, as they provide a high proportion of the overall energy requirements of 1–5 year-old children without providing essential nutrients.
    1. Foods such as confectionery, cakes, crisps, biscuits, sugar-coated breakfast cereals, etc. are not recommended for 1–5 year-olds. Such foods either overwhelm the child's capacity for nutrient-dense foods, or provide additional calories and, consequently, increase the risk of the child becoming overweight or obese.

[i] Portion sizes increase as the child grows. A rough guide for a single portion is the amount of fruit, salad or vegetables that the child can hold in one hand.

2. Small amounts of sugar can be added to nutrient-dense foods (stewed fruit, milk puddings, jam on wholemeal bread, etc.) in order to increase palatability and acceptability. It is important to familiarise children with the variety of flavours and textures in the wide range of foods required for a healthy diet. Snacking on sugary foods and drinks should be avoided in order to protect dental health.
3. Foods which could be used as a dessert for this age group include rice pudding, stewed fruit (with a small amount of added sugar), custard, and jam on toast.
4. Salt and salty foods should be limited because high salt intakes can become habitual and are linked with cardiovascular disease in later life.
5. Children have a very keen sense of taste, do not require the addition of salt to an otherwise balanced diet, and should be protected from acquiring the habit of adding salt to food at the table.
6. Salt should not be added in cooking for 1–5 year-olds.

- **Beverages**
  1. Water and milk are the only drinks recommended for this age group.
  2. Sugar-containing and acidic drinks should be limited and, if consumed at all, should be kept to mealtimes.
- **Supplements**
  1. In order to improve the overall vitamin D intake status of this population group, a low-dose vitamin D-only supplement (5 µg) is recommended for all 1–5 year-olds from Halloween to St Patrick's Day (i.e. during the extended winter months).
  2. Dietary intake of iron is unlikely to be sufficient for smaller 1–3 year-old children (growing at ≤25th percentile level). This report highlights the need for an additional 4 mg of iron/day for 1–3 year-olds growing at ≤25th growth percentile level. This additional iron can be provided through the use of iron-fortified full-fat milks or formulae (containing at least 1 mg of iron/100

mL). Alternatively, a low-dose iron supplement providing the RDA for iron[ii] (7 mg) can be given 4 days a week.

ii. Physical development, activity and play recommendations

- Health-enhancing physical activity is as important as healthy eating for the promotion of healthy body weight and prevention of obesity in 1–5 year-olds. Specific recommendations in the national and WHO guidelines on physical activity should be prioritised. These are integral to successful outcomes of interventions promoting healthy eating in this age group.

iii. Healthy eating for children with special needs recommendations

- Some adjustments to healthy eating guidelines (texture modification, emphasis on certain food groups, etc.) may be required for children with special needs because they are more vulnerable to feeding difficulties and malnutrition, leading to nutritional deficiencies and to some children being underweight, overweight or obese.
- Children with special needs require careful growth monitoring, as they are at greater risk of nutritional inadequacies. Resources that outline different adjustments and solutions to address feeding issues should be made available to parents and carers of children with special needs.

iv. Food behaviour recommendations

- Eating involves strong innate personal preferences and dislikes but is also learned from the food environments and people around us. Most children have innate preferences for sweet, salty and energy-dense foods but they can learn to like most foods, especially in these early years.
- Children require active adult support in order to learn to like and eat many foods, including healthier ones such as vegetables.

[ii] Current availability of low-dose iron supplements for this age group (at the RDA of 7 mg) is very limited.

v. Food allergy recommendations

- If a key food group is excluded from a child's diet because a food allergy is suspected without proper indication or appropriate professional advice being sought, the growth and development of that child could be compromised.
- Appropriate professional advice should be sought if a food allergy is suspected and before excluding any key food groups from the diet of a child.

vi. Dental health recommendations

- Dental caries and dental erosion are the two most common causes of oral ill health in preschool children.
- In addition to avoiding snacking on sugary foods and drinks, the national oral health guidance should be followed in order to help children adopt good oral health practices.[1]

vii. Research recommendation

- Funded research should be undertaken in order to address knowledge gaps and improve understanding of the nutritional requirements of 1–5 year-olds and therefore enhance food-based dietary guidelines (see Appendix IV).

1. WHAT THIS REPORT IS ABOUT - RATIONALE FOR APPROACHES TAKEN

1.1 Essential elements in food-based dietary guidelines for 1–5 year-old children

Food-based dietary guidelines, also known as healthy eating guidelines, are science-based advice to guide individuals in choosing a healthy diet for promotion of a healthy lifestyle. A healthy lifestyle, incorporating good nutrition and physical activity, is crucial for the prevention of many chronic conditions such as obesity, cardiovascular disease (heart disease and stroke), diabetes, osteoporosis and some cancers. Food-based dietary guidelines are provided in terms of food groups and serve to inform a population on how much and which types of food to eat for good health.

The period from the ages of 1–5 years is a very important time for a child's growth and development. It is also a time when young children want to become more independent and do things for themselves, yet they are still heavily dependent on their parents/caregivers. Healthy development during this period allows children to grow not only physically, but also socially and emotionally. Spending time with, and learning behaviours from, family members is very important during this time, as is good nutrition and physical activity.

Food-based dietary guidelines for this age group are particularly specialised in that milk still plays a significant role in the diet of 1–5 year-old children. As children move from the age of 1 year up to the age of 5 years, their milk intake progressively decreases and the amount of solid food in their diet increases. Therefore, when a child reaches the age of 5 years, the variety of foods in their diet should allow for a seamless transition to the healthy eating guidelines for the general population aged 5 years and older. Establishing food-based dietary guidelines for 1–5 year-olds will help children develop familiarity with, and acceptance of, a variety of foods needed for lifelong healthy eating.

In terms of physical development, there is a wide spectrum of healthy development, with some children developing earlier than others. For example, some infants are walking before the age of 1 year, whereas others may not begin to walk until they are 18 months old. This has implications for energy requirements, with those who are more active having higher energy needs. Therefore, this report includes a chapter on physical activity, which is in line with national guidelines and provides a more detailed picture of physical capacity in order to be useful for healthcare professionals working with this age group.

Food-based dietary guidelines apply to all children, including those with special needs. For a variety of reasons, including delays in diagnosis and gradual onset of physical symptoms of malnutrition, few children with special needs receive individual dietetic intervention. In addition, many children with special needs are not registered for disability services, but rather rely on primary care, where simple adjustments to healthy eating guidelines are used to address their feeding issues. Therefore, a chapter on healthy eating for children with special needs is included in this report. Children with special needs who require a therapeutic diet should be under clinical care; their dietary requirements are outside the scope of this report.

Food-based dietary guidelines for 1–5 year-olds are intended for use by parents/caregivers. This is an age when children are learning to communicate and assert their independence. It is a time when behavioural issues in relation to food, such as food neophobia, can occur. Therefore, this report also includes a chapter on relevant behavioural developmental features of children's eating from the ages of 1–5 years.

1.2 Closing the gap with healthy eating guidelines from infancy to age 5

Guidelines on best infant feeding practice and healthy eating for the population aged 5 years and older have been in place in Ireland for a number of decades. This report provides food-based dietary guidelines for 1–5 year old children, the only age group not currently covered by national healthy eating guidelines.

Infant feeding guidelines

In Ireland, recommendations for a national infant feeding policy were first developed by the Food Safety Authority of Ireland (FSAI) in 1999,[2] and were subsequently revised and updated in 2011.[3] There is much legislation in place which aims to protect infants from birth up to 12 months of age, as this is a very vulnerable period of life where rapid growth and development occurs with corresponding high nutritional needs. The 2011 FSAI report, *Scientific Recommendations for a National Infant Feeding Policy, 2nd Edition*, addresses the unique food and nutritional needs of infants in the first year of life. During the first year of life, infants triple their birth weight and double their surface area. Infant feeding plays an important role in growth and development, and can affect health not only during infancy and childhood, but also throughout adolescence and adulthood. The period from conception throughout pregnancy and the first two years of life is now recognised as a critical period for the protection of health and well-being throughout life.[4] Best infant feeding practice includes exclusive breastfeeding for the first 6 months of life, with continued breastfeeding for 2 years and beyond, along with the provision of appropriate complementary foods.[5] These foods have an important role to play in establishing dietary diversity and healthy eating patterns. Infancy is a time when feeding skills are developed and when taste preferences and food acceptance is learned, which could influence eating patterns in later life.

In order to develop the infant feeding guidelines, it was important to consider a wide range of infants of different ages and sizes by examining the different food intakes of infants growing along different percentile levels in the growth charts (see Chapter 3, Section 3.1.1 for more details).

Healthy eating guidelines for the general population aged 5 years and older

In 2011, the FSAI published the report, *Scientific Recommendations for Healthy Eating Guidelines in Ireland*.[6] The report included a review of the Irish healthy eating guidelines and the food pyramid, as well as a revision of portion sizes and an assessment of affordability of healthy eating in Ireland. These guidelines considered the general healthy population from the age of 5 years to over 51 years. These guidelines were developed by modelling dietary intakes based on food groups. One of the main recommendations of this 2011 report was that healthy eating guidelines be developed for children aged 1–5 years in Ireland. However, there are as yet no recommendations for this age group. The current report is therefore the first publication from the FSAI providing scientific recommendations on healthy eating guidelines for children between 1 and 5 years of age.

Healthy eating guidelines for 1–5 year-old children

As outlined, healthy eating guidelines have been developed for adults, teenagers and children over the age of 5 years in Ireland, with the purpose of promoting healthy growth and development among children over 5 years and adolescents, and for the prevention of obesity, associated metabolic dysfunction and non-communicable diseases, such as cardiovascular disease and cancers.[6, 7] In addition, extensive research has been undertaken by the FSAI to develop best practice feeding guidelines for infants from birth to 12 months of age, as the nutritional needs of infants are quite different due to their rapid growth rate and relatively high energy and nutrient requirements.[2, 8-10] The purpose of the current report is to address the 2011 recommendation to develop food-based dietary guidelines for children aged 1–5 years in Ireland by outlining the scientific approaches used to develop such guidelines.

The period of growth and development from the age of 1–5 years has been the focus of much attention in terms of obesity prevention in recent years.[11] In 2012, the National Pre-School Nutrition Survey (NPNS), using United Kingdom (UK) and World Health Organization (WHO) criteria, concluded that 16% of children aged 2–4 years were overweight and 7% were obese. Gender differences were apparent, with one in four boys classified as overweight or obese compared with one in five girls (25% of boys compared with 21% of girls).[12] It is now accepted that the first years of life are a critical time for the development of healthy eating habits and food preferences, and for healthy growth and development, which has a profound impact on lifelong health and disease risk.[13-15] Young children are still growing rapidly and have high nutritional requirements, but they have a relatively small capacity for food intake. The balance of the diet during this time is important in order to provide adequate energy and nutrients for healthy growth and physical and neurological development, as well as for helping children to develop lifelong healthy food preferences and eating patterns.

The development of healthy eating guidelines for 1–5 year-olds needs to seamlessly progress this age group from the infant feeding guidelines, where the diet was predominantly milk based, to the healthy eating guidelines already in place for those aged 5 years and older, where the diet is based on food groups.

2. HEALTHY GROWTH AND DEVELOPMENT

2.1 Population: 1–3 year-olds; 4–5 year-olds

Under European legislation and international standards, young children are defined as those aged between 1 and 3 years. In many parts of the world, young children are also referred to as toddlers, with children aged between 4 and 5 years referred to as pre-schoolers.

Toddlers (aged 1–3 years) and pre-schoolers (aged 4–5 years) are different in terms of growth, development and behaviour, as outlined in the following sections. Infancy and early childhood is a period of rapid growth and development when nutritional needs are high. This period of rapid growth begins to slow down as the child approaches 4 or 5 years of age, and their nutritional needs begin to become more aligned with those of older children and adolescents. These early years of life are especially important for health and development.

2.2 Growth and growth monitoring

2.2.1 Growth

Physical growth and development in childhood can be considered the multiplication of cells and body size changes, in addition to the maturation of body structures and functions.[16] Normal physical growth is an important indicator of good health and development. All children will grow and develop at a different rate.

2.2.2 Growth monitoring

Growth monitoring, which can be defined as the routine measurement of a child's weight, height and other parameters, is a widely accepted practice for monitoring the health of children. Growth monitoring forms part of a whole-child service and should therefore be viewed in the context of this holistic approach. Worldwide, growth monitoring is used to validate healthy physical development and to identify abnormal growth in children.[17] Growth monitoring involves measuring a child's weight and height and plotting these on a growth chart in order to assess appropriate growth. Where abnormal growth is identified, nutritional and/or social interventions can be carried out by the healthcare professional in order to help determine the cause and intervention required. Growth monitoring can also be used to assist in the identification of chronic disorders and provide reassurance to parents about the child's health. Normal growth is a good indicator of well-being.

2.2.3 Growth charts

Growth charts are used to plot a child's weight and height. Growth curves are developed to include the individual patterns of many children, allowing for the smoothing of growth curve lines. However, they do not give a clear indication of where normality ends or where deviation from the norm begins. As such, longitudinal monitoring with charts standardised for gender, age and, ideally, ethnicity is essential in order to understand the growth rate or developmental progress of the individual child.

In 2006, the WHO released new growth standards describing normal growth in children aged 1–5 years. The standards are age-based growth charts for length, weight and body mass index (BMI), based on data from the WHO Multicentre Growth Reference Study, which was carried out in six countries over 6 years (1997–2003). Children who were born at term to healthy, non-smoking mothers, who were exclusively breastfed for at least the first 4 months of life, and who were living in family environments that were nutritionally secure and favourable for growth were included.[(18)] The WHO growth charts are a growth standard; therefore, they show how infants and children should grow, not how they actually grow in a specific place and time. The growth charts can be accessed on the WHO website.[iii] The UK-WHO growth charts[iv] prescribe the healthy growth pattern for all UK children from 2 weeks to 4 years, including both breastfed and formula-fed children. Growth charts have been introduced for babies born in Ireland after 1 January 2013.[(19)] The new charts have been adopted as policy by the Department of Health and have been adapted for Ireland from materials originally developed by the WHO and the Royal College of Paediatrics and Child Health in the UK.

2.2.4 How to use growth charts

When the weight and height of a child has been measured, the measurements should be plotted on the growth chart. The percentiles on the chart are used to assess and monitor growth. The WHO recommends that values of two standard deviations above and below the 50th percentile (median), i.e. the 2nd and 98th percentiles, should be used as cut-offs for identifying abnormal growth. Therefore:

- Children with a weight-for-length below the 2nd percentile are defined as low weight-for-length.

[iii] WHO growth charts are available at http://www.who.int/childgrowth/standards/en/
[iv] UK-WHO growth charts are available at http://www.rcpch.ac.uk/growthcharts/

- Children with a length-for-age below the 2nd percentile are defined as having short stature.
- Children with a weight-for-length above the 98th percentile are defined as high weight-for-length.
- The BMI-for-age growth chart is used to determine weight status (e.g. underweight or overweight). This is described in more detail in Section 2.3.

During growth monitoring, for children identified as falling outside the cut-offs according to the criteria in the charts listed above (e.g. short stature, underweight, overweight, etc.), intervention from a health professional is required in order to identify the aetiology and advise on implementation of appropriate solutions. [19]

2.3 BMI curves and BMI/adiposity rebound

2.3.1 What is BMI and how is it used in this age group?

BMI is a measure used to determine underweight, overweight and obesity. It is calculated by dividing an individual's weight (kg) by their height squared (m^2), i.e. kg/m^2. For children over the age of 2 years, BMI is age and sex specific, and is generally referred to as BMI-for-age. Once BMI has been calculated for a child, a BMI-for-age growth chart is then used to plot the BMI-for-age in order to determine what percentile the child falls on. As weight and height change with age and this population is constantly growing, the BMI-for-age is interpreted relative to other children of the same age and sex. According to the UK-WHO age- and gender-specific BMI charts,[20] a BMI falling between the 91st and 98th percentiles or above the 98th percentile is classified as 'at risk of overweight' or 'overweight', respectively.

BMI-for-age is used as a screening tool for potential weight-related issues. It is not a diagnostic tool. Further assessments (such as those described above) would need to be carried out in order to clarify and investigate any issues indicated by BMI-for-age measurements. Children measuring below the 2nd BMI percentile or above the 98th BMI percentile should be referred to paediatric services as recommended. [19]

If a child is found to be obese, there can be serious health consequences. Childhood obesity is associated with multiple health issues during childhood and can cause an increase in the risk factors associated with cardiovascular disease (such as high blood pressure), as well as with an increased risk of type 2 diabetes, asthma, sleep apnoea, and behavioural and social problems.[21-24] It is also well recognised that children with obesity are more likely to be obese later in life, and obesity is associated with an increased risk of weight-related mortality in adulthood.[25, 26]

2.3.2 What is the BMI/adiposity rebound?

There are natural trends in BMI which occur during infancy, toddlerhood and the pre-school years. During infancy, there is a rapid increase in BMI followed by a subsequent decrease and plateau. When BMI increases again, this is known as the ‘BMI or adiposity rebound’. This adiposity rebound generally occurs between the ages of 3 and 7 years and is defined as the point of inflexion of BMI percentiles with age.[27] Once the adiposity rebound has passed, growth into adulthood becomes more linear.[28]

2.3.3 BMI/adiposity rebound and the link with obesity in adulthood

The adiposity rebound is thought to play a critical role in later-life overweight and obesity. The timing of the adiposity rebound is thought to predict obesity in adulthood, and several studies have suggested that the earlier the adiposity rebound occurs in childhood, the higher the risk of obesity in adulthood.[29-31] One such study found that the earlier the adiposity rebound occurred, the greater the risk of developing metabolic syndrome (increased blood pressure, abnormal cholesterol or triglyceride levels, excess abdominal body fat, etc.).[32] Another study[33] concluded that an earlier increased weight-for-height (before the age of 2 years), and a slow decline in BMI after the age of 2 years, may help identify children at risk of developing cardiovascular disease in adulthood.

It is therefore important that routine growth monitoring (including BMI-for-age) is undertaken consistently in order to identify children at risk of becoming overweight and of having an early adiposity rebound.

2.4 Development

In addition to assessing growth, childhood development is assessed in terms of perceptual, neuromotor, cognitive, language, psychosocial and emotional development. Development is influenced by genetics and by pre- and postnatal environments. Between the ages of 1 and 5 years, such assessment can determine whether a child falls within the limits of typical development or has a degree of developmental delay. Determining whether development is typical or atypical is relevant to the healthy eating guidelines, as a developmental delay may indicate an underlying health condition (e.g. cerebral palsy) which may require adjustment of the volume, type or preparation of foods consumed in order to meet nutritional requirements (see Chapter 6). It is important to consider the assessments carried out on healthy children between the ages of 1 and 5 years when developing healthy eating guidelines to cover this period of growth and development. Such healthy eating guidelines must provide adequate detail to meet a wide spectrum of children's needs.

Physical development of children between 1 and 5 years of age influences their capacity for physical activity and physical function. Childhood physical development also includes the development of hearing, speech and vision; social behaviour (including play); and neuromotor development, including posture, gross- and fine-motor skills (see Chapter 5). A population of children at the same age does not develop at the same time and there is a wide spectrum of healthy typical development, with some children developing earlier than others. This physical development is highly linked to their energy requirements. Of particular importance is the prenatal to 3-year interval, as this is a period of rapid brain development, learning, and formation of caregiver-child attachment. Because of this, public health resources on a global basis are predominantly provided to assess childhood growth and development in order to offer early intervention, including dietary interventions, to positively impact future potential.

This report provides a brief overview of physical, cognitive and behavioural development, and outlines the wide spectrum of when these milestones are achieved.

3. APPROACHES USED TO DEVELOP THE SCIENTIFIC RECOMMENDATIONS FOR FOOD-BASED DIETARY GUIDELINES FOR 1 TO 5 YEAR-OLDS

Key issues to be considered when establishing food-based dietary guidelines for 1–5 year-old children:

- Energy is the nutrient that determines whether the amount of food provided is sufficient to provide adequate, but not excessive, energy in order to promote healthy growth and protect against overweight and/or obesity.
- Saturated fat intake should be kept as low as possible within a nutritionally adequate diet, recognising that the diet at 1 year is naturally high in saturated fat, but by the age of 5 years saturated fat intakes are approaching the goal of <10% of total energy intake.
- Docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and fibre intakes should be adequate.
- Free Sugar (added sugar) should be kept to a minimum.
- Key micronutrients where intakes might be inadequate in 1–5 year-old children in Ireland include vitamin D and iron.
- Milk is a critical food source of calcium and protein, and diets that restrict dairy foods for 1–5 year-olds are not suitable unless under medical supervision.

3.1 Approaches used to develop the guidelines for Best Infant Feeding Practice and Healthy Eating Guidelines for the Population Aged 5 Years and Older

Best practice in developing food-based dietary guidelines is to ensure that the recommended dietary intake patterns are as close to the usual diet as possible. This includes consideration for prevailing nutritional issues, food availability, culinary cultures and eating habits.

The healthy eating guidelines for 1–5 year-olds in Ireland will bridge the gap between the infant feeding guidelines, which apply from birth to 12 months old, and the healthy eating guidelines for the population aged 5 years and older. The approaches used for the development of Ireland's infant feeding guidelines and healthy eating guidelines for those aged 5 years and older differ, and these approaches are outlined below.

3.1.1 Infant feeding guidelines

As outlined in Chapter 1, the infant feeding guidelines for Ireland were first developed in 1999 and updated in 2011. The infant feeding guidelines cover infants from birth to 12 months of age. The aim of those guidelines was to provide advice and information on infant nutrition, starting with maternal nutrition in preconception and pregnancy and continuing to infant nutrition (from birth to 12 months), focusing on milk feeding and the progressive introduction of complementary solid foods. In addition, these guidelines encourage best infant feeding practice in terms of what is known about dietary prevention of chronic diseases in later life. The guidelines considered and took into account issues such as breastfeeding trends in Ireland and timing of the introduction of complementary foods.

Infancy is a period of rapid growth and development. Therefore, it was important to consider a wide range of infants of different ages and sizes by examining food intakes by infants growing along different percentile levels in the growth charts.[iii] Growth percentiles ranging from the 0.4th to the 99.6th were included, as this represents the healthy growth range. Dietary intakes were modelled for a sample of male and female infants at eight different age time points (1 month, 2 months, 3 months, 4 months, 5 months, 7.5 months, 10.5 months and 12 months) growing on seven different percentile levels on the growth charts (0.4th, 9th, 25th, 50th, 75th, 91st and 99.6th).

The dietary intakes modelled reflected best practice infant feeding, e.g. exclusive breastfeeding up to 6 months of age. In addition, other infant feeding practices reflecting current trends in Ireland were also modelled. This included infant formula (from birth) and follow-up formula (from the age of 6 months) so that the impact of different infant feeding practices prevalent in Ireland could be assessed in order to provide guidance on the various milks consumed. From the age of 5 months, introduction of complementary foods according to guidance outlined in three different weaning books were used to develop 7-day meal plans for infants up to the age of 12 months. The dietary intakes modelled were compliant with healthy eating principles (e.g. no added salt and minimal added sugar and fat), as well as using foods of appropriate texture.[34, 35]

Nutrient requirement goals were derived from internationally recognised authoritative scientific bodies, the European Food Safety Authority (EFSA) and the Institute of Medicine (IOM), and included energy, protein, total fat, DHA, carbohydrates, vitamins A and D, iron, zinc, sodium and calcium.[34, 35] Energy was the most important goal, as it determined total food intake and was prioritised before considering how dietary intake patterns met the other macro- and micronutrient goals.

This modelling approach to develop infant feeding guidelines was innovative, in that no similar approaches are apparent in the scientific literature. The population that was generated was a sample which included the range of growth percentile levels within healthy growth parameters. The modelling identified different nutritional issues according to the type of milk feeding the infant receives. The modelling approach for infants of different body sizes according to percentile levels at each age point, identified differences in nutritional intakes between smaller infants and larger infants, as well as differences according to age. This approach was very comprehensive, and it yielded detailed infant feeding guidelines and practical advice on milk feeding and how nutritional requirements can be achieved. This modelling approach has since been adopted by the FSAI for risk assessments of foods and supplements targeting infants.

3.1.2 Healthy eating guidelines for the population aged 5 years and older

As outlined in Chapter 1, the healthy eating guidelines for those aged 5 years and older were developed in 2011 and aimed to provide advice on the amount and types of foods needed to achieve and maintain optimal amounts of calories and nutrients for good health.

The modelling approach used for developing these guidelines was different to the approach used to develop the infant feeding guidelines. These guidelines were developed by modelling dietary intakes based on food groups, as opposed to milks and meals used in the infant feeding guidelines. Eleven age groups (including both genders) were modelled to develop the healthy eating guidelines. These 11 age groups spanned childhood and adulthood, with proportionately more children and adolescents being modelled compared with adults due to the growth and development occurring during these periods.

Nutrient goals were determined taking account of the diet-related diseases affecting people in Ireland. Nutrient requirement goals included energy, total fat, saturated fat, fibre, calcium, iron and vitamin D. Energy was the most important goal, as it determined total food intake and was prioritised before considering how dietary intake patterns met the other macro- and micronutrient goals.

In terms of food goals, the dietary intakes modelled were compliant with healthy eating principles such as minimal added salt, sugar and fat. The foods used were drawn from the five food groups: vegetables, salad and fruit; wholemeal cereal and breads, potatoes, pasta and rice; milk, yogurt and cheese; meat, poultry, fish, eggs, beans and nuts; and fats, spreads and oils. Modelling included assessing the impact of various reduced-fat products on the market (e.g. reduced-fat dairy, spreads, etc.).

3.1.3 Approaches used for developing food-based dietary guidelines for 1–5 year-olds

As outlined above, the infant feeding guidelines and healthy eating guidelines for those aged 5 years and older are already in place in Ireland and were developed using different approaches. When developing the infant feeding guidelines, a sample of infants was generated. There were no nationally representative dietary intake data available to describe what types of foods are consumed by infants or the nutritional intakes they achieve. The approach used to develop the infant feeding guidelines was more detailed than that used to develop the guidelines for those aged 5 years and older. This was necessary to cover the range of body size within the infant healthy growth parameters (seven percentile levels at each age), to reflect differences according to body size during this period of rapid growth, and to identify vulnerabilities within this population group.

The development of healthy eating guidelines for 1–5 year-olds evolved from the approach used to develop the infant feeding guidelines. These guidelines must seamlessly transition this age group from infancy, where the diet is predominantly milk based, to a diet based on food groups that aligns with the healthy eating guidelines for those aged 5 years and older.

Children from the age of 1–5 years have just emerged from infancy; therefore, it is still important to take account of differences between the smaller (i.e. 0.4th percentile on the growth charts) and larger (i.e. 99.6th percentile on the growth charts) 1–5 year-old children when developing these food-based dietary guidelines. Although national dietary intake data from the NPNS[12] are available for 1–5 year-olds based on a nationally representative sample of 500 children, these data do not represent children growing along different percentile levels within the healthy growth range. The modelling approach needs to identify nutritionally vulnerable children within the healthy growth range; therefore, a sample of 1–5 year-old children was generated to represent children at five different percentiles and at six age time points between the ages of 1 and 5 years (see Section 3.2.2 for more details). The food intake patterns were generated using the foods commonly consumed according to the national dietary survey of this age group (see Section 3.3 for more details).

In summary, the approaches used to develop both the infant feeding guidelines and the healthy eating guidelines for those aged 5 years and older informed the approach developed to establish the scientific recommendations for food-based dietary guidelines for 1–5 year-olds. Many modelling approaches for developing food-based dietary guidelines exist worldwide. The approach chosen for the purposes of this work is a modified approach used previously in Canada to develop healthy eating guidelines for the general population aged 2 years and older.[36] The approach used for this work is outlined in the following sections.

3.2 Guiding principles and modelling goals used for formulating healthy eating guidelines for 1–5 year-olds

3.2.1 Guiding principles

Guiding principles for developing these healthy eating guidelines were established, as there are no clear goals for some nutrients (e.g. saturated fat and sugar), especially up to the age of 2 years, when the diet is progressing from a predominantly milk-based diet to a food-based diet. The five guiding principles used to develop healthy eating guidelines for 1–5 year-olds are outlined in Figure 3.1. The guiding principles are as follows:

1. *Food intake patterns meet goals for healthy eating*

   The food intake patterns modelled needed to provide adequate, but not excessive, energy intakes so that healthy growth is supported and the development of overweight or obesity is avoided. The food intake patterns needed to provide adequate fibre, micronutrients and fat, and to be achieved using general healthy eating principles including avoiding excessive intakes of saturated fat and having minimal amounts of added sugar, no added salt and no processed meats (see *Food goals* in Section 3.2.4 for more details).

2. *Develop food intake patterns for children representing a range of body sizes within the healthy range and as close as possible to the usual diet*

   The 4-day food intake patterns modelled should be as close to the usual diet for this age group as possible. The NPNS[12] database was used to identify the most commonly consumed foods for this sub-group and the eating occasion (i.e. breakfast, lunch, dinner and snacks). A questionnaire was provided, and a focused discussion was held with paediatric and community dietitians in order to add context to the national survey data. In addition, information was collected on the changes dietitians recommend to improve dietary intakes of this age group (see Section 3.3 for more details).

3. *Seamless transition from infant feeding guidelines to healthy eating guidelines for those aged 5 years and older*

   These healthy eating guidelines need to seamlessly transition the 1–5 year-old age group from a predominantly milk-based diet to a diet developed using the five food groups. The modelling approach developed for the 1–5 year-olds incorporated the different approaches used for the infant feeding guidelines and the healthy eating guidelines for those aged 5 years and older. This ensured a progressive transition that was seamless.

4. *Age-appropriate foods*

   Foods modelled for 1–5 year-old children should be appropriate for their age. This was accomplished by ensuring that the amounts of food were adequate and realistic, the texture was suitable, and choking hazards were avoided (e.g. whole nuts). Different types of milks commonly consumed by 1–5 year-olds were also modelled (see Section 3.2.3).

5. *Fostering good food habits*

   The foods used in the food intake patterns needed to support oral motor development for this age group. In addition, the foods used needed to foster good food behaviour by encouraging the acceptance of the full range of foods required to ensure a healthy, balanced, and varied diet throughout life.

Guiding principles for food-based dietary guidelines for 1–5 year-olds

Food intake patterns meet goals for healthy eating

- Energy – adequate, but not excessive, to support healthy growth and protect against overweight/obesity
- Fat – adequate for fat-soluble vitamins but low in saturated fat
- Fibre – adequate but not excessive
- Sugar – minimal amounts added
- Micronutrients – adequate but not excessive
- No added salt
- No processed meat.

Develop food intake patterns for children representing a range of body sizes within the healthy range and as close as possible to usual diet

- Five percentile levels on the growth charts were used for both males and females
- Foods most commonly eaten by 1–5 year-olds (NPNS)
- Usual eating patterns were modelled (informed by paediatric and community dietitians).

Seamless transition from infant feeding guidelines to healthy eating guidelines for those aged 5 years and older

- Progressive transition from infant feeding guidelines (predominantly milk-based diet) to healthy eating guidelines for those aged 5 years and older (food group-based diet)
- Milk is still a major part of the diet for 1–5 year-olds; however, milk becomes less important and foods become more predominant as the child gets older
- Development of healthy eating guidelines for 1–5 year-olds incorporates the detailed approach used for infants (different body size percentiles at different ages) and the approach used for those aged 5 years and older.

Age appropriate foods

- Appropriate texture
- Appropriate amounts of foods in relation to food intake capacity
- Use of different milks, reflecting the range of milks used by this age group
- Avoidance of inappropriate foods, e.g. whole nuts, as they are a choking hazard.

Fostering good food habits

- Foods used support oral motor development
- Foods used foster good food behaviour
- Acceptance of a range of foods required for healthy eating throughout life.

Figure 3.1 Guiding principles used for developing healthy eating guidelines for 1–5 year-olds

3.2.2 Defining the number of children needed for the modelling of food intake patterns

As described in Chapter 2, young children are defined as 1–3 year-olds, and they undergo a more rapid period of growth and development than 4–5 year-olds. Therefore, more extensive modelling was carried out on the younger age group. For the age range of 1–3 years, there were four age time points modelled (1 year, 1.5 years, 2 years and 3 years) and for the age range of 4–5 years, there were two age time points modelled (4 years and 5 years).

There are various stages of growth and development, and not all children grow at the same rate. Therefore, five different growth percentiles (0.4^{th}, 25^{th}, 50^{th}, 75^{th}, and 99.6^{th}) were modelled using the WHO[iii] and UK-WHO growth charts, which are used in Ireland. [19]

Both males and females were modelled for each time point and growth percentile. Figure 3.2 outlines the process and how the population for modelling were defined to represent the full range of different growth rates. Figure 3.3 describes the number of 4-day food intake patterns that were developed and modelled for female and male 1–5 year old children (*n*60), representing the full range of different growth rates.

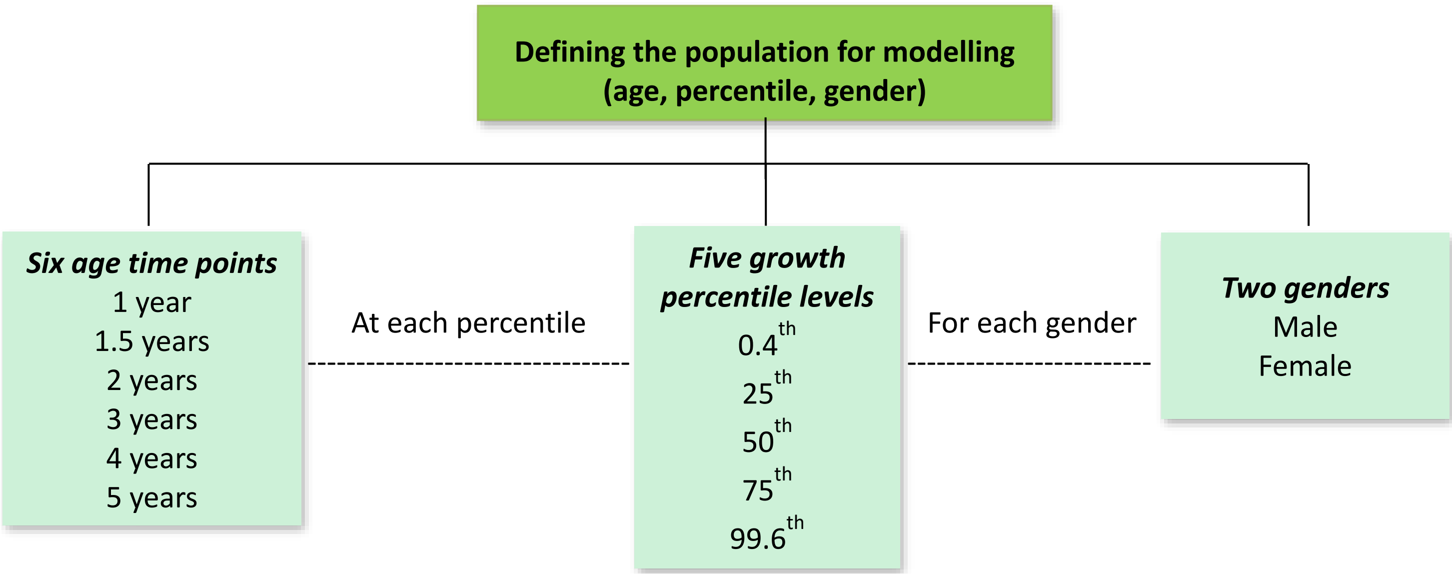

Figure 3.2 Defining the population used in the modelling process

3.2.3 Milk intakes

Dietary patterns for this age group undergo a transition from a predominantly milk-based diet to a diet based on food groups. Various milks commonly used for 1–5 year-old children were modelled in order to examine their effects on nutrient intakes.

Breast milk was modelled for those up to the age of 2 years, as outlined by the Department of Health's policy,[5] which supports the WHO Global Strategy on Infant and Young Child Feeding.[37] However, it was recognised that the majority of young children in Ireland are not breastfed up to 2 years of age. Therefore, the food intake patterns were also modelled using whole cow's milk and fortified whole cow's milk. Low-fat cow's milk (1.5% fat) and fortified low-fat cow's milk (1.5% fat) were modelled from the age of 2 years. Follow-up formula was modelled for 1 year-olds only, and young child formula was modelled at the 1.5, 2 and 3 year time points (see Figure 3.3).

Following infant feeding recommendations in Ireland, where exclusive milk feeding (breastfeeding preferably, or formula) is recommended for the first 6 months of life, it is not unusual for healthy infants of average weight to consume 1000 mL of breast milk/formula from 4–7 months of age. After 6 months of age, the amount of breast milk/formula consumed progressively decreases as solid foods and other liquids are introduced into the diet (see Table 3.1). As a child gets older, it is recommended that some milk intake is consumed as yogurt and cheese (see Table 3.2). By 12 months of age, 500–600 mL of breast milk/formula, or equivalent dairy foods such as yogurt or cheese, is recommended to be consumed on a daily basis, and this remains stable throughout early childhood (i.e. 1–5 years of age). Data from the NPNS show that actual milk, yogurt and cheese intakes are close to the recommended amounts.

Table 3.1 Amount of breast milk/formula milk consumed by infants growing at the 0.4^{th}, 50^{th} and 99.6^{th} percentile[a]

Age	Percentile	kg	mL of breast milk or formula/day
1 month[b]	0.4^{th}	3	450
	50^{th}	4.4	660
	99.6^{th}	6.2	930
2 months[b]	0.4^{th}	4	600
	50^{th}	5.6	840
	99.6^{th}	7.7	1155
3 months[b]	0.4^{th}	4.6	690
	50^{th}	6.4	960
	99.6^{th}	8.6	1290
4 months[b]	0.4^{th}	5.2	780
	50^{th}	6.8	1020
	99.6^{th}	9.4	1410
5 months[b]	0.4^{th}	5.5	825
	50^{th}	7.5	1125
	99.6^{th}	10	1500
6 months[b]	0.4^{th}	5.8	870
	50^{th}	7.8	1170
	99.6^{th}	10.5	1575
7 months[c]	0.4^{th}	6.2	850
	50^{th}	8.3	900
	99.6^{th}	11	950
8 months[c]	0.4^{th}	6.4	800

	50th	8.5	850
	99.6th	11.4	900
9 months[c]	0.4th	6.6	725
	50th	8.8	775
	99.6th	11.9	850
10 months[c]	0.4th	6.7	650
	50th	9.2	700
	99.6th	12.3	800
11 months[c]	0.4th	6.5	575
	50th	9.4	625
	99.6th	12.5	700
12 months[c]	0.4th	7.2	500
	50th	9.6	550
	99.6th	12.8	600

[a]http://www.who.int/childgrowth/standards/en/
[b]Calculated for infants (0–6 months) consuming 150 mL of infant formula per kg body weight.
[c]For the ages of 7–12 months, the amount of formula intake was progressively reduced to reflect the introduction of solids and other liquids in the infant's diet.

Table 3.2 Milk and milk alternatives showing the amounts of milk, yogurt and cheese that are considered equivalent

Milk	Yogurt	Cheese
1 cup low-fat milk (240 mg calcium)	¾ cup natural or fruit yogurt (240 mg calcium)	1 cup cottage cheese (240 mg calcium)
1 cup full-fat milk (260 mg calcium)	1 cup natural yogurt drink (240 mg calcium)	1 piece of hard cheese (e.g. cheddar) the width and depth of 2 thumbs (100–240 mg calcium, depending on thumb size)
1 cup low-fat fortified milk (320 mg calcium)	1 cup fruit yogurt drink (240 mg calcium)	1 piece of soft cheese (e.g. Brie) the width and depth of 2 thumbs (80–220 mg calcium, depending on thumb size)
1 cup flavoured milk (240 mg calcium)	1 cup flavoured yogurt drink (240 mg calcium)	
1 cup fortified soya 'milk' (240 mg calcium)	¾ cup natural pouring yogurt (200 mg calcium)	
1 cup rice pudding made with milk (200 mg calcium)	¾ cup flavoured pouring yogurt (200 mg calcium)	
¾ cup custard made with milk (200 mg calcium)	¾ cup diet yogurt (210 mg calcium)	

1 cup = 200 mL
Table adapted from the FSAI *Healthy eating, food safety and food legislation* guide[38] and the *Scientific Recommendations for Healthy Eating Guidelines in Ireland*.[6]

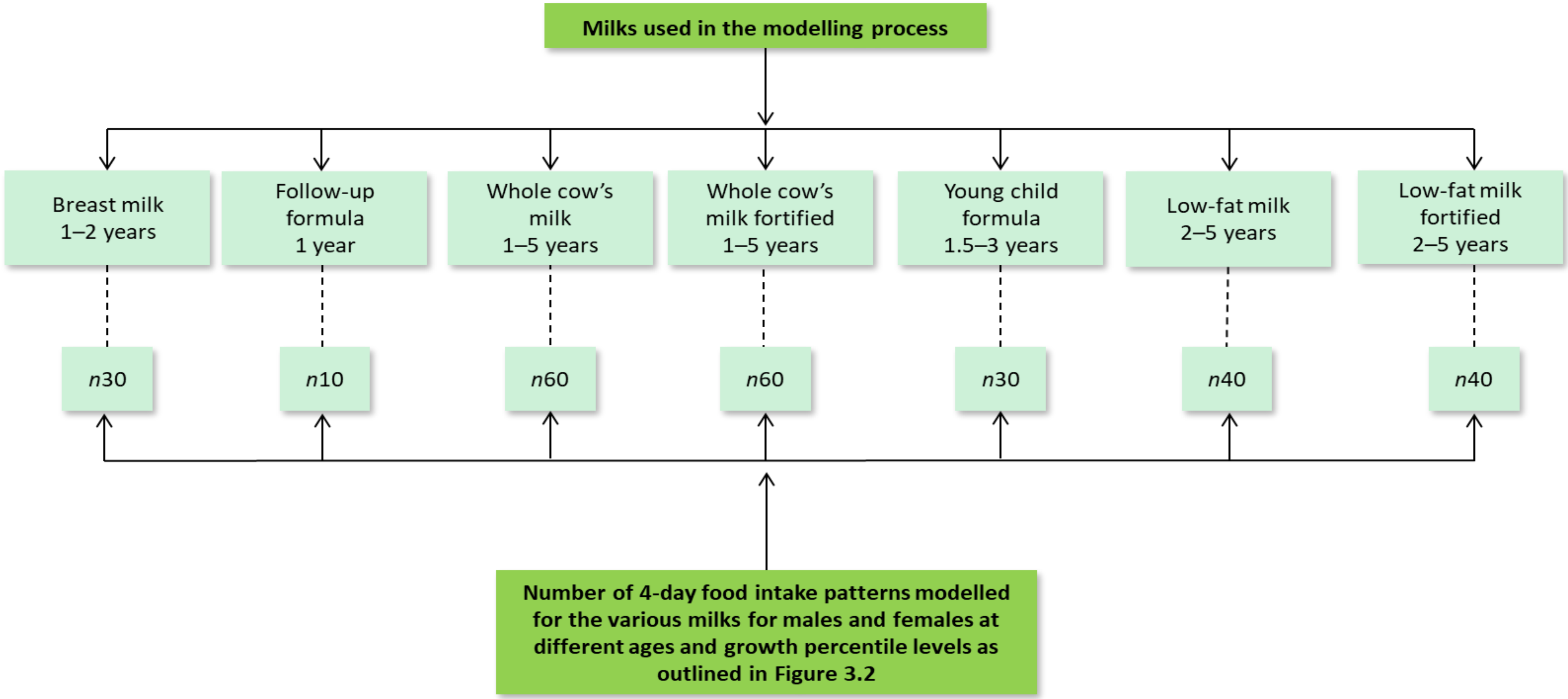

Figure 3.3 Milks used for each age group and the number of 4-day food intake patterns modelled using these milks at different ages, covering all five growth percentiles for both males and females

Total number of 4-day food intake patterns initially developed for modelling using these milks:
1–3 years = 190 (95 female; 95 male) [760 daily food intake patterns]
4–5 years = 80 (40 female; 40 male) [320 daily food intake patterns]
Total, 1–5 years = 270 [1,080 daily food intake patterns]

3.2.4 Nutrient and food characteristics

Nutrient goals

The food intake patterns developed as a basis for healthy eating guidelines for 1–5 year-olds met a range of macro- and micronutrient goals. These goals are outlined in Tables 3.3 and 3.4. This shows how these goals change with age, with some increasing and others decreasing as the child gets older.

Well-established, international nutritional goals for children living in developed countries were considered the most appropriate goals for this age group. The majority of the goals came from EFSA, with some also coming from IOM in North America. For selected micronutrients, the 4-day food intake pattern aimed to provide at least the Average Requirement (AR) or Estimated Average Requirement (EAR) with consideration also given to the Recommended Dietary Allowance (RDA) levels.

Table 3.3 The macronutrient daily intake goals used to develop healthy eating guidelines for 1–5 year-olds in Ireland outlined for the different age time points modelled

Age (years)	Average energy kcal/day (total for 0.4th–99.6th %ile)[a] AR	Protein[(39)] g/kg body weight (total g for 0.4th–99.6th %ile)[a] RDA	Total fat[(40)] (% energy) RI	Saturated fat[(40)]	Carbohydrates[(41)] (% energy) RI	Free Sugars[(42)] (% energy)	Fibre[(43)] (age + 5 g)[b]	DHA + EPA[(40)] (mg) AI
1	757 (569–968)	1.14 (8–15)	35–40	Low as possible in nutritionally adequate diet	45–60	Low as possible in nutritionally adequate diet	6	100[c]
1.5	881 (674–1118)	1.03 (8–15)	35–40	Low as possible in nutritionally adequate diet	45–60	Low as possible in nutritionally adequate diet	6.5	100[c]
2	988 (755–1261)	0.97 (8–16)	35–40	Low as possible in nutritionally adequate diet	45–60	Low as possible in nutritionally adequate diet	7	250
3	1136 (1005–1293)	0.90 (9–18)	35–40	Low as possible in nutritionally adequate diet	45–60	Low as possible in nutritionally adequate diet	8	250
4	1388 (1223–1593)	0.86 (11–20)	20–35	Low as possible in nutritionally adequate diet	45–60	Low as possible in nutritionally adequate diet	9	250
5	1477 (1286–1726)	0.85 (12–23)	20–35	Low as possible in nutritionally adequate diet	45–60	Low as possible in nutritionally adequate diet	10	250

AR: Average requirement (EFSA); RDA: Recommended Dietary Allowance (EFSA); RI: Reference Intake (EFSA); AI: Adequate Intake (EFSA).
[a]Range for those growing at the smallest (0.4th) and largest (99.6th) growth percentile (%ile) levels on the growth charts.
[b]1995 goal from the United States of America (USA) for fibre intake of 'age + 5 g' for children up to 18 years old.[(43)]
[c]DHA only.

The macronutrients examined were:

- *Energy* – the most important nutrient for modelling, as it determined the amount of food which could be used in the food intake patterns. The goal for energy was determined by using the Henry equation,[44] the Physical Activity Levels (PALs; 1–3 year-olds had a PAL of 1.4; 4–5 year-olds had PALs of 1.4, 1.6 and 1.8) according to EFSA,[45] and the WHO and UK-WHO 1990 growth charts used in Ireland. [19]
- *Protein* – adequate to support healthy growth. As this age group is usually consuming a high volume of milk (~550 mL/day), this goal was easily achieved.
- *Fat* – adequate to support fat-soluble vitamins and energy requirements, but not excessive, in order to protect against the development of overweight/obesity. Fat is a rich source of calories but is low in nutrients, and excessive amounts may limit the capacity for other, more nutrient-dense foods in the diet.
    - *Saturated fat* – diet in infancy is naturally high in saturated fat. As a child progresses from 1 to 5 years old, the goal is to keep saturated fat intake as low as possible within a nutritionally adequate diet. By the age of 5 years, children’s intakes of saturated fat should approach the goal of ≤10% of total energy intake. In many countries, low-fat milks are given from the age of 2 years in order to limit saturated fat intakes. In line with this, the use of low-fat milks was explored in the dietary patterns from the age of 2 years.
- *Carbohydrate* – source of energy and fibre in the diet.
    - *Sugar* – added sugar should be kept to a minimum. The amount of added/Free Sugar was assessed in order to evaluate intakes with respect to the WHO recommendation.[46] The WHO, which refers to added sugar as Free Sugar, defines it as follows: “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”.[42] The WHO strongly recommends that Free Sugar intake represent <10% of total energy intake, with a further recommendation to reduce this to <5% of total energy intake. Unfortunately, the nutritional analysis software used for analysing the nutritional composition of the modelled food intake patterns did not have the capacity to calculate Free Sugar

intake accurately. Therefore, the WHO goal for Free Sugars (<10% and ideally <5% of energy intake) was not incorporated into the model of ideal food intake patterns. Instead, these Free Sugar goals were used in a *post hoc* assessment of how much Free Sugar was provided by finalised food patterns (when all other goals were met). This analysis was undertaken manually, where every food intake pattern was assessed for total sugar intake and the amount of sugar presenting as Free Sugar was calculated in grams. The energy provided by the Free Sugar content of each meal pattern was estimated and expressed as a percentage of the total energy provided.

- *Fibre* – the aim was to provide an adequate but not excessive amount, as fibre can lead to a bulky diet and limit capacity for food intake. Various goals for fibre were considered. The IOM goals(47) were rejected as being too high (19 g/day for 1–3 year-olds and 25 g/day for 4–8 year-olds). The EFSA goals(41) (10 g/day for 1–3 year-olds and 14 g/day for 4–6 year-olds) were also considered, but the absolute goal given to cover all children over a 2–3 year time frame, regardless of body size, was considered to be a disadvantage. The American Health Foundation goal for fibre intake has the advantage of allowing for yearly increments and is expressed as ‘age (in years) + 5 g/day’.(43) This was considered to be the most appropriate goal for this population sub-group (i.e. 1–5 year-olds) and it also aligns with the fibre goal used to develop food-based dietary guidelines for older children (aged 5–18 years) in Ireland.(7)

Further information on each of these macronutrients can be found in Appendix I.

Table 3.4 The micronutrient daily intake goals used to develop healthy eating guidelines for 1–5 year-olds in Ireland

Age group (years)	Vitamin A[48] (µg RE/day) AR (RDA)	Vitamin D[49] (µg/day) EAR (RDA/AI)[a]	Calcium[50] (mg/day) AR (RDA)	Iron[51] (mg/day) AR (RDA)	Iodine[52] (µg/day) EAR (RDA)[a]	Zinc[53] (mg/day) AR (RDA)
1–3	205 (250)	10 (15)	390 (450)	5 (7)	65 (90)	3.6 (4.3)
4–6	245 (300)	10 (15)	680 (800)	5 (7)	65 (90)	4.6 (5.5)

RE: Retinol Equivalent; AI: Adequate Intake (EFSA); AR: Average Requirement (EFSA); EAR: Estimated Average Requirement (IOM); RDA: Recommended Dietary Allowance (EFSA).
[a]IOM EAR and RDA, and EFSA AI.

The micronutrients examined were:

- *Vitamin A* – an important nutrient for visual development and maintenance. For young children in Ireland, adequacy is generally not an issue due to the amount of milk and animal products consumed in the diet. However, the Tolerable Upper Intake Level (UL) for vitamin A is close to the RDA for this age group. In other words, the RDA levels which are more than enough for virtually all healthy people in a population group are 250 µg RE/day and 300 µg RE/day, and the ULs are 800 µg RE/day and 1100 µg RE/day for 1–3 year-olds and 4–5 year-olds, respectively. As the child gets older, the gap between the RDA and UL gets larger; however, the gap is much smaller between these levels for younger children, which can result in younger children exceeding the UL. Therefore, the modelling of the food intake patterns included assessment of vitamin A intakes in order to examine how many individuals could be expected to exceed the UL from food intakes alone and by what extent.
- *Vitamin D* – has a key role in the regulation of calcium and phosphorus metabolism and is a critical nutrient for healthy bone growth in childhood. Vitamin D is unlike other vitamins in that there are two sources of intake: sun exposure and diet.

  The first source, skin intake from sun exposure, occurs through the action of ultraviolet B (UVB) rays on the skin. These particular UVB rays (290–320 nm) are only present during the summer months in Ireland. Due to Ireland's location (between latitudes 51° and 55° North), little or no vitamin D can be produced from the weaker sunlight during the winter months, i.e. October to March. For skin cancer prevention, individuals are advised to use sunscreen (SPF 15 blocks more than 95% of UVB 290–320 nm rays) and to stay out of direct sunlight. Nonetheless, studies have shown that children using sunscreen have better vitamin D status, which possibly indicates that the higher use of sunscreen by these children is associated with more time outdoors.[54, 55] Several studies have also shown that vitamin D status in the population, including children, is significantly better during the summer months compared with the winter months.[56, 57]

The second source of vitamin D is diet, either from foods that are naturally rich in vitamin D or fortified with vitamin D, or from vitamin D-containing supplements. There are very few natural food sources of vitamin D – e.g. oily fish, liver and egg yolks – and such foods are not commonly eaten. Therefore, dietary intakes of vitamin D have been very low until recent years when, due to the increased interest in vitamin D as a nutrient of public health importance, there has been a growing number of foods fortified with vitamin D. The main foods fortified with vitamin D include breakfast cereals, yogurts and milks. Another dietary source of vitamin D is food supplements. However, while vitamin D requirements are relatively low, some supplements can provide very high amounts of vitamin D.

The dietary recommendation for vitamin D of 10 µg/day[49] does not take into account vitamin D intake from sunlight, as it is not possible to quantify sunlight exposure due to the number of factors that affect vitamin D synthesis in the skin. Overall, vitamin D intakes in the population are inadequate. However, studies that examine blood status show that actual vitamin D status is higher than would be expected, indicating the importance of vitamin D intake from sunlight.[54, 55]

The NPNS indicated that inadequate vitamin D intakes were very prevalent; however, there were no blood data with which to assess actual status. The EAR of 10 µg and the RDA of 15 µg for vitamin D intakes in children aged 1–5 years assumes no exposure to sunlight. Unlike in the case of vitamin A, there is a large gap between these dietary requirements (EAR 10 µg and RDA 15 µg) and the UL (50 µg/day). Nonetheless, the modelling of food intake patterns in order to assess the adequacy of vitamin D dietary intakes also assessed the risk of exceeding the UL when consuming vitamin D-fortified milks in addition to vitamin D-fortified foods.

- *Calcium* – important for the formation and maintenance of healthy teeth and bones. Calcium intakes in this age group are generally not an issue in children who consume cow’s milk.
- *Iron* – essential micronutrient required for almost all metabolic pathways in the body. The NPNS identified iron as a nutrient at risk of inadequacy in this age group.

Prolonged iron deficiency in early childhood – with or without anaemia – is associated with poorer cognitive, motor and behavioural outcomes, which can persist into adulthood.[58, 59]

- *Iodine* – necessary for optimum cellular metabolism, growth, and psychomotor and physical development and function. There are uncertainties about iodine nutrition in young children from the risk of both under- and overexposure.[60] The UL for iodine (200 µg/day and 250 µg/day for 1–3 year-olds and 4–5 year-olds, respectively) is close to the RDA (90 µg/day for 1–5 year-olds). Therefore, the modelling of the food intake patterns included assessment of iodine intakes in order to examine the risk of exceeding the UL and how much the UL could be exceeded by.
- *Zinc* – crucial for growth and development through facilitation of several enzymatic processes and the formation of the structure of proteins and enzymes. It has been reported elsewhere that zinc may be an issue in this age group in terms of dietary intakes exceeding the UL of 7 mg/day. Therefore, the modelling of the food intake patterns included assessment of zinc intakes in order to examine the risk of exceeding the UL and how much the UL could be exceeded by.

Further information on each of these micronutrients can be found in Appendix I.

Food goals

The 4-day food intake patterns were developed in terms of energy requirements, as these are the critical determinant of total food intake. The 4-day food intake patterns were based on an omnivore diet. These dietary patterns are in line with the guiding principles (outlined in Section 3.2.1) of minimal added sugar and fat (including saturated fat), no added salt and no processed meat.

Meat

Red meat is recommended for this age group, as it is one of the best sources of bioavailable iron. Processed meat, however, is not recommended for this age group for a variety of reasons, such as its high salt content, generally high fat content and its links with colorectal cancer. Processed meat is defined as meat that has been transformed through salting, curing, fermentation, smoking, or other processes in order to enhance flavour or improve preservation, e.g. hot dogs (frankfurters), ham, sausages, bacon and salami.[61] Processed meat contains additives known as nitrites and nitrates which are endogenous forms of Nnitroso compounds, which are known carcinogens.[62-66] The recent World Cancer Research Fund International[61] report concluded that there is probable evidence that processed meat causes colorectal cancer. According to the most recent National Cancer Registry statistics,[67] colorectal cancer is the third most common form of cancer in Ireland, accounting for 11% of cancers in women and 14% of cancers in men, and is the second most common cause of death from cancer. This report recommends that adult red meat consumption be limited to 350–500 g a week in order to obtain the benefits of red meat (essential macro- and micronutrients) while avoiding the increased risk of colorectal cancer, and that processed meat should be avoided. It should also be noted that under EU food law, additives and preservatives present in processed meat are not permitted to be included in foods for young children[v]. These issues notwithstanding, processed meat, in the form of bacon and ham, is widely consumed by 1–5 year-olds in Ireland (40% of 1 year-olds consume about one-third of a portion per day while 69% of 4 year-olds consume half a portion per day). Advice to replace such processed meat with other protein sources is a key recommendation of paediatric and community dietitians involved in providing services for 1–5 year-old children in Ireland (see Section 3.3). Considering all these issues, processed meat was not included in the dietary modelling of food intake patterns for 1–5 year-old children.

Added sugar and fat

Minimal added sugar was defined as avoidance of sugary foods or drinks that only provide energy – for example cake, biscuits, confectionery, soft drinks, sugar-sweetened juices, etc. Nonetheless, small amounts of sugar were added to foods such as stewed fruit and milk-based puddings in order to increase acceptability of the flavours and textures provided by these foods, which can be part of healthy eating habits. Minimal added fat was defined as no fried foods and no oil added to foods; however, foods such as thick-cut oven chips were included very occasionally.

Food groups

Foods used were grouped into the five food groups used for those aged 5 years and older. These include: (1) vegetables, salad and fruit; (2) wholemeal cereal and breads, potatoes, pastas and rice; (3) milk, yogurt and cheese; (4) meat, poultry, fish, eggs, beans, and nut

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[v] Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives available at https://eur-lex.europa.eu/eli/reg/2008/1333/oj/eng

butters/nut spreads;[vi] and (5) fats, spreads and oils. Foods that are not necessary for a healthy diet and that need to be minimised due to a high content of sugar, fat and/or salt are grouped into a sixth food group. In the food pyramid for those aged 5 years and older, this sixth group is shown as being separate from the five food groups required for healthy eating. As 1–5 year-olds have a very limited capacity for food intake and high nutritional requirements, the impact of such foods in the diets of these children was examined in the modelling.

Vegetarian diet

A vegetarian diet was also modelled for all 1–5 year-olds. This was restricted to two milk types, as the main objective was to examine the impact of replacing meat, poultry and fish intakes with vegetarian protein sources. Therefore, this modelling was carried out for 1–2 year-olds who were breastfed (in line with Department of Health policy) and 3–5 year-olds fed on low-fat cow's milk (which is recommended in this report).

3.3 The modelling process used to develop healthy eating guidelines for 1–5 year-olds in Ireland

Four-day food intake patterns (including one weekend day) were developed to represent dietary intakes for each child in the modelling sample (see Figure 3.2). In order to ensure that the food intake patterns generated were as close to the usual diet as possible, the NPNS[(12)] database was analysed using SPSS (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). Analysis was carried out to identify the mean daily intakes of each food item. This was undertaken only for those who chose to consume the particular food item (excluding non-consumers is important to avoid reducing the amounts of food items actually consumed). In addition, the proportion of children surveyed in the NPNS choosing each food was also determined. Only foods consumed by 10% or more of consumers were used in modelling food intake patterns at each age time point. The NPNS database also provided the times that the foods were consumed. These times were used to identify what foods were consumed at each eating occasion (i.e. breakfast, lunch, dinner and snacks). For the purposes of this work, and following the approach taken by Gaal *et al.*,[(68)] breakfast was defined as all food and drinks consumed between 6.00am and 11.00am; lunch was defined as all food and drinks consumed between 12.00pm and 2.00pm; dinner was defined as all food and drinks consumed between

[vi] Whole nuts are not recommended for this age group as they pose a risk of choking.

5.00pm and 8.00pm; and snacks were defined as all food and drinks consumed between 11.00am and 12.00pm, 2.00pm and 5.00pm, and 8.00pm and 6.00am. Eating occasions were analysed to identify foods consumed by 10% or more of consumers at each eating occasion for each age time point.

In order to provide context to the NPNS data, a questionnaire was provided and a focused discussion was held with paediatric and community dietitians working with 1–5 year-olds in Ireland on a daily basis. The dietitians also provided information on adjustments they have to make to meals for this age group, such as using lean meat instead of processed meat and switching to wholemeal bread and pasta. The questionnaire was circulated to dietitians on the Irish Nutrition and Dietetic Institute Paediatric Interest Group mailing list (*n*104) and community dietitians in the Community Health Organisation Region 5 Group (*n*12). Only those working with the 1–5 year-old age group were asked to respond. Seven dietitians working specifically with this age group initially responded to the questionnaire and provided detailed information. A meeting was then held with the paediatric and community dietitians to allow for a focused discussion on the information gathered from those who had completed the questionnaire. This meeting, attended by 24 dietitians, also provided an opportunity to obtain any other information not captured in the questionnaire. Three additional questionnaire responses were received after the focused discussion group meeting. In total, 34 responses were received from both the questionnaire and the focused discussion group meeting combined.

The amounts and types of foods used in the modelling of 4-day food intake patterns were determined by the energy goal, which had to be accommodated in all the finalised food intake patterns. The energy requirements varied according to the body weight of the child. Therefore, modelling of dietary intakes of children representing different growth percentiles (as described in Section 3.2.2) provided a very comprehensive assessment of nutritional needs at each age.

Advice and guidance on every stage of developing the food intake patterns was provided by two senior dietitians with extensive paediatric experience; one in clinical paediatric dietetics and one in population and public health. The established food goals, including daily milk intakes of approximately 550 mL (with some of this replaced by yogurt and cheese – see Section 3.2.3 for more details), were incorporated into the food intake patterns for every age.

These food intake patterns were inputted into food nutrient composition analysis software (Nutritics, Research Edition v5.042) and examined to determine whether the food intake patterns met the nutritional goals (as outlined in Section 3.2.4). The results, in terms of nutritional intakes obtained from the food intake patterns, were reviewed by the research team and the two senior dietitians in order to ensure that: (1) the foods used were suitable and the amounts were appropriate, and (2) the nutrient goals were achieved. The amounts and types of foods were changed on an iterative basis until the food intake patterns achieved most of the food and nutrient goals.

Where nutritional issues were identified, a 'food-first' approach, as opposed to the use of dietary supplements or fortified milks, was used first in order to try to rectify the nutritional issues. Patterns achieving the nutritional goals were used to identify good food sources of certain nutrients, such as iron and vitamin D. These foods were then included more frequently in the food intake patterns that were providing inadequate amounts of those nutrients. For example, some iron-fortified breakfast cereals were identified as a good source of iron. Therefore, a scan of the Irish market was carried out and five products were identified as being equivalent and available in Ireland. An average of these five iron-fortified breakfast cereals was then included in the food intake patterns to increase iron intakes in the patterns that were providing inadequate amounts of iron. This food-first approach was important, as eating solid foods enables children to develop their oral motor skills and fine motor skills. In addition, the nutrients found in solid foods are also generally more bioavailable and easily absorbed by the body. In total, there were 640 iterations of the 4-day food intake patterns (a breakdown of these food intake patterns is outlined in Appendix II, Table 9). The modelling process is outlined in Figure 3.4.

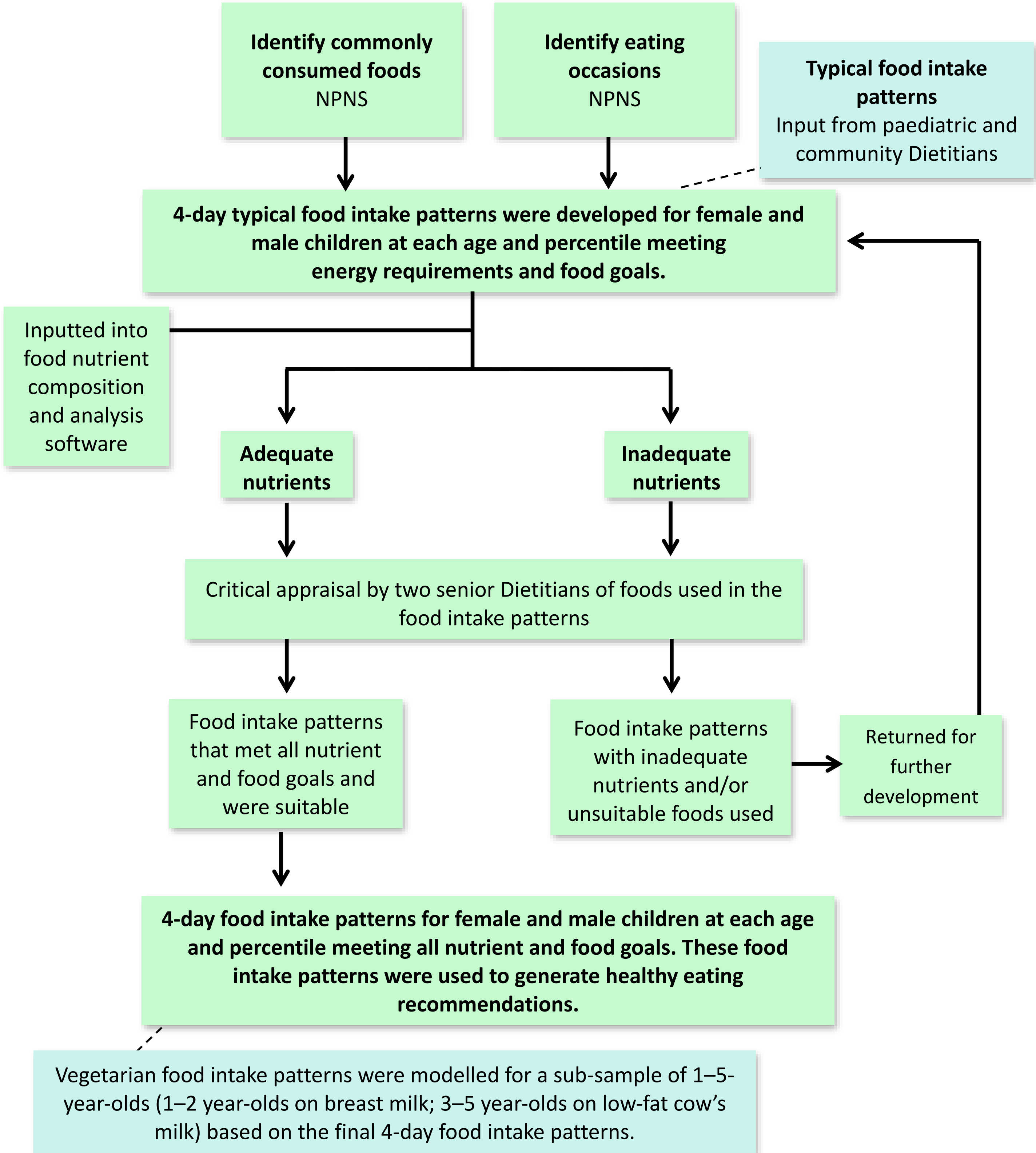

Figure 3.4 The modelling process used to develop healthy eating guidelines for 1–5 year-old children in Ireland

4. RESULTS, DISCUSSION AND RECOMMENDATIONS FROM THE MODELLING OF FOOD INTAKE PATTERNS FOR HEALTHY 1 TO 5 YEAR-OLD CHILDREN IN IRELAND

4.1 Who is at risk of dietary inadequacies?

Results of the modelling show that children of smaller body size are most at risk of micronutrient deficiencies, especially iron and vitamin D. Smaller children, in the context of this work, are defined as those in the youngest age range, i.e. 1–3 years, who are growing along the ≤25th percentile levels on the growth charts. It is worth noting that in Ireland, the average birth weight of infants is 3.6 kg[(69)] with the average male birth weight falling between the 50th and 75th percentiles and the average female birth weight falling on the 50th percentile of the WHO growth charts.

Modelling food intake patterns for all older children (aged 4–5 years) and those of larger body size (>25th percentile level) in the 1–3 year-old age group yielded adequate nutrient intakes, with the exception of vitamin D intake based on oral-derived intake alone.

4.2 Why were children of smaller body size most at risk?

The daily goals for adequate micronutrient intakes are the same for all children aged 1–3 years, i.e. they are absolute values and do not take into consideration variation in body size. Therefore, smaller children (≤25th percentile level) with a lower capacity for food intake will be more at risk of failing to meet micronutrient goals. As children become older, or are bigger in terms of growth percentiles, their energy requirements are higher (see Table 3.3 in Section 3.2.4) resulting in a greater capacity for food intake. Higher food intakes make it easier to achieve micronutrient goals. Thus, among younger children, those growing along the lower growth percentiles (≤25th percentile level) have lower energy requirements and lower capacity for food intake, which increases their risk of micronutrient deficiencies.

4.3 Macronutrients provided by food intake patterns modelled for a sample of children aged 1–5 years representing the range of healthy growth percentiles and the development of food-based dietary guidelines

The average daily macronutrients achieved from the finalised food intake patterns are outlined in Tables 4.1 and 4.2, for 1–3 year-olds and 4–5 year-olds, respectively. The finalised patterns are those where food intakes were iteratively adjusted in order to ensure the most adequate intake of all micronutrient goals examined, including those identified as problematic (iron and vitamin D) (see Section 4.4). As can be seen in Tables 4.1 and 4.2, the modelled food intake patterns for 1–3 year-olds yielded different macronutrient intakes compared with those of 4–5 year-olds.

Milk is a key food for children in the 1–5 year-old age group and was provided as 550 mL/day to all children regardless of age or body size (i.e. percentile level). Some of this milk was given as yogurt or cheese (see Table 3.2 in Section 3.2.3). This meant that the modelled diets for 1–3 year-olds were proportionately higher in milk intakes, particularly at the younger ages, in comparison with those for 4–5 year-olds. The modelling work on food intake patterns for 1–5 year-olds demonstrates that milk is a key source of protein and calcium (see Section 4.4). Nut and plant 'milks' (e.g. almond 'milk', rice 'milk', coconut 'milk') represent examples of milk replacement beverages. This raises concerns for the dietary adequacy of protein and calcium for 1–5 year-old children who are not given milk (or a fortified plant-based 'milk' alternative, e.g. soya 'milk', which is fortified to be equivalent to breast or cow's milk in terms of protein and calcium).

Protein intakes were well above the requirement per kilogram of body weight per day. This is also the case for protein intakes in the general population older than 5 years of age in Ireland and most developed countries.

At all ages, fat intakes were well within the recommended range. As expected, fat intakes were highest at 1 year of age and progressively decreased as age increased. After the age of 2 years, reduced-fat (1.5%) cow's milk (fortified and non-fortified) was modelled, as this is in line with dietary guidance in other developed countries experiencing high rates of childhood obesity.[70] The modelling process demonstrated that the use of low-fat cow's milk does not impact negatively on nutritional adequacy. Nonetheless, modelling of full-fat cow's milk demonstrated that where increasing calories is a priority (e.g. for picky eaters), full-fat cow's milk can be used, prioritising the achievement of energy requirements over a reduction in saturated fat intakes. The diet at 1 year of age is naturally high in saturated fat, therefore the saturated fat intakes shown in Table 4.1 were in line with expectations. As stated in Section 3.2.4, one of the nutritional aims of the modelling process was to maintain saturated fat intakes as low as possible within a nutritionally adequate diet so that, by the age of 5 years, saturated fat intakes approach the goal of ≤10% energy. As can be seen in Table 4.2, the saturated fat intakes from the modelled food intake patterns followed this guidance. Saturated fat intakes from the modelled food intake patterns of 5 year-olds were slightly higher than the 10% energy goal, in line with recent observations from modelling work on dietary intakes among 2–5 year-old children internationally (personal communication, Mary Flynn Public Health Nutrition Food Safety Authority of Ireland, 2018). As shown in Tables 4.1 and 4.2, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) intakes from the modelled food intake patterns were inadequate for all except 1 year-olds receiving approximately 400 mL of breast milk/day (very few 1 year-olds in Ireland receive this much breast milk). From February 2020, new EU legislation[vii] will increase DHA in follow-up formula on a mandatory basis which is likely to prompt an increase in the DHA content of young child formula. Apart from breast milk and fortified formula milks, the main source of DHA and EPA is fish, especially oily fish. However, in order to meet a lower threshold of dioxin contaminants found in fish, particularly oily fish, it is recommended that oily fish only be included in the diet once (rather than twice) a week. This subsequently reduced the levels of DHA and EPA in the diet.

Overall carbohydrate intakes for 1–3 year-olds tended to be at the lower end of the recommended range, but this increased as age increased. The modelled food intake patterns easily provided adequate fibre at recommended intakes according to the American Health Foundation goal of 'age + 5 g/day'[(43)] used for this work. The average fibre intakes for 1–3 year-olds and 4–5 year-olds were 10 g/day and 20 g/day, respectively. These fibre intakes are also in line with EFSA-recommended intakes of 10 g/day for 1–3 year-olds and 14 g/day for 4–8 year-olds. Foods used in the food intake patterns included a mixture of wholemeal and

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[vii] Commission Delegated Regulation (EU) 2016/127. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R0127&from=EN.

refined cereals. Daily amounts of vegetables and fruit increased gradually with age. This demonstrates differences in food-based dietary guidelines for this age group compared with the general population aged 5 years and older, where only wholemeal cereals, breads, etc. are advised. Food-based dietary guidelines for the population aged 1–5 years need to advise how adequate fibre can be achieved without overwhelming the child's capacity for intake of other foods. Nonetheless, these guidelines on fibre can be adjusted to be more in line with those of the general population aged 5 years and older for children who may, for a variety of reasons, have higher requirements (e.g. those who are more prone to constipation).

Free Sugar intakes for all food intake patterns modelled for 1–5 year-olds were within the WHO recommendation of <10% of total energy, and many met or approached the further recommended limit of 5% of total energy. Minimal amounts of Free Sugar were used in the modelled food intake patterns in order to add palatability to nutrient-dense foods, e.g. sugar in stewed fruit and milk-based puddings, jam on wholemeal bread, etc. The age range of 1–5 years is a critical period for introducing foods with different textures and flavours that are part of a healthy, balanced and varied diet in order to ensure that such foods become acceptable.

An inverse relationship exists between fat and sugar intakes,[(71)] and this also extends to saturated fat.[(72)] This was observed in this modelling work on food intake patterns for 1–5 year-old children. Tables 4.1 and 4.2 show that as age increases, Free Sugar intake increases, and saturated fat intake decreases. This suggests that very low Free Sugar intakes may only be achieved at the expense of higher fat and saturated fat intakes.

Table 4.1 Mean daily macronutrients provided by modelled food intake patterns for a hypothetical sample of 1–3 year-olds[a] in Ireland after food intake patterns had been adjusted[b] to meet micronutrient goals

Macronutrients	**1–3 year-olds (*n*40)**	1 year-olds[c] (*n*10)	1.5 year-olds[d] (*n*10)	2 year-olds[d] (*n*10)	3 year-olds[e] (*n*10)
Protein (g/kg body weight)	**3.6**	3	3.8	3.9	3.7
Goal (RDA)	***1.0***	*1.14*	*1.03*	*0.97*	*0.9*
Fat (% energy)	**35**	40	37	37	28
Goal (RI)	***35–40***	*35–40*	*35–40*	*35–40*	*35–40*
Saturated fat (% energy)	**17**	18	18	19	12
Goal	***As low as possible***	*As low as possible*	*As low as possible*	*As low as possible*	*As low as possible*
DHA (mg)[f]	**114**	125	103	-	-
Goal (AI)	***100***	*100*	*100*	-	-
DHA + EPA (mg)	**104**	-	-	84	124
Goal (AI)	***250***	-	-	*250*	*250*
Carbohydrate (% energy)	**47**	45	45	44	54
Goal (RI)	***45–60***	*45–60*	*45–60*	*45–60*	*45–60*
Total sugar (% energy)	**24**	26	22	21	26
Free Sugar (% energy)	**5**	3	4	4	7
Goal[g]	***≤10***	*≤10*	*≤10*	*≤10*	*≤10*
Fibre (g)	**10**	7	9	10	14
Goal (age + 5 g/day)[h]	***6.9***	*6*	*6.5*	*7*	*8*

RI: Reference Intake (EFSA); RDA: Recommended Dietary allowance (EFSA); AI: Adequate Intake (EFSA)

[a] Hypothetical sample of 1–3 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1–3 years.

[b] Adjusted = iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week and red meat (30 g) approximately 3 days a week.

[c] Modelled on breast milk.

[d] Modelled on a mixture of breast milk and whole cow's milk.

[e] Modelled on low-fat cow's milk.

[f] For 1 and 1.5 years of age, the goal is for DHA only; there is no DHA + EPA goal for 1 and 1.5 year-olds. The DHA + EPA goal only applies to those aged ≥2 years.

[g] WHO recommendation for adults and children.

[h] American Health Foundation goal.

Table 4.2 Mean daily macronutrients provided by modelled food intake patterns for a hypothetical sample of 4–5 year-olds[a] in Ireland

Macronutrients	**4–5 year-olds (*n*20)**	4 year-olds[b] (*n*10)	5 year-olds[b] (*n*10)
Protein (g/kg body weight)	**4**	3.8	3.5
Goal (RDA)	***0.85***	*0.85*	*0.85*
Fat (% energy)	**27**	29	26
Goal (RI)	***20–35***	*20–35*	*20–35*
Saturated fat (% energy)	**13**	13	12
Goal	***As low as possible***	*As low as possible*	*As low as possible*
DHA + EPA (mg)	**108**	131	85
Goal (AI)	***250***	*250*	*250*
Carbohydrate (% energy)	**55**	53	56
Goal (RI)	***45–60***	*45–60*	*45–60*
Total sugar (% energy)	**29**	27	31
Free Sugar (% energy)	**6**	6	6
Goal[c]	***≤10***	*≤10*	*≤10*
Fibre (g)	**19**	17	21
Goal (age + 5 g/day)[d]	***9.5***	*9*	*10*

RI: Reference Intake (EFSA); RDA: Recommended Dietary Allowance (EFSA); AI: Adequate Intake (EFSA)
[a] Hypothetical sample of 4–5 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 4 and 5 years.
[b] Modelled on low-fat cow's milk.
[c] WHO recommendation for adults and children.
[d] American Health Foundation goal.

4.4 Micronutrients identified as problematic and the approaches used to address these

The average intakes of micronutrients for 1–3 year-olds and 4–5 year-olds from the initial food intake patterns modelled are shown in Tables 4.3 and 4.4, respectively. The initial food intake patterns are those which were developed to be as close as possible to the usual diet using information gathered from the NPNS and the paediatric and community dietitians (as described in Section 3.3). Calcium intakes for all 1–5 year-olds were adequate due to the volume of milk being consumed by this age group (see Section 4.3 for more details). Intakes of zinc, iodine and vitamin A were also adequate for all 1–5 year-olds, with no age group exceeding the UL for any of these micronutrients.

As can be seen in Tables 4.3 and 4.4, iron (for 1–2 year-olds) and vitamin D (for all children aged 1–5 years) were the problem nutrients where inadequate intakes were identified. A more detailed examination of iron and vitamin D, and the iterative changes to the food intake patterns that were made in order to address the inadequate intakes, are outlined in the following sections (4.4.1 and 4.4.2).

Table 4.3 Mean daily micronutrients provided by modelled food intake patterns for a hypothetical sample of 1–3 year-olds[a] in Ireland: (a) *before* and (b) *after* adjusting to correct iron intakes

Micronutrients	**1–3 year-olds (*n*40)**	1 year-olds[b] (*n*10)	1.5 year-olds[c] (*n*10)	2 year-olds[c] (*n*10)	3 year-olds[d] (*n*10)
Before; Calcium (mg)	**546**	362	518	512	791
After; Calcium (mg)	**661**	392	650	812	790
Goal (AR)	***390***	*390*	*390*	*390*	*390*
Before; Iron (mg)	**5**	3	4	4	7
After; Iron (mg)	**6**	5	6	6	6
Goal (AR)	***5***	*5*	*5*	*5*	*5*
Before; Zinc (mg)	**4.7**	3.6	4.2	4.6	6.4
After; Zinc (mg)	**4.7**	3.5	4.4	5	5.7
Goal (AR)	***3.6***	*3.6*	*3.6*	*3.6*	*3.6*
Before; Iodine (µg)	**93**	71	77	80	146
After; Iodine (µg)	**111**	60	107	140	139
Goal (EAR)	***65***	*65*	*65*	*65*	*65*
Before; Vitamin A (µg)	**340**	366	351	420	224
After; Vitamin A (µg)	**290**	332	299	323	206
Goal (AR)	***205***	*205*	*205*	*205*	*205*
Before; Vitamin D (µg)	**2**	2	2	2	4
After; Vitamin D (µg)	**2**	2	2	1	3
Goal (EAR)	***10***	*10*	*10*	*10*	*10*

Before = Food intake patterns developed using information gathered from the NPNS and focused discussion with Expert Group of Registered Dietitians (paediatric and community dietitians specialising in managing nutritional issues for 1–5 year-olds); including red meat up to 3 days a week and excluding processed meats and foods high in fat, sugar and salt; and containing no added salt and minimal added sugar and fat.
After = Food intake patterns further adjusted to include iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week and red meat (30 g) approximately 3 days a week.
AR: Average Requirement (EFSA); EAR: Estimated Average Requirement (IOM)
[a] Hypothetical sample of 1–3 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1–3 years.
[b] Modelled on breast milk.
[c] Modelled on a mixture of breast milk and whole cow's milk.
[d] Modelled on low-fat cow's milk.

Table 4.4 Mean daily micronutrients provided by modelled food intake patterns for a hypothetical sample of 4–5 year-olds[a] in Ireland

Micronutrients	**4–5 year-olds (*n*20)**	4 year-olds[b] (*n*10)	5 year-olds[b] (*n*10)
Calcium (mg)	**1124**	1118	1129
Goal (AR)	***680***	*680*	*680*
Iron (mg)	**9**	8	10
Goal (AR)	***5***	*5*	*5*
Zinc (mg)	**7.5**	7.1	7.9
Goal (AR)	***4.6***	*4.6*	*4.6*
Iodine (µg)	**212**	200	225
Goal (EAR)	***65***	*65*	*65*
Vitamin A (µg)	**291**	303	279
Goal (AR)	***245***	*245*	*245*
Vitamin D (µg)	**3**	4	2
Goal (EAR)	***10***	*10*	*10*

AR: Average Requirement (EFSA); EAR: Estimated Average Requirement (IOM)
[a] Hypothetical sample of 4–5 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 4 and 5 years.
[b] Modelled on low-fat cow's milk.

4.4.1 Adjustments to ensure adequate iron

Food-based approaches

Iron intakes provided by the food intake patterns modelled were inadequate only for children aged 1–3 years[viii], but adequate for the older children aged 4–5 years (see Figure 4.1a). For those aged 4–5 years, iron intakes were adequate due to their higher energy needs and greater capacity for food intake. Therefore, food intakes were only adjusted for the younger children's food intake patterns.

Two key foods rich in iron were identified from the modelled food intake patterns. These were red meat and breakfast cereals fortified with iron to a level of ≥12 mg/100 g. The fortified breakfast cereals that provide this level of iron were identified and used in the adjustment of food intake patterns.

The first adjustment to increase iron intakes in those aged 1, 1.5 and 2 years involved including a small portion (30 g) of red meat on 2 out of the 4 days modelled (i.e. translating into 3 of 7 days a week). However, this adjustment only increased iron intakes slightly (by

[viii] Although 3 year-olds had adequate iron intakes, 1–3 year-olds as a whole were grouped together to cover 2 year-olds up to the age of 3 years

approximately 0.3 mg/day on average) and did not resolve the issue. The second adjustment to increase iron intakes involved including an iron-fortified (12 mg of iron/100 g) breakfast cereal (30 g) on 3 out of the 4 days modelled (i.e. translating into 5 of 7 days a week). The inclusion of fortified breakfast cereal at this level had a more significant effect, increasing average iron intakes by almost 1 mg/day. Finally, the combination of including both red meat on 2 out of the 4 days (i.e. 3 of 7 days a week) and an iron-fortified (12 mg of iron/100 g) breakfast cereal (30 g) on 3 out of the 4 days (translating into 5 of 7 days a week) was modelled. However, this combination did not resolve the iron issue for children aged 1–3 years growing at the lower percentiles, i.e. ≤25th percentile level (see Figure 4.1b).

Impact of different milks on iron intake

In terms of the different milks modelled in the food intake patterns, there was very little difference in iron between children on breast milk and those on whole cow's milk. This is because both breast milk and whole cow's milk contain minimal amounts of iron (0.07 mg/100 mL and 0.02 mg/100 mL, respectively).

For 1 year-olds, the use of a follow-up formula fortified with iron (1 mg/100 mL with an average consumption of 442 mL/day), along with the inclusion of an iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week and red meat (30 g) 3 days a week, resulted in adequate iron intakes (above the AR and at or above the RDA) for all children (see Figure 4.2). Similar to the impact of follow-up formula, the use of young child formula fortified with iron (1.2 mg/100 mL with an average consumption of 330 mL/day) for 1.5, 2 and 3 year-olds resulted in adequate iron intakes for all children (see Figure 4.3). An average iron intake of 4 mg/day was derived from these fortified milks (with 442 mL of follow-up formula per day for 1 year-olds and 330 mL young child formula per day for 1.5 –3 year-olds), indicating that this amount of iron would address the inadequate intakes identified in 1–3 year-olds.

Approaches to address iron inadequacy in smaller children aged 1–3 years (those growing along ≤25th percentile level)

An additional 4 mg of iron/day, through the use of an iron-fortified milk, was included in the food intake patterns of smaller children (i.e. 1–3 year-olds growing at ≤25th growth percentile level) and this resulted in adequate intakes for all children (see Figures 4.2 and 4.3). Adequate iron intakes in these smaller children were also achieved by the inclusion of a supplement providing the RDA for iron (7 mg) 4 days a week (Figure 4.4).

Conclusions

The final adjustment to the food intake patterns to include both an iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week and red meat (30 g) 3 days a week, as described above, resolved the iron issue for all children except those aged 1–3 years growing at the lower percentiles, i.e. ≤25th percentile level (see Figure 4.1b). An additional 4 mg of iron/day, through the use of a low-dose iron supplement providing the RDA for iron[ix] (7 mg) given 4 days a week, resulted in these smaller children achieving an adequate daily intake of iron. Alternatively, an iron-fortified milk (providing approximately 1.2 mg of iron/100 mL), would also ensure an adequate intake of iron among children at risk (i.e. aged 1–3 years growing at ≤25th percentile level).

[ix] Current availability of low-dose iron supplements for this age group (at the RDA of 7 mg) is very limited.

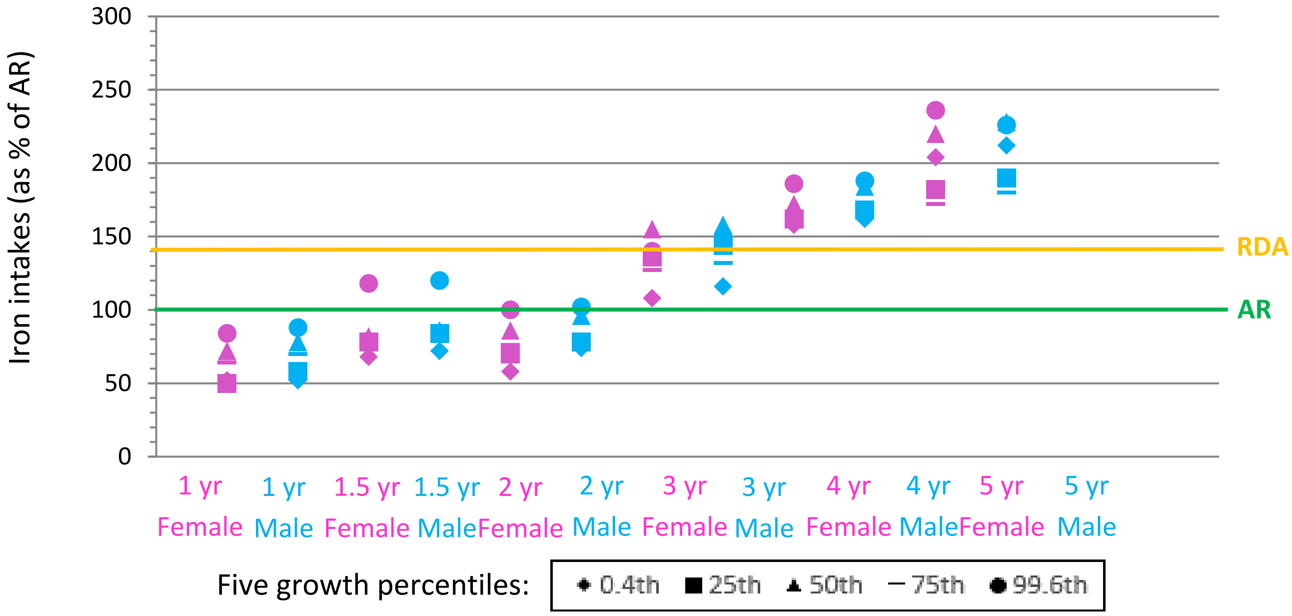
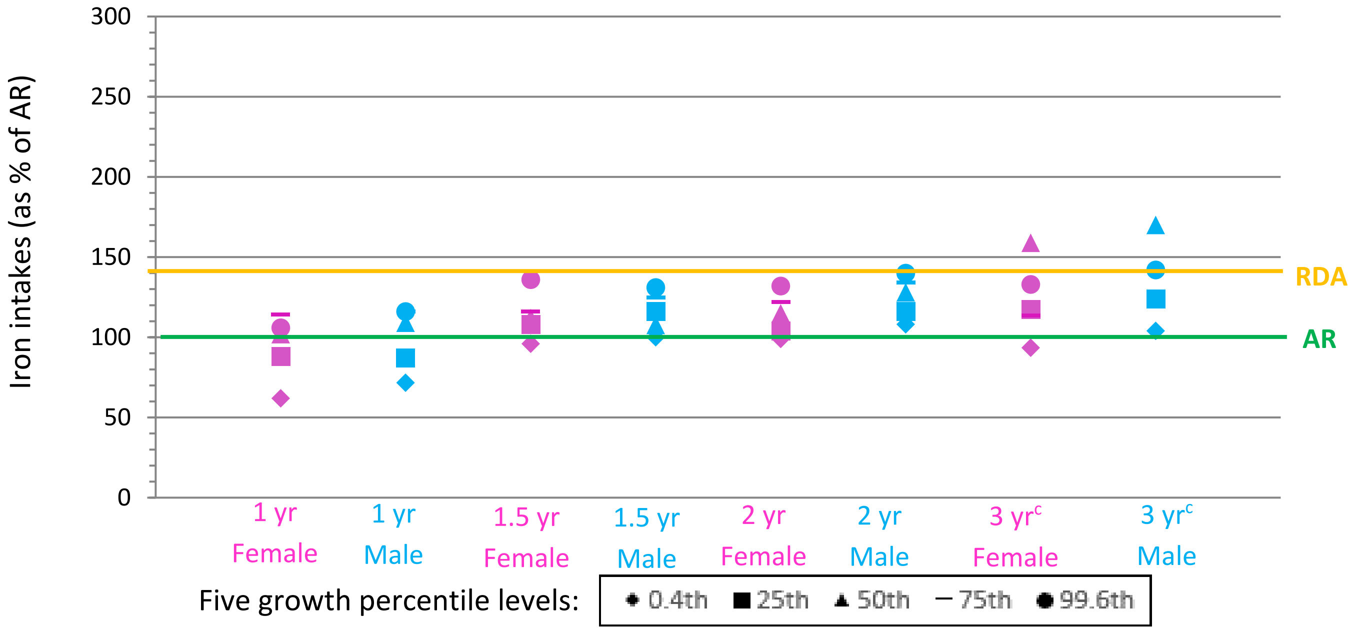


Figure 4.1 Mean daily iron intakes as % AR provided for a hypothetical sample[a] of males and females aged 1–5 years, growing along five growth percentiles (a) *before* and (b) *after* adjusting food intake patterns of 1–3-year-olds to increase iron intake[b]

(a) ***Before, showing data for 1–5 year-olds***



(b) ***After adjusting food intake patterns to increase iron intake, showing data for 1–3 year-olds***

AR: Average Requirement (EFSA); RDA: Recommended Dietary Allowance (EFSA) shown for reference

[a] Hypothetical sample of 1–5 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1–5 years

[b] Iron was increased by including an iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week and red meat (30 g) approximately 3 days a week.

[c] 3 year-olds' food intake patterns were not adjusted to increase iron-rich foods, but values are shown to indicate the effect of increasing iron-rich foods for those aged 1, 1.5 and 2 years.

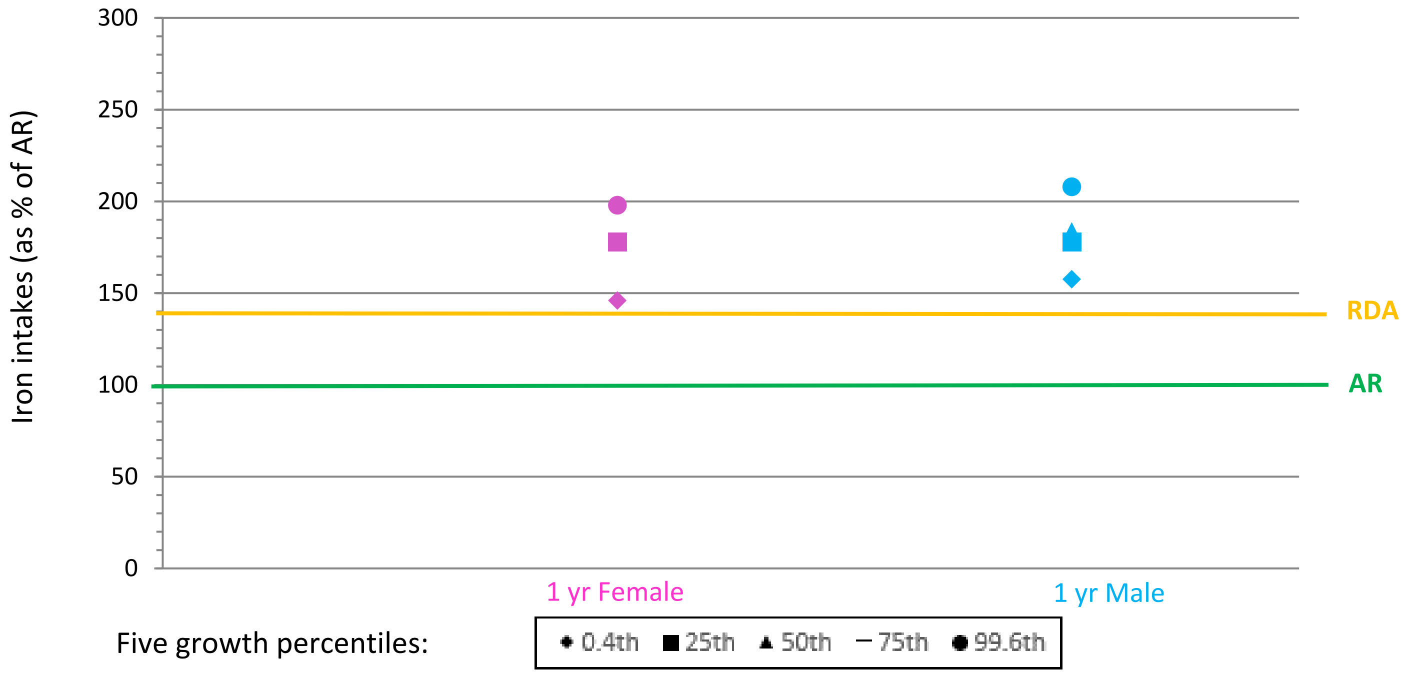


Figure 4.2 Mean daily iron intakes as % AR provided for a hypothetical sample[a] of males and females aged 1 year growing along five growth percentiles, including iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week, red meat (30 g) approximately 3 days a week, and a follow-up formula (1 mg/100 mL)[b]

AR: Average Requirement (EFSA); RDA: Recommended Dietary Allowance (EFSA) shown for reference
[a] Hypothetical sample of 1 year-olds: 10 male and female children representing five percentiles within the healthy range on UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th).
[b] Average consumption of follow-up formula was 442 mL/day.

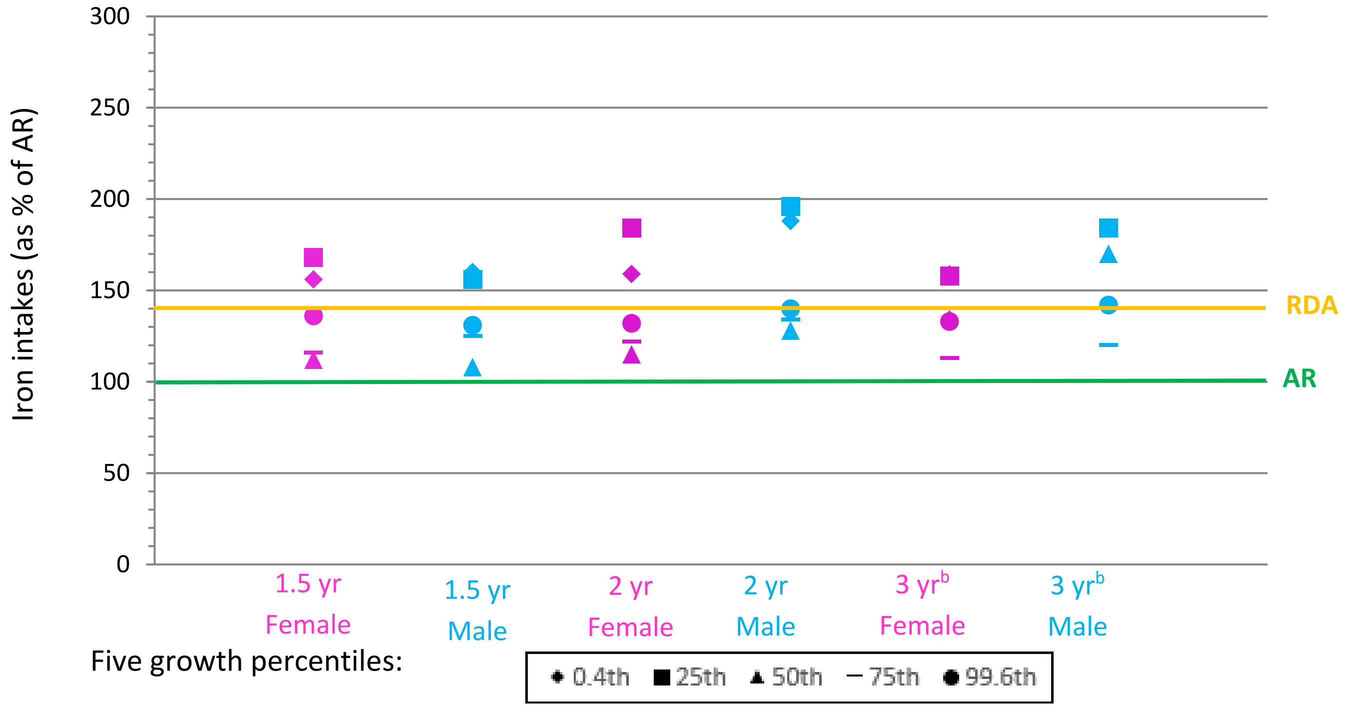


Figure 4.3 Mean daily iron intakes as % AR provided for a hypothetical sample[a] of males and females aged 1.5–3 years, growing along five growth percentile levels including iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week, red meat (30 g) approximately 3 days a week and a young child formula (1.2 mg/100 mL) or iron-fortified milk (1.3 mg/100 mL)[c] for smaller children aged 1.5–3 years (growing on ≤25th percentile)

AR: Average Requirement (EFSA); RDA: Recommended Dietary Allowance (EFSA) shown for reference
Only children aged 1.5, 2 and 3 years growing at ≤25th percentile had a young child formula included in the food intake pattern.
[a] Hypothetical sample of 1.5–3 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1.5–3 years.
[b] 3 year-olds' food intake patterns did not contain an iron-fortified cereal 5 days a week or red meat approximately 3 days a week.
[c] Average consumption of young child formula was 330 mL/day.

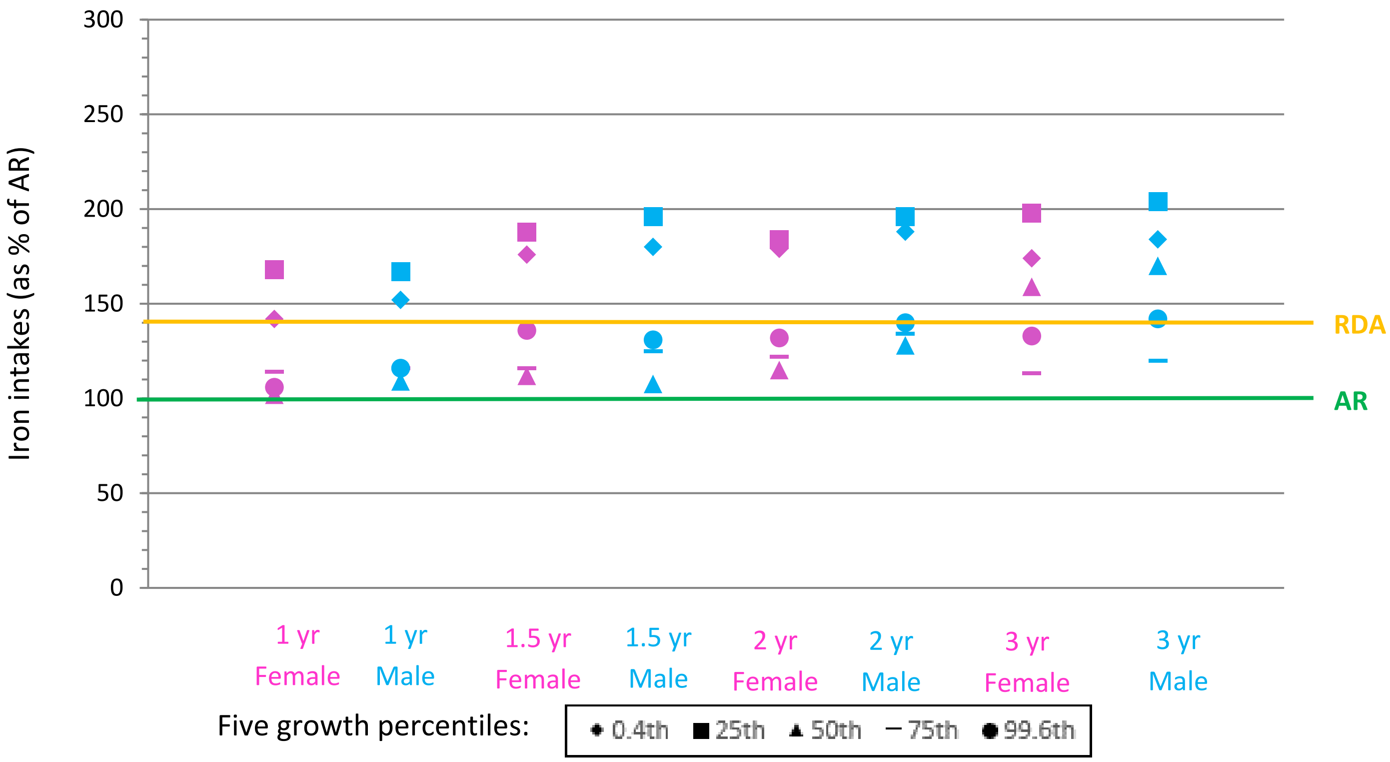


Figure 4.4 Mean daily iron intakes as % AR provided for a hypothetical sample[a] of males and females aged 1–3 years growing along five growth percentiles, including iron-fortified (12 mg/100 g) cereal (30 g) 5 days a week, red meat (30 g) approximately 3 days a week and a 7 mg iron supplement for smaller children (i.e. 1–3 year-olds growing ≤25th percentile) 4 days a week

AR: Average Requirement (EFSA); RDA: Recommended Dietary Allowance (EFSA) shown for reference
Only children aged 1–3 years growing at ≤25th percentile had an iron supplement included in the food intake pattern; 3 year-olds' food intake patterns did not contain an iron-fortified cereal 5 days a week, red meat approximately 3 days a week (all growth percentiles), or an iron supplement (growth percentiles ≥50th percentile).
[a] Hypothetical sample of 1–3 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1–3 years.

4.4.2 Adjustments to ensure adequate oral vitamin D

In order to protect bone health, children aged 1–4 years need vitamin D equivalent to an average daily intake of 10 µg(73) to 15 µg.(49, 74) Recommended daily intakes of 15 µg are needed to maintain blood levels of 25(OH)D above 50 nmol/L in order to ensure adequate vitamin D for good bone health (maintenance of bone density),(49, 74) while a recommended intake of 10 µg is considered adequate to maintain blood levels of 25(OH)D above 25 nmol/L, below which there is increased risk of poor musculoskeletal health (e.g. rickets). These recommended intakes are based on the assumption of no vitamin D formation through the action of sunlight on skin, i.e. during winter months, and are thus greater than the intakes needed during summer months, when skin intake can contribute to vitamin D needs.

Data from the NPNS indicate that daily vitamin D intake in most Irish children is much less than 10 µg: mean daily intake of children aged 1–4 years was 3.5 µg, and 93% of children in this age group had intakes below 10 µg/day.(75) Similarly, in 2-year-olds from the prospective Cork BASELINE Birth Cohort Study, the mean daily intake of vitamin D was 3.5 µg, and 96% had vitamin D intakes <10 µg/day.(57) This is supported by the modelling undertaken for this report, which shows that all children aged 1–5 years had inadequate intakes of vitamin D (see Figure 4.5a).

This low intake is reflected in the proportions of children with inadequate blood levels of vitamin D, particularly in winter when there is no skin formation of vitamin D and children will need to rely on dietary sources of vitamin D only. In 2 year-old children from the Cork BASELINE Birth Cohort Study, 45% had serum 25(OH)D <50 nmol/L in winter (November–April) compared with 10% in summer (May–October), while 9% had serum 25(OH)D <30 nmol/L (with increased risk of adverse musculoskeletal effects such as rickets)(49, 74) in winter and 1% in summer. In the Cork BASELINE Birth Cohort Study (Kiely *et al*., unpublished), 20% of 5-year-olds had serum 25(OH)D <50 nmol/L (on a year-round basis), increasing to 40% in winter, while 2.9% of children had 25(OH)D <30 nmol/L (year-round), which increased to 6% during winter. In a cohort of 5-year-olds from the ROLO Kids Study,(54) 6.3% had 25(OH)D below 25 nmol/L (year-round), but seasonal variation was not reported.

In summary, the evidence indicates that during the summer, most young Irish children get enough vitamin D through diet and through the effect of sunlight on the skin. However, during the winter, dietary sources are inadequate to maintain blood levels of 25(OH)D above 50 nmol/L (the level needed to ensure adequate vitamin D for good bone health) in a considerable proportion of young children (40% to 45%). In addition, a small proportion of young children (6% to 9%) have blood levels of 25(OH)D below 30 nmol/L in winter and are at increased risk of adverse musculoskeletal effects, such as rickets.

In order to address the inadequate vitamin D status in a very sizeable proportion (40% to 45%) of Ireland's young child population in winter, two approaches to increase vitamin D intake may be considered: food fortification and supplementation.

The potential of food fortification to provide additional vitamin D has been investigated. In Finland, systematic fortification of fluid milk products with vitamin D (1 µg/100 mL) and fat spreads (20 µg/100 g) has reduced the prevalence of inadequate vitamin D status (serum 25(OH)D ≤50 nmol/L) in adult non-users of supplements from 59% to 14%, and risk of deficiency (serum 25(OH)D ≤30 nmol/L) from 14% to 1%.[(76)] Dietary modelling using the NPNS food consumption data showed that consumption of cow's milk fortified with vitamin D at up to 2 µg/100 mL would significantly increase vitamin D intakes and reduce the prevalence of inadequate intakes in children aged 1–4 years.[(77)] This is supported by the modelling undertaken for this report.

While there is potential to increase the intake of vitamin D from this source, vitamin D fortification of foods is not extensive or systematic in Ireland. Except for fortified follow-up formula and young child formula, few commercially available cow's milks are currently fortified with vitamin D in Ireland.[(77)] Currently, fortified foods (mainly milks and cereals) contribute an average additional 1.5 µg/day of vitamin D to dietary intakes of children aged 1–4 years.[(75)] Thus, while increased intake of vitamin D-fortified foods, e.g. milks and cereals, may be recommended to increase intake of vitamin D, in the absence of a systematic fortification of foods with vitamin D, the potential increase will be limited.

The potential of vitamin D supplements to provide additional vitamin D has also been investigated. Data from the NPNS indicate that the mean daily vitamin D intake in those Irish children aged 1–4 years who use vitamin D supplements (typically 5 µg) regularly (about 17%) is 8.2 µg, with 74% having intakes <10 µg. This is supported by the modelling undertaken for this report, which shows that a daily 5 µg vitamin D supplement in 1–5 year-olds (as given from birth to 1 year under national policy)[(78)] significantly increased their vitamin D intakes, although the goal of 10 µg daily intake was still not achieved for all children (see Figure 4.5b).

Thus, a daily 5 µg vitamin D supplement could potentially increase vitamin D intakes significantly. However, this would require adequate promotion of such a policy, since vitamin D supplements are currently consumed by only a minority of this age group.

A daily supplement of 5 µg/day may be considered safe for children aged 1–5 years. The Tolerable Upper Intake Level (UL) for children aged 1–5 years is 50 µg/day.[73, 79] Data from the NPNS indicate that daily vitamin D intake in Irish children aged 1–4 years is much less than the UL, even in high consumers.[75] The P95 (i.e. the 95th percentile; highest consumers) of daily intake of the 17% of Irish children aged 1–4 years who use vitamin D-containing supplements (typically 5 µg) is 19 µg (38% of the UL). A recommendation for a daily vitamin D supplement of 5 µg/d should be in place of, not in addition to, any current vitamin D supplement. Furthermore, modelling undertaken for this report showed that with a daily supplement of 5 µg of vitamin D, together with vitamin D-fortified formula (about 4 µg/100 mL), in children aged 1-3 years, intake of vitamin D is much less than the UL, even in the highest consumers (see Figures 4.6 and 4.7). This is supported by the Cork BASELINE Birth Cohort Study, in which there was no evidence of excessive serum 25(OH)D concentrations in children aged 2 years (median 63 nmol/L; interquartile range 49–77 nmol/L; range 17–131 nmol/L).[57]

Conclusions

- The mean dietary intake of vitamin D in children aged 1–5 years is low (about 3.5 µg/day) and most children have intakes less than the recommended intake of 10–15 µg/day.
- This low intake is reflected in the proportions of children with inadequate blood levels of 25(OH)D (≤50 nmol/L) in winter, when there is no skin formation of vitamin D and children need to rely solely on dietary sources of vitamin D.
- Despite the low intakes, during the summer the majority of children get enough vitamin D through diet and through the effect of sunlight on the skin. However, during the winter, dietary sources are inadequate to maintain blood levels of 25(OH)D above the 50 nmol/L needed to ensure adequate vitamin D for good bone health in a considerable proportion of children (40% to 45%). In addition, a small proportion (6%

to 9%) of young children have blood levels of 25(OH)D below 30 nmol/L in winter and are at increased risk of adverse musculoskeletal effects, such as rickets.

- In order to address the inadequate vitamin D intakes in winter, two approaches to increase vitamin D intake may be considered: food fortification and supplementation.
- There is the potential to increase intake of vitamin D from vitamin D-fortified foods such as milks and cereals, and this may be recommended. However, the potential for increased intake is limited, since vitamin D fortification of foods in Ireland is not extensive or systematic.
- A daily 5 µg vitamin D supplement could potentially increase vitamin D intakes significantly and may be recommended during the winter for children aged 1–5 years. However, this would require adequate promotion of such a policy, since vitamin D supplements are currently consumed by only a minority of this age group.
- Based on the available evidence, a daily supplement of 5 µg/day may be considered safe for children aged 1–5 years, as intake of vitamin D would be much less than the UL of 50 µg/day even in the highest consumers.

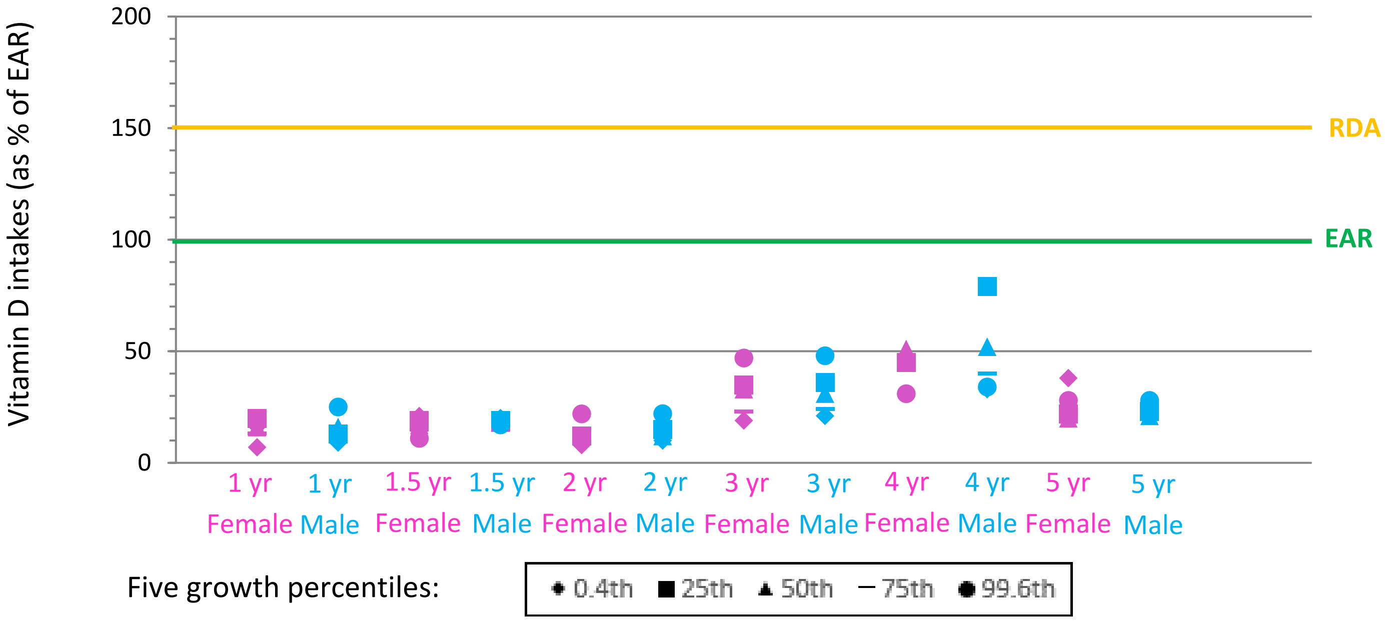
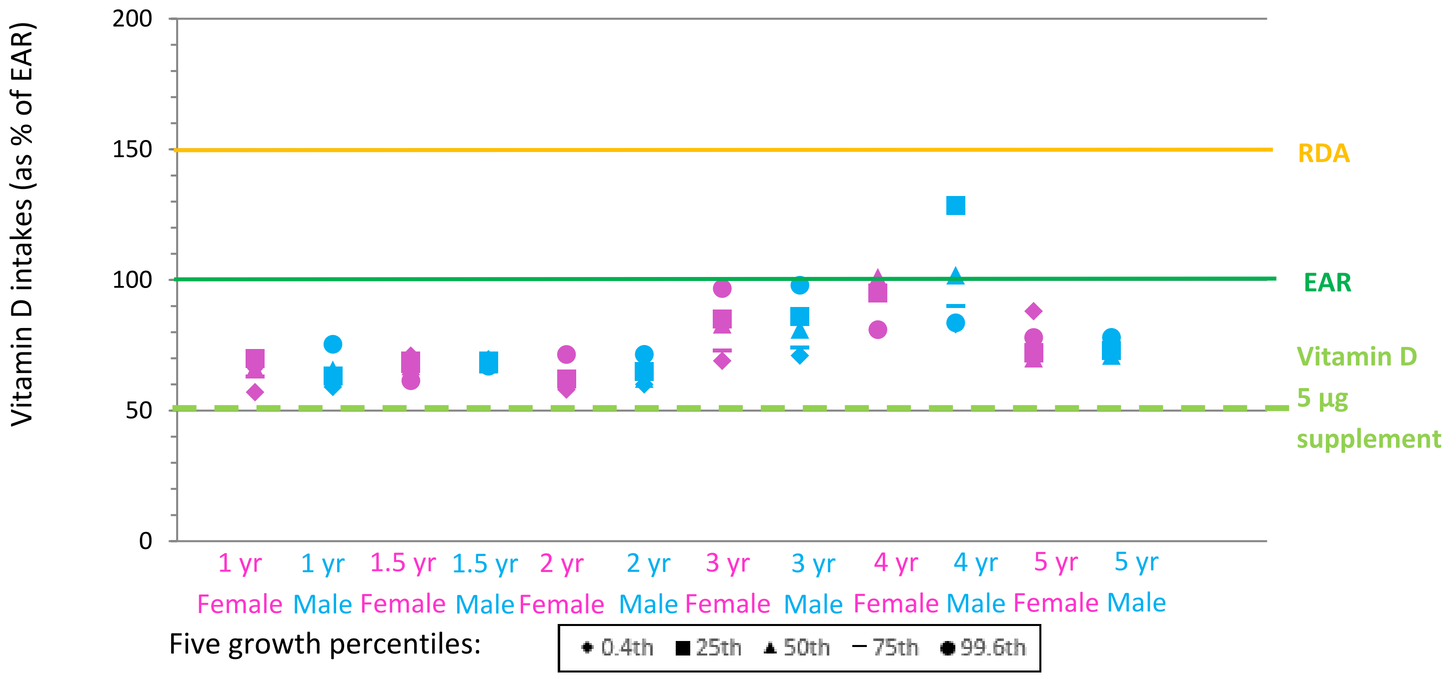


Figure 4.5 Mean daily oral vitamin D intakes as % EAR provided for a hypothetical sample[a] of males and females aged 1–5 years growing along five growth percentiles, consuming milks not fortified with vitamin D,[b] (a) before and (b) after addition of daily 5 µg vitamin D supplement

(a) ***Before***



(b) ***After addition of daily 5 µg vitamin D supplement***

EAR: Estimated Average Requirement (IOM); RDA: Recommended Dietary Allowance (EFSA) shown for reference

[a] Hypothetical sample of 1–5 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1–5 years.

[b] Children aged 1 and 1.5 years were mainly breastfed, while children aged 2, 3, 4 and 5 years were fed unfortified whole cow's milk.

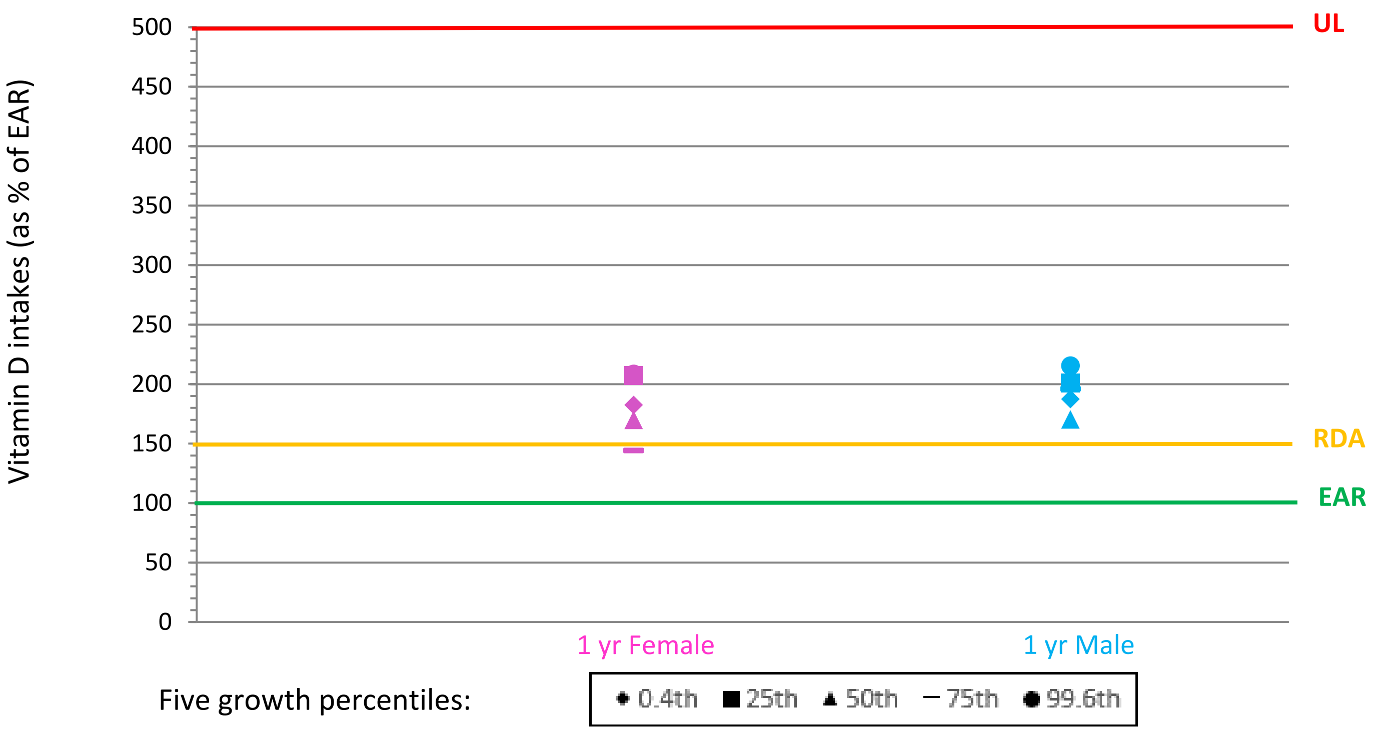


Figure 4.6 Mean daily oral vitamin D intakes as % EAR provided for a hypothetical sample[a] of males and females aged 1 year growing along five growth percentiles, taking a 5 µg vitamin D supplement and consuming follow-up formula[b]

EAR: Estimated Average Requirement (IOM); RDA: Recommended Dietary Allowance (EFSA) shown for reference

[a] Hypothetical sample of 1 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th).

[b] Average of follow-up formulae on the Irish market containing 4 µg vitamin D/100 mL with an average consumption of 442 mL follow-up formula.

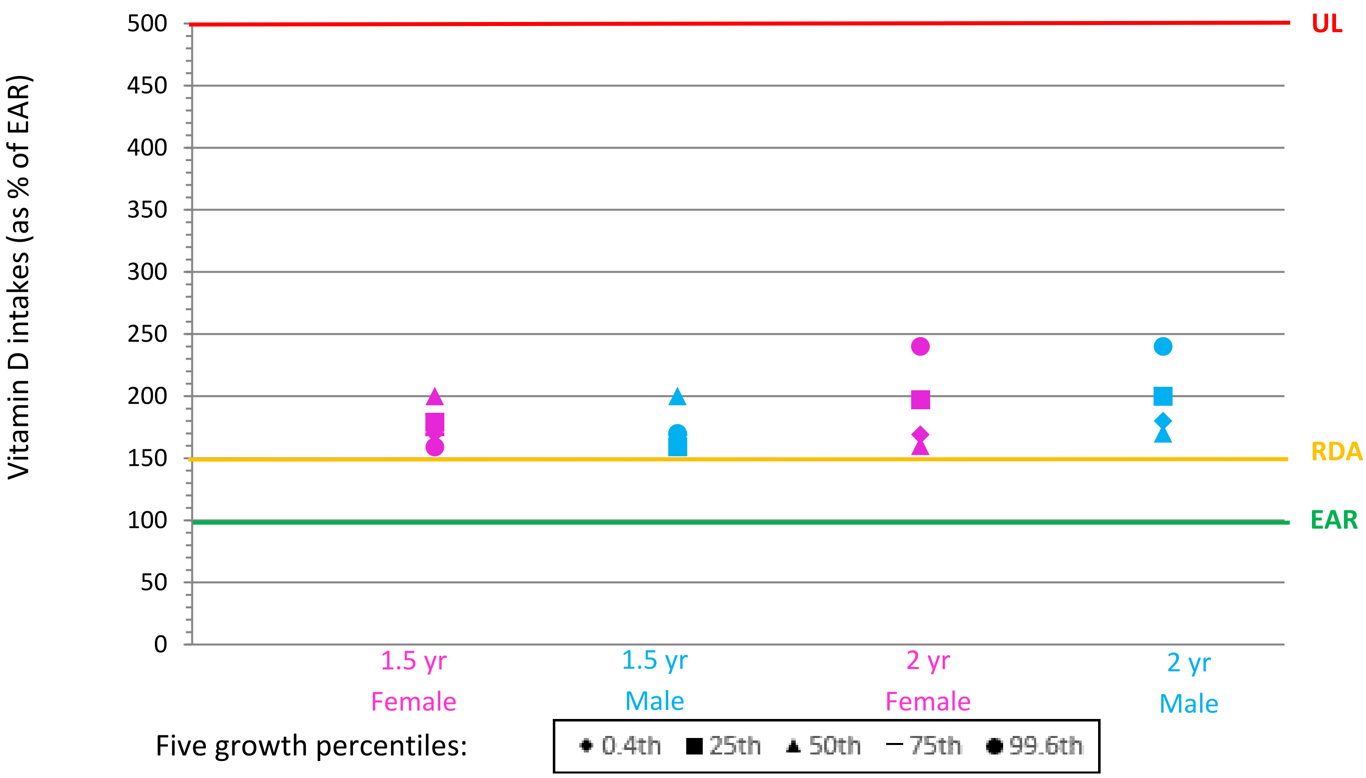


Figure 4.7 Mean daily oral vitamin D intakes as % EAR provided for a hypothetical sample[a] of males and females aged 1.5–2 years growing along five growth percentiles, taking a 5 µg vitamin D supplement and consuming young child formula[b]

EAR: Estimated Average Requirement (IOM); RDA: Recommended Dietary Allowance (EFSA) shown for reference

[a] Hypothetical sample of 1.5–2 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1.5–2 years

[b] Average of young child formulae on the market in Ireland containing 4.2 µg vitamin D/100 mL with an average consumption of 330 mL young child formula.

4.4.3 Vegetarian diets

Vegetarian food intake patterns for 1–5 year-old children were also modelled. The vegetarian food intake patterns included vegetarian protein sources such as eggs, cheese, beans, peas, lentils and tofu. Breast milk was used up to 2 years of age and low-fat cow's milk from 3–5 years of age. Adequacy of iron intake was the main focus of this phase of modelling. The differences in iron content of the various foods used in the vegetarian food intake patterns (i.e. non-haem iron food sources) and the omnivore food intake patterns (i.e. haem iron food sources) are outlined in Table 4.5.

Historically, it was generally accepted that non-haem iron, found in vegetables and cereal-type foods, was less well absorbed than haem iron found in red meat. However, a recent EFSA report on Dietary Reference Values (DRVs) for iron[(51)] considers that DRVs do not need to be derived for vegetarians as a separate population group. This is because the bioavailability of iron from European vegetarian diets is not substantially different than in diets containing meat.

The vegetarian food intake patterns modelled provided comparable iron intakes to the omnivore patterns. As shown in Figure 4.8, iron intakes were inadequate for children aged 1–2 years growing at ≤25th growth percentile level.

Conclusions

The modelling of vegetarian food intake patterns found inadequate iron intakes for children aged 1–2 years growing at ≤25th growth percentile level. Therefore, the recommendation for smaller children on an omnivore diet (i.e. 1–3 year-olds growing at ≤25th percentile level) to include a low-dose iron supplement providing the RDA for iron[ix] (7 mg) 4 days a week, or, alternatively, an iron-fortified milk, would ensure adequate iron intakes for those on a vegetarian diet. Furthermore, in order to enhance non-haem iron absorption, vegetarian children should be given vitamin C-containing foods when eating foods containing non-haem iron.[(51)] Parents should seek advice from a CORU-registered dietitian before embarking on any type of vegetarian diet for their child.

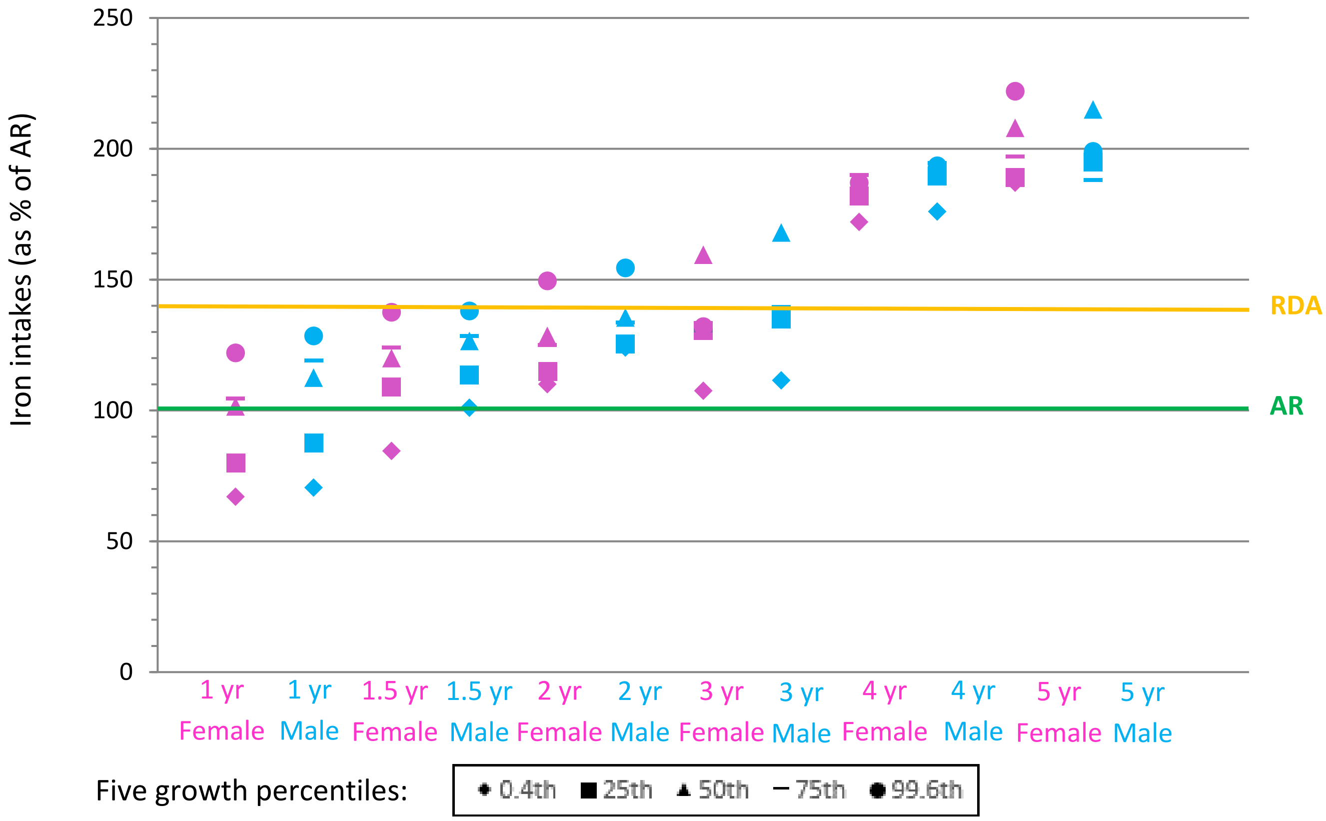


Figure 4.8 Mean daily iron intakes as % AR provided for a hypothetical sample[a] of males and females aged 1–5 years, growing along five growth percentiles, consuming a vegetarian diet

AR: Average Requirement (EFSA); RDA: Recommended Dietary Allowance (EFSA) shown for reference
[a] Hypothetical sample of 1–5 year-olds: 10 male and female children representing five percentiles within the healthy range on the UK-WHO growth charts (0.4th, 25th, 50th, 75th and 99.6th) at ages 1–5 years.

Table 4.5 Iron content of food portions used in the modelling of food intake patterns for 1–5 year-olds in Ireland

Haem iron food sources (portion in g)	**Iron (mg) per portion**
Minced beef, stewed (30 g)	0.81
Lamb chop (30 g)	0.75
Pork chop (40 g)	0.28
Chicken, roasted (25 g)	0.1
Chicken, leg (30 g)	0.27
Turkey meat, roasted (25 g)	0.2
Salmon, grilled (30 g)	0.14
Fish fingers (42 g)	0.24
Tuna, canned in sunflower oil (25 g)	0.3
Rainbow trout (30 g)	0.12
Non-haem iron food sources (portion in g)	
Iron-fortified (12 mg/100 g) breakfast cereal (30 g)	3.6
Baked beans (80 g)	1.1
Egg (60 g)	1.2
Omelette (120 g)	1.8
Tofu (40 g)	1.4
Macaroni cheese (100 g)	0.42
Red kidney beans (30 g)	0.60
Red lentils (30 g)	0.72
Chilli bean and lentil stew (50 g)	1.1
Falafel (30 g)	0.87
Houmous (30 g)	0.57

4.5 Food-based dietary guideline recommendations for 1–5 year-old children in Ireland

The recommendations outlined below should be considered in their totality, i.e. the recommendations are not independent from each other.

- A **wide variety of foods** should be included in order to increase acceptability of and familiarisation with foods that are part of a lifelong healthy diet.
- **Milk** is a key food in the diets of 1–5 year-old children. Milk is an important source of a range of nutrients, including protein, and is a critical source of calcium.
    1. A daily intake of 550 mL of milk, or equivalent amounts of yogurt or cheese, should be provided (where 200 mL of milk is equivalent to 150 mL of yogurt or 30 g of cheese).

2. Low-fat (1% to 2%) cow's milk can be used from the age of 2 years where there is no concern about the adequacy of calorie intake.
3. Plant-based milk replacement beverages (e.g. soya 'milk') can be used to replace cow's milk, provided they are fortified with the same level of nutrients, particularly calcium. Use of plant-based milk replacement beverages such as almond 'milk', coconut 'milk' and rice 'milk', is not recommended, as they are nutritionally inadequate.
4. While not necessary for this age group, fortified full-fat milk, follow-up formula and young child formula will contribute to the intake of three key nutrients (iron, vitamin D and n-3 polyunsaturated fatty acids) in 1–3 year-olds (see additional comments under the Supplements recommendation).
5. It is important that children aged 1–5 years are not given more than the recommended amount of milk as a drink, as this reduces intake of solid food and of some nutrients, such as fibre, and may result in iron deficiency anaemia.
6. It is important that very young children are not given milks in an infant feeding bottle with a teat, as this will delay the development of the child's oral motor and fine motor skills.

- **Breads, cereals, potatoes, pastas and rice** are an important source of calories and fibre.
    1. A combination of both white and wholemeal breads, cereals, potatoes, pastas and rice will provide adequate fibre. For children prone to constipation, an increased proportion of these foods can be given as wholemeal varieties.
    2. Breakfast cereals fortified with iron (containing ≥12 mg/100 g) and vitamin D help to ensure adequate intakes of these nutrients. Vitamin C-containing fruit or vegetables, or a small amount of very well-diluted fruit juice, should also be consumed along with the iron-fortified cereal in order to increase iron absorption.
- **Meat, poultry, fish, eggs, beans, lentils and smooth nut butters** are important sources of protein, iron, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA).
    1. Red meat is a rich bioavailable source of iron in the diet of 1–5 year-olds. Including 30 g of red meat approximately three times a week helps ensure

adequate iron intake. However, smaller children (i.e. 1–3 year-olds ≤25th growth percentile level) will require an additional 4 mg of iron/day.

2. Unprocessed meats (e.g. lean red meat, chicken, fish, etc.) are preferable to processed meats (e.g. ham, sausages, deli meat, etc.), which have high salt and fat content.
3. Fish should be included at least once a week in the diet of 1–5 year-olds. As important sources of DHA, EPA and vitamin D, oily fish can be included up to once a week, or white fish can be eaten twice a week.
4. Eggs, beans and lentils are important sources of non-haem iron and, in the case of beans and lentils, provide soluble fibre. These foods may be used as alternatives to meat, fish and poultry. It is important to include these foods during these early years in order to increase acceptability and familiarisation. Vitamin C-containing fruit or vegetables, or a small amount of very well-diluted fruit juice, consumed along with such foods will increase iron absorption from these non-haem sources.

- **Fruit, salad and vegetables** are important sources of vitamins and fibre.
  1. A portion[x] of vegetables should always be included at the main meal. In addition, a number of small pieces of fruit, salad or vegetables should be included to match the age in years of the child, as follows:
     - One small piece of fruit, salad or vegetables for 1 year-olds
     - Two small pieces of fruit, salad or vegetables for 2 year-olds
     - Three small pieces of fruit, salad or vegetables for 3 year-olds
     - Four small pieces of fruit, salad or vegetables for 4 year-olds
     - Five small pieces of fruit, salad or vegetables for 5 year-olds
  2. Small amounts of fruit and vegetables given at different times of the day minimise the risk of overwhelming the child's capacity to consume other foods required for critical nutrients such as iron.
- **Fats, spreads and oils** should be used minimally.
  1. A small amount of fat spreads can be added to foods such as bread in order to increase palatability and acceptability.

[x] Portion sizes increase as the child grows. A rough guide for a single portion is the amount of fruit, salad or vegetables that the child can hold in one hand.

2. Frying of foods should be avoided as far as possible, and foods should instead be baked, steamed or grilled.
3. Roast potatoes or thick-cut oven chips can be used very occasionally (once a week).

- **Foods high in fat, sugar or salt** should be limited, as they provide a high proportion of the overall energy requirements of 1–5 year-old children without providing essential nutrients.
  1. Foods such as confectionery, cakes, crisps, biscuits, sugar-coated breakfast cereals, etc. are not recommended for 1–5 year-olds. Such foods either overwhelm the child's capacity for nutrient-dense foods, or provide additional calories and, consequently, increase the risk of the child becoming overweight or obese.
  2. Small amounts of sugar can be added to nutrient-dense foods (stewed fruit, milk puddings, jam on wholemeal bread, etc.) in order to increase palatability and acceptability. It is important to familiarise children with the variety of flavours and textures in the wide range of foods required for a healthy diet. Snacking on sugary foods and drinks should be avoided in order to protect dental health.
  3. Foods which could be used as a dessert for this age group include rice pudding, stewed fruit (with a small amount of added sugar), custard, and jam on toast.
  4. Salt and salty foods should be limited because high salt intakes can become habitual and are linked with cardiovascular disease in later life.
  5. Children have a very keen sense of taste, do not require the addition of salt to an otherwise balanced diet, and should be protected from acquiring the habit of adding salt to food at the table.
  6. Salt should not be added in cooking for 1–5 year-olds.

- **Beverages**
  1. Water and milk are the only drinks recommended for this age group.
  2. Sugar-containing and acidic drinks should be limited and, if consumed at all, should be kept to mealtimes.

- **Supplements**
  1. In order to improve the overall vitamin D intake status of this population group, a low-dose vitamin D-only supplement (5 µg) is recommended for all 1–5 year-olds from Halloween to St Patrick's Day (i.e. during the extended winter months).
  2. Dietary intake of iron is unlikely to be sufficient for smaller 1–3 year-old children (growing at ≤25th percentile level). This report highlights the need for an additional 4 mg of iron/day for 1–3 year-olds ≤25th growth percentile level. This additional iron can be provided through the use of iron-fortified full-fat milks or formulae (containing at least 1 mg of iron/100 mL). Alternatively, a low-dose iron supplement providing the RDA for iron[xi] (7 mg) can be given 4 days a week.

[xi] Current availability of low-dose iron supplements for this age group (at the RDA of 7 mg) is very limited.

5. PHYSICAL DEVELOPMENT AND PHYSICAL ACTIVITY

Key issue and recommendation

- Health-enhancing physical activity is as important as healthy eating for the promotion of healthy body weight and prevention of obesity in 1–5 year-olds. Specific recommendations in the national and WHO guidelines on physical activity should be prioritised. These are integral to successful outcomes of interventions promoting healthy eating in this age group.

Chapter 2 described childhood growth and development, and highlighted the typical normal variations observed between children. Knowledge and understanding of childhood physical development are essential for health professionals committed to optimising nutritional health, as (1) malnutrition and nutritional risk are recognised preventable causes of developmental delay,[(80-82)] and (2) those children with developmental delay may require additional care and services in order to optimise nutrition, reduce mortality and ensure equity.[(83)]

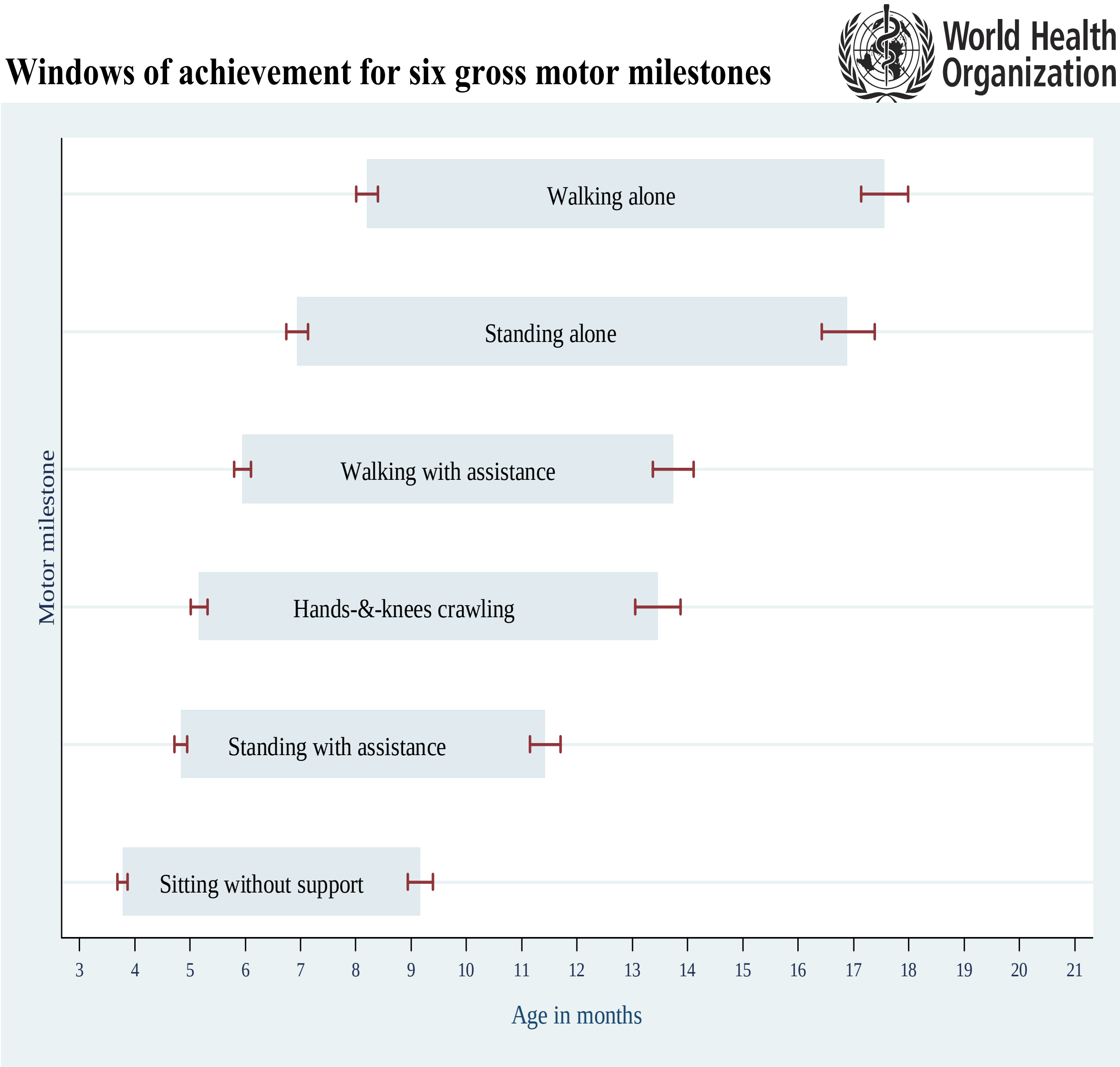
Child development is a dynamic process through which children progress from dependency on caregivers during infancy towards growing independence in childhood and beyond. Development in a number of domains proceeds through a series of milestones and is influenced by individual and environmental factors.[(84-86)] One domain of relevance to optimal nutritional health is motor development, as motor coordination, competence and capability directly affect physical activity and energy expenditure. Failure to recognise the influence of this developmental stage on physical activity level can lead to overestimation of energy requirements in pre-school children, an observation that prompted a recommendation to revise the dietary reference intakes for energy for pre-schoolers in the United States.[(87)]

5.1 Motor development

Motor development is influenced by genetic, environmental and social factors, and there is a wide range for achievement of developmental milestones. Validated outcome measures are used to assess and monitor development,[(88)] and where there is significant variation in attaining expected milestones for a given age, a developmental delay is suspected.[(89)] The WHO's Multicentre Growth Reference Study provides useful standards to compare child development against a reference sample of multi-ethnic healthy children who were breastfed and were born to non-smoking mothers.[(90)] Figure 5.1 describes the windows of achievement for six gross motor milestones. For instance, walking alone on average will occur around 12 months of age; however, the window ranges from under 9 months to 18 months, and any child achieving independent walking within this time frame is considered to have typical achievement of the walking milestone. If a child achieves walking before 8 months or after 18 months, this is considered ‘atypical’ and necessitates review by a paediatrician, paediatric physiotherapist or suitably qualified health professional trained in childhood gross motor assessment and treatment. For the purposes of this document, infants 12–18 months of age who have developed typically will be able to: sit without support and stand with assistance; and may be able to crawl, walk with assistance, stand alone and walk alone. Children older than 18 months of age should have achieved each of these milestones, and if a child has not done so, further investigation is warranted.

In Ireland, screening of motor development occurs as part of public health nurse visits at the following time points:

- Within 72 hours of birth
- At 3 months
- At 7–9 months
- At 18–24 months
- At 3.25–3.5 years
- At 4.5 years, during school visits in junior infants.



Source: WHO Multicentre Growth Reference Study Group (2006)[91]

Figure 5.1 Windows of achievement for six gross motor milestones

In addition to the achievement of gross motor milestones, additional developmental skills are required for establishing feeding skills after the age of 12 months. Table 5.1 describes the developmental domains and skills observed from 12 months to 5 years old. These skills are necessary for the child to learn how to feed themselves and develop the independence required prior to formal schooling.

Table 5.1 Developmental domains and skills

Age	Gross motor	Fine motor	Visual, perceptual and play	Oromotor and speech
12 months	Uses both hands freely but may show preference for one. Sits for mealtimes without support. Helps with dressing. Extends arm for putting on feeding apron/clothes.	Points with index finger at object/food of interest. Picks up small objects/food with neat pincer grasp (tip of thumb and index finger). Can hold food and bring to mouth. Can hold spoon and will attempt to feed, but very messy. Can drink from a closed cup.	Recognises food by sight, smell and taste. Drops and throws object/food, watches it fall and looks in correct place when falls out of sight. Moves/shakes cup and bowl/plate to make noise.	Says first words and may say word for known food. Signals or says 'no' to unwanted food. Can chew softer lumps and keep most food within the mouth. Diminished gag reflex in response to solid, textured foods. Can bite into harder foods once teeth have erupted. Closes lips to clear spoon.
18 months	Moves away from meal or table. Walks well and starts/stops safely. Enjoys climbing and will climb up to adult chair, turn and sit. Squats to pick up food from the floor and will stand without support of hands. Kneels without support. Can help with dressing, takes of bib/apron but can rarely replace again.	Can drink from an open cup. Can feed independently using a spoon. Picks up small objects/food with pincer grasp. Holds crayon with whole hand and will scribble. Builds tower of 3 blocks when shown. Points to distant interesting objects when outside.	Has begun to reject known foods from 14 months and, neophobic response peaks by 20 months and diminishes until 8 years. Rarely takes toys to mouth. Fascinated by household objects and imitates everyday activities (sweeping floor). Enjoys putting food in/out of containers.	Will imitate adult eating behaviour and preference. Can chew most textures of food. Says 6–20 recognisable words and understands many more. Demands a desired object/food by pointing and using loud urgent sounds or single words. Enjoys nursery rhymes and tries to join in. Understands 'no'.

24 months	Imitates behaviour of other children. Runs safely and can avoid obstacles. Pushes and pulls wheeled toys forward. Throws small ball overhead and forward without falling over. Walks upstairs and downstairs holding rail (1 step at a time).	Picks up tiny objects quickly and replaces neatly. Can stack 6–7 cubes. Holds crayon down shaft using thumb and first finger. Turns single pages in a book. Can feed self well with spoon – easily distracted. Lifts cup, drinks without spilling and replaces cup on table.	Little understanding of danger. Imitates domestic activities. Engages in make-believe play. Constantly demands parental attention. Tantrums when frustrated, but readily distracted. Plays near other children but not with them.	Chews most textures of food offered as part of meal. Can fully clear feeding spoon. Will eat larger portion sizes if given. Uses 50+ words and understands more. Asks names of objects/food and people.
36 months	Goes upstairs with alternating feet. Comes downstairs with two feet together. Climbs with agility. Can catch large ball on or between extended arms. Rides tricycle using pedals.	Can stack 9–10 cubes. Can use a fork and spoon. Threads large wooden beads on lace. Holds crayon near point with good control. Cuts with toy scissors.	Likes to help adults with household chores. Can tidy up toys. Understands sharing toys. Shows affection to siblings. Can pull pants up and down.	May choose to eat the same foods that other children of similar age are eating. Can count up to 10+. Asks many questions. May eat more when prompted to or may reduce intake in response to prompts to eat more.
48 months	Walks/runs alone up and down stairs taking alternate steps. Climbs ladders and trees. Rides tricycle well and can turn sharply with ease. Picks up objects from floor by bending from waist with knees extended.	Holds crayon/pencil in adult fashion with good control. Can build tower with 10+ cubes. Eats skilfully with spoon and fork. Washes/dries hands. Brushes teeth. Can dress/undress but rarely laces/buttons.	Starts to name drawings before completion. Matches and names 4 primary colours correctly. More independent and strong-willed. Understands taking turns and sharing. Appreciates past, present and future time.	Eats an established range of foods which predicts range of foods in late childhood and adulthood. Speech is grammatically correct. Listens to and tells long stories. Counts by rote to 20 or more.

	Increased ball skills (throws, catches, bounces, kicks, uses bat).			
60 months	Walks easily on narrow line. Runs lightly on toes. Active and skilful in climbing, sliding, swinging and jumping. Can stand on one foot for 8–10 seconds. Can hop 2–3 times on each leg. Plays ball games well.	Picks up and replaces minute objects. Uses knife and fork competently. Washes and dries face and hands. Dresses/undresses alone. Builds elaborate models when shown. Good control with writing and drawing with pencils and brushes. Draws square.	Colours pictures neatly within lines. Counts fingers on one hand with index of other. Names 4+ primary colours. Loves to be read or told stories. Chooses own friends and understands need for rules and fair play. Appreciates meaning of time in relation to daily routine.	Speech is fluent. Delights in singing and rhymes. Constantly asks meaning of abstract words. Enjoys jokes and riddles.

Source: Developed from Sheridan (2001)[92] and the Infant and Toddler Forum (2014).[93]

5.2 Physical activity and play

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure.[94] Much of the physical activity in early childhood is comprised of play activities in addition to activities of daily living and locomotor activities (e.g. walking and cycling). Physical activity is vital for childhood development of cardiorespiratory, metabolic, musculoskeletal and emotional health domains, in addition to the regulation of body composition throughout growth. The National Guidelines on Physical Activity for Ireland[95] recommend at least 60 minutes of moderate to vigorous physical activity every day in childhood (2–18 years) and are based on the WHO’s global recommendations (Table 5.2).

Table 5.2 WHO physical activity guidelines

Age	Type	Frequency	Benefit
5–17 years	For children and young people, physical activity includes play, games, sports, transportation, chores, recreation, physical education, or planned exercise, in the context of family, school, and community activities. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone,* at least three times a week.	At least 60 minutes of moderate- to vigorous-intensity physical activity daily.	Improves cardiorespiratory and muscular fitness, bone health, and cardiovascular and metabolic health biomarkers. Physical activity greater than 60 minutes has additional health benefits. *For this age group, bone-loading activities can be performed as part of playing games, running, turning or jumping.

Source: WHO (2010)[96]

Different types or intensities of physical activity/active play confer different effects on the physical and emotional health of the child. Activity which is moderate to vigorous in intensity (the child is breathing hard, turning red and getting warm) leads to greater gains in cardiorespiratory health, making the heart and lungs stronger and allowing them to work with greater efficiency.[97-100] In addition, moderate and vigorous activity can have varying effects on neuromusculoskeletal health in children, including building muscle strength, muscle flexibility, postural balance and bone health.[101-104] Ensuring that growing children develop adequate bone tissue is vital for lifelong bone health and helps protect against bone fractures or conditions such as osteopenia and osteoporosis. Bone health is optimised through weight-bearing activity (e.g. jumping, skipping or hopping), in addition to intake of foods and drinks rich in calcium and vitamin D and avoidance of carbonated and caffeinated drinks. Physical activity/active play also positively influence motor development and motor skill,[104-106] in addition to having a positive impact on mental health and well-being in childhood.[107, 108] Physical challenge is required for the acquisition of the fundamental movement skills essential for participation in physical activity/active play. Importantly, fundamental motor skills (e.g. locomotor skill and object control skill) do not develop naturally but instead must be learned, practised and reinforced throughout childhood. Without exposure to and practice of these skills through play, children are less likely to participate in active play and physical activities (e.g. chasing, skipping, cycling, football, etc.) and research suggests that children with poorer fundamental motor skills are more likely to be overweight or obese.[109] Similarly, achieving adequate levels of physical activity in early childhood not only affects healthy physical, emotional and social development,[110] but also contributes to daily energy expenditure and is important for the maintenance of a healthy body weight. Research findings confirm the greater risk of gaining weight and becoming overweight or obese when a child is not achieving the recommended levels of daily active play/physical activity.[111-113]

Sedentary play

Play that is not physically active but is creative and imaginative, like playing with books or puzzles, is essential for the development of language, as well as social and spatial awareness. In addition, play that provides positive exposure to foods that are essential for healthy eating, such as fruits and vegetables, may increase acceptance of such foods. Increasingly, more time is spent in sedentary pursuits, including the use of electronic devices (e.g. televisions, mobile phones and tablets). Use of such devices in children under 2 years of age is not recommended, and for those aged 2–5 years, use should be limited to 1 hour/day[114] and should not take place during meals, nor before bedtime due to potential negative effects on sleep.[115] Screen time (for either parent or child) should also not take place during mealtime due to its distracting effects and impact upon the speed of eating. Additionally, even 1 hour of television time in children aged 2–6 years has been linked with lower levels of fruit and vegetable intake and higher levels of consumption of energy-dense products.[116]

6. HEALTHY EATING FOR CHILDREN WITH SPECIAL NEEDS

Key issue

- Some adjustments to healthy eating guidelines (texture modification, emphasis on certain food groups, etc.) may be required for children with special needs because they are more vulnerable to feeding difficulties and malnutrition, leading to nutritional deficiencies and to some children being underweight, overweight or obese.

Key recommendation

- Children with special needs require careful growth monitoring, as they are at greater risk of nutritional inadequacies. Resources that outline different adjustments and solutions to address feeding issues should be made available to parents and carers of children with special needs.

6.1 Healthy eating guidelines adjusted to support children with special needs

Healthy eating guidelines apply to everyone in the population. Children with special needs are the most vulnerable population group because, due to their compromised ability, feeding difficulties are more common, leading to an increased risk of malnutrition (both over- and undernutrition). For a range of reasons, including delays in diagnosis and the gradual onset of physical symptoms of malnutrition, few children with special needs receive individual dietetic intervention. In addition, some children with special needs are not registered for disability services and rely on primary care. These circumstances underline the importance of considering the special needs of these vulnerable children, which very often involve simple adjustments to general advice such as texture modification, a reduction or an increase in energy-dense foods, or supplementation. An example of such adjusted healthy eating guidelines include nutrient-specific targets and a menu planning guide based on healthy eating guidelines for children 1–4 years of age.[117] These are widely used in the UK. They are designed to ensure a well-balanced diet, with or without modified texture consistency, and can be offered to children with disabilities in schools and residential care facilities.

In 2011, there were 66,437 children with a disability registered in Ireland. This accounted for 5.8% of the total child population of Ireland.[118] Although a wide range of presentations from intellectual, mental health and physical disabilities pose feeding challenges, children with special needs often express common nutritional complications that can be addressed by simple adjustments to the healthy eating guidelines. This ensures, as far as possible, that children with special needs achieve a healthy, balanced diet that offers optimum health throughout childhood and protection from disease in later life (as outlined in Chapter 1). This chapter describes the most common feeding challenges experienced by children with special needs that can, in many cases, be addressed through simple adjustments to the healthy eating guidelines. These feeding challenges are described generally in terms of special needs arising from intellectual/behavioural disabilities (e.g. intellectual disability, trisomy 21 and autism) and physical disabilities (e.g. cerebral palsy and spina bifida). Children who require intensive clinical intervention (e.g. partial or total enteral or parenteral nutrition) due to metabolic disorders or medication-nutrient interactions, have unique clinical needs and as such are not relevant to this report.

6.2 Measuring growth as an indicator of nutritional status in children with special needs

As outlined in Chapter 2, normal growth is a reflection of overall health and nutritional status, and children with special needs should be checked in line with Health Service Executive (HSE) policy unless more frequent monitoring is clinically indicated. Regular monitoring and recording of growth (height, weight, head circumference and body mass index (BMI)) will identify deviations from a normal growth pattern which will warrant further investigation, and possibly intervention, by a healthcare professional. In the main, children with special needs are plotted on the standard growth charts to monitor growth. A single anthropometric measurement taken in isolation is of little value, but a record of serial measurements can indicate the individualised growth trajectory for a child. In children with chronic conditions, growth may significantly deviate from the norm. Such children need to be referred to a multidisciplinary team (including a CORU-registered paediatric dietitian) for clinical follow-up. It should be noted that for some clinical conditions, such as trisomy 21, specific growth charts are used to measure growth.[119]

6.3 Intellectual/behavioural disabilities

6.3.1 Intellectual disability

Intellectual disability (ID) is a neurodevelopmental disorder that begins in childhood and is characterised by limitations in both intelligence (including learning, reasoning and problem-solving, abstract thinking, and judgement) and adaptive skills, with at least one of three adaptive domains (conceptual, social, and practical) affected, which requires ongoing support as compared with others in the same age group. It affects 1% of 1–4 year-olds in Ireland and the prevalence doubles to 2% in children aged 5–9 years.[120]

In children with ID, both ends of the nutritional spectrum (obesity and malnutrition) are prevalent and depend on the severity of the ID.[121, 122] Early intervention is an essential part of treatment to improve quality of life. Long-term monitoring and review is fundamental in improving eating behaviours, BMI and overall health.[123] A significant number of children with ID can be managed with the support of a primary care team that includes a CORU-registered dietitian.

Impact on growth and nutritional status with altered dietary intake

Many children with learning difficulties are significantly more overweight or obese compared with controls, often with low levels of activity.[124] In addition, the risk of developing obesity is greater in children with ID when their dietary intake is challenged by inappropriate eating behaviours and chronic health conditions.[125] However, there is good evidence that family-based weight management intervention programmes provided by a multidisciplinary team can achieve good outcomes.[126-128]

Malnutrition is reported to affect up to 44% of patients with learning disabilities,[129] and it can increase with age and the severity of the learning disability,[130] leading to a reduced quality of life.[131] Early diagnosis of feeding disorders and referral for clinical follow-up by a multidisciplinary team is essential to address nutritional issues and improve quality of life.[132, 133]

Micronutrient issues

There is a paucity of recent research conducted on the effectiveness of dietary supplementation in children with learning difficulties. One small randomised controlled trial with 20 subjects suggested improved academic performance with vitamin supplementation.[134] Vitamin D, vitamin E and zinc deficiencies, as well as and scurvy, have been described in the literature,[135-138] but Morgan[139] concluded that there was insufficient high-quality evidence from randomised controlled trial or quasi-randomised controlled trials to provide conclusive results on the effectiveness of any dietary supplementation.

6.3.2 Autism and autism spectrum disorders

Autism spectrum disorder (ASD) is a neurodevelopmental disorder associated with restrictive or repetitive behaviours and difficulties with verbal and interpersonal communication, in which some problems involving nutrition may be present.[140] It is estimated that 1% of the Irish childhood population has a diagnosis of autism.[141] Food selectivity is the most common problem seen in children with ASD, and can lead to elimination of entire food groups due to colour, smell and texture aversion, which can subsequently result in severe nutritional deficiencies.[142, 143]

Impact on growth and nutritional status with altered dietary intake

Nutritional inadequacy is frequently not identified in this patient group, as children with autism often achieve a normal growth pattern (using the WHO BMI-for-age percentile charts), and it has been reported in one study that only 11% of children with autism were underweight.[144] Despite food selectivity and a limited range of foods consumed, children with autism often achieve adequate energy intake due to a high carbohydrate intake[140] or indeed demonstrate a higher BMI[145, 146] and/or waist circumference.[147]

Micronutrient issues

From the literature listed in Table 10 in Appendix III, calcium, iron, B vitamins, vitamin C and vitamin D have been frequently identified as being inadequate in children with autism. Case reports in the literature have described clinical manifestations of vitamin C deficiency in the form of scurvy,[148, 149] as well as visual impairment due to vitamin A deficiency,[150] one of which reported two cases in Irish teenagers[151] (see Table 10 in Appendix III).

Dietary supplementation

Primary care teams responsible for the care of children with ASD should monitor children demonstrating food selectivity that results in a limited range of foods eaten for micronutrient deficiency. Referral for clinical follow-up by a specialist multidisciplinary team may be warranted.

There is mixed evidence to support supplementation of nutrients in this patient group, despite the majority taking some form of supplement.[152, 153] In the case-control studies reviewed, supplementation with docosahexaenoic acid (DHA), folic acid and omega-3 fatty acids showed moderate improvements in social skills,[154-158] and vitamin D supplementation was found to be safe.[159, 160] The National Institute for Health and Care Excellence *Guideline on the Management and Support of Children and Young People on the Autism Spectrum* states that “the evidence was very limited and further randomised placebo-controlled studies are required to corroborate the existing evidence for ... dietary supplements in children and young people with autism”. [161]

Special dietary requirements/treatments

A Cochrane review of 17 studies found weak evidence of benefits of the gluten-free/casein-free diet.[162] Based on the available evidence, the National Institute for Health and Care Excellence[161] does not recommend a gluten- and casein-free diet for children with autism and ASDs. However, in clinical practice, many parents choose to trial the gluten- and casein-free diet. It is important that parents can access scientific evidence to help inform their decision to make any dietary changes, and it would be prudent to ensure that families are supported by a CORU-registered dietitian to prevent any possible harm or the possibility of subjecting a child to any further nutritional inadequacy, particularly when significant food groups are eliminated from a potentially already limited diet.[163, 164]

6.3.3 Trisomy 21 (Down syndrome)

Down syndrome (DS) is one of the more commonly occurring genetic disorders in Ireland, affecting 1 in 546 babies born in Ireland.[165] It is caused by having a third copy of chromosome 21. DS is associated with many health problems, attributed in part to cardiac defects and thyroid function abnormalities.[166]

Impact on growth and nutritional status with altered dietary intake

Malnutrition is common in children with DS, particularly in those with congenital heart disease or those requiring surgical intervention, often occurring pre-surgery and between surgeries.[167] However, a retrospective review covering the years 1984–2007 reported that post-operative recovery in growth occurred within 6 months for weight and 1 year for height, irrespective of age at the time of surgery. This suggests that nutritional support is not indicated when growth has corrected following surgery, and healthy eating should be the primary objective thereafter, based on age and ability of the individual child.

In the context of prevention of obesity, healthy eating and physical activity/active play are important for 1–5 year-old children with DS. There is evidence in older children (aged 6–18 years) that a preoccupation with food and low levels of physical activity contribute to the development of overweight and obesity in some individuals with DS.(168)

Micronutrient issues

Children with DS are also at risk of iron deficiency anaemia, similar to the general population.(169) In a Cochrane review of 69 studies dating from 1967–2016, Saghazedeh(170) reported lower blood levels of calcium, selenium and zinc in those with DS compared with controls. However, it was documented in the report that it was unclear if this was a feature of DS or the effect of comorbidities.

Another systematic review indicated that dietary supplements in children with DS can improve cognitive function and psychomotor skills but, due to the lack of quality of the studies undertaken, their effects cannot be guaranteed and recommendations for dietary supplements should be given with caution to parents.(171)

Dietary reviews showed a trend for excessive sodium consumption and insufficient intakes of calcium, B vitamins and water in children with DS,(172) and as children became independent in their food choices, the nutrient quality of their dietary intake deteriorated.(173) A longitudinal study by Stagi(174) showed low vitamin D levels in children with DS who also had autoimmune disease and obesity.

6.4 Physical disabilities

6.4.1 Cerebral palsy

Cerebral palsy (CP) is the most common cause of physical disability in childhood, occurring in 1 in 500 children in Ireland. It is caused by a static brain lesion in the neonatal period leading to a range of activity limitations. Oral motor and swallowing dysfunction can lead to poor nutritional status and poor growth in young children.(175) Feeding problems are common, and as many as 60% of children with CP(176) have feeding issues, often present within the first year of life. The type and severity of neurological impairment, ambulatory status, the degree of cognitive impairment, and the use of anti-epileptic medication can all impact on feeding ability and, therefore, the nutritional status of each individual child.(177) Problems commonly reported in children with CP include chronic constipation, gastro-oesophageal reflux, vomiting, abdominal pain and swallowing disorders.(178) These issues can affect appetite and the enjoyment of food, and may necessitate texture or dietary modification in order to meet nutritional requirements.

Impact on growth and nutritional status with altered dietary intake

Herrera-Anaya(179) suggests that stunting and malnutrition are prevalent conditions among paediatric patients with CP, and both are directly associated with higher levels of gross motor dysfunction which impedes ability to consume a sufficient dietary intake. In a case-control study of pre-school-aged children conducted by Walker,(180) issues with dietary intake and body composition did not initially exist, but developed longitudinally over time as the children got older. Sullivan identified the need to investigate the effect of energy intake on nutritional status and suggested that more research is needed to determine energy requirements for children with CP or neurological impairment.(181) In practice, estimates for energy and protein requirements provide a starting point only, and ongoing assessment and monitoring is essential in order to ensure that nutritional needs are being met and that complications are adequately managed to avoid further underfeeding.(182)

Feeding issues

Children with CP can have problems with their ability to suck, chew and swallow, which over time leads to undernutrition. Feeding time and experience at mealtimes can be distressing for both the child and their carers, which impacts on quality of life.(183) Feeding problems can also result in aspiration of food into the lungs. Fortification of food is the first line of dietary modification, followed by the use of oral nutrition supplements in addition to food.

Micronutrient issues

There is little consistency in micronutrient deficiencies in children with DS reported in the literature, and there is a lack of research conducted on children with DS aged 2–5 years. The majority of the literature includes children up to 18 years of age and is outlined in Table 11 in Appendix III. Low dietary intakes or biochemical indices for iron, calcium, vitamin D and vitamin C were most frequently reported in the studies listed in Table 11 (Appendix III). Monitoring at primary care level should include dietary intake assessments of children who are experiencing feeding difficulties. Referral for clinical follow-up by a specialist multidisciplinary team may be warranted.

6.4.2 Spina bifida

Spina bifida is a condition which affects about 1 in every 1,000 children born per year in Ireland. Ireland has one of the highest incidences of spina bifida births in the world. Spina bifida is the most common neural tube defect and causes incomplete development of the spinal cord in the womb.[xii]

Impact on growth and nutritional status with altered dietary intake

Children with spina bifida may have the physical appearance of being over-nourished, despite a seemingly relatively low energy intake.[(176)] More recent studies indicate that children with spina bifida present with comorbidities of obesity, such as insulin resistance, in addition to altered bone and mineral metabolism and a higher risk of cardiovascular complications.[(184, 185)] For these reasons, it is suggested that healthcare professionals need to emphasise the benefits of healthy eating and physical activity from an early age and offer strategies to enable children with spina bifida to incorporate healthy lifestyle behaviours appropriate to their level of ability.[(186)]

6.5 Clinical conditions where healthy eating guidelines do not apply

There are many instances when healthy eating recommendations are not appropriate. Some medical conditions may require manipulation of diet that removes entire food groups or nutrients. In other conditions, some food groups or nutrients are increased dramatically, and other nutrients are otherwise manipulated. Inherited metabolic disorders – including phenylketonuria, galactosaemia and homocystinuria – are examples of such conditions. These conditions are managed by a paediatric consultant with a multidisciplinary team at the National Centre for Inherited Metabolic Disorders.[xiii] Cystic fibrosis, renal disease and multiple food allergies are other examples in which dietary modification is therapeutically indicated as part of medical management and is done with the close supervision of a CORU-registered paediatric dietitian within the multidisciplinary team.

[xii] http://www.sbhi.ie
[xiii] http://www.metabolic.ie

6.6 Summary of healthy eating guidelines for children with special needs

The aim for children with disabilities is to achieve a healthy, balanced diet which includes the relevant food groups and nutrients to achieve optimum growth, development and functional ability. Nutritional management can be challenging for these children and their families, and they need to be supported to achieve a healthy, balanced diet. While there is much research, there is little conclusive evidence for taking a standardised approach in optimising nutritional intake and/or preventing nutritional deficiency. Nutritional care is determined by the individual child's needs and is often based on regular observation rather than a set of guidelines. The healthy eating guidelines are recommended in all children with special needs. However, when a child is not able to meet the dietary and nutritional targets, they should be referred for clinical follow-up by a specialist multidisciplinary team, including a CORU-registered paediatric dietitian.

A review of the literature indicates that there is a range of issues that may affect the ability of a child with special needs to consume a healthy diet. Evidence is not strong to support deviation from the current recommendations for children with special needs. However, greater monitoring needs to be implemented for this group of children in order to prevent complications of malnutrition, nutritional deficiencies and obesity from manifesting. With the support of their families, these children should be encouraged to follow the healthy eating guidelines. Education on how to manage periods of acute illness and to prevent other complications as the children get older is important. There is consensus in the literature that children with disabilities should have access to regular growth and nutrition monitoring and intervention by nutrition and dietetic services that belong to a multidisciplinary team[161, 187] in order to manage nutritional comorbidities. However, it is recognised that many children with special needs in Ireland are managed in primary care, which should ideally be family focused and community based.[188]

7. BEHAVIOURAL ISSUES

Key issue

- Eating involves strong innate personal preferences and dislikes, but is also learned from the food environments and people around us. Most children have innate preferences for sweet, salty and energy-dense foods, but they can learn to like most foods, especially in these early years.

Key recommendation

- Children require active adult support to learn to like and eat many foods, including healthier ones such as vegetables.

7.1 Background

Food preferences develop from a complex, multisystemic interplay of innate, developmental, relational and environmental factors, including caregiver(s), psychosocial processes, and the social and nutritional context. Understanding early preference development is crucial, as children's early food preferences strongly predict their food choices and life course preferences.[189-191] This chapter briefly highlights the relevant behavioural and developmental features of children's eating from age 1–5 years before synthesising key findings on food preferences, eating, caregiver interactions and environmental effects. Note that the evidence base is skewed towards cross-sectional studies of single effects. Multiple reviews point to the lack of high-quality longitudinal and experimental studies and studies examining interacting factors, e.g. knowledge is weak even about interactions between parental factors, such as food parenting versus parents' eating practices.[189, 192-196] The evidence for behavioural issues and parent/carer food practices should be reviewed in the near future, as there is extensive research being carried out at present. Nevertheless, there is evidence to support the provision of advice to parents, caregivers, pre-school and junior infants teachers, and healthcare professionals.

Children vary in awareness of hunger, and in their sensitivity and openness to tastes, smells, and a food's visual, auditory or tactile features (colour, crunch, viscosity).[189, 193, 197, 198]

Food preferences are partially genetic. Twin studies demonstrate high heritability for protein food preferences, and moderate heritability for fruit, vegetable and dessert food preferences,[190, 191] possibly due to genetic differences in taste perception for sweet, bitter and umami flavours.[190] Variation in bitter perception has been studied most; some studies suggest that genes for sensitivity to bitter flavours cause brassicas and other foods with bitter compounds to be rated as more bitter, and sweet flavours to be preferred, although others have not found these associations.[190] Appetite is also strongly genetic[199] and thus subject to individual variation.

Environments also influence food preferences[191, 193, 200] and no simple account of relative impact can be given. Genetic taste sensitivity also interacts with food parenting practices,[191] and food dislikes can often be reduced or even reversed through modelling and taste exposure.[191] Some twin studies indicate a strong environmental influence; others indicate both genetic and environmental effects. Importantly, relative effects may vary with age and food type, as discussed below.

7.1.1 Behavioural issues in 1–3 year olds

Smell, taste and sensory preferences

Several features of young children's food preferences and behaviours are thought to be innate. Infants and young children almost uniformly prefer sweet and saltier tastes and are more likely than adults to dislike bitter flavours, such as in vegetables, which is thought to potentially signal toxins.[189-191, 201, 202]

Taste and eating during infancy and early childhood contain developmental arcs with some sensitive periods.[190, 203] Taste receptivity is influenced by exposure to flavour compounds in the maternal diet (in utero and through breast milk), formula milk and complementary feeding,[190, 203] so many taste preferences already exist by the age of 1 year. However, it is crucial to note that a malleable period for learning about flavour and eating extends through early childhood.[189-191, 200, 204] Therefore, the earliest taste experiences need not necessarily determine future preferences, although they may affect how easy it is to establish a more varied diet. Note that interactions are complex and that parental environmental influences may be stronger when children are younger, with genetic effects becoming more pronounced later.[193, 205]

Specific sensory features of food, such as texture, may also play a part in dislike or rejection. These are less well understood,[206] although anecdotally, there is widespread reporting of dislike of textured 'bits' (distinct solid pieces within smooth foods) among young children.[206, 207] In one study with children aged 2.5–4 years, adding fruit pieces to fruit-flavoured yogurt significantly reduced intake, whereas colour and taste manipulations of the same yogurts did not.[206]

Ability to compensate for earlier energy intake reduces from 1 year

From the age of 1 year on, young children begin to lose their ability to adjust food intake to compensate for the energy density of earlier meals.[208] Rapid early growth and weight gain in infancy peaks by about 2 years of age, slowing until the age of 5 years,[209] with a consequent reduction in appetite.[210]

These developmental features of appetite mean that parents are recommended not to assume that they can determine their child's appetite, as portion sizes have implications for weight.

Recognising, categorising, requesting and rejecting foods

By the age of 1 year, children can group food into visual categories[211] and point to items they want,[212] and thus also refuse items they do not want. By the age of 2 years, they can group foods into conceptual categories such as 'vegetables', 'breakfast' or 'healthy'[213, 214] and thus start to learn about social and cultural expectations regarding food and eating.

Autonomy from about 2 years

Individual autonomy, a key social-psychological developmental goal, particularly in Western cultures, is first expressed in the toddler years.[215, 216] However, where food is concerned, parents and caregivers may not ascribe autonomy to children,[210] possibly reflecting their strong sense of responsibility for children's thriving, and adults often assume they are the better judge of children's appetite.[217]

Imitating others, in person and on screen, from 1 year

From the age of about 1 year, young children learn to imitate adult behaviours effectively, and from about 2–3 years of age, they also start to imitate older and similar-aged peers' eating.[218-222] Pre-schoolers also imitate eating behaviours from screen viewing.[196, 222, 223]

Food neophobia,[xiv] disgust and contamination responses: a key developmental feature of the first years

A key characteristic of taste/eating development in the early years is sensitivity to, and rejection of, new smells, flavours and foods. This begins at 1–2 years of age, when even previously accepted foods may be rejected for some time.(205, 210, 224-227) This may include disgust towards disliked foods and rejecting food that has been touched by disliked food, which is a contamination response.(228)

Taste and smell neophobia and picky eating are very widespread, such that this should be considered a typical developmental feature. Estimates vary but cohort data (parent reports) indicate that parents rate up to 74% of children as 'very choosy' about food at some point between the ages of 2 and 5 years.(227) Picky eating often peaks by the age of about 3 years, but may not diminish until about 8 years of age or even later.(225, 229, 230) Hypotheses suggest that fussy or picky eating is a response to three biopsychosocial developmental factors: (1) slower growth, with a consequent adjustment of portions; (2) more independent exploration, possibly resulting in caution about new tastes; and (3) increasing psychological autonomy, often expressed in feeding interactions.(191, 210, 231)

As well as being developmental, neophobia is related to strongly heritable temperamental factors such as emotionality, shyness and anxiety.(189, 191) Strong associations are found between parent and child food neophobia,(232, 233) tactile sensitivity and tactile play enjoyment, suggesting that food neophobia may be inherited through tactile sensory processing sensitivity.(234) These heritability factors suggest that healthcare practitioners should carefully consider how advice is offered to parents who may be neophobic themselves. Although food fussiness (selective eating frequently including a focus on texture) is often linked more with environmental influences, it shares a considerable genetic aetiology in early childhood with neophobia, diverting blame from the home.(235) However, both fussiness and neophobia may be decreased effectively with parent-led eating behaviour change programmes.(235)

Some studies suggest that picky eaters eat fewer fruits and vegetables and less dietary fibre, and that they have lower energy intake than the norm, and some (though not all) studies

[xiv] Food neophobia is generally regarded as the reluctance to eat, or the avoidance of, new foods.

report an impact on growth.[205, 210, 236] However, health risks are considered low for mild to moderate fussy/picky eating and neophobia if this is transient.[205, 237] Nevertheless, parents are often very concerned about this behavioural change.

Note that assessment of genetic and environmental contributions to 114 food preferences (by parent-completed questionnaire) of 3 year-olds in the UK Gemini twin study sample[200] found, as expected, significant genetic and environmental effects for all foods. Interestingly, however, genetic effects dominated for vegetables, fruit and protein preferences, whereas environmental effects dominated for starches, dairy and snacks preferences.[200] The study authors propose, therefore, that this may explain a common conflict where health professionals consider the home to determine children's food preferences, whereas parents perceive these preferences to be innate; in fact, both may be correct. Note that if environments play a stronger role in consumption of energy-dense, nutrient-poor foods, this has implications for food parenting and the broader food environment.

7.1.2 Behavioural issues in 4–5 year-olds

From 4–5 years of age, the malleable period for learning about flavour and eating continues, and many of the behavioural issues described above still apply.

Picky eating may appear, may start to reduce, or may persist into later childhood. On average, 4-5 year-olds disliked 10 of 94 common foods, which were more likely to be vegetables and protein foods than starches and sweet foods.[191] In general, children prefer energy-dense foods, possibly an innate response or linked to positive post-ingestion experiences of satiety from energy-dense food: for example, young children tend to prefer bananas and potatoes to melon or courgette, and a study by Birch and colleagues demonstrated that after several exposures, higher-energy drinks and yogurts were preferred to lower-energy ones.[191] Pre-schoolers and children up to 6 years old with higher neophobia ate fewer fruits, vegetables and protein foods, but not fewer starchy, sugary or fatty foods.[191]

Regarding cognitions about foods, from the age of 3 years, children recognise a majority of food brand logos, matching these to images of the foods they represent. Thus, before they begin school, their learning about heavily marketed foods is well advanced, and unhealthy brands are recognised at twice the rate of healthy ones.[238] The knowledge that fruit and vegetables are healthy is gained quickly, but an understanding of what is not healthy increases later, around 4 years of age.(214) Thus, learning about what is healthy and what is not healthy in pre-school is important.

7.2 Key issues that arise and how to address these

Children's early caregivers are crucial to a child's learning about food and eating through direct modelling of eating practices, the food environment they create, and food parenting practices. Parental eating, social facilitation and social norms, as well as the family food environment (including food availability and accessibility) all affect the foods that children come to prefer.(189, 192, 198, 200, 239) Food parenting practices – perhaps better termed 'food caring practices', as they apply to all carers – are characterised by varying degrees of adult/parental control and child autonomy.(193, 240) They may be broadly classified as directive/non-directive(210) or clustered into coercive control (e.g. restrictions, pressure to eat, threats or bribes), structure (e.g. rules, limits and monitoring) and autonomy support (e.g. nutrition education, child involvement and reasoning).(240)

Parents often pressure children to eat certain foods or to eat larger portions, sometimes with bribes of food or non-food items, or with threats. They may also restrict children's diets, monitor their intake, apply food rules or limits, or reason with children. However, cross-sectional experimental studies strongly indicate that seeking to change children's eating through controlling feeding strategies, such as pressure to eat or restriction, is counterproductive.(192) Effects of food parenting practices on children's behaviours are complex, and vary with the food being promoted or restricted, parent behaviours, and children's preferences.

Food caring practices

- Pressure to eat a particular food decreases liking for it.
- Maternal pressure to eat fruit or vegetables at the age of 1 year predicted lower levels of intake at the age of 2 years.(192)
- Restriction of a food may increase preoccupation with, preference for, and subsequent intake of the food.(192)
- Restriction is consistently associated with child weight gain and overweight.(241)
- Food-based rewards should not be used, as they decrease preference of the food in question and enhance the preference for rewards such as sweets or desserts.

- Small, non-food-based rewards (e.g. stickers) may help initially with neophobia, but should be used with caution.[192]

Social facilitation: modelling of eating

Parents are strong models, particularly in the earlier years when food preferences are more malleable. Parent eating and enjoyment is observed and imitated by children (see also study with preschool educators in the '*Parent and preschool interventions'* Section).

- Children are more likely to try something unfamiliar if they have seen someone else try it.[191]

However, note that social facilitation has complex effects on children's eating, depending on the child's age, relationship with the model, whether the model likes or dislikes the food, and whether or not the food is healthy.

- Parents and adults may exert a stronger influence on young children; older children may imitate peers' eating more.
- Parents, friends and peers expressing a dislike of specific foods and high levels of neophobia and/or pickiness can also affect children.
- Children can also be influenced by social modelling of unhealthy foods.[192, 242]

Availability and accessibility: preparation and serving style

- Free access to fruits and vegetables appears to have long-term positive effects, although there are relatively few studies on this.
- "Preparation method, serving style, and serving order clearly have the ability to influence children's intake and liking".[192]

Food availability and parent modelling are more important than more direct food parenting practices such as restriction, pressure, rewards and encouragement (note, however, that the available evidence is mostly cross-sectional or short-term experimental).[193] Parents can support children's attendance to internal satiety signals while encouraging healthy dietary behaviour by:

- Covertly avoiding (consumption of) 'junk food'
- Avoiding using unhealthy foods for rewards or emotional regulation
- Providing clear and healthy rules about what can be eaten and when
- Providing healthy foods in larger portions and unhealthy foods in smaller portions with less variety, and stimulating healthy intake through:

- Repeated exposure
- Active healthy food modelling (e.g. smiling when eating healthy food themselves).

Bidirectional effects

Often, associations are interpreted as parental influence on the child, but in fact parents and children influence one another. Parents (specifically mothers) in twin studies used more pressure to eat and more rewards with the fussier twin, suggesting that they respond to children's behaviour.(210) Longitudinal research found that parental pressuring developed in response to pre-schooler's food avoidance, but also created fussiness.(243) Similarly, parents of pickier eaters tended to engage in less autonomy-supportive food parenting; yet, controlling food parenting was associated with more food refusals.(244)

Researchers conclude that parents need alternative methods to deal with their child's fussy eating and reduce controlling food parenting.(243, 244)

Feeding and BMI

The feeding-BMI relationship is also bidirectional, but note that BMI influences parent feeding practices more than parent feeding practices influence BMI for both restriction and pressure to eat, suggesting that parents adopt controlling feeding practices in response to their child's BMI.(243) Mothers of 2–6 year-olds who overvalued low weight and shape engaged in more dietary fat restriction, while those with knowledge of strategies for promoting positive child body image and eating patterns had lower weight restriction, as well as fewer instrumental, emotional, and pushing-to-eat feeding practices.(245) Note that Larsen *et al*.(193) importantly sought to bridge two generally distinct literatures: parents' own eating and their child feeding practices. Parents' eating and their food parenting practices interact to influence children's eating and BMI. Children's eating and BMI are also mediated by changes in the child's home food environment.

Fathers

Research into fathers' food parenting practices and the interaction of these with mothers' food parenting practices is very limited. Existing studies suggest that pressure to eat is widely adopted by fathers, who are also generally less likely to monitor children's food intake, and to limit access to food, than mothers.(246, 247) However, one study found that fathers' feeding practices and feeding style were not associated with children's diet quality or weight status.(248)

Parent and preschool interventions

A systematic review of parenting studies targeting the effect of parents' nutrition knowledge and/or parenting practices on the development of healthy dietary habits, conducted with parents of young children aged 2–5 years, found few good-quality studies.(195) Mikkelsen *et al.*(194) found that, although preschool healthy eating interventions increased fruit and vegetable consumption and nutrition-related knowledge, only two of their selected studies reported achieving the goal of reducing BMI. A meta-analysis of child obesity interventions to date found that they were not effective at long-term follow-up.(249)

An experimental study aiming to increase consumption of fruit and vegetables involved parents and children aged 21–24 months who looked at picture books with either the target fruit or vegetables, or a non-food book, for 2 weeks. Children were then offered the target fruit and the target vegetable every day over 2 weeks. In all groups, liking of both foods increased after taste exposure as well as at 3-month follow-up. Children who looked at vegetable books liked the vegetable post-intervention and at follow-up, and ate more at follow-up. They also showed lower increases in food fussiness and neophobia than controls.(250)

In early childhood settings for children aged 3-5 years in Finland, sensory-based food education was associated with increased willingness to choose and eat vegetables, berries and other fruit; the association was stronger among children whose mothers had a low level of education.(251) Furthermore, preschool teachers' modelling and exaggerated liking of food is effective, but peers' influence is more powerful than teachers' when these are directly compared.(252)

Media effects

Although there is limited research about the developmental effects of media in general on pre-school children,(253) the effects of food marketing and advertising on children are well-established by systematic reviews.(254)

On the island of Ireland, young children (*n*172, aged 3–5 years, attending preschools and primary schools in diverse socioeconomic settings) had a very strong ability to identify healthy foods as important for growth and health, but considerably less ability to reject unhealthy items, with food brand knowledge already increasing significantly between the ages of 3 and

4 years.[214, 238] Parents of these children held very high negative attitudes towards food advertising to children, yet believed that their own child was only moderately influenced by television advertising, although they pointed to free toys, cartoon programmes, friends and other factors that they perceived did have influence. More than half said that their child asked for food when shopping and nearly one-quarter reported that saying 'no' resulted in their child being angry, yet most never talked with their child about advertising and almost all never encouraged their child to switch television advertisements off.[255]

In an eight-country study of 'pester power', diet and weight outcomes among children aged 2–9 years with a 2-year follow-up,[256] asking for food items seen on television had the most robust relationships across 23 child outcomes and over time: children who never asked for items seen on television were less likely to become overweight, whereas children who often asked were more likely to become overweight. Huang and colleagues note that differences in pestering may be attributed to culture or policy factors, giving the example of Sweden, which has strict regulations on commercials broadcast during children's television programmes and which had the lowest proportion of children who often asked for food items shown on television. Notably, parents on the island of Ireland reported routinely giving food treats (usually high in fat, sugar or salt) to children, and most frequently did so either as a reward or because children asked.[257] Furthermore, adults who care for children on the island of Ireland report that even though they think of treats as something special, giving these foods has become routinised compared with their own childhoods.[257]

Taken together, these findings regarding families in Ireland indicate that media advertising may be having an effect on children's food awareness and knowledge; that there is little parental mediation of such effects, as parents believe their children are not subject to such influences; and that food treat-giving, including in response to children's requests, has become normalised to the extent that it is now routine.

Guidance for carers to encourage positive healthy eating practices with children

In addition to the guidance given in this chapter for food caring practices, key factors required to facilitate a positive experience are time, patience and focus.

Young children exposed to new foods of different shapes, textures, colours and odours need time to first observe, feel, explore and experience the food at all sensory levels, and parents eager to increase the range of foods should be aware that this learning requires time and may require minimal distraction.

Wherever possible, eating should be a social activity and carers should eat with children, modelling not only the eating but also the enjoyment of food. After turning off all screens (televisions, tablets and phones – their own included), carers should seat the child in the same position at a table for each meal and talk encouragingly to the child through each phase of the meal (e.g. serving, tasting, eating, and finishing eating). Chastising the child for spilling food or drink should be avoided. It is important to be fully aware of the messy nature of learning to feed. Play may be harnessed to foster positive healthy eating behaviours, making mealtime more of a calm yet fun learning experience than a stressful one for the child and parent(s). Depending on the child's age and developmental stage, simple play can, if necessary, be incorporated into feeding time to encourage handling and manipulation of food by the child, including hide and seek games with the food (e.g. placing a piece of vegetable under the plate or in a cup and encouraging the child to find it) or spoon-feeding with sound effects.

The suggestions below may be useful through the stages of development. At all stages, it is important that children have the experience of observing parents and carers eating and enjoying the food they want the child to eat.

12 months:

- Encourage the child to pick up berries or small pieces of chopped food themselves.
- Describe the colour, smell and taste of the food and count the pieces as they are eaten.
- Try some of the food to encourage modelling of eating and chewing.
- Allow the child to use the spoon themselves and then use the spoon to feed the child with aeroplane/train games, etc.
- Provide a drink of water with a closed cup

18 months:

- Amuse the child by asking them to move food from one bowl to another and then eat it.
- Encourage the child to use a spoon independently, with the parent making playful sound effects (aeroplane, train, etc.).

- The child may not want to sit still in a high chair, so preparing food options that do not require a spoon may be useful (e.g. small pieces of cheese, bread, vegetables, etc.).
- If the child is really resisting sitting at the table, place a bowl of bite-sized foods on the floor and encourage the child to pick up the pieces by using squatting or kneeling.
- Provide a drink of water with an open cup.

24 months and beyond:

- Amuse the child by asking them to move food from one bowl to another and then eat it.
- Encourage the child to use a spoon independently, with the parent making playful sound effects (aeroplane, train, etc.).
- Encourage the child to show a clear spoon after each mouthful.
- Name and describe the foods in the meal and the actions taken to eat the meal.
- Manage tantrums as able with distractions and storytelling.
- Sit with siblings/adults at mealtimes to imitate eating behaviour.

8. FOOD ALLERGIES

Key issue

- If a key food group is excluded from the diet of a child because a food allergy is suspected, without proper indication or appropriate professional advice being sought, the growth and development of that child could be compromised.

Key recommendation

- Appropriate professional advice should be sought if a food allergy is suspected and before excluding any key food groups from the diet of a child.

8.1 Food allergy versus food intolerance

Food hypersensitivity is the overarching term used to describe food allergies and food intolerances. It is important that a food hypersensitivity is diagnosed by a medical professional and that the difference between a food allergy and food intolerance is known to the parents/carers of the child.

A food allergy is an immune response to an allergen (i.e. a food protein). The immune response can affect a number of organs in the body and can be life-threatening if not managed and treated correctly.

A food intolerance does not involve the immune system. The symptoms of a food intolerance generally affect the digestive system (e.g. diarrhoea, bloating, etc.) and take longer to develop than those of a food allergy. A food intolerance is generally not life-threatening.

8.2 Food allergy symptoms

The immune response to a food allergen can be either immediate or delayed. Immediate food allergy symptoms occur within minutes and up to 2 hours after exposure to the allergen. Delayed food allergy symptoms take several hours to appear. Food allergy symptoms also differ in terms of severity. Symptoms of a food allergy can be mild, moderate or severe. Mild symptoms include itchy tongue, small patches of hives or a rash, and mild sneezing. Moderate symptoms include swelling of the face, lips or eyes, and large areas of hives or rash. Severe symptoms include difficulty breathing and swallowing, dizziness/weakness, and collapse.

Anaphylaxis is a severe, life-threatening allergic reaction requiring immediate treatment. Adrenaline is the best treatment for anaphylaxis, and those at higher risk of anaphylaxis should carry two adrenaline pens with them at all times in case of allergic reaction.

8.3 Common types of food allergies in this age group

More than 90% of food allergies in the West are caused by eggs, cow's milk, nuts, molluscs and wheat.[258] The most common food allergies in young children are egg, milk and peanut. However, most children appear to grow out of food allergies to egg and milk before they begin school. Peanut allergies, on the other hand, tend to be lifelong.

8.4 Development of food allergies (timing of the introduction of certain foods)

In recent years, it has been recommended that foods likely to cause allergies should not be avoided or their introduction delayed; instead, these foods should be introduced into the diet by 4–6 months of age. A recent Scientific Advisory Committee on Nutrition (SACN) report on feeding in the first year of life[259] has concluded that deliberate exclusion or delayed introduction of egg or peanut until after the age of 6–12 months can increase the risk of allergy to these foods. The report recommends that these foods be included in the diet along with and in the same way as other complementary foods from the age of 6 months, and that they continue to be consumed as part of the normal diet. However, where an infant is at higher risk of food allergy (family history of eczema or food allergy), medical advice may be sought before introduction of these foods. If complementary foods are introduced before the age of 6 months, the SACN advises that these allergenic foods not be introduced until the age of 6 months.

8.5 Diagnosis of food allergy

If a food allergy is suspected, a detailed allergy-focused clinical history should be taken by a trained medical professional. If the trained medical professional suspects a food allergy, they will then refer the individual for further testing. Further testing can include a skin prick test or a blood test to measure the level of specific immunoglobulin E (IgE) antibodies. A skin prick test involves placing diluted drops of the suspected food allergen on the arm and then piercing the skin with a needle. If itching or swelling occurs, this indicates a positive result. A blood test involves exposing the individual to a small amount of the suspected food allergen and then testing the blood for any increase in the level of specific IgE antibodies. These two tests have been validated as measures of allergic reactions.

8.6 Legislation in relation to allergen labelling

Food law, introduced in December 2014,[xv] has made it mandatory for food businesses to provide information on 14 categories of allergens. The 14 allergens that must be declared are:

- Cereals containing gluten, e.g. wheat (such as spelt and khorasan wheat), rye, barley, oats (note: the cereal name, e.g. 'wheat', must be declared and highlighted, not 'gluten')
- Crustaceans, e.g. crabs, prawns, lobsters
- Eggs
- Fish
- Peanuts
- Soybeans
- Milk
- Nuts, e.g. almonds, hazelnuts, walnuts, cashews, pecan nuts, Brazil nuts, pistachio nuts, macadamia nuts (note: the name of the nut, e.g. 'almond', must be declared and highlighted; it should not be declared as 'nuts')
- Celery
- Mustard
- Sesame seeds
- Sulphur dioxide and sulphites (at concentrations of more than 10 mg/kg or 10 mg/L in terms of total sulphur dioxide) – used as a preservative
- Lupin (not very commonly eaten in Ireland)
- Molluscs, e.g. mussels, oysters, squid, snails.

For prepacked foods, the allergen(s) must be listed on the ingredients label and highlighted in a way that makes them stand out from all the other ingredients (e.g. using bold font for the

[xv] Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011; S.I. No. 489/2014 - Health (Provision of Food Allergen Information to Consumers in respect of Non-Prepacked Food) Regulations 2014.

allergen). For non-prepacked foods (e.g. foods sold loose in restaurants, foods packed on the premises, etc.), the allergens must be indicated in writing at the point of sale, presentation or supply. In Ireland, the allergen information must be in written form (legibly handwritten or typed) in English and/or Irish and be easily accessible so that the consumer does not have to ask for the information. The information must also identify exactly which food the allergen information is related to in order to avoid confusion.

Some individuals may have an allergy to other foods which are not listed as part of the 14 allergens which have to be declared by law; however, it is only these 14 allergens that are legally required to be indicated on prepacked and non-prepacked foods in Ireland.

8.7 What to do if a child has a food allergy

For parents/caregivers who have children with a food allergy, it is important that the child continues to eat a healthy, balanced diet in order to meet nutrient requirements while avoiding the allergenic food(s). It is advised that children with a food allergy are referred to a registered dietitian for this reason (see Section 8.8).

It is important that the child understands that they have a food allergy and what foods they need to avoid. It is also important that they recognise the symptoms of an allergic reaction and know to tell an adult if they think they are having an allergic reaction to a food.

If the child has a childminder or attends crèche, it is important that those minding the child are fully aware of the food allergy in question and are properly equipped and informed on what to do if the child has an allergic reaction.

8.8 How food allergies interfere with nutrient intakes

Food allergies require avoidance of the particular allergenic food. A lot of food allergens (e.g. egg and milk) are not only standalone foods, but are also found as ingredients in many other foods and dishes. This means that a large variety of foods will have to be avoided by those with a food allergy. Avoidance of foods can lead to inadequate nutrient intakes, resulting in stunted growth and development in children. For example, if a child has a milk allergy, they have to avoid milk and milk-containing foods. If the nutrients inherent to these foods are not adequately replaced by milk substitutes, fortified foods or supplements, children can have low energy, protein, fat, calcium and riboflavin intakes, as well as stunted growth.[260, 261] For children who have more than one food allergy, the risk of nutrient deficiency is even greater.[262]

Therefore, children with a diagnosed food allergy should be referred to a CORU-registered dietitian who can help identify which foods to avoid. A dietitian can ensure that the nutrients contained in the foods that must be eliminated from the diet will be adequately replaced with alternative foods. Regular monitoring and continued supervision by a CORU-registered dietitian is recommended in order to ensure that nutrient requirements continue to be achieved.

9. DENTAL HEALTH

Key issue

- Dental caries and dental erosion are the two most common causes of oral ill health in preschool children.

Key recommendation

- In addition to avoiding snacking on sugary foods and drinks, the national oral health guidance should be followed in order to help children adopt good oral health practices.[1]

9.1 Background

By 2–2.5 years of age, generally 20 primary teeth have erupted. They fall out at various times throughout childhood, but the first permanent teeth can erupt as early as 5 years of age.[1] Good dental care is essential in preschool children, as primary teeth are important not only for eating, appearance and speech, but also as a guide for the positioning of the permanent teeth. In addition, dental decay in preschool children can cause significant pain, which can make treatment difficult due to their young age. Furthermore, longitudinal studies suggest that children who suffer from dental decay in their primary teeth have a greater risk of developing dental decay in their permanent teeth than children who maintained healthy primary teeth.[263-265]

9.2 Causes of poor dental health

The two main causes of poor dental health in preschool children are dental caries and dental erosion.

Dental caries is also called tooth decay or tooth cavities. Many different types of bacteria live in the mouth, gathering in a sticky plaque with saliva, food particles and other natural substances. Dental caries are caused by the action of some of these bacteria, which convert fermentable carbohydrates (sugars and starches) into acid. The acid produced softens or demineralises the tooth surfaces. This repeated action can eventually lead to holes or cavities developing in the teeth, particularly when there is poor oral hygiene and frequent consumption of sugary foods and drinks. Some of the bacteria convert sugar and starch from the foods we eat into acids. It is these acids that dissolve minerals on the surface of the tooth, causing demineralisation. Often, the first indication of dental caries is a patch of softened (demineralised) enamel on the tooth surface, which may be a slightly different shade (opaque) and can be hidden from sight in the grooves of the teeth or between teeth.[266]

In contrast, dental erosion is the progressive loss of tooth surfaces by chemical or acid dissolution; no bacteria are involved. It occurs primarily as a result of too frequent or inappropriate use of acidic foods and drinks. Any food or drink with a pH <5.5 is acidic (i.e. has an erosive potential) and is deemed harmful to teeth, with relevant examples including all carbonated beverages (both sugary and non-sugar-containing) and fruit juices.

Although comprehensive data on the prevalence of dental caries and erosion in preschool children are lacking, data from the *Growing Up in Ireland* study (2010/2011) suggest that 5% of 3 year-olds surveyed had dental problems, with 48% of the cohort analysed reporting brushing their teeth less than twice a day.[267] Furthermore, using data collected from 1,879 5 year-olds in Cork and Kerry in 2013–2014, the Fluoride and Caring for Children’s Teeth (FACCT) study showed that 41% of the 5 year-olds measured had caries. This is despite the fact that 81% of the children studied started using toothpaste before 2 years of age and 65% reported brushing their teeth twice or more a day.[268]

9.3 Foods and drinks contributing to dental caries and erosion

There are some differences in the major dietary causes of dental caries and dental erosion. The single most important cause of dental caries is the frequency with which sugar-containing foods and drinks are eaten. In particular, intake of sugar between meals increases the length of time plaque dips below a pH of 5.5, the critical level below which demineralisation occurs (see Figure 9.1). Exposing teeth to regular bouts of demineralisation, for example by frequent ‘grazing’ throughout the day, allows less time for tooth recovery or remineralisation, and teeth become more prone to decay. Of particular concern is the frequent intake of, or snacking on, foods high in free or added sugars, where sugar has been added to a food along with the sugars present naturally in honey, fruit juice and syrups. Some examples include confectionery, cakes, biscuits, pastries, chocolates and all sugar-containing beverages, including some plant-based ‘milks’ (e.g. soya ‘milks’). Savoury snacks (e.g. crisps) should also be limited, as they can adhere to teeth and promote tooth decay. When eaten, such foods are best consumed as part of a meal. Milk and water are the only recommended drinks for preschool children.

Dental erosion is primarily caused by high and/or frequent intakes of acidic foods and drinks, e.g. all carbonated beverages and fruit juices such as orange juice. Regular sipping of such drinks throughout the day is associated with a greater risk of dental erosion. Where given, unsweetened fruit juices should be very well diluted and consumed at mealtimes, preferably from a cup. As there are no differences in pH between sugar-sweetened beverages and those sweetened with intense sweeteners, both will affect incidence of dental erosion. It is also recommended that beverages sweetened with artificial (intense) sweeteners are very well diluted before consumption by preschool children.

9.4 Good diet-related dental habits for the prevention of dental caries/erosion

In preschool children, the most effective methods for preventing both dental caries and dental erosion involve a combination of healthful dietary choices and good oral healthcare.

Dietary strategies

Dietary strategies to prevent dental caries typically focus on encouraging a varied, healthy, balanced diet and reducing the amount and frequency of consumption of both sugar-containing foods and beverages and those with an erosive potential. Milk and water remain the only recommended drinks for preschool children. However, of note, some young child formulae and plant extract 'milks' also contain sugar and should not be sipped continuously. As young children are more likely to consume foods between main meals, snack options should include vegetables, cheese and whole fruits, with sugary foods and drinks limited to mealtimes, if consumed at all. As a practical aid to choosing foods and drinks with a lower sugar content, parents and carers may find it useful to read the nutrition panel and ingredient listing on foods in order to aid choice of lower-sugar options.

Other practical advice for young children includes:

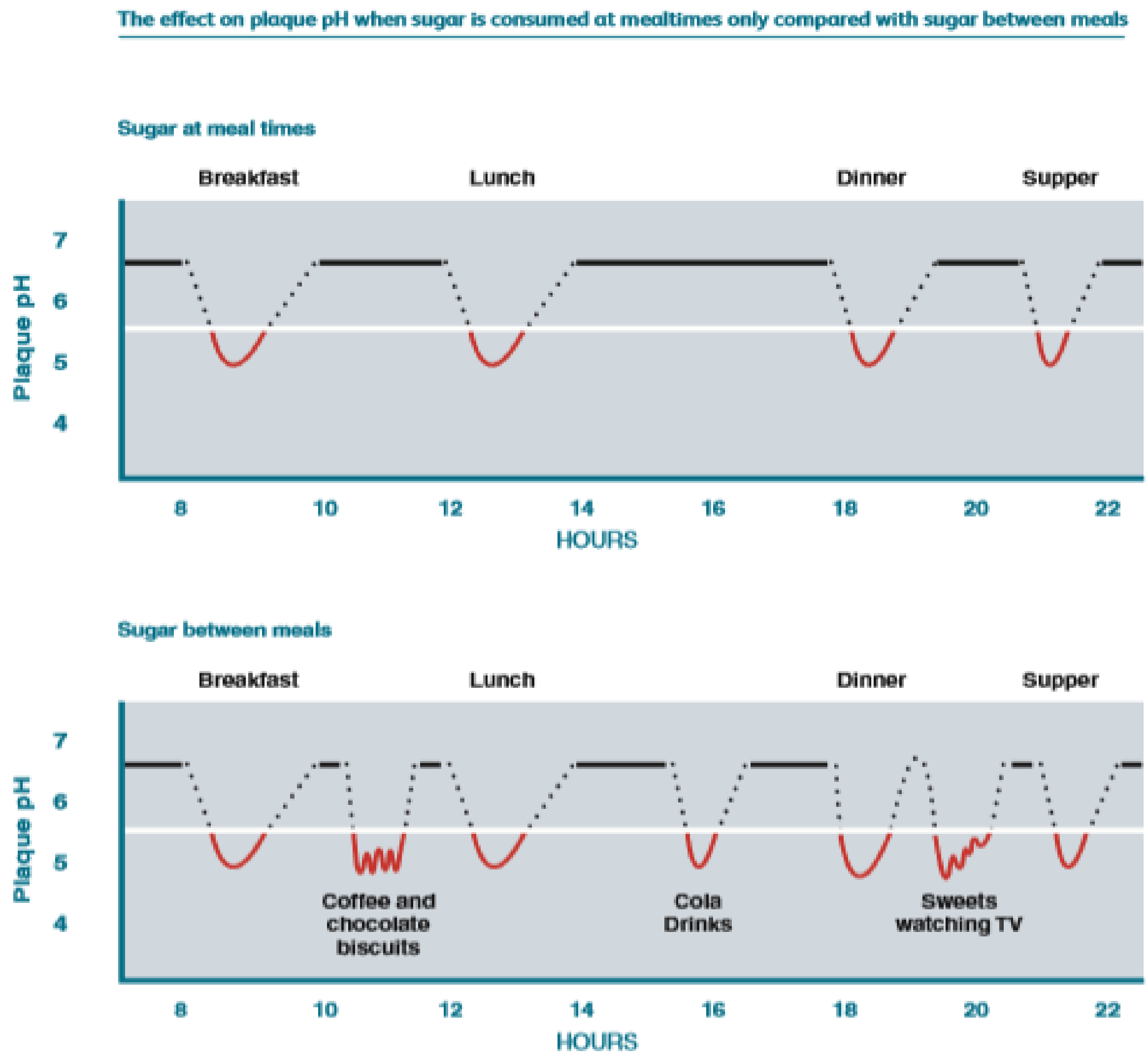
- Making sure that children do not sleep with a bottle in their mouth (irrespective of the contents)
- Avoiding putting any sugar-containing liquids in the nap or bedtime bottle
- Encouraging drinking from a cup

- Discontinuing bottle feeding by the child's first birthday and not dipping a soother in sugar, honey or anything sweet before giving it to the child.[266]

It is important to avoid such practices in order to prevent the development of conditions such as early childhood caries or 'baby bottle decay'.

Oral health guidance

Good oral health guidance focuses on regular brushing, early interaction with dental health practitioners, and appropriate use of fluoride-containing dental hygiene products as per national guidance.[269] The use of bottled water containing levels of fluoride greater than 1.5 mg/L is not recommended for infants and young children and is labelled as such.[270]



Source: Dental Health Foundation (2014)[1]

Figure 9.1 The reduction of plaque pH when sugar is consumed at mealtimes only, compared with sugar between meals

10. RECOMMENDATIONS FOR CHILDREN AGED 1–5 YEARS LIVING IN IRELAND

10.1 Food-based dietary recommendations

The recommendations outlined below should be considered in their totality, i.e. the recommendations are not independent of each other.

- A **wide variety of foods** should be included in order to increase acceptability of, and familiarisation with, foods that are part of a lifelong healthy diet.
- **Milk** is a key food in the diets of 1–5 year-old children. Milk is an important source of a range of nutrients, including protein, and is a critical source of calcium.
    1. A daily intake of 550 mL of milk, or equivalent amounts of yogurt or cheese, should be provided (where 200 mL of milk is equivalent to 150 mL of yogurt or 30 g of cheese).
    2. Low-fat (1% to 2%) cow's milk can be used from the age of 2 years where there is no concern about the adequacy of calorie intake.
    3. Plant-based milk replacement beverages (e.g. soya 'milk') can be used to replace cow's milk, provided they are fortified with the same level of nutrients, particularly calcium. Use of plant-based milk replacement beverages such as almond 'milk', coconut 'milk' and rice 'milk', is not recommended, as they are nutritionally inadequate.
    4. While not necessary for this age group, fortified full-fat milk, follow-up formula and young child formula will contribute to the intake of three key nutrients (iron, vitamin D and n-3 polyunsaturated fatty acids) in 1–3 year-olds (see additional comments under the Supplements recommendation).
    5. It is important that children aged 1–5 years are not given more than the recommended amount of milk as a drink, as this reduces intake of solid food and some nutrients, such as fibre, and may result in iron deficiency anaemia.
    6. It is important that very young children are not given milks in an infant feeding bottle with a teat, as this will delay the development of the child's oral motor and fine motor skills.

- **Breads, cereals, potatoes, pastas and rice** are an important source of calories and fibre.
    1. A combination of both white and wholemeal breads, cereals, potatoes, pastas and rice will provide adequate fibre. For children prone to constipation, an increased proportion of these foods can be given as wholemeal varieties.
    2. Breakfast cereals fortified with iron (containing ≥12 mg of iron/100 g) and vitamin D help to ensure adequate intake of these nutrients. Vitamin C-containing fruit or vegetables, or a small amount of very well-diluted fruit juice, should also be consumed along with the iron-fortified cereal in order to increase iron absorption.
- **Meat, poultry, fish, eggs, beans, lentils and smooth nut butters** are important sources of protein, iron, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA).
    1. Red meat is a rich bioavailable source of iron in the diet of 1–5 year-olds. Including 30 g of red meat approximately three times a week helps ensure adequate iron intake. However, smaller children (i.e. 1–3 year-olds growing at ≤25th percentile level) will require an additional 4 mg of iron/day.
    2. Unprocessed meats (e.g. lean red meat, chicken, fish, etc.) are preferable to processed meats (e.g. ham, sausages, deli meat, etc.), which have high salt and fat content.
    3. Fish should be included at least once a week in the diet of 1–5 year-olds. As important sources of DHA, EPA and vitamin D, oily fish can be included up to once a week, or white fish can be eaten twice a week.
    4. Eggs, beans and lentils are important sources of non-haem iron and, in the case of beans and lentils, provide soluble fibre. These foods may be used as alternatives to meat, fish and poultry. It is important to include these foods during these early years in order to increase acceptability and familiarisation. Vitamin C-containing fruit or vegetables, or a small amount of very well-diluted fruit juice, consumed along with such foods will increase iron absorption from these non-haem sources.

- **Fruit, salad and vegetables** are important sources of vitamins and fibre.
  1. A portion[xvi] of vegetables should always be included at the main meal. In addition, a number of small pieces of fruit, salad or vegetables should be included to match the age in years of the child, as follows:
     - One small piece of fruit, salad or vegetables for 1 year-olds
     - Two small pieces of fruit, salad or vegetables for 2 year-olds
     - Three small pieces of fruit, salad or vegetables for 3 year-olds
     - Four small pieces of fruit, salad or vegetables for 4 year-olds
     - Five small pieces of fruit, salad or vegetables for 5 year-olds
  2. Small amounts of fruit and vegetables given at different times of the day minimise the risk of overwhelming the child's capacity to consume other foods required for critical nutrients such as iron.
- **Fats, spreads and oils** should be used minimally.
  1. A small amount of fat spreads can be added to foods such as bread in order to increase palatability and acceptability.
  2. Frying of foods should be avoided as far as possible, and foods should instead be baked, steamed or grilled.
  3. Roast potatoes or thick-cut oven chips can be used very occasionally (once a week).
- **Foods high in fat, sugar or salt** should be limited, as they provide a high proportion of the overall energy requirements of 1–5 year-old children without providing essential nutrients.
  1. Foods such as confectionery, cakes, crisps, biscuits, sugar-coated breakfast cereals, etc. are not recommended for 1–5 year-olds. Such foods either overwhelm the child's capacity for nutrient-dense foods, or provide additional calories and, consequently, increase the risk of the child becoming overweight or obese.
  2. Small amounts of sugar can be added to nutrient-dense foods (stewed fruit, milk puddings, jam on wholemeal bread, etc.) in order to increase palatability and acceptability. It is important to familiarise children with the variety of

[xvi] Portion sizes increase as the child grows. A rough guide for a single portion is the amount of fruit, salad or vegetables that the child can hold in one hand.

flavours and textures in the wide range of foods required for a healthy diet. Snacking on sugary foods and drinks should be avoided in order to protect dental health.

3. Foods which could be used as a dessert for this age group include rice pudding, stewed fruit (with a small amount of added sugar), custard, and jam on toast.
4. Salt and salty foods should be limited because high salt intakes can become habitual and are linked with cardiovascular disease in later life.
5. Children have a very keen sense of taste, do not require the addition of salt to an otherwise balanced diet, and should be protected from acquiring the habit of adding salt to food at the table.
6. Salt should not be added in cooking for 1–5 year-olds.

➢ **Beverages**

1. Water and milk are the only drinks recommended for this age group.
2. Sugar-containing and acidic drinks should be limited and, if consumed at all, should be kept to mealtimes.

➢ **Supplements**

1. In order to improve the overall vitamin D intake status of this population group, a low-dose vitamin D-only supplement (5 µg) is recommended for all 1–5 year-olds from Halloween to St Patrick's Day (i.e. during the extended winter months).
2. Dietary intake of iron is unlikely to be sufficient for smaller 1–3 year-old children (growing at ≤25th percentile level). This report highlights the need for an additional 4 mg of iron/day for 1–3 year-olds growing at ≤25th percentile level. This additional iron can be provided through the use of iron-fortified full-fat milks or formulae (containing at least 1 mg of iron/100 mL). Alternatively, a low-dose iron supplement providing the Recommended Dietary Allowance (RDA) for iron[xvii] (7 mg) can be given 4 days a week.

[xvii] Current availability of low-dose iron supplements for this age group (at the RDA of 7 mg) is very limited.

10.2 Physical development, activity and play recommendations

- Health-enhancing physical activity is as important as healthy eating for the promotion of healthy body weight and prevention of obesity in 1–5 year-olds. Specific recommendations in the national and WHO guidelines on physical activity should be prioritised. These are integral to successful outcomes of interventions promoting healthy eating in this age group.

10.3 Healthy eating for children with special needs recommendations

- Some adjustments to healthy eating guidelines (texture modification, emphasis on certain food groups, etc.) may be required for children with special needs because they are more vulnerable to feeding difficulties and malnutrition, leading to nutritional deficiencies and to some children being underweight, overweight or obese.
- Children with special needs require careful growth monitoring, as they are at greater risk of nutritional inadequacies. Resources that outline different adjustments and solutions to address feeding issues should be made available to parents and carers of children with special needs.

10.4 Food behaviour recommendations

- Eating involves strong innate personal preferences and dislikes, but is also learned from the food environments and people around us. Most children have innate preferences for sweet, salty and energy-dense foods but they can learn to like most foods, especially in these early years.
- Children require active adult support in order to learn to like and eat many foods, including healthier ones such as vegetables.

10.5 Food allergy recommendations

- If a key food group is excluded from a child's diet because a food allergy is suspected without proper indication or appropriate professional advice being sought, the growth and development of that child could be compromised.
- Appropriate professional advice should be sought if a food allergy is suspected and before excluding any key food groups from the diet of a child.

10.6 Dental health recommendations

- Dental caries and dental erosion are the two most common causes of oral ill health in preschool children.
- In addition to avoiding snacking on sugary foods and drinks, the national oral health guidance should be followed in order to help children adopt good oral health practices.[(1)]

10.7 Research recommendation

- Funded research should be undertaken in order to address knowledge gaps and improve understanding of the nutritional requirements of 1–5 year-olds and therefore enhance food-based dietary guidelines (see Appendix IV).

APPENDIX I – BACKGROUND INFORMATION ON CRITICAL NUTRIENTS FOR 1 TO 5 YEAR-OLDS

Macronutrients

i. Energy

Background

Role of energy in the diets of 1–5 year-olds

The most important nutritional aspect of any diet is energy. Energy is essential for a variety of functions including respiration, circulation, metabolism, growth and physical activity. Energy is supplied by carbohydrates, proteins and fats in the diet.

Recommended dietary allowances/average requirements for this age group

Energy requirements vary from individual to individual depending on factors such as age, gender, body composition and physical activity levels. Energy requirements are established in order to maintain optimal heath by balancing energy expenditure and retaining body mass.

The Institute of Medicine (IOM)[(47)] has not established a Recommended Dietary Allowance (RDA) for energy, as it states that any energy intake above the Estimated Energy Requirement (EER; average dietary energy intake required to maintain energy balance) would result in weight gain. For the same reason, it states that the concept of a Tolerable Upper Intake Level (UL; highest daily nutrient intake that is unlikely to pose a risk of adverse effects) does not apply to energy.

The European Food Safety Authority (EFSA)[(45)] calculated an Average Requirement (AR) for energy for children over the age of 1 year using the Resting Energy Expenditure (REE) and adjusted Physical Activity Level (PAL) for growth. PAL values of 1.4, 1.6, 1.8 and 2.0 were used for three age groups (1–3 years, >3–<10 years, and 10–18 years), and energy expenditure for growth was accounted for by a 1% increase in PAL values for each age group.

The Scientific Advisory Committee on Nutrition (SACN)[(271)] has established an Estimated Average Requirement (EAR) for children for energy, calculated from measurements of Total Energy Expenditure (TEE) plus the energy cost associated with tissue deposition.

Adverse effects of deficiency and overload of energy

When energy intake is less than energy expenditure, the body adapts by reducing voluntary physical activity, reducing growth rates (in children), and mobilising energy reserves. All these adaptations lead to individuals losing weight. In children, reduced growth rates result in stunting (short stature and low weight-for-age). This lack of energy in children can result in an increased susceptibility to infections, delayed bone age and decreased school performance.[47]

When energy intake is greater than energy expenditure, individuals put on weight. Excess weight increases the risk of type II diabetes, cardiovascular disease and some types of cancers.[45]

Main food sources in Ireland

The main contributors to energy intakes are the macronutrients: carbohydrates, proteins and fats.

Energy intakes in Ireland

1–3 year-olds

The National Pre-School Nutrition Survey (NPNS)[12] found that the mean daily energy intake was 1005 kcal, 1122 kcal and 1148 kcal in 1 year-olds, 2 year-olds and 3 year-olds, respectively. This survey found that the biggest contributor to energy intake was milk and/or formula, making up 29% of energy intake in 1 year-olds, with this decreasing to 13% in 3 year-olds. Other sources of energy included meat, bread, breakfast cereals, fruit/fruit juices, biscuits and cakes, and yogurt.

4-5 year-olds

The NPNS[12] found that the mean daily energy intakes for 4 year-olds was 1264 kcal, indicating an increase of 259 kcal/day from the age of 1 year. Although the contribution of milk to the energy intake of 4 year-olds decreased (11%) from that of 1–3 year-olds, it still remained an important contributor. The other sources of energy are the same as those outlined as important sources for 1–3 year olds. Of note, the contribution of confectionery to energy was 4% in 4 year-olds in comparison to 1% in 1 year-olds.

Ways to improve energy intakes/status

Data from the NPNS show that energy requirements for this population sub-group are easily achieved. This is due to the high milk intakes in the diet of this age group. If energy intakes fall below the child's requirements, macronutrient-dense foods (such as meat, fish, poultry, breads, pastas, rice, and some starchy vegetables and fruit) should be consumed to increase energy intakes. The NPNS reported that 16% of 2–4 year-olds were overweight and 7% were obese. Therefore, it is important that energy intakes are adequate for growth but do not exceed the requirements, as this can lead to overweight and/or obesity.

ii. Protein

Background

Role of protein in the diets of 1–5 year-olds

Proteins are the building blocks within the body, responsible for all functions and metabolism. Protein is required for the maintenance and repair of tissue and muscle, and is therefore essential for growth. Protein is made up of nitrogen and amino acid residues, which can be classified as essential (cannot be made by the body and need to be obtained from the diet) or non-essential (as they are made by the body), with the proportion of essential amino acids being more critical in younger children. Protein is particularly essential for young children, as it supports growth and development. During this time of growth and development, there is a high demand for essential, and sufficient non-essential, amino acids in order to make new tissue protein. Proteins can also be used as an energy source if energy is insufficient.

Recommended dietary allowances/average requirements for this age group

The IOM has set Dietary Reference Values (DRVs) for protein based on careful analysis of nitrogen balance (the difference between nitrogen intake and loss in urine, faeces and skin) studies. It has also set an Acceptable Macronutrient Distribution Range (AMDR)[xviii] for protein of 5% to 10% of total calories for children aged 1–3 years, and 10% to 35% of total calories for children aged 4–18 years of age.[(47)]

EFSA has also used the nitrogen balance approach to determine protein requirements. In order to determine protein requirements for children, EFSA used an approach that derived estimates of protein requirements for children aged 6 months and older as the sum of requirements for maintenance and growth corrected for protein utilisation.[(39)] See Table 1 below for EFSA and IOM dietary reference values for protein for this age group.

[xviii] An AMDR is defined as a range of intakes for a particular energy source that is associated with reduced risk of chronic disease while providing adequate intakes of essential nutrients.

Table 1 DRVs for protein in children aged 1–3 years and 4–5 years

Authority/country	DRV	Protein (g/kg/day)	
		1–3 years	**4-5 years**
EFSA, 2012 (Europe)	RDA	1.14–0.90	0.86–0.85
	AR	0.95–0.73	0.69
IOM, 2006 (United States of America (USA))	EAR	0.87	0.76
	RDA	1.05	0.95

Adverse effects of deficiency and overload of protein

A lack of protein energy and energy from other macronutrients results in a condition known as protein-energy malnutrition, which is prevalent in both adults and children worldwide, accounting for approximately 6 million deaths annually. Protein deficiency has been associated with impaired function of the brain in infants and young children, as well as impaired immune system and kidney function.(47) There are no known benefits to consuming high intakes of protein, and current data suggest that high intakes are a risk factor for obesity and obesity-related diseases.(272)

Main food sources in Ireland

Protein can be obtained in the diet from both animal and plant sources. Plant sources of protein include legumes, grains, nuts, seeds and vegetables. Animal sources include meat, poultry, fish, eggs, milk and dairy products. Protein from animal sources is of higher quality than protein from plant sources, because the pattern of amino acids more closely matches what is required by humans.

Protein intakes in Ireland

1–3 year-olds

Data from the NPNS(12) found that protein accounted for 15% to 16% of total energy intake in 1–3 year-olds, and that milk and meat were the main contributors to protein intake in 1–3 year-olds. The contribution of milk to the protein intake of 1 year-olds was 30%, decreasing to 18% in 3 year-olds. The contribution of meat to protein intake of 1 year-olds was 22%, increasing to 28% in 3 year-olds. Other sources of protein intake included bread, breakfast cereals and yogurt.

4–5 year-olds

Similar to the 1–3 year-olds, the NPNS[12] found that protein accounted for 15% of the total energy intake of 4 year-olds, and that milk and meat were the primary contributors to protein intakes. Milk contributed 16% of total protein intake, with meat contributing 29% of total protein intake for this age group. As with 1–3 year-olds, other sources of protein for 4 year-olds included bread, breakfast cereals and yogurt.

Ways to improve protein intakes/status

Intake data indicate that protein requirements are easily achieved by 1-3 year-olds and 4–5 year-olds. In order to ensure adequate intakes of protein, foods such as eggs, meat, poultry, legumes, beans, milk, cheese, yogurt and nut spreads should be included in the diet.

iii. Fat (including saturated fat)

Background

Role of fat in the diets of 1–5 year-olds

Fats play a key role in a range of functions, including structure, storage and metabolism. Dietary fat is made of various compounds including cholesterol, phospholipids and steroids, with the majority of dietary fat (98%) being made up of triglycerides. Triglycerides provide 9 kcal/g, making fat the most concentrated source of energy in the diet. Fat also helps in the absorption of the fat-soluble vitamins A, D, E and K. There are three types of fatty acids, of which a combination is found in a typical dietary fat: saturated, monounsaturated and polyunsaturated.

Saturated fat is made in the body and is therefore not essential. When absorbed by the body, saturated fat supresses low-density lipoprotein (LDL) receptor expression, in turn raising LDL cholesterol. Saturated fat can also raise high-density lipoprotein (HDL) cholesterol.[47]

Recommended dietary allowances/average requirements for this age group

The IOM[47] has not set an EAR, RDA or adequate intake (AI) for total fat for those aged 1 year and above, as there were insufficient data in relation to levels of inadequacy and prevention of chronic disease. However, they have set an AMDR for total fat of 30% to 40% of energy for children aged 1–3 years, and 20% to 35% of energy for children aged 4 years and older.

EFSA[40] has set a Reference Intake (RI) range for adults of 20% to 35% of energy, which has been adjusted for infants and young children accordingly (see Table 2).

Table 2 DRVs for total fat in children aged 1–3 years and 4–5 years

Authority/country	DRV	Total fat (% energy)	
		1–3 years	4–5 years
EFSA, 2010 (Europe)	RI range	35–40	20–35
IOM, 2006 (USA)	AMDR	30–40	20–35

Saturated fat is linked with an increased risk of cardiovascular disease, and both EFSA[40] and the IOM[47] have recommended that saturated fat intakes in young children are kept "as low as possible while consuming a nutritionally adequate diet" [39, 45].

Adverse effects of deficiency and overload of fat

Inadequate intakes of fat, and in turn reduced energy intakes, may lead to impaired growth, which is of particular concern during childhood when energy requirements are high in order to support healthy growth and development.[47]

Diets high in fat which lead to energy intakes in excess of the requirements can result in overweight and obesity. There have also been several studies showing an association between high-fat diets and an increased risk of cardiovascular disease, insulin resistance and some cancers.[40, 47]

Diets too high in fat may also lead to increased saturated fat intake, which has been found to raise total and LDL cholesterol, which in turn increases the risk of cardiovascular disease.

Main food sources in Ireland

The main food sources of total fat include fresh meat, meat products and meat dishes; butter, spreading fats and oils; dairy produce (including cheeses); biscuits, cakes, pastries and buns; and savoury snacks, including fried foods.

The main food sources of saturated fat are spreading fats, oils and butter; whole-fat dairy foods (including cheeses); meats, including meat products and meat dishes; and biscuits, cakes, pastries and buns.

Fat intakes in Ireland

1–3 year-olds

According to the NPNS,[12] fat accounted for 32% to 34% of total energy intake in 1–3 year-olds. The percentage of energy from fat decreased with age, from 34% in 1 year-olds to 32% in 3 year-olds. The percentage of energy from saturated fat (16% in 1 year-olds; 15% in 3 year-olds) and monounsaturated fat (12% in 1 year-olds; 11% in 3 year-olds) also decreased with age. The main contributors to fat intake were milk/formula and meat, including meat products. The contribution of milks decreased with age, from 38% in 1 year-olds to 18% in 3 year-olds. The contribution from meat and meat products increased from 14% in 1 year-olds to 17% in 3 year-olds. Other contributors to fat intake included biscuits and cakes, spreads, and cheeses.

4–5 year-olds

Similar to the 1–3 year-olds, the NPNS(12) found that fat accounted for 32% of total energy intake in 4 year-olds. The percentage of energy from saturated fat decreased further in 4 year-olds (14%), while the percentage of energy from monounsaturated fat remained at 11%. The percentage of energy coming from polyunsaturated fats was seen to be greater in 4 year olds (5%) than 1-3 year-olds (4%). As outlined for 1–3 year-olds, the main sources of fat intake for 4 year-olds were also milk and meat, including meat products. The contribution of milk decreased in 4 year-olds to 16% and the contribution of meat increased to 18%. Other contributors to fat intake included biscuits and cakes, spreads, and cheeses.

Ways to improve fat intakes/status

As outlined above, data from the NPNS indicate that fat intakes of 1–3 year-olds are just below the target range as set by EFSA; however, 4–5 year-olds are reaching their target range. Dairy foods (e.g. milk, yogurt, cheese) can be included in the diet in order to ensure that total fat intake is being reached. However, it is important to note that intakes of saturated fats should be kept as low as possible. In order to reduce the amount of saturated fat in the diet, leaner meats should be chosen rather than high-fat cuts and processed meats, meats and poultry should have visible fat and skin removed, individuals should use low-fat dairy products (after the age of 2 years), and there should be lower consumption of biscuits, cakes and confectionery.

iv. Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA)

Background

Role of DHA and EPA in the diets of 1–5 year-olds

DHA and EPA are omega-3 polyunsaturated fatty acids, a type of dietary fat. Omega-3 polyunsaturated fatty acids play an important structural role in the nerve tissue and retina. DHA is primarily accumulated in large quantities in the brain during the first two years of life.

A growing body of evidence suggests that DHA and EPA could be associated with cognitive development, including language development, in children,[273, 274] and is associated with normal brain development and a reduced risk of developing chronic disease including cardiovascular disease, stroke and diabetes.[275]

Recommended dietary allowances/average requirements for this age group

EFSA[40] took into account the prevention of cardiovascular conditions when setting DRVs for DHA and EPA. EFSA has set an Adequate Intake (AI) of 100 mg for children aged 6 months to 2 years, and 250 mg for those older than 2 years.

Adverse effects of deficiency and overload of DHA and EPA

As there is evidence that DHA and EPA may reduce the risk of cardiovascular disease through various mechanisms, such as reducing atherosclerosis and increasing HDL concentration, a deficiency as well as long-term suboptimal intakes of DHA and EPA in the diet may increase the risk of developing cardiovascular disease.

Main food sources in Ireland

The main dietary sources of DHA and EPA are fish, in particular oily fish, and seafood. A dietary pattern rich in fish is associated with better DHA and EPA status.[276] Additional sources include fish oil supplements and foods fortified with DHA and EPA. Plant sources include flaxseed, hemp, walnuts, and canola or rapeseed oil. Plants are rich in the fatty acid alpha-linolenic acid (ALA), which must be converted to EPA or DHA in the body in order to have the same health benefits. The body’s ability to convert ALA to EPA and DHA is limited, therefore direct sources of DHA and EPA provide the richest source.

DHA and EPA intakes in Ireland

1–3 year-olds

A study conducted using the NPNS[277] database found that EPA and DHA intakes in this age group were inadequate. Mean (standard deviation; SD) intakes of DHA in 1–3 year-olds ranged from 36 mg/day (51 mg/day) to 33 mg/day (56 mg/day), respectively. Mean (SD) intakes of EPA in 1–3 year-olds ranged from 31 mg/day (37 mg/day) to 40 mg/day (55 mg/day), respectively. The main sources of DHA and EPA were found to be fish, fish products and fish dishes.

4-5 year-olds

The study[(277)] also found that the EPA and DHA intakes of 4 year-olds was inadequate. The mean (SD) intakes of EPA and DHA were 37 mg/day (97 mg/day) and 66 mg/day (278 mg/day), respectively. As with the 1–3 year-olds, the main sources of EPA and DHA were found to be fish, fish products and fish dishes.

Ways to improve DHA and EPA intakes/status

In order to increase the amount of DHA and EPA in the diet, foods rich in these fatty acids should be consumed, which include fish and seafood. A healthy diet should include at least two portions of fish a week, one of which should be an oily fish. Plant sources include flaxseed, hemp, walnut, and canola or rapeseed oil, which can supplement the diet especially where fish or seafood are not consumed. Foods fortified with, or supplements containing, EPA and DHA could also be included in the diet in order to ensure adequate intakes.

v. Carbohydrates (including sugar)

Background

Role of carbohydrates in the diets of 1–5year-olds

Carbohydrates (sugars and starches) are the main source of energy in the diet. Carbohydrates play an important role in digestive functions and blood glucose control, and are also involved in the structure of cells within the body. Glucose, a monosaccharide, is essential for all body tissues, in particular the central nervous system, with the brain almost exclusively using glucose as its energy source.

Sugars (monosaccharides and disaccharides) can either be defined as natural sugars or added/Free Sugars. Natural sugars include those found in milk and intact fruit and vegetables. Free Sugars are defined by the WHO as sugars "added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrations". [(278)] Free Sugars can increase overall energy intakes, in turn reducing the amount of nutrient-dense foods consumed.

Recommended dietary allowances/average requirements for this age group

The IOM[(47)] has determined DRVs based on the average minimum amount of glucose used by the brain. The EAR and RDA values the IOM has set are the same for all those aged 1 year and older, except pregnant and lactating women.

EFSA[41] has set RIs for carbohydrates based on the effects of carbohydrates (and fat) intakes on body weight and blood lipids. The RIs set by EFSA apply to both adults and children older than 1 year.

The SACN[279] has set recommended intakes for carbohydrates based on energy intakes that are appropriate to maintain a healthy weight. The SACN recommends an intake of carbohydrates of approximately 50% of total energy for adults and children older than 2 years. It also recommends that Free Sugar intakes of those aged 2 years and older do not exceed 5% of total energy intake.

The WHO[278] recommends that both adults and children reduce the intake of Free Sugars to less than 10% of total energy intake. The WHO also suggests a further reduction of the intake of Free Sugars to below 5% of total energy intake. See Table 3 for the dietary reference values for carbohydrate for this age group.

Table 3 DRVs for carbohydrates in children aged 1–3 years and 4–5 years

Authority/country	**DRV**	**Carbohydrate**	
		1–3 years	**4–5 years**
EFSA, 2010 (Europe)	RI	45–60% of total energy	45–60% of total energy
IOM, 2006 (USA)	EAR	100 g/day	100 g/day
	RDA	130 g/day	130 g/day
SACN, 2015 (United Kingdom (UK))	Recommended intake	50% of total energy	50% of total energy

Adverse effects of deficiency and overload of carbohydrates

The IOM has stated that a diet low in carbohydrates, which leads to increased keto acid production, may cause long-term effects such as bone mineral loss, hypercholesterolaemia and impaired function of the central nervous system.

There are no known adverse effects of consuming natural sugars. However, intakes of Free Sugars, especially those found in sugar-sweetened beverages, increase energy intakes but negatively impact on the consumption of nutrient-dense foods. This can result in an unhealthy diet, weight gain and increased risk of diseases.[278] There is also a strong association between Free Sugar intake and dental caries[266] (see Chapter 9).

Main food sources in Ireland

Most carbohydrates are found as starches in foods such as bread, cereals, pasta, rice, potatoes and pulses. The main dietary sources of sugars are fruits, fruit juices, some vegetables, milk and milk products, with the main sources of Free Sugars being carbonated drinks and sweets.

Carbohydrate intakes in Ireland

1–3 year-olds

Data from the NPNS(12) found that carbohydrates accounted for 50% to 54% of the total energy intake of 1–3 year-olds, increasing with age. Milk/formula was the biggest contributor to carbohydrate intakes in 1 year-olds (20%), but this had decreased to 8% by 3 years of age. Fruit and fruit juices, bread, breakfast cereals, and biscuits and cakes all contributed significantly to carbohydrate intake for this age group. The contribution of fruit and fruit juices (16%) as well as breakfast cereals (13%) remained stable with age. An increase in the contribution of biscuits and cakes (7% in 1 year-olds; 8% in 3 year-olds) and breads (9% in 1 year-olds; 16% in 3 year-olds) to carbohydrate intake was found with age. A further study(280) using the NPNS data found that mean (SD) total sugar intake ranged from 70.7 g (5.3 g) to 75.9 g (5.9 g) in 1 year-olds and 3 year-olds, respectively. Mean (SD) Free Sugar intakes ranged from 9% of total energy (1.2% of total energy) to 13.4% of total energy (1.7% of total energy) in 1 year-olds and 3 year-olds, respectively. The main food contributors to Free Sugar intakes in 1–3 year-olds were yogurts and fromage frais, as well as fruit juices, smoothies and purées.

4–5 year-olds

Similar to the intakes outlined for 1–3 year-olds, data from the NPNS(12) found that carbohydrates accounted for 54% of the total energy intake of 4 year-olds. By 4 years of age, milk was the smallest contributor to carbohydrate intake (7%). The contribution of bread and breakfast cereals remained the same as 3 year-olds (16% and 13%, respectively). The contribution of fruit and fruit juices to carbohydrate intakes decreased slightly in 4 year-olds (15%, versus 16% in 3 year-olds), while the contribution of biscuits and cakes increased (9%, versus 8% in 3 year-olds). Mean (SD) total sugar intakes for 4 year-olds was 83.4 g (6.2 g), with mean (SD) Free Sugar intakes of 14.4 g (1.8 g).(280) The main sources of Free Sugars in this age group were fruit juices and squashes, smoothies, purées, confectionery and carbonated drinks.

Ways to improve carbohydrate intakes/status

As outlined above, NPNS data show that this population sub-group is easily meeting the EFSA target range of 45% to 60% of total energy coming from carbohydrates. In order to ensure adequate intakes of carbohydrates, foods such as starchy vegetables and wholemeal breads, pastas and rice should be included in the diet.

vi. Dietary fibre

Background

Role of fibre in the diets of 1–5 year-olds

Dietary fibre refers to plant-based carbohydrates and lignin components which are not digested or absorbed in the human small intestine, but are fermented in the large intestine. Adequate dietary fibre in the diet is important to support healthy bowel function and has been shown to increase faecal bulk and transit time, promoting normal laxation in both adults and children.[41] EFSA,[41] the IOM[47] and the SACN[279] have concluded that increasing fibre-rich foods in the diet is associated with reduced risk of cardiovascular diseases, type 2 diabetes and colorectal cancer. The SACN also suggests that dietary fibre intake has no effect on body weight or energy intake, and found no association between change in body fatness and dietary fibre intakes in children; however, more evidence is needed before conclusions can be made.[279]

Recommended dietary allowances/average requirements for this age group

EFSA found that there was limited evidence to set adequate intakes of fibre for children, and therefore extrapolated the value from that of adults, adjusting for energy intakes.[41]

The IOM has set an AI for fibre, as it determined that there was insufficient evidence to set an EAR or to calculate an RDA. The AI set was based on the amount of fibre intake needed to protect against cardiovascular disease.[47] The SACN also used the endpoint of cardiovascular disease for setting its recommended dietary fibre intakes. For children, the recommended intake is a proportion of that of adults, rounded to the nearest 5 g.[279]

In 1995, the American Health Foundation developed a new recommendation for dietary fibre intakes in children.[43] This recommendation was based on the age of the child, health benefits and safety concerns. The recommended intake it set was a dietary fibre intake equivalent to age + 5 g/day. See Table 4 for the dietary reference values for fibre for this age group.

Table 4 DRVs for fibre in children aged 1–3 years and 4–5 years

Authority/country	**DRV**	**Fibre (g/day)**	
		1–3 years	**4–5 years**
EFSA, 2010 (Europe)	AI	10	14
IOM, 2006 (USA)	AI	19	25
SACN, 2015 (UK)	RI	15	15
American Health Foundation, 1995 (USA)	Recommended intake	Age + 5	Age + 5

Adverse effects of deficiency and overload of dietary fibre

As dietary fibre is not an essential nutrient, inadequate intakes do not result in biochemical or clinical symptoms of deficiency. However, inadequate intakes can decrease faecal bulk, reducing optimal gut health.(47)

A high intake of dietary fibre in healthy individuals will not result in serious adverse health effects, but gastrointestinal symptoms, such as bloating, may occur. However, excess intake of fibre is self-limiting due to the bulky nature of fibre.(47)

Main food sources in Ireland

There are two types of dietary fibre – soluble fibre and insoluble fibre – and fibre-rich foods typically contain both types. Soluble fibre breaks down to form a gel-like material and is found in oats, peas, beans, apples, citrus fruits, bananas and carrots. Insoluble fibre promotes the movement of faecal load through the gut and increases faecal bulk. Insoluble fibre is found in foods such as wholegrain foods, cereal, bran, nuts, seeds, cauliflower, green beans and potatoes.

Dietary fibre intakes in Ireland

1–3 year-olds

According to the NPNS,(12) the average daily intake of dietary fibre for 1 year-olds was 10.5 g, increasing to 12 g in 3 year-olds. The main contributor to dietary fibre intake was found to be fruit (19% in 1 year-olds to 18% in 3 year-olds), with bread, breakfast cereals, vegetables and potatoes also being significant contributors.

4–5 year-olds

Data from the NPNS(12) showed that dietary fibre intake increases with age. As outlined above, dietary fibre intake increased from 10.5 g to 12 g in 1–3 year-olds, and this trend continued in 4 year-olds, increasing to 12.8 g. The main source of dietary fibre intake in 4 year-olds was breads (18%), followed closely by fruit (17%). Other contributors included breakfast cereals, vegetables and potatoes.

NPNS[12] dietary fibre intake data were also adjusted for energy and were found to be similar from the ages of 1–4 years, indicating that the increase in dietary fibre intakes was due to more food consumption as the child got older.

Ways to improve dietary fibre intakes/status

As indicated from the NPNS data, dietary fibre targets for 1-5 year-olds are easily achieved, with the intakes increasing as age increases due to more foods being consumed. Ensuring adequate intakes of fibre can be achieved by including wholegrain foods, seeds, fruit, vegetables, beans and lentils in the diet.

Micronutrients

vii. Vitamin A

Background

Role of vitamin A in the diets of 1–5 year-olds

Vitamin A is a generic term used to describe any compound with the biological activity of retinol. Vitamin A can be obtained in the diet from both animal (as preformed vitamin A) and plant (as provitamin A carotenoids) origins. Vitamin A, a fat-soluble vitamin, plays an important role in visual development and maintenance, development and differentiation of tissues and cells, growth, and reproduction.[48]

Recommended dietary allowances/average requirements and tolerable upper intake levels for this age group

Both EFSA and the IOM have established RDAs for vitamin A for this age group. The EFSA AR for vitamin A is 205 µg retinol equivalent (RE)/day for children aged 1–3 years and 245 µg RE/day for 4–6 year-olds.[48] The RDA for 1–3 year-olds is 250 µg RE/day, increasing to 300 µg RE/day for 4–6 year-olds. The IOM EARs for vitamin A are slightly higher, at 210 µg RE/day for 1–3 year-olds and 275 µg RE/day for 4–6 year-olds.[47] The IOM RDAs for vitamin A are 300 µg RE/day for 1–3 year-olds and 400 µg RE/day for 4–8 year-olds.

There is a low safety margin of less than fivefold between recommended intakes for vitamin A and intake levels which can cause harm. Both EFSA and the IOM have set a UL for preformed vitamin A (retinol and retinyl esters) of 800 µg RE/day for 1–3 year-olds and 1100 µg RE/day for 4–8 year-olds. These ULs were scaled down, according to body size, from the adult UL of 3000 µg RE/day, which was set based on data from Rothman *et al.*,[281] who concluded that 3000 µg RE/day of supplemental vitamin A can be considered as a threshold for teratogenicity. Ireland[282] has adopted the EFSA UL for vitamin A for the population aged older than 1 year. For infants aged less than 1 year, Ireland has adopted the IOM UL. See Table 5 for the dietary reference values for vitamin A for this age group.

Table 5 DRVs for vitamin A in children aged 1–3 years and 4–5 years

Authority/country	**DRV**	**Vitamin A (µg/day)**	
		1–3 years	**4–5 years**
EFSA, 2015 (Europe)	RDA	250	300
	AR	205	245
	UL	800	1100
IOM, 2001 (USA)	RDA	300	400
	EAR	210	275

Adverse effects of deficiency and overload of vitamin A

Vitamin A deficiency is rare in the high-income setting but remains common in low- to middle-income countries. Vitamin A deficiency can result in night blindness and xerophthalmia (abnormal dryness of the conjunctiva and cornea of the eye), as well as impaired cell differentiation and development, abnormal growth, keratinisation of the skin, reduced immunity and impaired reproduction. Vitamin A deficiency in young infants and children in low-income countries has been associated with increased infectious disease morbidity, including respiratory infection, diarrhoea and mortality.[48]

Pregnant women and infants are most at risk of vitamin A deficiency, as well as the toxic effects of excessive vitamin A. Therefore, pregnant women are advised to avoid supplements containing vitamin A and the consumption of liver and liver-containing products (such as liver pâté and liver sausage) during pregnancy, as these are rich sources of vitamin A. The Rothman *et al.*[281] study established a link between supplementation of vitamin A (from 3000 µg/day) prior to the seventh week of pregnancy and a higher risk of malformations in newborn babies, concluding that 3000 µg RE/day of supplemental vitamin A can be considered a threshold for teratogenicity.

Main food sources in Ireland

The main dietary sources of vitamin A are of animal origin. These include milk, cheese, eggs, fortified spreads, yogurt, meat and meat products. Liver is a particularly rich source of preformed vitamin A, with concentrations (per 100 g) in pig, lamb, calf and chicken livers of 25700 µg, 19700 µg, 25100 µg and 10400 µg, respectively.

Vitamin A intakes in Ireland

1–3 year-olds

According to data from the NPNS,[12] mean (SD) daily intakes of total vitamin A ranged from 757 µg (481 µg) in 1 year-olds to 696 µg (450 µg) in 3 year-olds. The main food source of vitamin A intakes for 1 year-olds was milk/formula (31%), followed by vegetables (21%) and meat (16%). This was similar for 2 year-olds. For 3 year-olds, the main contributor was vegetables (27%), followed by milk/formula (17%) and meat (9%).

4–5 year-olds

The mean (SD) daily intakes of total vitamin A for 4 year-olds was 650 µg (43 µg), while intakes in 5–8 year-olds reported in the National Children's Food Survey[283] were higher, at 735 µg (511 µg). Contributors to vitamin A intakes for 4 year-olds were very similar to those of 3 year-olds, with vegetables being the main source (28%), followed by milk (15%) and meat (9%). It was estimated that 14% to 22% of 2–4 year-olds had inadequate vitamin A intakes.

Ways to improve vitamin A intakes/status

As described previously, the majority of 1–5 year-olds in Ireland have sufficient intakes of vitamin A from the diet. For the 1–5 year-old population estimated to have inadequate intakes of vitamin A (14% to 22%), intakes and status could be improved by consuming vegetables such as carrots and sweet potatoes and by consuming more foods of animal origin.

viii. Vitamin D

Background

Role of oral vitamin D intake in 1–5 year-olds

Vitamin D is a fat-soluble vitamin that is obtained from two sources: skin intake (by the action of ultraviolet rays on skin) and oral intake (from food, both natural and fortified, as well as from supplements). Skin-derived intake in healthy adults and children is the dominant source for 7 months of the year (i.e. from March to October), unless individuals have minimal or no sunlight exposure. In the latter group, with minimal or no skin-derived vitamin D intake, it is very difficult to achieve adequate vitamin D intake from oral intake alone unless oral intake includes fortified foodstuffs and supplemental intake. In those with standard lifestyles that facilitate skin-derived intake, there is a seasonal variation in vitamin D status, with the highest status in late summer and the lowest status in late winter. In order to ameliorate seasonal decline in vitamin D status during the winter months, oral intake from fortified foodstuffs is advantageous.

Recommended dietary allowances/average requirements and tolerable upper intake levels for this age group

Current DRVs for total vitamin D intake in young children vary from 10–15 µg/d (400–800 IU), as shown in Table 6. These DRVs are based on skeletal health outcomes and intake recommendations, and aim to achieve target serum concentrations of 25-hydroxyvitamin D (25(OH)D, the biomarker of vitamin D status) of between ≥25 and ≥50 nmol/L. The IOM advises an RDA of 15 µg/d (600 IU) and an EAR of 10 µg/d (400 IU) for those with minimal or no sunlight exposure aged 1–70 years.[49] In 2016, the SACN proposed a safe intake of 10 µg/d for children aged 1–4 years and a Recommended Nutrient Intake (RNI) of 10 µg/d for children over the age of 4 years.[73] EFSA has set an AI value of 15 µg/d for children aged 1–17 years.[74]

Table 6 DRVs for vitamin D in children aged 1–5 years

Authority/country	**DRV**	**Vitamin D (µg/day)**	**Target serum 25(OH)D (nmol/L)**
IOM, 2011 (USA/Canada)	RDA	15	≥50
	EAR	10	≥40
SACN, 2016 (UK)	Safe intake	10	≥25
EFSA, 2016 (Europe)	AI	15	≥50

The dietary recommendations for vitamin D in Table 6 are based on very limited vitamin D 25(OH)D dose-response data in young children that were available to the agencies at the time. Since these reports have been published, two important studies were conducted in age groups that are just older than toddlers. Mortensen *et al.*[284] conducted a dose-response randomised controlled trial in 4–8 year-olds in Copenhagen during winter, and showed that Vitamin D_3 (cholecalciferol) intakes of 8 and 20 µg/day were required in order to maintain serum 25(OH)D ≥30 and ≥50 nmol/L during winter months in northern latitudes, respectively. A subsequent study in Sweden among 5–7 year-olds had a similar outcome; vitamin D_3 intakes of 6 and 20 µg/day were required by white children to maintain 25(OH)D >30 and >50 nmol/L, respectively, during winter.[285] However, there was a considerable ethnic difference; Ohlund and colleagues[285] reported that dark-skinned children in the same study needed 14 µg/day to maintain 25(OH)D >30 nmol/L and 28 µg/day to reach 50 nmol/L. Dark-skinned children, compared with fair-skinned children, had lower baseline 25(OH)D in both the 10 µg/day and 25 µg/day studies (61 nmol/L versus 51 nmol/L, and 66 nmol/L versus 48 nmol/L, respectively) and a higher incremental response in both the 10 µg/day and 25 µg/day studies (+16 nmol/L versus +10 nmol/L, and +30 nmol/L versus +20 nmol/L, respectively). This baseline difference reflects the lesser skin intake in the dark-skinned children than in the fair-skinned children and the potential need for supplementation during winter. The authors stated that they only studied vitamin D requirements during the winter months and that further studies were needed to evaluate fortification and supplementation strategies in the summer months. To date, dose-response studies have not been implemented in children between 1 and 4 years of age.

In summary, fair-skinned children in Ireland need approximately 10 µg/day of total vitamin D intake to prevent very low vitamin D status (i.e. <25 nmol/L) during wintertime, and about 20 µg/day of total vitamin D intake to reach the individual target of 50 nmol/L set by the IOM and EFSA, although according to the IOM, on a population basis only 2.5% are estimated to need 25(OH)D >50 nmol/L. Since dark-skinned children have a lower total vitamin D intake as a consequence of lower skin intake, they have a higher oral vitamin D intake requirement; this need is greatest during the winter months.

ULs for vitamin D also vary among younger children. The IOM set a UL of 63 µg (2500 IU) for children aged 1–3 years and 75 µg (3000 IU) for children aged 4–8 years. EFSA has set a more conservative UL of 50 µg (2000 IU) for children aged 1–10 years.[79] This value was also considered appropriate by the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) in the UK[73] and was adopted by the FSAI.[282]

Adverse effects of deficiency and overload of vitamin D

Although there is currently no universal consensus on the 25(OH)D thresholds that define vitamin D deficiency, serum concentrations of ≤ 25–30 nmol/L are associated with increased risk of adverse bone outcomes,[49, 73] including impaired bone mineralisation. Severe vitamin D deficiency manifests as nutritional rickets in children,[286] and prolonged low vitamin D status may influence bone mineral density and contribute to the risk of osteoporosis in later life. A recent systematic literature review of randomised controlled trials has shown that vitamin D supplementation for the prevention of 25(OH)D <25 nmol/L reduced risk of acute respiratory tract infection.[(287)] While there is ongoing debate on optimal vitamin D status, there is general agreement that prevention of 25(OH)D <25–30 nmol/L throughout life is a public health priority.[(288)]

Both acute and chronic excessive vitamin D intake may lead to toxicity and hypercalcaemia (elevated serum calcium) as a result of increased intestinal calcium absorption and resorption of calcium from bone.[(289)] Chronic hypercalcaemia can lead to the calcification of soft tissue, resulting in renal and cardiovascular damage.[(290)] Hypercalcaemia is used as the critical endpoint on which to base the ULs for vitamin D.[(73)] Less is known about the health effects of maintaining very high 25(OH)D concentrations through chronic high-dose vitamin D supplementation.[(291)]

It is only through the use of high-dose vitamin D supplements that high blood levels of vitamin D can be reached. Therefore, any population health approach advising parents to give infants and young children supplemental vitamin D must provide information on the importance of the dose (daily amount). For example, the use of low-dose (5 µg) vitamin D for infants must be stressed because the reality is that many products with higher vitamin D doses can be legally marketed in Ireland.

Main food sources in Ireland

In Ireland, insufficient ultraviolet B (UVB) for vitamin D synthesis in skin during winter months, as well as the need to protect skin from the harmful effects of UVB, places increased importance on vitamin D in the food supply.[(292)] However, foods containing substantial amounts of naturally occurring vitamin D are limited and are not consumed on a regular basis.[(293)] Small amounts of vitamin D_3 are found in meat, dairy and eggs, although due to their common consumption, these foods make an important contribution to intakes from the base diet.[(293)] Depending on legislation, some foods are fortified with vitamin D, including infant formula, milk, yogurts, fat spreads, cheese, juice, bread and breakfast cereal.[(294)] In addition, vitamin D is available as a dietary supplement, either as vitamin D_2 (ergocalciferol) or, most often, as vitamin D_3 (cholecalciferol). Studies in young children aged 1–5 years in Ireland show that the key food sources of vitamin D among consumers are vitamin D-fortified milks (particularly in 1–2 year-olds), fortified yogurts, nutritional supplements, fresh and processed meat, fortified breakfast cereals and eggs.[75, 295]

Vitamin D intakes in Ireland

1–3 year-olds

Data from the NPNS indicate that vitamin D intakes in children aged 1–3 years are suboptimal. Mean (SD) intakes ranged from 3.2 (3.1) to 4.5 (5.2) µg/day, and 88% to 95% had intakes below 10 µg/day.[75] Among a sample of 2-year-olds (*n*467) from the prospective Cork BASELINE Birth Cohort Study, the mean (SD) daily intake was 3.5 (3.1) µg/day; 96% of children had vitamin D intakes <10 µg/day.[295] There are no nationally representative data on vitamin D status in children aged 1–5 years in Ireland. Serum concentrations of 25(OH)D were measured in 741 2 year-old children from the Cork BASELINE Birth Cohort Study.[295] The year-round prevalence of low vitamin D status (serum 25(OH)D <30 nmol/L) was 4.6%, which increased to 8.6% in winter. Using an SACN threshold of <25 nmol/L, 1.6% had 25(OH)D <25 nmol/L (3.2% in winter and 0.3% in summer). Overall, 27% had 25(OH)D <50 nmol/L, which increased to 46% in winter. These prevalence rates were lower than the equivalent statistics among adults in the National Adult Nutrition Survey, at 11% <30 nmol/L and 45% <50 nmol/L,[296] and are directly comparable, as they were measured in the same laboratory.

4–5 year-olds

The mean (SD) daily intake of vitamin D in 4-year-olds in the NPNS was 2.9 (2.3) µg/day. While 99% of these children had vitamin D intakes below 10 µg/day, it is worth noting that 88% were <5 µg/day. While there are no nationally representative data on vitamin D status among 4–5 year-olds, serum 25(OH)D concentrations were measured in a sample of 485 children in the Cork BASELINE Birth Cohort Study at age 5 (Kiely *et al*., unpublished). Briefly, 2.9% of children had 25(OH)D <30 nmol/L, which increased to 6% of children during winter. Overall, 20.3% had concentrations <50 nmol/L, which doubled during the winter months. In a cohort of 5 year-olds (*n*79) from the ROLO Kids Study,[54] the median oral vitamin D intake was very low at 1.8 µg daily, but the median 25(OH)D of 55 nmol/L was in excess of the target of 50 nmol/L; 6.3% had 25(OH)D below 25 nmol/L.[54]

Including all sources, such as nutritional supplements and fortified foods, current intakes of vitamin D do not represent a risk of excessive intakes, as no intakes among 1–5 year-olds approached the EFSA UL of 50 µg/day.[75, 295]

Ways to improve vitamin D intakes/status

The evidence indicates that, during the summer, most young Irish children get enough vitamin D through diet and through the effect of sunlight on the skin. However, during the winter, dietary sources are inadequate to maintain blood levels of 25(OH)D above 50 nmol/L (the level needed to ensure adequate vitamin D for good bone health) in a considerable proportion of young children (40% to 45%). In addition, a small proportion of young children (6% to 9%) have blood levels of 25(OH)D below 30 nmol/L in winter and are at increased risk of adverse musculoskeletal effects, such as rickets.

In order to address the inadequate vitamin D status in a very sizeable proportion (40% to 45%) of Ireland's young child population in winter, two approaches may be considered to increase vitamin D intake: supplementation and food fortification.

Among children who regularly use vitamin D-containing supplements,[297-299] intakes and status of vitamin D are more likely to be adequate; however, consumption rates are low.[295] Data from the NPNS indicate that in those Irish children aged 1–4 years who use vitamin D supplements (typically 5 µg) regularly (about 17%), mean daily intake is 8.2 µg, with 74% achieving a daily intake <10 µg. The modelling undertaken for this report shows that a daily 5 µg vitamin D supplement in 1–5 year-olds significantly increased their vitamin D intakes, although the daily intake goal of 10 µg was still not achieved for all children. The vitamin D supplementation policy (5 µg/day) currently in place for infants up to 12 months of age[56, 78] has been largely complied with,[300] but there are no data to indicate whether such a policy would be effective among older children.

Food fortification with vitamin D represents another strategy to improve vitamin D intake, and may be the best opportunity to increase vitamin D intakes across the population.[288] In Ireland, vitamin D-fortified foods are widely consumed by preschool children;[75] however, the range of vitamin D intake from these foods varies greatly, and current levels of consumption and fortification are not sufficient to meet oral intake requirements. Strategic fortification of staple foods such as bread and milk with vitamin D has been shown to increase vitamin D intakes and status in children.[301] Consumption of vitamin D-fortified milk beverages has been positively associated with vitamin D intake and status.[295, 302-304] However, vitamin D-fortified milks are consumed by a minority of young children in Ireland.[77, 295] Dietary modelling using the NPNS food consumption data showed that fortifying cow's milk with vitamin D increases intakes and reduces the prevalence of inadequate intakes.[77] In Finland, systematic fortification of fluid milk products with vitamin D (1 µg/100 mL) and fat spreads (20 µg/100 g) has reduced the prevalence of inadequate vitamin D status (serum 25(OH)D ≤50 nmol/L) in adult non-users of supplements from 59% to 14%, and risk of deficiency (serum 25(OH)D ≤30 nmol/L) from 14% to 1%.[76] New regulations are being introduced in Canada[305] to increase the level and extend the range of foods fortified with vitamin D, in order to offset the public health risk of deficiency.

ix. Calcium

Background

Role of calcium in the diets of 1–5 year-olds

Calcium is important for the formation and maintenance of healthy teeth and bones, and almost all of the calcium in the body is found as calcium hydroxyapatite in bones and teeth. Calcium in circulation is involved in cell signalling, coagulation, muscle contraction, neural transmission and many other functions. Bone provides a reservoir of calcium that helps to regulate blood serum calcium concentrations within a narrow range (2.3–2.62 mmol/L).[49, 50]

Recommended dietary allowances/average requirements and tolerable upper intake levels for this age group

The IOM[49] set EARs for calcium among 1–3 year olds and 4-8 year-olds of 500 and 800 mg/day, respectively. The IOM RDAs for these age groups are, in turn, 700 and 1000 mg/day. The EFSA EARs for calcium intakes are 390 mg/day in 1–3-year-olds and 680 mg in 4–10 year-olds. The total quantity of calcium required for bone accretion and replacement of endogenous losses was adjusted for percentage absorption in order to derive population reference intakes (PRIs) for children aged 1–3 years and 4–10 years of 450 and 800 mg/day, respectively.[50] Excessive calcium intakes are mainly associated with supplementation, and long-term high exposure studies are few in young children. There is no EFSA UL for calcium in young children, and the USA's UL of 2500 mg for children aged 1–8 years has been unchanged since it was set in 1997.

Adverse effects of deficiency and overload of calcium

Hypercalcaemia is defined as a serum calcium >2.63–2.75 mmol/L (depending on individual laboratory reference ranges) and is mainly related to primary hyperparathyroidism or malignancy, but can also be induced by very high calcium or vitamin D intakes. Clinical symptoms of hypercalcaemia are fatigue, muscle weakness, anorexia, nausea, vomiting, constipation, tachycardic arrhythmia, soft tissue calcification, failure to thrive and weight loss.

Main food sources in Ireland

The best source of calcium is milk (120 mg/100 mL) and milk-based dairy products.(50) Milk and formula provided 52% of calcium in 1 year-old children in the NPNS,(12) which decreased year on year to 35% in 4 year-olds. Between them, yogurts and cheeses delivered approximately 20% of calcium consumed, regardless of age. Bread and breakfast cereals contributed 15% to 21% of total calcium intakes, depending on age.

Calcium intakes in Ireland

1–3 year-olds

Mean (SD) calcium intakes in the NPNS were 773 (76) mg/day, ranging from 716 (73) mg/day in 3 year-olds to 830 (73) mg/day in 1 year-olds. The prevalence of inadequate calcium intakes (relative to the EFSA EAR of 390 mg/day) was 10.1%, increasing from 1.4% in 1 year-olds to 3.2% in 3 year-olds.(306)

4–5 year-olds

Mean (SD) intakes of calcium in 4 year-olds were 743 (75) mg/day, and 34.1% had inadequate intakes relative to the current EFSA EAR of 680 mg for this age.(306) This represents a high prevalence of inadequate calcium intakes in children approaching school age; the steep increase in the EAR between the ages of 3 and 4 years (as 4 year-olds come into the 4–10-year age bracket) should be considered when evaluating the clinical significance of these data. As there is no biomarker of calcium exposure, it is not possible to say whether this high prevalence of inadequate calcium intakes in 4 year-olds indicates a risk of calcium deficiency, although this is unlikely.

Ways to improve calcium intakes/status

The diets of young children in Ireland are highly reliant on dairy foods, which offsets the risk of calcium deficiency. Children at risk of low calcium intakes (i.e. below the EAR) are those whose diets contain little dairy. Low intakes of calcium, particularly coupled with low vitamin D status, increase the risk of nutritional rickets.(286) High priority must be given to calcium-containing foods in early childhood for adequate bone mineralisation and dental formation.

It is not recommended for young children to follow diets that restrict dairy food intake. Substitution of milk or formula as a main beverage with non-dairy substitutes is contraindicated and has been shown to lead to adverse effects, including nutritional rickets in children who are fed poorly planned restrictive diets.(56) Plant, nut and other substitute 'milks' are not milk based, and do not have the appropriate nutritional composition for young children to consume as a staple food.

x. Iron

Background

Role of iron in the diets of 1–5 year-olds

Iron is an essential micronutrient required for almost all metabolic pathways in the body, particularly oxygen transport, electron transfer, oxidase activities and energy metabolism.(307) Therefore, adequate iron intakes and status are important in early childhood to ensure healthy physical growth and development.

Recommended dietary allowances/average requirements and tolerable upper intake levels for this age group

National authorities in the UK,(307) USA(308) and Europe(51) recommend a daily iron intake of 7 mg for 1–3 year-olds, with an AR ranging from 3 mg/day in the USA to 5.3 mg/day in the UK. For children aged 4–5 years, the recommendations vary from an RNI of 6.1 mg/day in the UK(307) to 10 mg/day in the USA.(308) ARs are between 4 and 5 mg/day (see Table 7).

Table 7 DRVs for iron in children aged 1–5 years

Authority/country	**DRV**	**Iron (mg/day)**	
		1–3 years	**4–5 years**
SACN, 2010 (UK)	RNI	6.9	6.1
	AR	5.3	4.7
EFSA, 2015 (Europe)	RDA	7.0	7.0
	AR	5.0	5.0
IOM, 2001 (USA)	RDA	7.0	10.0
	AR	3.0	4.1

Authorities in Ireland, the UK and Europe have not set a UL for iron in young children, due to a lack of suitable evidence. In the USA, the UL for infants and children has been set at 40 mg/day based on a 'no observed adverse effect level' for adverse gastrointestinal effects.(308) The FSAI has adopted the IOM values for iron intakes in children aged 1–5 years.(282)

Adverse effects of deficiency and overload of iron

Iron deficiency is considered to develop in three stages: iron depletion, iron-deficient erythropoiesis, and iron deficiency anaemia, which is a combination of iron deficiency and low haemoglobin concentrations. Prolonged iron deficiency in early childhood, with or without anaemia, has consistently been associated with poorer cognitive, motor and behavioural outcomes, with these adverse effects lasting into adulthood.[58, 59] Iron deficiency has also been suggested to negatively affect growth and immune function in children, especially in low-resource settings.[309, 310] The risk of iron overload from dietary sources is negligible in children with normal intestinal function; however, caution must be taken with iron supplementation. Acute iron toxicity resulting in gastrointestinal upset has been reported in young children, usually after elevated supplemental intakes of 20 mg of elemental iron per kilogram body weight.[311] Iron supplementation in iron-replete children has also been shown by some studies to impair growth and increase infection risk[312] and diarrhoea, secondary to adverse effects on gut microbiota.[313]

Main food sources in Ireland

Dietary iron consists of haem and non-haem iron; haem iron is mainly found in meat, poultry and fish and is more bioavailable than non-haem iron, which is found in cereals, vegetables, nuts, pulses and eggs. The absorption of non-haem iron can be influenced by other dietary factors; ascorbic/citric acid and meat proteins are enhancers, while phytate, polyphenols, calcium and cows' milk are strong inhibitors of non-haem iron absorption.[310] The main dietary sources of iron in young children in Ireland are fortified breakfast cereals, breads, and fresh and processed meat. Fortified milks are an important source in 1–3 year-olds especially.[12, 314]

Iron intakes in Ireland

1–3 year-olds

In the NPNS, mean (SD) daily iron intakes were 7.3 (0.8) mg/day (from 6.8 mg in 1 year-olds to 7.9 mg in 4 year-olds). Inadequate intakes (below the EFSA EAR of 5 mg/day) were observed in 9.4% of children, ranging from 13.7% of 1 year-olds to 5.4% of 4 year-olds.[306] In 468 2 year-olds from the Cork BASELINE Birth Cohort Study, a slightly lower mean (SD) daily intake of 6.8 (2.6) mg was reported, and 30% of these children had inadequate intakes (below the UK EAR of 5.3 mg/day).[314] No children in the NPNS or the Cork BASELINE Birth Cohort Study had intakes exceeding the UL of 40 mg/day.[282]

Data on the iron status of young children in Ireland are limited to just two studies. Freeman and colleagues recruited 121 infants at birth and measured their iron status up to 3 years of age.[315] Iron deficiency, indicated by serum ferritin concentrations <10 μg/L in this study, was observed in 23% of 1 year-olds and in 46% to 50% of 2 and 3 year-olds. The highest prevalence of iron deficiency anaemia was observed at 2 years; 9.2% had haemoglobin concentrations <110 g/L with serum ferritin <10 μg/L. More recently, in the largest study of iron status among toddlers in Europe, iron status was measured in 729 2 year-olds in the Cork BASELINE Birth Cohort Study.[314] Using WHO definitions, 5% of children had iron deficiency (serum ferritin <12 μg/L) and 1% had iron deficiency anaemia (haemoglobin <110 g/L and serum ferritin <12 μg/L), while serum ferritin concentrations <10 μg/L were observed in only 1.8% of children. As well as inadequate iron intakes, unmodified cow's milk intakes ≥400 mL/day (Odds Ratio [95% Confidence Interval]: 1.95 [1.07, 3.56]) increased the risk of low iron status. Relative to the earlier study by Freeman *et al.*,[315] the much lower prevalence of iron deficiency and iron deficiency anaemia in the Cork BASELINE Birth Cohort Study were partly attributed to higher intakes of iron-fortified foods and lower intakes of unmodified cow's milk in response to recommendations from the FSAI[3] to not exceed 500 mL of unmodified cow's milk consumption per day. In the NPNS, 1-year-olds had a mean cow's milk intake of 302 mL/day, compared with 524 mL/day in 1-year-olds reported by Freeman *et al.*[315] Also important is the early introduction of cow's milk as a drink (at age 2 months) in the Freeman *et al.* study, in contrast to the Cork BASELINE Birth Cohort Study, where no child was given cow's milk as a drink before the age of 6 months.[316] Only 15% of participants in the Cork BASELINE Birth Cohort Study consumed cow's milk as their main drink after their first birthday,[316] while 18% of 9-month-olds in the Euro-Growth study of the late 1990s[315] were already habitual cow's milk consumers. Possible explanations for the adverse effect of high unmodified cow's milk intake on iron status are its low iron content (approximately 0.5 mg/L), its limited absorption or the observation of small amounts of blood loss from the intestine among consumers.[317] ESPGHAN and others have recommended that unmodified cow's milk intakes in young children should be limited to 400–500 mL/day.[310, 318]

4–5 year-olds

According to the NPNS, mean (SD) daily iron intakes in 4 year-olds were 7.9 (0.8) mg,[319] while intakes in 5–8 year-olds in the National Children's Food Survey[283] were higher at 10.3 (3.8) mg/day. Currently, there are no iron status data for 4 and 5 year-old children in Ireland.

Ways to improve iron intakes/status

Adequate iron intakes and status can be achieved in young children aged 1–5 years by consuming a diet that includes of a variety of haem and non-haem iron sources, such as fresh meat and meat dishes, fish, eggs, green vegetables, and fortified, nutrient-dense foods.

xi. Iodine

Background

Role of iodine in the diets of 1–5 year olds

Iodine is an essential component of the thyroid hormones thyroxine (T4) and triiodothyronine (T3), which are necessary for optimum cellular metabolism, growth, psychomotor and physical development and function at all stages of life[320].

Recommended dietary allowances/average requirements and tolerable upper intake levels for this age group

Dietary reference values for iodine intake are summarised in Table 8. There is reasonable agreement internationally. In the UK[321], a lower reference nutrient intake (LRNI) of 40 µg and an RNI of 70 µg/day were proposed for 1–3 year-olds. For children aged 4–6 years, the LRNI and RNI are 50 and 100 µg/day, respectively.[321] EFSA recommends an AI of 90 µg/day for children aged 1–5 years.[322] In the USA, the EAR is 65 µg/day for 1–5-year-old children and the RDA is 90 µg/day.

Table 8 DRVs for iodine intake in children aged 1–3 years and 4–5 years

Authority/country	**DRV**	**Iodine (µg/d)**	
		1–3 year-olds	**4–5 year-olds**
Department of Health, 1991 (UK)	LRNI	40	50
	RNI	70	100
EFSA, 2014 (Europe)	AI	90	90
EFSA, 2002 (Europe)	UL	200	250
IOM, 2001 (USA)	EAR	65	65
	RDA	90	90
	UL	200	300

ULs were derived for iodine intakes in 1–5 year-olds by EFSA in 2002 and the IOM in 2001. EFSA proposed a UL of 200 µg/day for 1–3 year-olds and 250 µg/day for 4–5 year-olds,(323) and the IOM proposed a UL of 200 µg/day for 1–3 year-olds and 300 µg/day for 4–5 year-olds.(324) The FSAI adopted the EFSA ULs for Iodine in 2017.

Adverse effects of deficiency and overload of iodine

Iodine deficiency disorders (IDDs) are the clinical effects of iodine deficiency resulting from insufficient iodine intake, leading to hypothyroidism. The effects of IDDs are seen at all stages of development and are particularly noticeable in the foetus and the infant as goitre, characterised by swelling of the thyroid gland and increased production of thyroid hormones to compensate for impaired thyroid function. Mild iodine deficiency is associated with reduced school performance and impaired cognitive function, reduced growth and delays in psychomotor development, which can be evident from the age of 2.5 years onwards. Moderate deficiency can manifest as goitre in up to 30% of children, and severe deficiency is associated with a goitre frequency >30% and a 1% to 10% incidence of endemic cretinism.[xix](325)

Iodine correction during gestation in situations of mild to moderate deficiency has shown improvements in thyroid hormone concentrations and thyroid function.(326) The beneficial effect of correction of iodine status is not limited to the gestational period, as iodine supplementation in mildly and moderately deficient schoolchildren(327, 328) has shown efficacy in improving overall cognitive performance. These findings are relevant to Ireland, as the WHO now classifies Ireland as a region of mild iodine deficiency.(329)

Similar to iodine deficiency, excessive iodine intake is also associated with thyroid dysfunction. This may present as goitre, hypothyroidism with/without goitre, or as an overactive thyroid gland which results in the overproduction of thyroid hormones (hyperthyroidism). The manifestation of adverse effects as a consequence of high iodine intake is relatively low due to tight homeostatic control; however, some sub-groups (such as those with a history of IDD, autoimmune thyroid disease or nodular goitre) are sensitive to external iodine supply and may experience adverse effects on commencing iodine supplementation.

[xix] Endemic cretinism is a syndrome of mental and physical retardation found in areas of severe iodine deficiency.

Main food sources in Ireland

The main dietary source of iodine in Irish preschool children is cow's milk.[60, 330, 331] Other important sources of iodine in the diets of young children are yogurt, young child formula and fish.[60] Fish and marine foods, such as seaweeds, are rich sources of iodine. However, the NPNS[12] showed that fish is infrequently consumed; 40% of children consumed no seafood during the 4-day recording period. Iodised salt, used by 27% of households across European countries, has contributed substantially to iodine intake and status in young children in Germany[332] and schoolchildren in Spain.[333] However, iodised salt represents <5% of all salt sold in Ireland.[334]

Iodine intakes in Ireland

1–3 year-olds

The mean (SD) daily intake of iodine in Irish children in the NPNS[12] was 157 (22), ranging from 182 (22) to 142 (21) µg/day in 1 and 3 year-olds, respectively.[306] The prevalence of inadequate iodine intake in the NPNS was low. Intakes were below the USA's EAR of 65 µg/day in 5.3% of children overall, from 2.1% of 1-year-olds to 7% of 3-year-olds.[306] Similarly, mean (SD) daily iodine intake in toddlers in the Cork BASELINE Birth Cohort Study was 177 (93) µg/day, and 7% of children had inadequate intakes.[60]

Iodine intakes above the EFSA UL of 200 µg/day were observed in 36.5% of 1-year-olds, 27% of 2-year-olds and 18% of 3-year-olds in the NPNS.[306] Due to the higher UL of 250 µg/day in 4-year-olds, the percentage with intakes exceeding this threshold decreased to 6.7%. Similarly, 35% of 2-year-old children in the Cork BASELINE Birth Cohort Study had iodine intakes which exceeded the EFSA and FSAI UL. While a considerable proportion of children in the Cork BASELINE Birth Cohort Study exceeded the UL for iodine by a significant amount (95th percentile intake: 138% to 177% of UL), the risk of adverse effects in this population group is deemed to be relatively low, as the risk of chronic high exposure is low.[323] Currently, there is no individual biomarker of iodine status and no urinary iodine concentration (UIC) data to inform on the iodine status of young children living in Ireland.

4–5 year-olds

The mean (SD) daily intakes of iodine in Irish 4 year-olds in the NPNS was 142 (21) µg/day, and 8.1% had intakes below the USA's EAR. Of 4 year-olds, 6.7% had iodine intakes in excess of the EFSA and FSAI UL.[306] There are currently no data on the iodine intakes of 5 year-old children in Ireland.

Ways to improve iodine intakes/status

The current data on iodine intake in Irish preschool children indicate that iodine intakes are largely adequate, mainly due to the prominent role of dairy foods in the diets of this population group. Higher intakes of sustainable fish (e.g. cod, trout, mackerel, salmon) should be recommended as sources of quality protein, healthy fats and many minerals, including iodine. Given the challenges associated with estimating iodine exposure as a consequence of considerable variation within the food composition data,[60] evaluation of UIC among young children should be considered, as currently there are no estimates of iodine status among children in Ireland. Although large proportions of Irish preschool children exceed the EFSA UL for iodine, the risk of adverse effects occurring as a consequence of high iodine intakes is deemed to be low. However, careful consideration of the appropriateness of high levels of cow's milk intake on other nutrients (e.g. iron)[314] and indices of dietary quality[335] may be required.

APPENDIX II – BREAKDOWN OF MODELLING

Table 9 Breakdown of dietary modelling undertaken in order to develop healthy eating guidelines for 1–5 year-olds in Ireland

Description of children			Number of 4-day food intake patterns where various food interventions applied							Total number of 4-day food intake patterns created
Age (years)	Gender	Percentile	Milks	Red meat given 2 out of 4 days[a]	Fortified cereal given 3 out of 4 days[a]	Red meat and fortified cereal given 2/3 out of 4 days[a]	Vitamin D 5 µg supplement[b]	Vegetarian[c]	Adequate amounts of foods provided	
1	5 female 5 male	0.4^{th} 25^{th} 50^{th} 75^{th} 99.6^{th}	Breast milk (10) Follow-up formula (10) Whole cow's milk (10) Whole cow's milk, fortified (10)	10	10	10	10	10	40	**130**
1.5	5 female 5 male	0.4^{th} 25^{th} 50^{th} 75^{th} 99.6^{th}	Breast milk (10) Whole cow's milk (10) Whole cow's milk, fortified (10)	10	10	10	10	10	40	**130**

			Young child formula (10)							
2	5 female 5 male	0.4th 25th 50th 75th 99.6th	Breast milk (10) Whole cow's milk (10) Whole cow's milk, fortified (10) Young child formula (10) Low-fat milk (10) Low-fat milk, fortified (10)	10	10	10	10	10	40	**150**
3	5 female 5 male	0.4th 25th 50th 75th 99.6th	Whole cow's milk (10) Whole cow's milk, fortified (10) Young child formula (10)	N/A	N/A	N/A	10	10	20	**90**

			Low-fat milk (10) Low-fat milk, fortified (10)							
4	5 female 5 male	0.4^{th} 25^{th} 50^{th} 75^{th} 99.6^{th}	Whole cow's milk (10) Whole cow's milk, fortified (10) Low-fat milk (10) Low-fat milk, fortified (10)	N/A	N/A	N/A	10	10	10	**70**
5	5 female 5 male	0.4^{th} 25^{th} 50^{th} 75^{th} 99.6^{th}	Whole cow's milk (10) Whole cow's milk, fortified (10) Low-fat milk (10) Low-fat milk, fortified (10)	N/A	N/A	N/A	10	10	10	**70**
Total number of 4-day food intake patterns created for all 1–5 year-olds										**640**
Total number of days created for all 1–5 year-olds										2560

[a]Red meat and an iron-fortified cereal were given to 1, 1.5 and 2 year-olds in order to address the low iron intakes.

[b]A 5 µg vitamin D supplement was given to all 1–5 year-olds in order to address the low vitamin D intakes.

[c]All ages and percentiles were also modelled on a vegetarian diet.

APPENDIX III – OVERVIEW OF STUDIES ON CHILDREN WITH SPECIAL NEEDS

Table 10 Micronutrient deficiencies reported in the literature for children with Autism Spectrum Disorder (ASD)

Author	Study type	Sample size	Assessment	Deficiency reported
Al Farsi[336]	Case-control in Oman	40 ASD children vs 40 controls	Serum sampling and dietary intake	Vitamin B_9 and vitamin B_{12}
Benfer *et al.*[337]	Case-control in Hamad, Quatar	254 cases vs 254 controls	Serum vitamin D	Vitamin D
Castro *et al.*[140]	Case-control study	49 males with ASD and matched controls	3-day food record	Calcium, sodium, iron, vitamin B_5, vitamin B_9 and vitamin C
De Bie[338]	Cross-sectional population cohort study	18 children with ASD aged 59 months, ±15 months	3-day food record	Fibre, vitamin D, vitamin B_2, vitamin C, vitamin A, vitamin B_1 and calcium
Dosman *et al.*[339]	Cross-sectional population cohort study in Canada	96 children with ASD	Serum sampling	Iron
Feng[159]	Clinical trial	215 children with ASD vs 285 controls	Serum sampling	Vitamin D
Gongidi [148]	Case report in the USA	1	Clinical manifestation of scurvy	Vitamin C

Kaboli *et al.*[340]	Cross-sectional population cohort study in Iran	35 children with ASD aged 7–14 years	7-day food record	Calcium, zinc, magnesium, and n-3 polyunsaturated fatty acid
Kitcharoensakkul[341]	Case report in the USA	3	Clinical manifestation of scurvy	Vitamin C
Liu *et al.*[342]	Cross-sectional population cohort study in China	154 children with ASD vs 73 controls aged 5.21 ± 1.83 years	Serum sampling and dietary assessment	Vitamin A and iron
Ma[149]	Case report in the USA	7	Clinical manifestation of scurvy	Vitamin C
Malhi[145]	Case-control in India	63 cases vs 50 controls	Food diary and serum sampling	Thiamine, vitamin C and copper
Mari-Bauset *et al.*[164]	Case-control in Spain	105 children with autism (495 controls)	3-day food record	Vitamin B_1, vitamin B_2, vitamin C, iron and calcium
Meguid *et al.*[343]	Case-control in Egypt	80 children with ASD and 80 controls	Serum sampling and standardised dietary questionnaire	Calcium, magnesium, iron, selenium and sodium
Sharp[344]	Meta-analysis	17 studies	3-day food record	Calcium
Sun *et al.*[345]	Case-control in China	53 children with ASD vs 53 controls	3-day food record and serum sampling	Calcium, vitamin A and vitamin B_9

Xia *et al.*[346]	Cross-sectional population cohort study in China	111 children with ASD aged 2–9 years	3-day food record	Vitamin A, vitamin B_6, vitamin C, vitamin B_9, calcium and zinc

Vitamin B_9 = folate

Table 11 Micronutrient deficiencies reported in the literature for children with cerebral palsy (CP)

Author	Type and location	Sample size and age range	Assessment	Deficiency reported
Benfer *et al.*[(337)]	Cross-sectional population cohort study in Australia	99 children with CP aged 18–36 months	3-day weighed food record	Iron, vitamin C, phosphorous, sodium, magnesium and vitamin B_3
Boudokhane *et al.*[(347)]	Cross-sectional population cohort study in Tunisia	46 children with CP with a mean age of 6.8 years	Serum sampling	Iron and vitamin D
Davenport *et al.*[(348)]	Cross-sectional population cohort study	106 children with CP of pre-school age (mean: 2.7 years)	3-day weighed food record	Iron, calcium, vitamin C and zinc
Hillesund *et al.*[(349)]	Patient cases in Norway	36 children with CP aged 1.5–17 years	4-day food diary and serum sampling	Iron, vitamin B_9, vitamin B_3, calcium, vitamin D and vitamin E
Ipekci *et al.*[(350)]	Cross-sectional population cohort study	29 children with CP aged 5–15 years	Serum sampling	Vitamin D deficiency in 59%
Kalra *et al.*[(351)]	Case-control in India	50 cases of CP vs 50 controls	Food diary and serum sampling	Iron, copper and magnesium

Kilpinen-Loisa *et al*.[352]	Case-control In Finland	44 children	Plasma vitamin D	Vitamin D deficiency in 36%
Seth *et al*.[353]	Cross-sectional population cohort study	120 children aged 2–10 years vs 30 controls	Serum sampling	Vitamin D and calcium
Tosun *et al*.[354]	Case-control in Turkey	122 children with CP vs 30 controls	Serum sampling	Vitamin D

Vitamin B_9 = folate

APPENDIX IV – RESEARCH RECOMMENDATION QUESTIONS

The following research questions need to be addressed in order to improve understanding of the nutritional requirements of this vulnerable age group and thus improve food-based dietary guidelines.

1. Should recommended micronutrient intakes take variation in body size into consideration?

Energy requirements are calculated using the Henry equation, which takes into consideration variations in body size, as it is calculated using body weight. However, recommended daily intakes for micronutrients do not take body size into consideration and are provided for a relatively wide age range, e.g. 1–3 year-olds. Research is needed to explore if micronutrient intakes should take body size into account, i.e. should they be derived per kilogram of body weight rather than age?

2. What factors are associated with iron deficiency in this age group?

Iron deficiency in children aged 1–5 years affects growth and development and can have long-term negative consequences on cognitive function. Iron deficiency is not uncommon in this age group and research that helps identify vulnerable children is needed.

3. What are the nutritional implications of limiting processed meat intake among 1–5 year-olds in Ireland?

Processed meat is eaten regularly by 1–5 year-olds in Ireland. Due to the links with colon cancer in later life, processed meat intakes should be limited as far as possible. Research to explore if limiting processed meat has any negative nutritional effects, for example on iron status, is needed.

4. How should 1–5 year-old children at risk of vitamin D deficiency in Ireland be identified?

Inadequate vitamin D intakes in 1–5 year-olds in Ireland are not uncommon. Vitamin D is important for healthy growth and development in this age group. The two main sources of vitamin D are dietary intake and sunlight exposure. Research is needed to determine how children aged 1–5 years at risk of vitamin D deficiency are identified in Ireland.

5. What are the consequences of low docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) intakes of 1–5 year-old children living in Ireland?

DHA and EPA are important in the development of vision as well as in cognitive development. DHA and EPA intakes in this age group in Ireland are low. Research is needed to explore both the consequences of low DHA and EPA intakes, and the benefits of increased intakes, in 1–5 year-olds living in Ireland. The difficulties of true estimates of DHA and EPA intakes based on dietary data should be noted. It is suggested that up to 14 days of continuous recording of food intake is required to get a good handle on DHA and EPA intakes.

6. How should inadequate intakes of DHA and EPA among 1–5 year-old children in Ireland be addressed?

Intakes of DHA and EPA are inadequate among 1–5 year-old children living in Ireland, except 1 year-olds receiving approximately 400 mL of breast milk/day. The main source of DHA and EPA is fish, especially oily fish. However, intake of oily fish is low among 1–5 year-olds in Ireland and, due to the presence of dioxin contaminants, intake is recommended to be limited to once a week.

a) Research is needed to identify factors that promote weekly fish intake among 1–5 year-olds.
b) Research is needed to identify alternative and sustainable sources of DHA and EPA which can address the inadequate intakes in 1–5 year-old children in Ireland.

7. How does the increasing popularity of vegetarian eating patterns impact on the dietary intakes of 1–5 year-old children in Ireland?

Vegetarian diets are increasing in popularity throughout Ireland. Vegetarian diets among 1–5 year-old children may impact on nutrient intakes. Research is needed to explore how the increasing popularity of vegetarian diets impacts on dietary intakes of 1–5 year-old children in Ireland.

8. What are the compliance rates with recommendations on use of food supplements in 1–5 year-old children?

Vitamin D

This report recommends that a low-dose vitamin D-only supplement (5 µg) is given to all children aged 1–5 years from Halloween to St Patrick’s Day (i.e. during the extended winter months).

Iron

It also recommends that an iron supplement can be given to 1–3 year-olds growing at ≤25th percentile level.

Research is needed to explore the compliance rates of parents/caregivers of 1–5 year-old children with supplement recommendations.

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TERMS OF REFERENCE

The Scientific Committee of the Food Safety Authority of Ireland is requested:

To develop scientific recommendations for food-based dietary guidelines for 1–5 year-olds.

This report will:

1. Identify the population sub-groups within the 1–5 year age range that need to be established for developing food-based dietary guidelines
2. Identify which macronutrients and micronutrients need to be considered for developing food-based dietary guidelines
3. Propose macronutrient and micronutrient goals for a healthy diet for children aged 1–5 years living in Ireland and outline how these goals may vary throughout this age range
4. Examine, using recent survey data, where intakes are in relation to these goals and develop the scientific recommendations for food-based dietary guidelines that enable this age group to meet these goals.

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