Public consultation draft, March 31st, 2023

Disclaimer

In 2016, The Nordic Council of Ministers took the initiative to update the scientific foundation for national nutrient recommendations and dietary guidelines in Nordic and Baltic countries. The present draft for NNR2023 report is developed according to the project description and describes the science advice to the authorities in the Nordic and Baltic counties.

The scientific foundation of the NNR2023 report is approximately 100 qualified systematic reviews, 9 *de novo* qualified systematic reviews, and 61 *de novo* background reviews. All *de novo* reviews have been peer reviewed and fifty-seven reviews have to date underwent public consultation. While a large number of scientists have contributed to this project by developing *de novo* reviews, the text in the NNR2023 report is the sole responsibility of the NNR2023 Committee.

The draft NNR2023 report is now submitted for public consultation. While the public consultation is closing May 26th, we encourage interested parties to respond as early as possible, since the NNR2023 Committee will validate all included scientific evidence and calculations continuously up until the date for the final publication in June 21st, 2023.

Nordic Nutrition Recommendations 2023

Integrating environmental aspects

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Preface

In 2016, The Nordic Council of Ministers took the initiative to update the scientific foundation for national nutrient recommendations and dietary guidelines in the Nordic and Baltic countries. The present NNR2023 report has been developed according to the project description and describes the science advice to the authorities in the Nordic and Baltic counties.

The scientific foundation for the NNR2023 report consists of approximately 100 qualified systematic reviews, 9 *de novo* qualified systematic reviews, and 61 *de novo* background reviews. Many scientists have contributed to the NNR2023 project by developing a large variety of background papers and served as referees. All these papers will be available at the website of the Nordic Council of Ministers in the full version of the NNR2023 report. While the NNR2023 Committee highly appreciates and acknowledges the considerable and essential contributions and suggestions by these scientists, the present NNR2023 report is the sole responsibility of the NNR Committee.

The NNR2023 report has developed science advice based on the health effects of foods and respond to the country-specific public health challenges and burden of diseases, food consumption patterns, as well as the country-specific environmental impacts of food consumption.

The NNR2023 report has not formulated advice on country-specific priorities such as food production and accessibility (e.g., agricultural methods, import and export, self-sufficiency, food security) and sociocultural aspects (e.g., animal welfare) of food consumption. Such topics are briefly discussed in background papers and in relevant sections of NNR2023, but must be dealt with nationally.

Abbreviations/concepts

AI: Adequate intake, some places referred to as 'Provisional RI'

AR: Average requirement

Baltics: The three Baltic countries (Estonia, Latvia, and Lithuania)

BMI: Body mass index

CO_2eq: CO_2 Equivalents. For assessing the short-term effects of greenhouse gases, their total warming effect over a period, often 100 years, are compared to CO_2 and summed up.

CRC: colorectal cancer

CVD: cardiovascular disease

DRV: Dietary reference value

E: Energy

EFSA: European Food Safety Authority

EK-FJLS Executive and Food: Nordic Committee of Senior Officials for Fisheries, Aquaculture, Agriculture, Food and Forestry. Nordic Council of Ministers

FAO: Food and Agriculture Organization of the United Nations

FBDG: Food-based dietary guidelines

GHG: Greenhouse gases

HSSD: Healthy, Safe and Sustainable Diet, Nordic Council of Ministers

LCA: Life Cycle Assessment, an ISO-standardized environmental management tool to quantitatively assess and compare the overall environmental performance of products, services and technologies.

LNCSB: Low- and no-calorie sweetened beverages

IOM: Institute of Medicine, USA

IPCC: Intergovernmental Panel on Climate Change

NASEM: National Academies of Sciences, Engineering, and Medicine

NCM: Nordic Council of Ministers

Net zero: GHG emission regimes that do not produce further warming, i.e., no increase in total radiative forcing from atmospheric greenhouse gases

NNR: Nordic Nutrition Recommendations

NNR2023: The Nordic Nutrition Recommendations to be published in June 2023

Nordics: The five Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden)

PAL: Physical Activity Level

Provisional AR: Provisional average requirement, AR with high degree of uncertainty, derived from an AI (Provisional RI)

Provisional RI: Provisional recommended intake, equivalent to AI

qSR: Qualified Systematic Review

RI: Recommended intake

SD: Standard deviation

SDG: The UN Sustainable Developmental Goals (United Nations 2015)

SR: Systematic review

SSB: Sugar-sweetened beverages

T2D: Type 2 diabetes

UL: Upper intake level

UN: United Nations

WHO: World Health Organization

The NNR collaboration

The Nordic Nutrition Recommendations (NNR) is an international collaboration between the health and food authorities in Denmark, Finland, Iceland, Norway, and Sweden that was initiated more than 40 years ago. A major outcome of the collaboration has been a regular update of dietary reference values (DRVs). In the last edition, general advice on food-based dietary guidelines (FBDGs) was also included (1). Each updated edition serves as a science advice to the national authorities who establish country specific recommendations. Thus, NNR has constituted the scientific basis for national DRVs and FBDGs. In addition, NNR has served as a key scientific foundation for national food and health policies, food labelling, taxes and regulations, education, monitoring and research. The Baltic countries have used previous editions of NNR as a scientific background for their national DRVs, FBDGs and health policies. For the first time, representatives from the Baltic health authorities have contributed as observers in the NNR2023 Committee.

The pre-project

Since the first publication in 1980, NNR has been updated every 8-10 years. The leadership and organisation for updating the NNR has rotated among the health and food authorities in the Nordic countries. At a meeting in Reykjavik September 2016, the Working Group on Food, Diet and Toxicology (NKMT) under the auspices of the Nordic Committee of Senior Officials for Food Issues (ÄK-FJLS Livsmedel) decided to update the fifth edition of NNR and invited the Norwegian Directorate of Health to take on the task of administratively organise a sixth edition of the NNR. The health and food authorities in the Nordic countries established the following working group to assist in the development of a project plan for the new edition:

Denmark: Ellen Trolle, Rikke Andersen, Lisa von Huth Smith
Finland: Sirpa Kurppa, Heli Kuusipalo, Ursula Schwab, Katja Borodulin
Iceland: Inga Þórsdóttir, Þórhallur Ingi Halldórsson, Gígja Gunnarsdóttir, Sigríður Lára Guðmundsdóttir
Norway: Rune Blomhoff (head of pre-project), Helle Margrete Meltzer, Sigmund Anderssen
Sweden: Hanna Eneroth, Eva Warensjö Lemming, Marita Friberg

Based on funding from the Nordic Council of Ministers, the pre-project working group and the health and food authorities in the Nordic countries developed a project plan. In February 2018, the Norwegian Directorate of Health submitted the project plan to the Nordic Council of Ministers. Based on feedback from the Nordic Council of Ministers, an updated description of the project (NNR2023) was accepted and funded by the Nordic Council of Ministers for Fisheries, Aquaculture, Agriculture, Food and Forestry (MR-FJLS).

The major milestones in the accepted project description were:

1. Update dietary reference values for energy, macro- and micronutrients
2. Develop an evidence-based platform for national food-bases dietary guidelines
3. Develop an evidence-based platform for integration of environmental sustainability into food-bases dietary guidelines

The inclusion of milestones 2 and 3 represents a substantial extension from previous editions of NNR which had a main focus on updating dietary reference values for energy, macro- and micronutrients (milestone 1).

Funding of the NNR project

The NNR project is funded by the Nordic Council of Ministers (NCM) and the food and health authorities in Denmark, Finland, Iceland, Sweden, and Norway. Within the NCM, the following organs with different mandates have funded the project:

- Ministers for Co-operation (MR-SAM)
- Nordic Council of Ministers for Fisheries, Aquaculture, Agriculture, Food and Forestry (MR-FJLS)
- Nordic working group for Healthy, Safe and Sustainable Diet (HSSD)

NNR project period and project plan

The original project period was from January 2019 to December 2022. Due to delays during the COVID-19 pandemic, the delay in publication of the IPCC synthesis report from UN (2), and the extensive work related to preparing the background papers, the Nordic Council of Ministers decided to extend the project period to June 2023 based on an application from the NNR Committee. Some previous documents and background papers refer to the present NNR project as the NNR2022 project due to its originally planned delivery date. In this report we have corrected this and refer to the present NNR project as the NNR2023 project.

Based on the project description, the NNR Committee developed a project plan for project organization. The project plan also included general principles and methodologies for the project (3). During the project period, the project plan and process has been developed further in collaboration with the Nordic Council of Ministers. The text in this report reflects the final description of the project by the NNR2023 Committee. During the project period, the Nordic Committee of Senior Officials for Fisheries, Aquaculture, Agriculture, Food and Forestry (EK-FJLS Executive and Food) and the Healthy, Safe and Sustainable Diet (HSSD) working group were informed about project status and guided the development of the project.

Estonia, Latvia, and Lithuania are associated members of Nordic Council of Ministers, and they have previously used NNR editions as a main source for their national DRVs and FBDGs. Thus, it was decided that these countries should be invited to participate in the project. Specifically, the health authorities in Estonia, Latvia and Lithuania were invited to participate in the NNR Committee with one observer each.

Organization of the NNR2023 project

The NNR2023 project is commissioned by the Nordic Council of Ministers. The Norwegian Directorate of Health, Oslo, Norway has administered the NNR2023 project. Members of the Steering Committee and the NNR2023 Committee were recruited by the Nordic health and food authorities.

NNR2023 Steering Committee

The responsibilities of the Steering Committee were to approve the budget, set the criteria for conflict of interest, and evaluate the declaration of conflict of interest for the NNR2023 Committee. The Steering Committee did also regularly approve the progress and status reports from the NNR2023 Committee.

- Head of Steering Committee: Henriette Øien, The Norwegian Directorate of Health, Oslo, Norway
- Satu Männistö, Finnish Institute for Health and Welfare, Helsinki, Finland
- Hólmfríður Þorgeirsdóttir, Directorate of Health, Reykjavík, Iceland
- Ulla-Kaisa Koivisto Hursti, Swedish Food Agency, Uppsala, Sweden
- Anne Pøhl Enevoldsen/Else Molander, Danish Veterinary and Food Administration, Glostrup, Denmark

NNR2023 Committee

The NNR2023 Committee has been responsible for organizing and implementing the NNR2023 project and publishing the final NNR2023 report. The NNR2023 Committee has been responsible for appointing the Scientific Advisory Group, the NNR Systematic Review Centre, chapter authors, referees, and for approving any conflict-of-interest forms for involved experts. The project organization is described in detail in Christensen et al. (3).

- Head of Committee: Rune Blomhoff, University of Oslo, Oslo, Norway

NNR Committee members:

- Ellen Trolle, Technical University Denmark, Kgs. Lyngby, Denmark
- Rikke Andersen, Technical University Denmark, Kgs. Lyngby, Denmark
- Maijaliisa Erkkola, University of Helsinki, Helsinki, Finland
- Ursula Schwab, University of Eastern Finland, Kuopio Campus, Finland
- Þórhallur Ingi Halldórsson, University of Iceland, Reykjavík, Iceland
- Inga Þórsdóttir, University of Iceland, Reykjavík, Iceland
- Helle Margrete Meltzer, Norwegian Institute of Public Health, Oslo, Norway
- Jacob Juel Christensen, University of Oslo, Oslo, Norway
- Eva Warensjö Lemming, The Swedish Food Agency, Uppsala, Sweden
- Hanna Eneroth, The Swedish Food Agency, Uppsala, Sweden

Observers:

- Tagli Pitsi, National Institute for Health Development, Tallinn, Estonia
- Inese Siksna, Institute of Food Safety, Animal Health and Environment, Riga, Latvia/Lāsma Pikele, The Ministry of Health of the Republic of Latvia, Riga, Latvia
- Almantas Kranauskas, Ministry of Health, Vilnius, Lithuania
- Bjørg Mikkelsen, Food Department at Faroese Food and Veterinary Authority, Faroe Islands

Project administration:

- Scientific project secretary: Ane Sørlie Kværner (11.02.19-01.07.19), Anne Høyer (01.11.19-30.06.23), Norwegian Directorate of Health, Oslo, Norway
- Scientific advisor: Erik Kristoffer Arnesen (01.02.23-30.06.23), University of Oslo

NNR2023 Scientific Advisory Group

The NNR2023 Committee recruited a Scientific Advisory Group after consultation with the Steering Committee. The group has consisted of international leading scientists with experience in developing DRVs and FBDGs for national authorities or health organizations. The group has advised on principles and methodologies, they have given advice on general scientific issues related to the project, and peer-reviewed several background papers and the final NNR2023 report. The Scientific Advisory Group consisted of the following scientists:

- Amanda MacFarlane, Nutrition Research Division, Health Canada, Ottawa, Ontario, Canada.
- Joseph Lau, Center for Evidence Synthesis in Health, Brown University School of Public Health
- Susan Fairweather-Tait, Norwich Medical School, University of East Anglia, Norwich Research Park, Norwich, UK.
- Joao Breda, Head WHO European Office for Prevention and Control of Noncommunicable Diseases & a.i. Programme Manager Nutrition, Physical Activity and Obesity, Division of Noncommunicable Diseases and Promoting Health through the Life-course, Copenhagen, Denmark
- Dominique Turck, Division of Gastroenterology, Hepatology and Nutrition, Department of Pediatrics, Lille University Jeanne de Flandre Children's Hospital and Faculty of Medicine, Lille, France | Univ. Lille, Inserm, CHU Lille, U1286 - INFINITE - Institute for Translational Research in Inflammation, Lille, France
- Giota Mitrou, World Cancer Research Fund International, London, UK.
- Wulf Becker, Uppsala University, Department of Public Health and Caring Sciences, Clinical Nutrition and Metabolism, Uppsala University, Uppsala, Sweden

NNR2023 Systematic Review Centre

As the NNR2023 project aimed to develop *de novo* systematic reviews (SRs), an independent virtual Systematic Review Centre (SR Centre) was funded by the project. The following team members were recruited by the NNR2023 Committee based on competence and previous experience in developing SRs:

- Agneta Åkesson, Karolinska Institutet, Sweden (SR Centre leader)
- Christel Lamberg-Allardt, University of Helsinki, Finland.
- Erik Kristoffer Arnesen, Dept. of Nutrition, University of Oslo, Norway
- Linnea Bärebring, University of Gothenburg, Sweden
- Bright I. Nwaru, University of Tampere/University of Gothenburg, Finland/Sweden
- Jutta Dierkes, University of Bergen, Norway
- Birna Þhorisdóttir, University of Iceland, and the Icelandic Cancer Society, Reykjavik, Iceland
- Alfons Ramel, University of Iceland, Reykjavik, Iceland

- Fredrik Söderlund, Karolinska Institutet, Sweden

Recruitment of other experts

Approximately 400 scientists have been recruited as authors, peer-reviewers and members of reference groups for the development of 85 background papers. All experts are acknowledged in each of these papers and in Appendix 1. The experts were appointed by the NNR2023 Committee based on a public call and after careful evaluation of each expert´s competence and experience related to the tasks. To supplement the call, some experts were also recruited after invitation from the NNR2023 Committee. A fair distribution of experts among the Nordic countries were sought when appointing experts.

Handling of conflict of interest and bias of experts involved

Almost all scientists may have some sort of direct or indirect conflict of interest. Conflict of interest may arise due to the role of the institution where the scientist is employed, external funding to the institution or the scientist, or to personal economic interest, voluntary activities and memberships, or other personal biases. All scientists must compete for internal and external resources for scientific activities. The external sources that fund most research span from national research funds that distribute resources from governmental budgets to patient or interest organizations (e.g., cancer, heart or diabetes funds) and commercial entities (e.g., pharmaceutical industry and food producers). Furthermore, governmental funds, including those resources distributed through the European Union and national research councils, often demand collaboration with commercial companies. While industry-sponsored research is a large part of modern medical and nutrition science, it is essential that all such ties are declared and openly available. Scientists with strong ties to industry or ideological organizations have, however, been excluded from serving as experts.

The NNR2023 project is organised with a number of "checks and balances" (3) to reduce the risk of such influence of biases and to minimize the influence of innate bias of the scientists involved. Some important features of this system with "checks and balances" were that:

- the project was split into discrete parts done by separate experts to reduce experts influencing multiple parts of the process
- the project involved a large number of experts from several nutrition and non-nutrition sub-disciplines
- background papers were peer-review by independent scientists
- background papers and the final NNR2023 report were submitted to public consultation
- several papers were also developed based on workshops and consultations with reference groups
- the international Scientific Advisory Group peer reviewed and advised on principles and methodologies and the final NNR2023 report

The central goal of the Conflict-of-Interest policies is to protect the integrity of professional judgment and to preserve public trust. The disclosure of individual and institutional conflict of interest, including financial relationships, is a critical step in the process of identifying and responding to conflict of interest. All NNR2023 experts, including all committee members, background paper authors and peer reviewers, have declared their conflict of interest according to standard procedures used when health authorities in the Nordic countries recruit scientists for outsourced expert tasks. The NNR2023

Committee handled all matters regarding conflict of interest of the experts. In cases of any uncertainty, the NNR2023 Committee sought advice from the Steering Committee. The NNR2023 Steering Committee handled all matters concerning potential conflict of interest for the NNR2023 Committee members.

Updating scientific evidence used to set DRVs and formulate FBDGs

Qualified Systematic Reviews are considered as the preferred method to evaluate causality

More than 3 million nutrition science papers published in scientific journals can be retrieved when searching in standard library databases. The study quality varies considerably in these papers, similarly to all other scientific and medical disciplines. When setting DRVs and formulating national FBDGs, only adequately designed studies of high quality should be utilized.

In general, systematic reviews (SRs) are considered the method with highest quality for synthesizing original scientific evidence. The EQUATOR network has formulated requirements that must be met in reporting SRs (4, 5). A large number of SRs have been published in the field of diet, nutrition and health. However, the quality varies and control of risk of bias does often not meet the standard needed to inform national recommendations.

Due to sponsorship from commercial entities and ideological organizations, concerns have been raised about bias in the results of such systematic reviews. For example, evidence for substantial bias has been identified in conclusions of industry-sponsored systematic reviews. It has been suggested that industry-sponsored research will result in higher likelihood of a favourable conclusion, compared to government-sponsored research (6, 7). While industry-sponsored research is likely to be important for nutrition research also in the future, it is fundamentally important that industry sponsors should have no role in project design, implementation, analysis, or the interpretation of results. This independence minimizes the potential for bias.

The NNR2023 project has considered all SRs. However, to reduce the risk of bias, NNR2023 does not consider SRs commissioned or sponsored by industry or organizations with a business or ideological interest as qualified SRs. Only SRs commissioned by national food or health authorities, or international food and health organizations, have been used as a main fundament for setting DRVs and formulating national FBDGs. To evaluate bias and other quality aspects, we developed a guide for working with systematic reviews and formulated specific inclusion and exclusion criteria that had to be met for SRs to qualify as main science base in the NNR2023 project (8-10). SRs that meet all inclusion and exclusion criteria are called “qualified SRs”.

The following eight steps had to be included when developing qualified SRs for the NNR2023 project:

1. Precise definition of the research question
2. Development of protocol with predefined criteria
3. Adequate literature search

4. Screening and selection of studies according to protocol requirements
5. Data extraction according to protocol requirements
6. Assessing risk of bias following specific procedures
7. Synthesis and grading of total strength of evidence following specific procedures
8. Reporting according to standardized criteria

Details of these steps are described in Arnesen et al. (8, 9). For example, for the NNR *de novo* qualified SRs on randomized controlled trials, a modified version of the Cochrane's 'Risk of bias 2.0' tool (11) was used to critically appraise internal validity, i.e., bias. For non-randomized trials, the risk of bias assessment tool was based on the Risk of Bias in Non-randomized Studies of Interventions (ROBINS-I) instrument (12), and for observational studies (prospective cohort studies, case-cohort studies, or case-control studies), the recently developed 'Risk of Bias for Nutrition Observational Studies' (RoB-NObS) tool, developed by the US Department of Agriculture's (USDA) Nutrition Evidence Systematic Review (NESR) team (13), was used. These tools, or various other tools of similar quality, are used in all qualified SRs identified in the present NNR report.

Global collaboration between health authorities

NNR2023 should ideally build on recent qualified SRs of highest quality for all associations between nutrients and food groups and every relevant health-related outcome. A complete set of qualified SRs may include the following:

- qualified SRs for each of the indicators used to set Average Requirement (AR) for each of the 36 nutrients included in NNR2023
- qualified SRs for each of the indicators used to set Upper Limit (UL) for each of the 36 nutrients included in NNR2023
- qualified SRs for assessing indicator dose-response and additional candidate indicators for AR and UL
- qualified SRs for each of the candidate indicators used to formulate science advice for healthy FBDGs for all the 15 food groups, meal and dietary patterns assessed in NNR2023. A number of indicators should be assessed for each food group, such as various types of cardiovascular diseases and cancers, type-2-diabetes and other relevant chronic diseases. Often, there is also a need for qualified SRs several subcategories within each food group.

Thus, recent qualified SRs of several hundred possible exposure-outcome pairs would be needed in the ideal situation. However, due to the high cost and resources involved in developing qualified SR, no national authorities have the resources and competence for completing the task on their own. This calls for international harmonization and collaboration between national authorities. The NNR project is a long-standing example of international harmonization and collaboration.

Such global harmonization is possible since foods and nutrients have identical health effects across nations and regions. Scientific human studies conducted in regions outside the Nordic and Baltic countries are therefore equally relevant as human studies conducted within the Nordic and Baltic countries. There are a few noteworthy exceptions, but the majority of studies on health effects are universally applicable. All exceptions to this general rule were carefully considered in each relevant section in this report. When developing national DRVs and FBDGs, several country-specific issues need to be considered (see discussion later in the report).

Since around 2010, national health authorities and international organizations have gradually started to use qualified SRs as the preferred method for evidence-based evaluation of causal relations between nutrient or food exposures and health outcomes. Close to 100 SRs (Appendix 2) fulfil the inclusion and exclusion criteria for qualified SRs and were used as a main fundament when setting DRVs and formulating FBDGs in the NNR2023 project. The Institute of Medicine (IOM), National Academies of Sciences, Engineering, and Medicine (NASEM) (IOM was renamed to NASEM in 2011), the European Food Safety Authority (EFSA) and Nordic Council of Ministers (1) are among the authorities that have contributed to developing these qualified SRs.

These qualified SRs, some with overlapping topics, have been published in the period 2012-2023. While use of qualified SRs constitutes the most solid fundament available, it is important to independently review the literature in order to identify new significant and relevant evidence published after the publication date of the particular qualified SR. A major role of the background papers for the 36 nutrients, 15 food groups, and meal and dietary patterns, is to ascertain that NNR2023 also is up to date with the most recent scientific evidence.

Selection of topics for de novo qualified systematic reviews

An important aspect of the NNR2023 project was to select the topics which most likely would be relevant for updating DRVs and FBDGs that had not been covered in a previous recent qualified SR. The NNR2023 Committee selected 9 topics for development of qualified SRs by the NNR2023 SR Centre (see "Organization of the NNR project"). In an open call, scientists, health professionals, national food and health authorities, food manufacturers, other stakeholders and the general population in the Nordic and Baltic countries were invited to suggest SR topics. A total of 45 nominations with suggestion for more than 200 exposure–outcome pairs were received in the public call. The process of selecting topics is described in Høyer et al. (10).

In addition, to search for "hot topics" relevant for setting DRVs and FBDGs, the NNR2023 Committee developed scoping reviews (ScRs) for 36 nutrients, 15 food groups, meal patterns and dietary patterns aimed at identifying potential SR topics. After considering approximately 15,000 review papers, a number of topics were identified. The NNR2023 Committee shortlisted 52 exposure-outcome pairs based on the call and the ScRs.

The following nine top prioritised topics for *de novo* SRs were then selected by the NNR2023 Committee in a comprehensive Delphi process (10):

1. Protein intake in children and body growth and risk of overweight or obesity: A systematic review and meta-analysis (14)
2. Pulses and legume consumption in adults and risk of cardiovascular disease and type 2 diabetes: A systematic review and meta-analysis (15)
3. Animal versus plant-based protein and risk of cardiovascular disease and type 2 diabetes: A systematic review of randomized controlled trials and prospective cohort studies (16)
4. Quality of dietary fat and risk of Alzheimer's disease and dementia in adults aged ≥ 50 years: A systematic review (17)
5. Intake of vitamin B12 in relation to vitamin B12 status in groups susceptible to deficiency: A systematic review (18)

6. White meat consumption and risk of cardiovascular disease and type 2 diabetes: A systematic review and meta-analysis (19)
7. Supplementation with long chain n-3 fatty acids during pregnancy, lactation, or infancy in relation to risk of asthma and atopic disease during childhood: A systematic review and meta-analysis of randomized controlled clinical trials (20)
8. Nuts and seeds consumption and risk of cardiovascular disease, type 2 diabetes, and their risk factors: A systematic review and meta-analysis (21)
9. Dietary fibre and growth, iron status and bowel function in children 0-5 years old: A systematic review (22)

Developing background papers for 36 nutrients and food components and 15 food groups, meal patterns and dietary patterns

The present edition of NNR builds on the solid foundation of the comprehensive and well-recognized previous editions of NNR, including the nutrient reviews (in the form of nutrient *chapters*) in NNR2012 (1). Due to a substantial and rapidly developing production of new scientific evidence, all nutrient chapters have been updated in NNR2023. Additionally, since the present edition aimed to develop science advice for setting FBDGs in the Nordic and Baltic countries, new papers were developed for 15 food groups. In addition, papers were added for meal patterns and dietary patterns.

The recruited background paper authors followed an "Instruction to authors" (23) developed by the NNR2023 Committee. Authors were asked to use the corresponding chapter in NNR2012 and the ScR described above (i.e., scoping reviews for identification of topics for *de novo* qualified SRs (10)) as a starting point. Authors were responsible for developing appropriate literature searches and assess significant new relevant evidence published since NNR2012. When available, qualified SRs were used as the main fundament in the background papers. For exposure-outcome pairs not covered by qualified SRs, the authors assessed other reviews or original papers. These sections have, as a minimum, fulfilled the requirements for scoping reviews from the EQUATOR network (24). If any of these papers were used as main fundament for setting DRVs or formulating FBDGs, the quality of papers was assessed following standard procedures for randomized controlled trials and observational studies. For quality assessment of systematic reviews that include randomised or non-randomised studies and/or observational studies we adapted a modified version of AMSTAR2 (Appendix 3). All background papers were peer-reviewed and submitted to public consultation.

The original search strategy and date are reported in each background paper. The NNR2023 Committee updated all searches on April 15th, 2023. If the NNR2023 Committee considered the new paper especially relevant, they are cited and added to the assessment in the nutrient and food group sections in this report. Of special interest, some new qualified SRs were identified. These are also incorporated in the assessment in the nutrient and food group sections below.

These background papers constitute the main scientific update since NNR2012. Especially, they inform about the current status of the specific indicators used in setting DRVs and FBDGs, whether any new indicators should be considered, and they also discuss new qualified SRs. They also discuss any new recommendations available from EFSA and NASEM since NNR2012.

Handling of comments from public consultation

All background papers on nutrients, food groups, meal and dietary pattern were submitted to public consultation as well as the background papers developed in the NNR2023 project on environmental aspects of food consumption. A consultation period of 4 weeks was practiced for the first papers. However, the period was extended to 8 weeks for papers submitted to public consultation after May 2022. Thousands of comments were received and forwarded to the authors for consideration. The NNR2023 Committee have carefully considered all consultation comments. All consultation comments have been openly accessible through the NNR2023 website. The responsible authors have briefly formulated a response to each of the comments on nutrient, food group, meal patterns and dietary pattern background papers. All comments to the background papers on environmental aspects of food consumption have been considered by the NNR Committee and the responsible authors. The NNR Committee, in collaboration with the authors, has briefly formulated a response to each of the comments.

Throughout the project period, the public and all interested parties have also been invited to submit their comments to the NNR2023 Committee through the NNR2023 website. The NNR2023 Committee have carefully considered all comments. All comments and the response from the Committee have been openly accessible through the NNR2023 website.

After the NNR2023 project period, a separate report with all comments and responses to public consultation comments and public comments will be published.

Responsibility of experts and NNR2023 Committee

NNR2023 report

While a substantial number of scientists have contributed to the development of background papers (Appendix 1), the final text and conclusions in the present NNR2023 report are the sole responsibility of the NNR2023 Committee.

Principle and methodology papers

For guidance and transparency in the process of setting DRVs and FBDGs, several methodology papers have been developed by the NNR2023 Committee (3, 8, 9) . The final text and conclusions in these papers are the sole responsibility of the NNR2023 Committee.

Background papers

A number of background papers have been commissioned by the NNR2023 Committee, including 53 background papers on nutrient, food groups, meal patterns and dietary patterns, background papers on the local context in Nordic and Baltic countries such as burden of disease, physical activity, food and nutrient intake and body weight, and background papers on environmental aspects of food consumption. The text in all background papers is the sole responsibility of the authors. The NNR2023 Committee have had an editorial role in all background papers while the referees have peer-reviewed the manuscript.

Collaboration and harmonization of health based DRVs and FBDGs in Nordic and Baltic countries

The NNR2023 report constitutes science advice to the national authorities in Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, and Sweden. The report offers solutions and guidance for national authorities when they develop and formulate their own food and health policies.

Universal health effects of nutrients are the main basis for setting DRVs

The amounts of dietary nutrients needed for nutrient adequacy and the upper levels of dietary intake that will not lead to adverse effects are identical, with few exceptions, among the Nordic and Baltic countries, as well as other countries across the globe. Exceptions were considered and adjusted to the Nordic and Baltic populations when setting DRVs in the NNR2023 project.

Exceptions are reference values for energy intakes and all DRVs where energy, weight and physical activity are included when calculating the recommended intakes.

Dietary iron requirements may also vary depending on inhibitors and enhancers of iron absorption in the same meal, while zinc and iodine requirements vary depending on inhibitors such as phytate and goitrogens, respectively, in the same meal. Additionally, vitamin D requirements are dependent of sun exposure and skin pigmentation.

As a general rule, all of these factors are similar in Nordic and Baltic countries, with exception for vitamin D and specific nutrient fortification policies. We therefore suggest that the health and food authorities do not need to correct for these effects when setting national DRVs.

The integration of environmental sustainability in NNR2023 may open for more country-specific DRVs for alcohol and added sugar, both of which are unnecessary and not required for a healthy diet. Alcohol and added sugar, which are traditionally considered "nutrients" because they yield energy, may have substantial environmental impact when intake is high (25, 26). Country-specific priorities of environmental impacts may limit the recommendations for these dietary components even more than what is suggested in NNR2023.

All information for setting DRVs is summarized in the 36 nutrient background papers (27-62) and in the nutrient one-pagers in this report. Background papers of burden of diseases (63), food and nutrient intake (64), physical activity (65), and environmental impact (25, 26, 66-68) are cited when relevant.

Thus, we suggest that the authorities in the Nordic and Baltic countries adopt all DRVs set in NNR2023. Adaptations may be made in special cases, for example when formulating national recommendations for vitamin D, alcohol and added sugar.

FBDGs are based both on universal health effects and several country-specific contexts

FBDGs should provide country-specific guidance on food consumption. The context of the individual country is especially relevant when formulating national FBDGs. While the health effects of foods are more or less universal, the national FBDGs may also respond to the following country-specific contexts:

1. public health challenges and burden of diseases (63)
2. food consumption pattern (64)
3. environmental impact (25)
4. food production and accessibility (26)
5. sociocultural aspects (67)

The NNR2023 report gives science advice that is based on the health effects of foods and respond to the country-specific public health challenges and burden of diseases, and food consumption pattern, as well as the country-specific environmental impact of food consumption.

The NNR2023 report does not give advice on country-specific political priorities such as food production and accessibility (e.g., agricultural methods, import and export, self-sufficiency, food security, food safety) and sociocultural aspects (e.g., animal welfare) of food consumption. Such topics, which are briefly discussed in background papers and in relevant sections of NNR2023, may be dealt with nationally.

The health effects of food groups summarized in this report build on 15 food group background papers (69-83), as well as the background papers on meal patterns (84) and dietary patterns (85). Background papers on burden of diseases (63), food and nutrient intake (64) , physical activity (65), and environmental impact (25, 26, 66-68) are cited when relevant.

Thus, we suggest that the authorities in the Nordic and Baltic countries can use the science advice in NNR2023 for setting their country-specific FBDGs. The authorities may also consider giving priority to various environmental impacts described in this report. In addition, the national authorities may consider country-specific food production and accessibility issues, affordability/economic aspects, and sociocultural aspects of food consumption when formulating their country-specific FBDGs.

Integration of overweight and obesity in NNR2023

The NNR2023 report bases its conclusions on several qualified systematic reviews reporting strong or probable evidence between excessive weight gain, overweight or obesity, and the intake of foods, nutrients, and consumption patterns.

As overweight and obesity are major causes of morbidity and mortality in the Nordic and Baltic countries, the NNR2023 report has special focus on the role of the diet for overweight and obesity, and the consequences of the present weight status on national DRVs and FBDGs. As described below, a specific review paper has been developed to describe current knowledge for the relation between nutrients, foods, and body weight.

Recommendations for energy and nutrients are based on a healthy body weight for all life-stage groups. The same principle is used by IOM/NASEM and EFSA in their DRV reports. It is important to recognize that, while a large part of the population is overweight or obese, DRVs are set for healthy body weights.

Maintaining a healthy body weight and body weight stability is recommended in non-pregnant adulthood and for body weight and healthy growth in childhood, due to the associated health effects and the serious health risks of underweight, overweight and obesity (86).

Overconsumption of food and energy is not only associated with increased risk of chronic diseases, it has also a negative environmental impact (25, 26). For examples, as discussed in this report, high consumption of discretionary foods, such as sugar, sweets, beverages, and animal fat contribute to GHG emissions, deforestation, and decreased biodiversity. Thus, overconsumption of energy and food are both important causes of diseases and have a large environmental impact.

When defining science advice for DRVs and framework for FBDGs, overweight, obesity and food overconsumption are important aspects discussed in relation to several nutrients and food groups. The specific role for DRVs and FBDGs are described in the nutrient "one-pagers" and food group "two-pagers" in the present summary report.

Summary of background papers on country specific health effects in the Nordic/Baltic region

The NNR2023 Committee has developed background reviews on country-specific burden of diseases, nutrient and food intakes, and physical activity in Nordic and Baltic countries, and the role of diet on body weight. These papers are partly used as an essential background when formulating scientific advice for DRVs and FBDGs, but they are also intended to be used by the national health and food authorities when they formulate their national recommendations and guidelines.

Burden of diseases in the Nordic and Baltic countries

The Global Burden of Diseases, Injuries, and Risk Factors study (GBD) is the most comprehensive worldwide observational epidemiological study. Since 1990, there have been 12 iterations of the study, each with increased scope, new data sources, and methodological advancements. The most recent iteration, GBD 2021, included 286 causes of death, 369 diseases and injuries, and 87 risk factors, 15 of which were dietary factors. Age and sex-specific estimates were generated for 990 geographical units including all Nordic and Baltic countries for every year between 1990 and 2021. GBD, with its effort to provide comparative results, offers a useful resource to model trends in diet-related burden of diseases in the Nordic and Baltic countries. It can also provide countries with insight into the potential of reducing disease burden by targeting specific dietary risks.

GBD has previously not been used systematically by national food and health authorities when developing DRVs and FBDGs. In the paper commissioned by the NNR Committee by Clarsen et al. (63), the burden of diet-related diseases and dietary risk factors in the Nordic and Baltic countries were assessed from 1990 to 2021. In particular, a systematic analysis of the GBD 2021 for the NNR2023 project was performed. The integration of the GBD 2021 study into the 6th edition of NNR may serve as a model for other countries or regions in their development of national diet recommendations and guidelines.

The paper shows that there is a substantial disease burden attributed to dietary risk factors in the region, particularly from ischemic heart disease, diabetes mellitus, stroke, and colon and rectum cancer. A diet low in whole grains was the highest-ranked dietary risk factor in eight of the eight countries. Across all countries, whole grains were responsible for over a quarter of the total burden of disease attributed to dietary factors and it was the greatest overall contributor to ischemic heart disease and colon and rectum cancer.

A diet high in processed meat was the second highest contributor to disease burden in five of eight countries and among the top-5 dietary risk factors in all countries, while a diet low in seafood omega-3 fatty acids was the third-highest dietary-related contributor to disease burden in the Nordic and Baltic countries. The Baltic countries have the most to gain from increasing seafood omega-3 intake, largely because the Baltic countries have a substantially higher burden of ischemic heart disease than the Nordic countries do.

The Baltic countries also had a substantially higher disease burden attributed to a diet low in fruit. This was because fruit consumption was lower in the Baltic countries than the Nordic countries, and because the Baltic countries had higher rates of ischemic heart disease and stroke, which are both linked to low fruit consumption. Globally, low fruit consumption is the highest-ranked dietary risk factor for disability-adjusted life years (DALYs), and our analyses show that it is also an important factor to focus on in the Nordic and Baltic countries.

A diet high in red meat was the fifth-highest dietary risk factor for DALYs in the Nordic and Baltic countries. It was ranked second highest in Denmark, and the third highest in Norway, Sweden, and Iceland.

Physical activity in the Nordic and Baltic countries

The understanding of how physical activity and insufficient physical activity are associated with health outcomes has increased considerably over the past decades. Along with physical activity, the evidence on the associations between sedentary behaviour and health has increased, which has resulted in the introduction of recommendations on sedentary behaviour. The level of physical activity influences the energy requirement and is therefore associated with nutrition recommendations.

The aim of the background paper developed by Borodulin and Anderssen was to 1) present terminology for physical activity and sedentary behaviour epidemiology, 2) show the relevant scientific evidence on associations of physical activity and sedentary behaviour with selected health-related outcomes and 3) introduce the global guidelines for physical activity and sedentary behaviour by the World Health Organization (65). Health-related outcomes include cardiovascular morbidity and mortality, total mortality, glucose regulation and type 2 diabetes, adiposity, overweight, obesity, cancer, musculoskeletal and bone health, brain health, and quality of life. These are reflected across age groups and some population groups, such as pregnant and postpartum women. Further, physical activity levels across Nordic countries and over time was discussed. For the Nordic Nutrition Recommendations, shared common physical activity guidelines were not developed. Instead, each country has created their own guidelines that are referenced in the article, along with the global WHO guidelines.

Role of food consumption and intake and nutrients for body weight

Obesity is a chronic disease, which is associated with increased risk for several non-communicable diseases (NCDs), including cardiovascular diseases, type 2 diabetes, some cancers, and chronic respiratory diseases, including obstructive sleep apnea. In 2016, the age standardized prevalence of adult overweight (including obesity) in the Nordic-Baltic region varied between 55% (Denmark) and 60% (Lithuania), with an obesity prevalence between 20 (Denmark) and 26 % (Lithuania). Using the WHO growth reference, the prevalence of overweight (including obesity) among school-aged children varied from 23 (Estonia) to 31 % (Iceland), and among adolescents from 19 (Lithuania) to 27 % (Iceland). Despite several action plans to stop the obesity epidemic, the prevalence of overweight and obesity in the WHO European Region has increased, and no member state seems to reach the target of halting the rise in obesity by 2025 (87).

The aim of the paper by Hjelmesæth and Sjöberg (88) was to elucidate the current knowledge for the potential role of body weight for setting and updating DRVs and FBDGs in the NNR2023 project. They observed that the overall body of evidence based on findings from SRs and MAs of observational and clinical studies indicates that changes in intakes of specific nutrients (sugar, fibre, and fat) and/or foods (sugar sweetened beverages, fibre rich food, and vegetables) are associated with modest or small short-term changes (0.3–1.3 kg) in body weight in the general population (with or without obesity/overweight), while long-term studies are generally lacking. Limited evidence suggests, but does not prove, that some foods or nutrients may have specific effects on body weight or body weight measures independent of caloric content (e.g., nuts and dairy) (88).

Food consumption and nutrient intake in the Nordic and Baltic countries

Knowledge about the nutrient intakes and food consumption in the Nordic and Baltic countries is important for the formulation of dietary reference values (DRVs) and food-based dietary guidelines (FBDGs), as part of the Nordic Nutrition Recommendations 2022 project (NNR2023).

Information about the dietary surveys as well as the daily mean intakes was retrieved from the latest national dietary surveys available at that moment in each of the five Nordic and three Baltic countries (64). Nutrient intake (macronutrients, 20 micronutrients) and food consumption data at a broad level in the adult population was gathered for both sexes. The broader food groups were the following: Beverages, Cereals, Potatoes, Vegetables, Fruits and berries, Fish and seafood, Meat and meat products, Milk and dairy products, Cheese, Eggs, Fats and oils, and Sweets and confectioneries.

There were both similarities and differences in food consumption and nutrient intakes between the different countries, reflected in consumption of some foods and nutrients that were either higher or lower than current guidelines and DRVs. For example, the consumption of vegetables and fruits was too low while the consumption of red and processed meat was too high. The most notable similarities and differences between the countries in terms of nutrient intake compared to recommended intake (RI) in NNR 2012 were as follows:

- The percentage contribution of macronutrients to total energy was roughly similar among the populations in the Nordic countries as well as in Estonia and mostly in the range of recommendations. Since in the case of Latvia and Lithuania alcohol was not included in the total energy intake, the reported contribution of energy from fat was higher and lower from carbohydrates compared to the other countries.
- The percentage contribution from saturated fatty acids was too high compared to the recommendation in all countries.

- Fibre intake was lower than the recommendation in all countries.
- In general, mean reported intakes of most vitamins and minerals were above RI in the Nordic countries, but not to the same extent in the Baltic countries. Mean vitamin D and folate intakes were low among most population groups, while mean intake of sodium was too high. Mean iron intake was lower than RI among women in all countries.

The nutrient intake and, especially, food consumption differ between the Nordic and Baltic countries because of differences in food patterns, but also due to factors related to the dietary surveying, food grouping, and calculation procedures in each country. To facilitate future comparisons between countries, it would be of interest to harmonize food groupings and the age groups reported on.

Science advice on a framework for integrating environmental sustainability

Frames, scope and limitations

Sustainability is a broad and complex concept. Sustainable development has been defined as a development that meets the needs of the present, without compromising the ability of future, generations to meet their own needs. At the core of the concept is the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, and the 17 accompanying sustainable development goals (89). For sustainable development to be achieved, it is crucial to harmonize four core dimensions: the health, environment, economic as well as the social dimension. All these elements are interconnected and crucial for the well-being of individuals and societies and may be considered by the national authorities in the eight Nordic and Baltic countries when they formulate country-specific FBDGs.

In this edition of NNR, a framework for integrating environmental sustainability has been requested by the NCM.

When formulating science advice on FDBGs the following governing documents are used as a main fundament for the scope and mandate from the NCM; the Action Plan 2021-2024 Vision 2030 (90) and authoritative declaration from the Nordic Council of Ministers (see Box 1). The Action plan 2021-2024 from the NCM builds on the Paris Agreement and UN Agenda 2030 (89).

BOX 1. Declaration from the Nordic Council of Ministers

- *Declaration on Nordic Carbon Neutrality by the Nordic prime ministers (25.01.19)*
    - *"With this declaration, we commit ourselves to working towards carbon neutrality in the five Nordic states"*
    - *"We will catalyse global mitigation efforts to limit the increase in the global average temperature to 1.5°C in response to the findings of the IPCC of 1.5°C"*
    - *"catalyse the scaling up of Nordic sustainable solutions, reduce global greenhouse gas emissions, maintain or enhance carbon sinks and remove carbon dioxide from the atmosphere"*
    - *"encourage climate-conscious consumer choices by developing information on reducing individual climate impacts"*

- *Declaration on Biodiversity from the Nordic Council of Ministers for the Environment and Climate (MR-MK) (03.05.22)*
    - *We, the Nordic Ministers for Climate and the Environment from Sweden, Denmark, Norway, Finland, Iceland, the Faroe Islands, Greenland and Åland i) Recognizing that urgent integrated action is needed for transformative change, to halt and reverse biodiversity loss through the sustainable management of land, freshwater and ocean, ii) Promoting ways for Nordic consumers to make healthy and sustainable choices, with joint efforts relating to sustainable consumption reducing by at least half the waste, including food waste, and eliminating the overconsumption of natural resources and strengthening sustainable production; iii) Reduce our global ecological footprint to a level well within planetary boundaries; iv) Promote urgent national action to halt biodiversity loss and strengthen policy measures to mainstream biodiversity into all sectors*
- *Sustainable food systems by Nordic Council of Ministers for Fisheries, Aquaculture, Agriculture, Food and Forestry (MR-FJLS) (24.06.21)*
    - *Achieving Agenda 2030 goals including ending hunger, achieving food security, safer food and improved nutrition and promoting sustainable agriculture within planetary boundaries are amongst the greatest challenges facing the world today.*
    - *A healthy and sustainable diet should be accessible and an easy choice for everyone. Actors along the whole food chain, such as food industry, retailers and market actors, are all responsible. Nutritional guidance based on scientific evidence is essential in improving diets. The Nordic nutrition recommendations are an internationally recognized benchmark dating back over 40 years. The 2022 update of the NNR will integrate environmental sustainability into the dietary guidelines.*
- *Declaration on Nordic commitment for the global climate agenda*
    - *(30.04.20) We will work together with all countries to ensure good cooperation and dialogue in the climate negotiations leading to COP26. Climate finance to developing countries is necessary for the effective implementation of the Paris Agreement. The Nordic countries re-affirm their commitment to provide climate finance from a variety of sources. We will work together with all parties to keep up the momentum in the UN climate negotiations.*

Summary of background papers on environmental sustainability

The NNR2023 Committee commissioned five background reviews on sustainability issues related to food consumption. Four of these papers review environmental aspects of food consumption, both in relation to global and local impact of Nordic and Baltic food consumption.

These papers represent the main foundation for integrating environmental sustainability in science advice for DRVs and FBDGs. The last sustainability review deals with socioeconomic aspects of sustainability. This paper is a Nordic and Baltic summary of the SAPEA report that was commissioned by the European Commission. While the socioeconomic aspect for sustainability was not requested to be integrated by the Nordic Council of Ministers, the NNR2023 Committee have included this review as a general background that may be used by the national health and food authorities when they formulate and implement their national recommendations and guidelines.

To integrate environmental sustainability, the NNR2023 Committee has in large followed the guiding principles from the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) (91). Initially, the committee scrutinized recent developments of the health effects of nutrients, foods and dietary patterns. Then, the environmental impact of food consumption, and the corresponding food systems were examined, and the ranges and limits of the healthy food-based dietary guidelines (FBDGs) were transparently adjusted to encompass both health and environmental goals.

Assessing the environmental sustainability of diets – a global overview of approaches and identification of 5 key considerations for comprehensive assessments

Sustainability is a complex concept that includes environmental, health, as well as economic and social dimensions. The remit of the paper by Benton et al. (66) was to focus on the environmental dimension of sustainability. The paper focuses on global considerations and hence does not consider the local context in Nordic and Baltic countries. The review was developed as a collaboration between the NNR2023 project, Chatham House and an appointed reference group consisting of Nordic and Baltic scientists. The Nordic and Baltic scientists have given significant scientific input, while the members of the NNR Committee have ascertained that the relevance is within the scope of the NNR project.

Assessing the environmental impacts of food, food systems and diets is highly complex due to the multitude of processes involved, the uncertainty in assessment models, the variability in production systems and the large range of products available. No single assessment method can therefore provide a complete evidence base. However, the increasing number of LCA and food system approach studies, and the relation to integration of planetary boundaries, offers sufficiently precise estimates from which we can draw some robust conclusions, while recognising there is a need for more detailed analysis to capture the inherent nuances of more location and context specific situations.

Despite the complexity of assessing the environmental sustainability of food, diets and food systems, there are a number of key considerations that can be identified and used in the NNR2023 report, and in doing so help to increase utility of the outcomes and limit unintended adverse consequences. Benton et al. (66) formulated 5 key considerations (consider the thresholds, consider the system, consider the variables, consider the context, and consider the spill-over) that may be applied when integrating environmental sustainability into FBDGs in the Nordic and Baltic countries.

Overview of food consumption and environmental sustainability considerations in the Nordic and Baltic region

The paper examines environmental impacts related to current food production and consumption using a global and Nordic perspective, and discusses the implications across the 8 Nordic and Baltic countries (25). The aspects are discussed as an overview of each food group within the NNR2023. The content was largely drawn from scientific literature such as major reports, studies and systematic reviews. The assessment was done partly as an expert elicitation to ensure that the rich body of existing data on environmental impacts of foods and diets could be best interpreted within the context of the Nordic region. In the paper, data from different sources, all based on food availability data of FAOSTAT, were combined with a comprehensive database of environmental footprints, differentiated by country, food group, and environmental impact. Also, global footprint data are shown.

The paper provides suggestions for overall and food group specific changes in consumption and presents opportunities for the production. Estimates from the studies show that the environmental impacts of current diets in each of the Nordic countries mostly exceed the levels that would be required to stay within the planetary boundaries related to GHGE, cropland use, water use, nitrogen use, and phosphorus use. Also, estimates show that shifting to the current national Nordic and Baltic FBDGs (2018) would mostly improve the outcomes, but not enough. The estimates presented in the paper indicate that meat and dairy contribute the most to GHGE and crop land use. Food waste, the challenge applying to all food groups, is not covered in this paper (see paper 3).

Given that biodiversity impacts are generally related to agricultural biodiversity and practices, conclusions in this paper, shaped by LCA, should be interpreted with nuance. The production systems that may minimize GHGE may indirectly increase loss of biodiversity. Reducing demand on land through changing the composition of diets may allow more environmentally beneficial farming systems to be adopted.

The overarching recommendation for all countries, in line with the current body of scientific literature, is to shift to more plant-based dietary patterns. The extent to which this is necessary depends on the current consumption patterns. More specifically:

- Reduce meat and dairy consumption and increase the consumption of legume/pulse, whole grain, vegetable and fruit, vegetable oils, and nuts and seeds. The substitution process is somewhat dependent on current consumption patterns and potential to shift and should ensure nutritional adequacy and positive health impact at the dietary level.
- Explore potential shifts to sources of fish and seafood with lower impacts, e.g., freshwater fish stocks. Due to the potentially large-scale impacts on ecosystems, a precautionary approach to the fish group is essential – particularly in relation to an increase in consumption.
- Reduction in consumption of animal products would lead to an overall feed-to-food shift and increase provision of plant-based foods. This is relevant for cereals and pulses, as well as nuts, vegetables, and fruits. In the context where consumption of fruits and vegetables must increase, shifting production methods could help to further reduce environmental impacts (particularly water, pesticide, and fertilizer use).
- The scientific literature suggests that organic cultivation methods result in greater biodiversity benefits compared to non-organic production. At the global level, it is only possible to convert agricultural production to organic methods in conjunction with substantial shifts in demand to plant-based diets.
- A national land use assessment could inform optimal land uses for meeting a range of environmental goals, also accounting for the environmental impacts of food imports in producer countries. One important inclusion would be an assessment of different types of pasture lands in terms of their value for biodiversity and necessity for food production and

alternative potential for other uses, such as restoring portions of native habitats to help meet other social goals (i.e., climate change mitigation and restoring biodiversity).

- While there are interventions that could be implemented in the short, medium and long term, the overarching approach to reducing the environmental impacts of food consumption must take a longer-term perspective, in addition rather than being limited to the realities of today's market.

Integrating sustainability into food based dietary guidelines – how far are we in investigating environmental sustainability in the Nordic diets?

The paper provides knowledge for science-based advice for developing Food-Based Dietary Guidelines (FBDGs) that include environmental sustainability within the Nordic and Baltic countries (68). It gives an overview of the work done previously in the Nordics on the environmental impact, including climate impact of foods and dietary patterns, and on the development of FBDGs from the viewpoint of sustainability. Finally, approaches for developing national sustainable FBDGs in the Nordic and Baltic countries are suggested. The paper is a scoping review, based on literature searches regarding Nordic and Baltic studies on sustainability of diets and foods.

The Nordic studies conclude that animal-based foods are the largest contributors to dietary greenhouse gas emissions (GHG emission) and land use in current diets. Modelling, optimization, and intervention studies confirm the potential to reduce negative environmental impacts, like GHG emission, but also to improve positive impacts e.g., on biodiversity, by shifting towards a pre-dominantly plant-based diet that is nutritionally adequate and includes health-based evidence on amounts of specified food groups. A sole focus of reducing climate impact may result in nutritionally inadequate diets and may not decrease the biodiversity loss. Similarly, a healthy diet may have large environmental impacts. Thus, health and environmental impact of diets are considered simultaneously to achieve sustainable diets.

Sustainable plant-based diets can be characterized as high in a variety of vegetables, fruits and berries, cereal products as mainly whole grain products, vegetable oils, legumes (pulses), and nuts and seeds. They contain animal-protein sources such as fish from sustainably managed stocks, limited to moderate amounts of low-fat dairy and eggs, and a limited amount of meat, particularly limited on ruminant and processed meats. In addition, the content of discretionary food and drinks, (e.g., sugar-sweetened beverages) should be limited. Food group-specific considerations are essential to simultaneously reduce the environmental impacts and achieve nutritional adequacy. These considerations may include e.g., favouring more robust type of vegetables that store well and favouring meat products from dairy herds and grazing ruminants. Further, food waste is to be decreased or avoided, as well as overconsumption, i.e., excessive consumption. Dominantly or fully plant-based diets, as vegan diet, require solutions beyond dietary guidelines in terms of food fortification and dietary supplementation to ensure nutritional adequacy.

The current FBDGs in the Nordic countries are described in the paper. There is a need for further development of the country specific sustainable FBDGs, taking into account the development of food production, and increased scientific research and available data covering also the new foods on the market. We suggest using standardized approaches for developing sustainable FBDGs and engaging an interdisciplinary group of food and nutrition experts. The approach should maintain nutritional adequacy and health-based evidence regarding food intake and dietary patterns at the population level as boundaries for integrating the different aspects of sustainable development into the FBDGs. The transition to sustainable diets must be affordable and acceptable for consumers. In the Nordic countries, cultural and sociodemographic differences in dietary composition pose challenges in defining and implementing national FBDGs. More knowledge is needed about successful implementation of plant rich "flexitarian" diets, also among vulnerable groups. Since the transition is urgent, monitoring and evaluation should go hand in hand with public-private partnership initiatives, campaigns, and development and piloting of case-studies to facilitate the transition at consumer level and to involve all food system actors. Examples are presented in the summary of the SAPEA report (67).

In conclusion, it is possible to develop FBDGs that support the transition to healthier and more environmentally, sustainable diets in the Nordic and Baltic countries. Failing to reduce environmental impacts predisposes the population to another kind of public health threat: the environmental crisis.

Challenges and opportunities when incorporating sustainability into food-based dietary guidelines in the Nordics

The overall aim of the paper is to provide background information to be used for science advice for setting sustainable Food Based Dietary Guidelines (FBGDs) in the Nordics and Baltics (26). We identify, summarize, and discuss important challenges and opportunities with current Nordic food systems, based on literature reviews and the assessments of Nordic food systems experts. Applying FAO/WHO's guiding principles for healthy, sustainable diets (91), we have evaluated how the Nordic countries are doing on environmental impact (principle #9 - #13) and sociocultural aspects (#14 - #16). In addition, the paper includes reflections at the food system level, including food security, self-sufficiency and resilience issues.

The geographical location of the five Nordic countries has determined the characteristics of food production in each country – mirrored in local food heritage. A substantial part of Nordic land is above the Arctic Circle, limiting the growth season and choice of crops. Forests dominate large parts of Nordic lowlands. Iceland and Norway have large patches of mountainous terrains unfit for crop cultivation, yet have large coastal regions suitable for extensive fishing and aquaculture. At high latitudes farming is dominated by dairy and meat production, including cattle, sheep, goats, and reindeer. Together with Denmark, the southern parts of Norway, Finland and Sweden are more suitable for growing cereals, oilseeds, legumes, sugar beets and vegetables. Denmark, Finland, and Sweden are net exporters of cereal grain.

Although the Nordics score high in overall global assessments like the Sustainable Development Indexes, there is still a long way to go to reach net zero emissions and employ thoroughly sustainable practices within food production and consumption (92). Furthermore, when the total global effects of our consumption are assessed, the Nordic countries are not top performers. Thus, for optimizing the total sustainability of Nordic diets, the global food system must be considered (93).

Some challenges are unavoidable. Large parts of the Nordics are best or only suited for grass production and pastures, utilization of resources resulting in significant methane emissions from ruminant meat and dairy production. In addition, fractions of the crops may be best suited for animal fodder due to marginal conditions for grain production. Thus, utilisation of resources needs careful balancing between ensuring local production that can balance demand for dairy and meat on the one hand, but without resulting in a large environmental footprint domestically as well as the indirect impact from import of feed for food production. Production must also conform to net zero climate emissions and limitations on nitrogen and phosphorous spill-over. The issues connected with biodiversity, domestically and directly from import of feed, must also be adequately resolved.

If Nordic agricultural production is aligned with net-zero emission paths, and other main challenges connected with environmental and social sustainability are considered, the sustainability considerations implemented in FBDG could work as a quality assurance step easing the adoption of local or regional produce.

As several sustainability goals are to varying degrees in conflict, it is important that all aspects are taken into consideration, the most relevant concerns are prioritized, and improvements in one field do not come at high costs in others.

A sustainable food system for the European Union. The SAPEA report – a summary with focus on the Nordic and Baltic countries

This review seeks to outline some of social and economic dimensions of sustainability, based on evidence available in the peer-reviewed literature. The review relies on a recent Evidence Review Report undertaken by an expert group of academics, convened under the auspices of SAPEA (Scientific Advice for Policy by European Academies). The SAPEA report provides an independent review of the evidence required to inform the transition to a more just and sustainable food system for the EU, including the identification of 'good practice' examples, some of which are drawn from the Nordic and Baltic countries. The SAPEA report concluded that fundamental, system-wide changes were required in order to promote the transition towards a fairer, more sustainable and healthier food system. Environmental, health and socio-economic issues are thoroughly interconnected and do not exist in separate silos. Meeting the growing global demand for food will require significant dietary change as well as large reductions in food waste, as technological change or yield increases are unlikely to meet demand alone. Evidence of 'what works' in policy terms requires strengthening, including further research on the public understanding of science and consumer acceptance of new technologies.

The SAPEA report identified a series of 'good practice' examples where there was strong peer-reviewed evidence of positive long-term impacts including health and sustainability benefits (67). Examples included state support for the growth of the Danish organic sector (94); the RETHINK project in Latvia and Lithuania, an action-research programme which explored the structures and opportunities for small and medium-size agricultural holdings that are not well incorporated into the mainstream market (95); and the Danish Wholegrain Partnership, which achieved a significant increase in wholegrain consumption through a process of multi-sector collaboration involving the Danish Veterinary and Food Administration, the food industry and health NGOs such as the Danish Cancer Society (96). The SAPEA report also noted a series of other initiatives, including the Finnish Nutrition Commitment (https://www.ruokavirasto.fi/en/foodstuffs/healthy-diet/nutrition-commitment/), which encourages food business operators and stakeholders to improve the nutritional quality of the national diet and to adopt nutritionally responsible practices; the ForMat project in Norway (https://norsus.no/wp-content/uploads/or1716-format-sluttrapport-english.pdf) which aimed to achieve a significant (25%) reduction in edible food waste; the Danish salt partnership (https://altomkost.dk/fakta/kort-om-naeringsstoffer/salt/) which aimed to reduce the intake of salt among consumers, through increased awareness of the link between salt and health as well as collaboration with the food industry on reducing the salt content in processed food; and the Norwegian Partnership for a Healthier Diet (https://www.helsedirektoratet.no/english/partnership-for-a-healthier-diet), which provides information to consumers and healthcare professionals, aimed at supporting stakeholders to make healthy, safe and more sustainable food choices. Other initiatives from the Nordic and Baltic states that were noted in the SAPEA report include Matsentralen (https://www.matsentralen.no/), a non-profit organisation that fights food waste and helps disadvantaged people by redistributing surplus food at risk of going to waste; SkolmatSverige (https://www.skolmatsverige.se/), which supports Swedish primary schools in their work to provide good school meals; and Eldrimner (https://www.eldrimner.com/), which provides knowledge, support and inspiration to artisanal food producers throughout Sweden and the Nordic region, including those at the early stages of their careers.

As the foregoing discussion reveals, there are some 'win-wins' in the field of health and sustainability policy. However, difficult choices between competing policy options will occur, similar to those facing ordinary consumers in their everyday lives. Being clear about the way food is framed as an issue and how different framings shape policy outcomes is a useful way forward in addressing the inevitable trade-offs and compromises between competing objectives.

Principles for setting DRVs in NNR2023

Ever since the nutrients were discovered, e.g., the vitamins between 1910-1950, societies have strived to give advice to avoid deficiency and protect health and wellbeing. Recommendations for nutrients were based on an estimation of the human body´s requirement from studies on the nutrients' biochemical and physiological roles as reported in available studies, e.g., balance studies. Varying body sizes were typically used to estimate the distribution of the requirement in a population. In the first editions of NNR, the recommended intake (RI) of nutrients were based on various such studies and conclusions in Nordic expert committees. Among the major references for the recommendations were the "Recommended Dietary Allowances" produced by the Food and Nutrition Board of the US National Academy of Sciences (previously Institute of Medicine), UK's Committee on Medical Aspects of Food Policy (COMA), and the World Health Organization (WHO). No formal criteria or systematic methodology were available and utilized to derive the RIs.

The ideal method to set RIs was early recognized, but rarely achieved. This method included 1) determinations of average requirement (AR) of a healthy and representative segment of each age group for the nutrient under consideration, 2) assess statistically the variability among the individuals within the group, and 3) calculate from this the amount by which the average requirement must be increased to meet the need for nearly all healthy individuals. Similar methodologies were developed for setting the upper intake level (UL), which is the dose where risk of excess in population is close to zero.

While this is still the basic principle, the principles and methods have developed considerably and made much more advanced recently. The two major organizations that have contributed to this development of methodology are the Institute of Medicine (IOM) of the US National Academies (renamed and incorporated in 2011 into the National Academies of Science, Engineering, and Medicine

(NASEM)), and the European Food Safety Authority (EFSA). The recent framework for developing DRVs are most comprehensively described in the following reports from IOM/NASEM, EFSA and NNR:

- EFSA NDA panel. Scientific Opinion for principles for deriving and applying Dietary Reference Values, 2010 (97)
- Guiding principles for Developing Dietary Reference Intakes Based on Chronic Diseases, NASEM, 2017 (98)
- The Nordic Nutrition Recommendations 2022 – principles and methodologies. Food & Nutrition Research, 2020 (3)

Ideally, the first step is to identify the functional outcome or indicator used to set AR and UL for all life-stage groups of each micronutrient under consideration. The causality of the exposure-outcome pair should ideally be considered in a recent qualified SR, and the strength of evidence should be graded above a certain predefined level. Then, a dose-response curve should be established and the average requirement of a healthy and representative segment of each age group for the nutrient determinations. If data are not available for all life-stage groups, interpolation or extrapolation to the remaining life-stage groups is performed, so that all life-stage groups have a defined set of ARs and ULs. Based on the life-stage specific ARs, the corresponding RIs are then calculated. Typically, if normally distributed, the RI is calculated as AR + 2 standard deviations (SD). This ideal methodology is, however, often not possible to implement fully due to a lack of appropriate scientific data.

Similar formal methodologies have been developed to define recommended intake ranges of macronutrients and reference values for energy intakes (99).

There are considerable uncertainties about some of the DRVs. If AR cannot be formally defined, for example if dose-response curve is not available or a factorial approach cannot be established, an adequate intake (AI) recommendation can be made based on observed intakes in a healthy population or other methods (100). In those cases, a “provisional AR” is calculated as AI x 0.8. Also, for consistency, we refer to AI as “provisional RI”.

For many nutrients, AR, AI and UL is not defined at all due to lack of appropriate data.

Previous editions of NNR have not performed a formal setting of ARs, AIs, RIs, ULs for micronutrients, recommended intake ranges of macronutrients and reference values for energy intakes as described above. Values corresponding to the values set in IOM/NASEM and EFSA reports have instead in general been used. Sometimes these values have been adjusted based on expert consensus and alternative scientific assessments or local conditions in the Nordic countries.

In each new edition of NNR, new scientific evidence published since last edition have been assessed. If significant new evidence for changing the DRVs of a nutrient was not found, the values were kept unchanged. If new significant evidence was detected, the DRVs were updated accordingly. During the various updates, the visibility of the original basis for setting the DRVs and the reason for adjustments varies. Therefore, while the DRVs in the previous editions of NNR are based on careful scrutiny of scientific evidence, the exact values may deviate from the last updates of IOM/NASEM and EFSA, sometimes without an apparent reason.

In NNR2023, we have been much more explicit in identifying the source document used for setting AR and UL (i.e., the specific IOM, NASEM or EFSA report). We have first identified the source document for AR and UL for each nutrient in the previous NNR editions. Then, we considered the most recent reports from IOM/NASEM and EFSA. The specific source document for each nutrient is presented in

Tables 1 and 2. In general, we selected the most recent source document that was based on a methodology similar to those described in the NNR2023 methodology papers (3, 8, 10).

Table 1: Basis for setting DRVs for vitamins in NNR2023[1]

Nutrient	Type of reference value	Source	Criteria for setting reference values
Vitamin A	AR RI	EFSA, 2015 (101)	Factorial approach, target liver concentration of 20 µg retinol/g.
Vitamin D	AR RI	NNR 2023 (31)	Dose-response approach, biomarker (25(OH)D).
Vitamin E	Provisional AR Provisional RI	NNR 2023 (58) For infants: EFSA, 2015 (102)	Prevention of PUFA oxidation (relationship to PUFA intake). For infants: estimated intake from human milk.
Vitamin K	Provisional AR Provisional RI	EFSA, 2017 (103)	Observed intakes in European countries. Biomarkers.
Thiamin	AR RI	EFSA, 2016 (104)	Erythrocyte transketolase activity coefficient, urinary excretion. NNR 2023 reference intakes for energy.
Riboflavin	AR RI	EFSA, 2017 (105)	Urinary riboflavin excretion.
Niacin	AR RI	EFSA, 2014 (106)	Urinary excretion of niacin metabolites. NNR 2023 reference intakes for energy.
Pantothenic acid	Provisional AR Provisional RI	EFSA, 2014 (107)	Observed intakes in European countries. For infants: estimated intake from human milk.
Vitamin B6	AR RI	EFSA, 2016 (108)	Biomarker (plasma pyridoxal 5-phosphate).
Biotin	Provisional AR Provisional RI	EFSA, 2014 (109)	Observed intakes in European countries. For infants: estimated intake from human milk.
Folate	AR RI	EFSA, 2014 (110)	Biomarker (serum and red blood cell folate), plasma homocysteine.
Vitamin B_{12}	Provisional AR Provisional RI	EFSA, 2015 (111)	Vitamin B12 biomarkers, and observed intakes in European countries.
Vitamin C	AR RI	EFSA, 2013 (112)	Biomarker (fasting plasma ascorbate concentration).
Choline	Provisional AR Provisional RI	EFSA, 2016 (191)	Observed intakes in European countries, and deficiency symptoms (organ dysfunction)

[1] Scaling of all nutrients uses NNR2023 reference weights. AR: Average/provisional average requirement. RI: Recommended/provisional recommended intake.

Table 2: Basis for setting DRVs for minerals in NNR2023[1]

Nutrient	Type of reference value	Source	Criteria for setting reference values
Calcium	AR RI	EFSA, 2015 (113)	Factorial approach, calcium balance and calcium accretion in bone. For infants: estimated intake from human milk.
Phosphorus	Provisional AR Provisional RI	EFSA, 2015 (114)	Scaled to RI for calcium (molar calcium to phosphorus ratio of 1.4:1).
Potassium	Provisional AR Provisional RI	EFSA, 2016 (115)	Prevention of high blood pressure and risk of stroke.
Sodium	Provisional RI	NASEM, 2019 (116)	Sodium reduction trials and one balance study. Extrapolations to children and adolescents using NNR 2023 reference energy intakes.
Magnesium	Provisional AR Provisional RI	EFSA, 2015 (117)	Observed intakes in European countries. For infants 7-11 months: midpoint between extrapolated values from infants 0-6 m and the highest range of observed intakes.
Iron	AR RI	NNR 2023 (56)	Factorial approach, replacement of daily iron loss, and need for growth.
Zinc	AR RI	EFSA, 2014 (118)	Factorial approach, zinc balance, accounting for phytate intake (assuming a phytate intake of 300 mg/day in adults).
Copper	AR ARI	IOM, 2002 (119)	A combination of copper biomarkers (including plasma copper, serum ceruloplasmin, platelet copper concentration). For infants: estimated intake from human milk, and estimated additional intake from complementary foods in infants 7-11 months.
Iodine	Provisional AR Provisional RI	EFSA, 2014 (120) NNR 2023 (36)	Biomarker (urinary iodine concentration), prevention of goitre.
Selenium	Provisional AR Provisional RI	EFSA, 2014 (121) NNR 2023 (27)	Biomarker (plasma selenoprotein P, target >100 µg/L). For infants: estimated intake from human milk.

Fluoride	Provisional AR Provisional RI	EFSA, 2013 (122)	Prevention of caries (for adults: extrapolated from data in children).
Manganese	Provisional AR Provisional RI	EFSA, 2013 (123)	Observed intakes in European countries, and null balance. For infants 7-11 months: a combination of extrapolation from infants 0-6 months, extrapolation from adults' AI, and observed intakes.
Molybdenum	Provisional AR Provisional RI	EFSA, 2013 (124)	Observed intakes in European countries, and null balance.
Chromium	Provisional AR Provisional RI	IOM, 2001 (119)	Estimated mean intakes from well-balanced diets.

[1] Scaling of all nutrients uses NNR2023 reference weights. AR: Average/provisional average requirement. RI: Recommended/provisional recommended intake.

The indicator used to set AR, AI and UL in each source document was then identified. The recent scientific evidence on the indicator is discussed in the corresponding nutrient background paper. Evidence based on new qSRs were especially emphasized. If new evidence since the publication of the source document had appeared that changed the strength of evidence relative to the predefined criteria (3), the corresponding change in AR, AI and UL were implemented. Additionally, if new SRs revealed new indicators, these were also implemented.

Next, we identify whether the AR and UL were set by dose-response or factorial approach. Again, the corresponding nutrient background papers were essential in assessing recent evidence published since the last edition of NNR. In specific cases, the NNR2023 project performed new meta-analyses (see list of *de novo* qSRs above). Otherwise, we based our evaluation on dose-response curves in source documents (see table).

If data were not available for all life-stage groups, interpolation or extrapolation to the remaining life-stage groups was performed in the NNR2023 project, so that all life-stage groups have a defined set of ARs and ULs. The methodology of scaling to other life stage groups was identified from the relevant source document (i.e., isometric scaling or allometric scaling, with or without a growth factor).

An important basis for scaling is the representative healthy weights for each life-stage group. For life stage groups aged 18 years or more, healthy weights are, in agreement with the consideration in NNR2012, defined as a BMI of 23 kg/m^2 (calculated from the most recent population height information in national dietary surveys (125-131)). For children and adolescents 6-17 years of age, healthy weights were calculated based on height in the most recent growth curves in the Nordic and Baltic countries and corresponding healthy BMIs for age defined by WHO (132-136). For age groups 5 years and younger, healthy weights were based on the growth curves. For detailed values for weight, see Appendix 4. The new weight values are an important update from previous editions and ascertain that scaling is performed according to healthy weight curves representative for Nordic and Baltic countries. In addition, age groups have also updated and harmonized with EFSA and IOM/NASEM.

Similarly, a Physical Activity Level (PAL) of 1.6 is used when calculating AR for nutrients based on energy requirements. For the age groups 1-3 years, 4-10 years and 11-17 years, an average PAL of 1.4, 1.6 and 1.7 was used, respectively (33).

The background papers on all individual nutrients (27-62) have been essential in the assessments described above and has been used as a major source in developing the one-pagers on nutrients and the specific DRVs.

Based on the life-stage specific ARs, the NNR2023 project then calculated corresponding RIs. The standard deviation used to calculate RIs are taken from the corresponding source document (Table 1-2).

Finally, standard rounding of all AR, AI, RI and UL values were performed.

The science advice for specific recommendations to authorities in the Nordic and Baltic countries are formulated in the text and tables below, and build on the detailed considerations described in the nutrient sections later in this report.

New DRVs for Nordic and Baltic countries

NNR 2023 includes recommended intake ranges for macronutrients, upper or lower threshold levels or certain subcategories, and ARs, AIs, RIs and ULs of essential micronutrients. The macronutrient sub-categories are polyunsaturated, monounsaturated, saturated, and trans-fatty acids; protein; dietary fibre; and added, refined sugars.

Recommended intake ranges of macronutrients

Age group up to 2 years of age

Exclusive breastfeeding for about 6 months is advised and continued breastfeeding parallel to giving complementary foods from that age until 12 months of age, or longer if it suits mother and child. There is convincing evidence that the risk of obesity in childhood and adolescence increases with increased protein intake during infancy and early childhood. Protein intake should increase from about 5 % of the total energy intake (E%) (the level in breast milk) to the intake range of 10–20 E% for older children and adults.

Box 2. Fatty acids

- n-6 fatty acids should contribute at least 4 % of the total energy intake (E%) for children 6–11 months and 3 E % for children 12–23 months of age.
- n-3 fatty acids should contribute at least 1 E% for children 6–11 months and 0.5 E% for children 12–23 months.
- During the first year, the intake of trans fatty acids should be kept as low as possible.
- From 12 months, the recommendation on saturated and trans fatty acids for older children and adults should be used.

Box 3. Recommended intake of fat, carbohydrates, and proteins

Expressed as percent of total energy intake (E%) for children 6–23 months[1]

Age	E%
6–11 months	
Protein	7–15
Fat	30–45
Carbohydrates	45–60
12–23 months	
Protein	10–15
Fat	30–40
Carbohydrates[2]	45–60

[1]Because exclusive breastfeeding is the preferable source of nutrition for infants <6 months, no recommendations for fat, protein, or carbohydrate intakes are given for this age group. For non-breastfed infants, it is recommended that the values for infant formula given in the EC legislation (REGULATION (EC) No 1243/2008 and Directive 2006/141/EC) is used.
[2]Intake of added sugars should be kept as low as possible.

Age groups 2 years and older

Fatty acids (expressed as triglycerides)

Partly replacing saturated fatty acids with cis-polyunsaturated fatty acids and cis-monounsaturated fatty acids (oleic acid) from vegetable dietary sources (e.g., olive or rapeseed oils) is an effective way of lowering the serum LDL-cholesterol concentration. Replacement of saturated or trans-fatty acids with cis-polyunsaturated or cis-monounsaturated fatty acids decreases the LDL/HDL-cholesterol ratio. Replacing saturated and trans-fatty acids with cis-polyunsaturated fatty acids reduces the risk, for example, of coronary heart disease, and replacement of saturated and trans-fatty acids with cis-monounsaturated fatty acids from vegetable dietary sources (e.g., olive or rapeseed oils) has similar effects.

Box 4. Fatty acids (expressed as triglycerides)

- Intake of cis-monounsaturated fatty acids should be 10–20% of the energy intake (E%).
- Intake of cis-polyunsaturated fatty acids should be 5–10 E%, of which n-3 fatty acids should provide at least 1 E%.
- Cis-monounsaturated and cis-polyunsaturated fatty acids should constitute at least two thirds of the total fatty acids in the diet. Intake of saturated fatty acids should be limited to less than 10 E%.
- Intake of trans-fatty acids should be kept as low as possible.
- The total fat recommendation is 25–40 E% and is based on the recommended ranges for different fatty acid categories.
- Linoleic (n-6) and alpha-linolenic (n-3) acids are essential fatty acids and should contribute at least 3 E%, including at least 0.5 E% as alpha-linolenic acid. For pregnant and lactating

women, the essential fatty acids should contribute at least 5 E%, including 1 E% from n-3 fatty acids of which 200 mg/d should be docosahexaenoic acid, DHA (22:6 n-3).

Even though total fat intake varies widely, population and intervention studies indicate that the risk of atherosclerosis can remain quite low as long as the balance between unsaturated and saturated fatty acids is favourable. In addition to the quality of fat, it is important to pay attention to the quality of carbohydrates and the amount of dietary fibre, that is, the recommendations for dietary fibre and carbohydrates (with low intakes of added sugar) should be achieved through an ample supply of plant-based foods. The recommended range for the total amount of fat is 25–40 E% based on the sum of the ranges of the recommendations for individual fatty acid categories.

For the intake of total fat, a suitable target for dietary planning is 32–33 E%.

At total fat intakes below 20 E%, it is difficult to ensure sufficient intake of fat-soluble vitamins and essential fatty acids. A reduction of total fat intake below 25 E% is not generally recommended because very low-fat diets tend to reduce HDL-cholesterol and increase triglyceride concentrations in serum and to impair glucose tolerance, particularly in susceptible individuals.

<u>Carbohydrates and dietary fibre</u>

Health effects of dietary carbohydrates are related to the type of carbohydrate and the food source. Carbohydrates found in whole-grain cereals, whole fruit, vegetables, pulses, and nuts and seeds are recommended as the major sources of carbohydrates. Total carbohydrate intakes in studies on dietary patterns associated with reduced risk of chronic diseases are in the range of 45–60 E%. A reasonable range of total carbohydrate intake is, however, dependent on several factors such as the quality of the dietary sources of carbohydrates and the amount and quality of fatty acids in the diet.

Box 5. Dietary fibre

- Adults: Intake of dietary fibre should be at least 25–35 g/d, or approximately 3-3.5 g/MJ.
- Children: An intake corresponding to 2-3 g/MJ or more is appropriate for children from 2 years of age. From school age, the intake should gradually increase to reach the recommended adult level during adolescence.

An adequate intake of dietary fibre reduces the risk of constipation and contributes to a reduced risk of colorectal cancer and several other chronic diseases such as cardiovascular disease and type-2 diabetes. Moreover, fibre-rich foods help in maintaining a healthy body weight. Intake of appropriate amounts of dietary fibre from a variety of foods is also important for children.

For dietary planning purposes, a suitable target is >3-3.5 g/MJ from natural fibre-rich foods such as vegetables, whole grains, fruits and berries, pulses, and nuts and seeds.

Box 6. Added sugar

- Intake of added/free sugars should be below 5-10 E%.
- Avoid foods and beverages with added sugar and free sugar for children below two years.

Restricting the intake of added sugars is important to ensure adequate intakes of micronutrients and dietary fibre (nutrient density) as well as to support a healthy dietary pattern. This is especially important for children and persons with a low energy intake. Consumption of sugar-sweetened beverages has been associated with an increased risk of type-2 diabetes and excess weight gain and should, therefore, be limited. Frequent consumption of sugar-containing foods should be avoided to reduce the risk of dental caries. The recommended upper threshold for added sugar is also compatible with the food-based recommendation to limit the intake of sugar-rich beverages and foods. The consumption of added sugar contributes to negative environmental impact.

The recommended range for the total amount of carbohydrate is 45–60 E%. For dietary planning purposes, a suitable target for the amount of dietary carbohydrate is 52–53 E%.

Proteins

In order to achieve an optimal intake in a varied diet according to Nordic dietary habits, a reasonable range for protein intake is 10–20 E%. This intake of protein should adequately meet the requirements for essential amino acids.

Box 7. Protein

- AR and RI for adults are 0.66 and 0.83 g/kg (both women and men) (Table 3).
- Adults and children from 2 years of age: Protein should provide 10–20% of the total energy intake (E%).
- Elderly (≥65 years): Protein should provide 15–20 E%, and with decreasing energy intake (below 8 MJ/d) the protein E% should be increased accordingly.
- For young children it is advisable not to exceed a range of 10–15 E% protein intake.
- Dietary proteins of animal origin or a combination of plant proteins from, for example, legumes and cereal grains, give a good distribution of indispensable amino acids.

For planning purposes, 15 E% protein can be recommended.

For food planning purposes in the elderly, a suitable target for the amount of protein intake should be 18 E%. This corresponds to about 1.2 g protein per kg body weight per day.

Table 3: Average requirements and recommended intakes of protein by life stage

Age group	AR g/kg	RI g/kg
≤6 mo		
7-11 mo	1.04	1.23
Children		
1-3 y	0.82	1.02
4-6 y	0.70	0.86
7-10 y	0.75	0.91
Females		

11-14 y	0.72	0.88
15-17 y	0.68	0.84
18-24 y	0.66	0.83
25-50 y	0.66	0.83
51-70 y	0.66	0.83
>70 y	0.66	0.83
≥18 y	0.66	0.83
Pregnant	add 0.5/7.2/23 g/d[1]	add 1/9/28 g/d[1]
Lactating	add 10/15 g/d[2]	add 13/19 g/d[2]
Males		
11-14 y	0.74	0,9
15-17 y	0.71	0,87
18-24 y	0.66	0,83
25-50 y	0.66	0,83
51-70 y	0.66	0,83
>70 y	0.66	0,83
≥18 y	0.66	0,83

[1] Pregnancy: Additional protein requirement per trimester.

[2] Lactation: Additional protein requirement for 0-6 months and >6 months postpartum.

<u>Alcohol</u>

Based on the overall evidence, it is recommended to avoid alcohol intake. Alcohol is not an essential nutrient, and from a nutritional point of view, energy contribution from high intake of alcoholic beverages affects diet quality negatively. Based on this and new systematic reviews and recommendations, and that no threshold for safe level of alcohol consumption has currently been established for human health, the NNR2023 recommends avoidance from alcohol. For children, adolescents and pregnant and lactating women abstinence from alcohol is advised. The consumption of alcoholic beverages contributes to negative environmental impact.

Recommended intake of micronutrients

The RI (Table 4) and provisional RI (Table 5) for vitamins, RI (Table 6) and provisional RI (Table 7) for minerals, expressed as average daily intakes over time, are given below. The values for RIs are intended mainly for planning diets for groups of individuals of the specified age intervals and sex. The values include a safety margin accounting for variations in the requirement of the group of individuals and are set to cover the requirements of 97.5 % of the group. An alternative way to plan a diet is to use the requirements in combination with the distribution of reported or usual intakes for the specific nutrients.

Table 4. RI for vitamins – all life-stage groups

Age group	Vitamin A RE[2]	Vitamin D µg[3]	Thiamin mg[4]	Riboflavin mg	Niacin NE[4,5]	Vitamin B6 mg	Folate µg	Vitamin C mg
≤6 mo[1]				0.3		0.1	64	20
7-11 mo	250	10	0.3	0.4[6]	5	0.4[6]	86[6]	20[6]
Children								
1-3 y	300	10	0.5	0.6	8	0.6	120	25
4-6 y	350	10	0.6	0.7	10	0.7	130	30
7-10 y	400	10	0.7	0.9	12	1	190	45
Females								
11-14 y	650	10	0.9	1.4	14	1.3	280	75
15-17 y	650	10	1.0	1.5	15	1.5	310	90
18-24 y	700	10	1.0	1.6	15	1.6	330	95
25-50 y	700	10	0.9	1.6	14	1.6	330	95
51-70 y	700	10	0.9	1.6	13	1.6	330	95
>70 y	650	20	0.8	1.6	13	1.6	330	95
≥18 y	700	10	0.9	1.6	14	1.6	330	95
Pregnant	750	10	1.0	1.9	17	1.9	600[7]	105
Lactating	1400	10	1.3	2.0	20	1.7	490	155
Males								
11-14 y	650	10	1.0	1.2	17	1.4	250	70
15-17 y	750	10	1.3	1.6	21	1.8	320	100
18-24 y	800	10	1.2	1.6	19	1.8	330	110
25-50 y	800	10	1.2	1.6	18	1.8	330	110
51-70 y	800	10	1.1	1.6	16	1.8	330	110
>70 y	800	20	1.0	1.6	16	1.8	330	110
≥18 y	800	10	1.1	1.6	17	1.8	330	110

[1] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are provisional RIs based on estimated intake from human milk.
[2] RE = Retinol equivalents (1 RE = 1 µg retinol = 2 µg of supplemental β-carotene, 6 µg of dietary β-carotene, or 24 µg other dietary provitamin A carotenoids, e.g., α-carotene and β-cryptoxanthin).
[3] From 1-2 weeks of age, infants should receive 10 µg vitamin D_3 per day as a supplement. For people with little or no sun exposure, an intake of 20 µg/d is recommended.
[4] Daily intake at an energy intake corresponding to a physical activity level (PAL) of 1.6 (e.g., 8.7 MJ in females and 10.9 MJ in males ≥18 years). RI for thiamin and niacin is 0.1 mg/MJ and 1.6 NE/MJ, respectively.
[5] NE = Niacin equivalent (1 NE = 1 mg niacin = 60 mg tryptophan).
[6] Provisional RI, extrapolated from exclusively breast-fed infants 0-6 months.
[7] Provisional RI based on adequate intake (AI), not including supplementation before and during pregnancy. This provisional RI does not include the recommended supplementation for women before and during the first trimester of pregnancy.

Table 5. Provisional RI[1] for vitamins – all life-stage groups

Age group	Vitamin E α-TE[4]	Vitamin K µg	Pantothenic acid	Biotin µg	Vitamin B_{12} µg	Choline mg
≤6 mo[2]	4		2	4	0.4	120
7-11 mo	5[3]	10	3[3]	5[3]	1.2	160[3]
Children						
1-3 y	9	15	4	20	1.5	140
4-6 y	10	20	4	25	1.5	160
7-10 y	11	30	4	25	2.5	140
Females						
11-14 y	13	45	5	35	3.5	340
15-17 y	13	60	5	35	4	390
18-24 y	13	65	5	40	4	400
25-50 y	13	65	5	40	4	400
51-70 y	12	60	5	40	4	400
>70 y	12	60	5	40	4	400
≥18 y	13	65	5	40	4	400
Pregnant	14	75	5	40	4.5	480
Lactating	17	65	7	45	5	520
Males						
11-14 y	14	45	5	35	3	300
15-17 y	17	65	5	35	4	390
18-24 y	16	75	5	40	4	400
25-50 y	15	75	5	40	4	400
51-70 y	14	70	5	40	4	400
>70 y	14	70	5	40	4	400
≥18 y	15	75	5	40	4	400

[1] Provisional recommended intakes based on adequate intake (AI).

[2] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are based on estimated intake from human milk.

[3] Extrapolated from exclusively breast-fed infants 0-6 months.

[4] Assuming a PUFA intake of 7.5 % of energy intake. α-TE = α-tocopherol equivalents (i.e., 1 mg RRR α-tocopherol).

Table 6. RI for minerals – all life-stage groups

Age group	Calcium mg	Iron mg	Zinc mg[2]	Copper µg
≤6 mo[1]	*120*			*200*
7-11 mo	*280*[3]	9	3	*220*[3]
Children				
1-3 y	450	7	4	330
4-6 y	800	6	5	370
7-10 y	800	9	7	530
Females				
11-14 y	1100	13	11	770
15-17 y	1300	11	12	880
18-24 y	1100	12	8	900
25-50 y	900	12	8	900
51-70 y	900	8	8	900
>70 y	900	9	8	900
≥18 y	900-1100	9–12	8	900
Pregnant	950	26	10	1000
Lactating	950	12	11	1300
Males				
11-14 y	1100	10	10	690
15-17 y	1050	11	13	890
18-24 y	1000	8	10	900
25-50 y	900	8	10	900
51-70 y	900	8	10	900
>70 y	900	7	10	900
≥18 y	900-1000	8	10	900

[1] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are provisional AR based on estimated intake from human milk.
[2] Assuming a mixed animal/vegetable diet with a phytic acid intake of about 300 mg/d.
[3] Provisional AR, extrapolated from exclusively breast-fed infants 0-6 months.

Table 7. Provisional RI[1] for minerals – all life-stage groups

Age group	Phosphorus mg[3]	Sodium mg	Potassium mg	Magnesium mg	Iodine µg	Selenium µg	Fluoride mg[4]	Manganese mg	Molybdenum mg	Chromium µg[5]
≤6 mo[2]		110	400	25	80-90	10		12 µg		0.2
7-11 mo	160	370	700	80[6]	80-90	20[6]	0.5	0.02-0.5[7]	10	5.5
Children										
1-3 y	250	700	800	170	90	20	0.6	0,5	15	11
4-6 y	440	900	1050	230	90	25	1	1	20	13
7-10 y	440	1100	1650	230	90	40	1.4	1.5	30	18
Females										
11-14 y	610	1300	2350	250	120	60	2.3	2	50	24
15-17 y	720	1500	2800	250	120	70	2.9	2.5	60	27
18-24 y	610	1500	3500	300	150	80	3.2	3	65	30
25-50 y	500	1500	3500	300	150	75	3.2	3	65	29
51-70 y	500	1500	3500	300	150	75	3.1	3	65	26
>70 y	500	1500	3500	300	150	75	3	3	65	26
≥18 y	520	1500	3500	300	150	75	3.1	3	65	28
Pregnant	530	1500	3500	300	200	95	3.1	3	70	34
Lactating	530	1500	3500	300	200	85	3.1	3	65	48
Males										
11-14 y	600	1300	2350	300	120	60	2.2	2	40	26
15-17 y	580	1500	3300	300	130	85	3.2	2.5	60	34
18-24 y	550	1500	3500	350	150	90	3.8	3	65	38
25-50 y	500	1500	3300	350	150	90	3.7	3	65	36
51-70 y	500	1500	3500	350	150	90	3.7	3	65	33
>70 y	500	1500	3500	350	150	85	3.5	3	65	32
≥18 y	500	1500	3500	350	150	90	3.7	3	65	35

[1] Provisional recommended intakes based on adequate intake (AI).
[2] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are provisional AR based on estimated intake from human milk.
[3] Assuming the RI of calcium is consumed.
[4] Based on an adequate intake of 0.05 mg/kg bodyweight, using population reference weights. For pregnant and lactating women, this refers to pre-pregnancy weight.
[5] Daily intake at an energy intake corresponding to a physical activity level (PAL) of 1.6 (e.g., 8.7 MJ in females and 10.9 MJ in males ≥18 years).
[6] Extrapolated from exclusively breast-fed infants 0-6 months.
[7] Range based on upwards extrapolation from intake of infants 0-6 months, the mean of observed intakes and downwards extrapolation from adult AI.

Sodium as salt

The EFSA Panel considered 2.0 g sodium/day to be a safe and adequate intake for the general EU population of adults (EFSA, 2019). In the U.S., the reference level of sodium intake of adults was set to 1.5 g/d due to limited evidence on health effects of sodium intakes lower than that and suggested to reduce the intake if above 2.3 g/d (116). Based on an overall evaluation of the available data in the recent reviews (116, 137) the provisional RI in NNR2023 is set at 1.5 g sodium per day for adults (females and males), which corresponds to 3,75 g salt per day. There is strong evidence to aim for a reduction of sodium intakes in the Nordic and Baltic populations. NNR2023 adapts the reasoning from NASEM to recommend limiting intake above 2.3 g/d.

Dietary supplements

Prolonged intakes of nutrients from supplements have generally not been associated with decreased risk of chronic diseases or other health benefits in healthy individuals eating a varied diet that covers their energy requirements. In contrast, there is a large body of evidence suggesting that elevated intakes of certain supplements, mainly vitamins with antioxidative properties, might increase the risk of certain adverse health effects, including mortality. Thus, there is no scientific justification for using supplements as a tool for adjusting an unbalanced diet. Important exceptions concern the intake of vitamin D, iron, iodine and folate, which may be low or marginal in some subgroups of the population such as infants, pre-pregnant, pregnant and lactating women and frail elderly.

Reference values for energy intake

Both excessive and insufficient energy intake in relation to energy requirements can lead to negative health consequences in the long term. In adults, therefore, an individual's long-term energy intake and energy expenditure should be equal.

In Table 8, reference values are given for energy intake for groups of adults with three different physical activity levels. An active lifestyle, corresponding to PAL 1.8, is considered desirable for maintaining good health. An activity level of PAL 1.6 is close to the population median and corresponds to a common lifestyle with sedentary work and some increased physical activity level during leisure time. The reference body weights used for the calculations are based on self-reported weights in Nordic populations. The original weights have been adjusted so that all individuals would have a body mass index (BMI) of 23. Therefore, the reference values indicate an energy intake that would maintain normal body weight in adults.

Specific recommendations for energy intake cannot be given due to the large variation between individuals with respect to metabolic rate, body composition, and degree of physical activity.

Table 8. Reference values for energy intakes in groups of adults with sedentary and active lifestyles

Age, years	Reference weight, kg	REE, MJ/d	Average PAL 1.4, MJ/d	Average PAL 1.6, MJ/d	Active PAL 1.8, MJ/d
Females					
18-24	64,2	5,9	8,3	9,4	10,6
25-50	64,1	5,7	8	9	10,2
51-70	62,5	5,2	7,2	8,3	9,3
>70	60,6	5,1	7,1	8,2	9,2
18+	62,9	5,5	7,7	8,7	9,8
Males					
18-24	75,2	7,4	10,4	11,8	13,2
25-50	74,8	7,1	9,9	11,3	12,7
51-70	73	6,4	9	10,3	11,6
>70	70,6	6,3	8,8	10,1	11,3
18+	73,4	6,8	9,5	10,9	12,2
Pregnancy[1]					
≤18[2]	72,9	6,5	9,1	10,5	11,8
19-30	78,2	6,5	9,1	10,4	11,7
31-50	78,1	6,1	8,6	9,8	11
Lactation[3]					
≤18[2]	58,9	7,9	11,1	12,6	14,2
19-30	64,2	7,9	11	12,6	14,2
31-50	64,1	7,7	10,7	12,2	13,8

[1] Weight gain of 14 kg during pregnancy, assuming a pre-pregnancy BMI of 18.5-24.9
[2] REE calculated with the equation for adolescents 15-17 years old
[3] Exclusive breastfeeding 0-6 months postpartum

Tables 9 and 10 presents reference values for energy intakes in groups of children. It must again be mentioned that individual energy requirements might be very different from these group-based average values.

Table 9. Reference values for estimated average daily energy requirements per kg body weight for children 6-12 months, assuming partial breastfeeding

Age, months	Average daily energy requirements, kj/kg body weight	
	Boys	Girls
6	339	342
12	337	333

Table 10. Reference values for estimated daily energy requirements (MJ/d) for children and adolescents, 1-17 years

Age	Reference weight, kg	REE, MJ/d	Estimated energy requirement, MJ/d[1]
1-3 y	12.8	3.2	4.4
4-6 y	19.2	3.8	6.1
7-10 y	28.5	4.7	7.5
Females			
11-14 y	45.5	5.4	9.1
15-17 y	57.5	5.9	10.1
Males			
11-14 y	44.2	6.6	11.1
15-17 y	64.2	8.1	13.7

[1]PALs (average) for age groups: 1-3 years = 1.4; 4-10 years: 1.6; 11-17 years: 1.7

Reference values (AR and provisional AR) for assessing nutrient intakes in dietary surveys

Vitamins and minerals

<u>Assessing nutrient adequacy</u>

AR and provisional AR for vitamins and minerals are presented in Table 11-14). The values are intended only for use in assessing results from dietary surveys. Before comparing intake data with these reference values, it is crucial to check whether the intake data derived from a particular survey are suitable for assessing adequacy. More guidance on this topic and on how to use NNR in this context is given in Trolle et al (100).

The AR is the value to be primarily used to assess the risk for inadequate intake of micronutrients in a certain group of individuals. The percentage that has an intake below the AR indicates the proportion having an increased risk of inadequate intake.

Table 11. Average requirements of vitamins

Age group	Vitamin A RE[2]	Vitamin D µg	Thiamin mg[3]	Riboflavin mg	Niacin NE[3, 4]	Vitamin B6 mg	Folate µg	Vitamin C mg
≤6 mo[1]				*0.2*		*0.1*	*50*	*16*
7-11 mo	200	7.5	0.2	0.3[5]	4	0.3[5]	70[5]	16[5]
Children								
1-3 y	220	7.5	0.4	0.5	7	0.5	90	20
4-6 y	250	7.5	0.4	0.6	8	0.6	100	25
7-10 y	320	7.5	0.5	0.8	10	0.8	150	40
Females								
11-14 y	480	7.5	0.6	1.1	11	1.1	210	60
15-17 y	500	7.5	0.7	1.3	12	1.2	240	75
18-24 y	540	7.5	0.7	1.3	12	1.3	250	75
25-50 y	540	7.5	0.7	1.3	12	1.3	250	75
51-70 y	530	7.5	0.6	1.3	11	1.3	250	75
>70 y	510	7.5	0.6	1.3	11	1.3	250	75
≥18 y	530	7.5	0.6	1.3	11	1.3	250	75
Pregnant	590	7.5	0.7	1.6	13	1.5	480[6]	75
Lactating	1070	7.5	0.9	1.6	16	1.4	380	75
Males								
11-14 y	480	7.5	0.8	1	14	1.1	190	60
15-17 y	580	7.5	0.9	1.3	17	1.5	240	85
18-24 y	630	7.5	0.9	1.3	15	1.5	250	90
25-50 y	630	7.5	0.8	1.3	15	1.5	250	90
51-70 y	610	7.5	0.7	1.3	13	1.5	250	90
>70 y	590	7.5	0.7	1.3	13	1.5	250	90
≥18 y	620	7.5	0.8	1.3	14	1.5	250	90

[1] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are provisional AR based on estimated intake from human milk.
[2] RE = Retinol equivalents (1 RE = 1 µg retinol = 2 µg of supplemental β-carotene, 6 µg of dietary β-carotene, or 24 µg other dietary provitamin A carotenoids (e.g., α-carotene and β-cryptoxanthin).
[3] Daily intake at an energy intake corresponding to a physical activity level (PAL) of 1.6 (e.g., 8.7 MJ in females and 10.9 MJ in males ≥18 years). AR for thiamin and niacin is 0.07 mg/MJ and 1.3 NE/MJ, respectively.
[4] NE = Niacin equivalent (1 NE = 1 mg niacin = 60 mg tryptophan).
[5] Provisional AR, extrapolated from exclusively breast-fed infants 0-6 months.
[6] Provisional AR based on adequate intake (AI), not including supplementation before and during pregnancy.

Table 12. Provisional average requirements of vitamins

Age group	Vitamin E α-TE[4]	Vitamin K µg	Pantothenic acid	Biotin µg	Vitamin B_{12} µg	Choline mg
≤6 mo[2]	3		1.6	3	0.3	96
7-11 mo	4[3]	5	2.1[3]	4[3]	1.2	129[3]
Children						
1-3 y	7	10	3.2	16	1.2	114
4-6 y	8	15	3.2	20	1.2	131
7-10 y	9	25	3.2	20	2	188
Females						
11-14 y	10	35	4	28	2.8	271
15-17 y	11	45	4	28	3.2	308
18-24 y	11	50	4	32	3.2	320
25-50 y	10	50	4	32	3.2	320
51-70 y	10	50	4	32	3.2	320
>70 y	10	50	4	32	3.2	320
≥18 y	10	50	4	32	3.2	320
Pregnant	11	60	4	32	3.6	381
Lactating	13	50	5.6	35	4	416
Males						
11-14 y	12	35	4	28	2.4	243
15-17 y	13	50	4	28	3.2	313
18-24 y	13	60	4	32	3.2	320
25-50 y	12	60	4	32	3.2	320
51-70 y	11	60	4	32	3.2	320
>70 y	11	55	4	32	3.2	320
≥18 y	12	60	4	32	3.2	320

[1] Provisional average requirements (AR) calculated as 0.8 times the adequate intake (AI), assuming a CV of 12.5 %. This likely overestimates the true AR.

[2] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are provisional AR based on estimated intake from human milk.

[3] Extrapolated from exclusively breast-fed infants 0-6 months

[4] Assuming a PUFA intake of 7.5 % of energy intake. α-TE = α-tocopherol equivalents (i.e., 1 mg RRR α-tocopherol).

Table 13. Average requirements of minerals

Age group	Calcium mg	Copper µg	Iron mg	Zinc mg[2]
≤6 mo[1]	96	160		
7-11 mo	238[3]	180[3]	7	2.5
Children				
1-3 y	395	250	5	3.5
4-6 y	680	290	5	4.5
7-10 y	675	410	7	5.9
Females				
11-14 y	950	590	10	8.8
15-17 y	1090	670	9	10
18-24 y	950	700	9	7
25-50 y	750	700	9	7
51-70 y	750	700	6	7
>70 y	750	700	6	6
≥18 y	750-950	700	6-9	7
Pregnant	800	800	20	8
Lactating	800	1000	9	9
Males				
11-14 y	930	530	8	8
15-17 y	900	680	8	11
18-24 y	850	700	6	9
25-50 y	750	700	6	8
51-70 y	750	700	6	8
>70 y	750	700	6	8
≥18 y	750-850	700	6	8

[1] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are provisional AR based on estimated intake from human milk.

[2] Assuming a mixed animal/vegetable diet with a phytic acid intake of about 300 mg/d.

[3] Provisional AR, extrapolated from exclusively breast-fed infants 0-6 months.

Table 14. Provisional average requirements of minerals

Age group	Phosphorus mg[3]	Potassium mg	Magnesium mg	Iodine µg	Selenium µg	Fluoride mg[4]	Manganese mg	Molybdenum mg	Chromium µg[5]
≤6 mo[2]		320	20	64-72	10		9.6 µg		0.2
7-11 mo	131	550	63[6]	64-72	15[6]	0,4	0.02-0.4[7]	7	4.4
Children									
1-3 y	199	650	136	80	15	0.5	0.5	10	9
4-6 y	353	850	184	60	20	0.8	0.7	15	10
7-10 y	353	1300	184	70	30	1.1	1	22	15
Females									
11-14 y	486	1850	200	90	45	1.8	1.7	38	19
15-17 y	574	2250	200	100	55	2.3	2.2	48	21
18-24 y	486	2800	240	120	60	2.6	2.4	52	24
25-50 y	419	2800	240	120	60	2.6	2.4	52	23
51-70 y	419	2800	240	120	60	2.5	2.4	52	21
>70 y	419	2800	240	120	60	2.4	2.4	52	21
≥18 y	442	2800	240	120	60	2.5	2.4	52	22
Pregnant	434	2800	240	160	75	2.5	2.2	55	27
Lactating	434	2800	240	160	70	2.5	2.2	51	39
Males									
11-14 y	486	1850	240	90	45	1.8	1.4	31	21
15-17 y	464	2650	240	110	65	2.6	2.1	45	27
18-24 y	442	2800	280	120	70	3	2.4	52	30
25-50 y	419	2800	280	120	70	3	2.4	52	29
51-70 y	419	2800	280	120	70	2.9	2.4	52	26
>70 y	419	2800	280	120	70	2.8	2.4	52	26
≥18 y	425	2800	280	120	70	2.9	2.4	52	28

[1] Provisional average requirements (AR) calculated as 0.8 times the adequate intake (AI), assuming a CV of 12.5 %. This likely overestimates the true AR.
[2] Exclusive breastfeeding is the preferable source of nutrition for infants during the first six months of life. Values for infants 0-6 months are provisional AR based on estimated intake from human milk.
[3] Assuming the recommended intake (RI) of calcium is consumed.
[4] Based on an adequate intake of 0.05 mg/kg bodyweight, using population reference weights. For pregnant and lactating women, this refers to pre-pregnancy weight.
[5] Daily intake at an energy intake corresponding to a physical activity level (PAL) of 1.6 (e.g., 8.7 MJ in females and 10.9 MJ in males ≥18 years).
[6] Extrapolated from exclusively breast-fed infants 0-6 months
[7] Range based on upwards extrapolation from intake of infants 0-6 months, the mean of observed intakes and downwards extrapolation from adult AI.

Assessing high intakes

For some nutrients, high intakes can cause adverse or even toxic symptoms. Upper intake levels (UL) have thus been established for some nutrients (Table 15). For certain nutrients, especially preformed vitamin A (retinol), vitamin D, iron, and iodine, prolonged intakes above these levels can lead to an increased risk of toxic effects. For other nutrients the adverse effects might be different and milder, e.g., gastrointestinal problems or interference with the utilization of other nutrients. The ULs are not recommended levels of intake but are maximum levels of daily chronic intakes judged to be unlikely to pose a risk of adverse health effects in humans. The ULs are derived for the normal healthy population, and values are given for adults. For other life stages, such as infants and children, specific data might exist for deriving specific values or such values could be extrapolated.

To establish whether a population is at risk for adverse effects, the fraction of the population exceeding the UL and the magnitude and duration of the excessive intake should be determined. There is a substantial uncertainty in several of the ULs, and they must be used with caution for single individuals. UL values do not necessarily apply in cases of prescribed supplementation under medical supervision.

Table 15. UL of vitamins and minerals for adults

		UL per day
Boron[1]	mg/d	10
Calcium[1,2]	mg/d	2500
Copper[2]	mg/d	5
Iodine [1,2]	µg/d	600
Iron[2]	mg/d	25
Magnesium[1,3]	mg/d	250
Molybdenum[1]	mg/d	0.6
Phosphorus[2]	mg/d	3000
Potassium[2]	g/d	3.7
Selenium[1,2]	µg/d	300
Zinc[1,2]	mg/d	25
Fluoride[1]	mg/d	7
Folic acid (synthetic)[1,2]	µg/d	1000
Nicotinamide[1,2]	mg/d	900
Nicotinic acid[1,2]	mg/d	10
Vitamin A[1,2,4]	µg RE/d	3000
Vitamin B6[1,2]	mg/d	25
Vitamin C [2]	mg/d	1000
Vitamin D1,2	µg/d	100
Vitamin E[1,2]	mg/d	300

1) Based on EFSA 2018
2) Based on NNR2012
3) Readily dissociable Mg salts (e.g. chloride, sulphate, aspartate, and lactate) and compounds like MgO in food supplements, water or added to foods; does not include Mg naturally present in foods and beverages.
4) Retinol and retinyl esters

Energy-providing nutrients

The assessment of macronutrient intake mainly concerns the energy distribution (as energy per cent, E%) from protein, fat, fatty acids, added sugars, and total carbohydrates. For protein intake, i.e., gram per kg body weight and day, is also used and for dietary fibre the intake amount is given per day or per MJ.

In the assessment of the usual energy contribution from protein, fat, and carbohydrates, the proportion of the group that has energy contributions from these macronutrients within (or outside) the recommended intake range is estimated. In the assessment of the energy contribution from macronutrients with a recommended upper threshold (i.e., saturated fat and added sugars) the proportion of the group that exceeds this threshold is estimated. Likewise, when energy contribution from macronutrients with a recommended lower threshold (e.g., dietary fibre) is assessed, the proportion of the group that goes below this level is estimated.

Principles for developing a framework for setting FBDGs in NNR2023

Country-specific national FBDGs must be built on 5 pillars

The role of national FBDGs is to inform country-specific public food and nutrition, health and agricultural policies and nutrition education programs to foster healthy eating habits and lifestyles. More than 100 countries worldwide, all EU countries and all EU associated countries have developed healthy FBDGs (FBDGs). The national FBDGs varies considerably across the countries, because several country-specific dimensions should be taken into account when formulating national FBDGs.

The scientific evidence for health effects of foods and food groups are more or less universal: similar health effects are established for the same foods or food groups independent of the country where the study population originate. There are exceptions to this rule, but these exceptions are few and will be discussed when relevant.

National FBDGs are not only informed by the universal health effect of foods. They are also informed by several country-specific factors (Food-based dietary guidelines, FAO (138); Sustainable healthy diets: guiding principles, WHO/FAO (2019) (91); Food-based dietary guidelines in the WHO European Region, WHO (2003) (139); Preparation and use of food-based dietary guidelines, WHO/FAO (1996) (140)).

First, they need to respond to the public health challenges in the individual countries. While the Nordic and Baltic countries are relatively similar compared to many other countries, there are significant differences in burden of diseases in the countries that needs to be addressed. This is why we have included a separate background paper on burden of diseases in the 8 Nordic and Baltic countries in the present NNR report. There may be other public health factors relevant for national FBDGs than those described in the NNR report. Thus, national authorities should consider carefully all relevant public health factors.

Second, food consumption pattern varies considerably across and within countries and are dependent on national food culture and tradition. While nutrient adequacy can be met by a huge variety of cultural diets, it is essential to consider whether national food patterns are in accordance with national nutrient recommendations. This is why we have included a separate background paper on food and nutrient intakes in the 8 Nordic and Baltic countries in the present NNR report. We have performed some preliminary calculations of nutrients intakes based on the FBDG described in the NNR report (see Appendix 5), but national authorities should perform more precise assessment of nutrient adequacy when they formulate country-specific FBDGs.

Third, food availability varies considerable across countries and are dependent for example on the country's ability for food production, national agricultural policies and import restriction. For example, while Japanese FBDGs include recommendations on rice, and Greek FBDGs include recommendations on olives, the global food production and the countries' food availability needs to be taken into account when developing country-specific FBDGs. Thus, while food availability is briefly discussed and considered in general terms in the NNR report, these factors are dependent on national policies and priorities, and are not taken into consideration in the NNR framework for developing FBDGs. National authorities may or may not align their country-specific food availability when they formulate national FBDGs.

Fourth, there are sociocultural or socioeconomic aspects that need to be considered and prioritised. A general overview of socio-economical aspects relevant for the Nordic and Baltic countries are described in Jackson and Holm (67). These are also country-specific issues that depends on national policies that needs to be considered by the national authorities.

Fifth, the project description of the present NNR project includes milestones not only for development of a framework for setting FBDGs, but also a framework for integrating environmental sustainability into the FBDGs. That is why we have included several background papers on environmental sustainability in the present report and include specifically environmental issues when we give science advice in the NNR framework for formulation of country-specific healthy and environmental-friendly FBDGs. Sustainable healthy diets should promote all dimensions of individuals health and well-being, have low environmental pressure and impact, be accessible, affordable, safe and equitable, and culturally acceptable, as described by FAO and WHO (91).

Thus, the major contribution of the present NNR for the national authorities in the 8 Nordic and Baltic countries, is to give science advice on health and environmental effects of food. It is important to realize that other country-specific aspect than those assessed in the NNR report is needed to be considered by the national authorities when they formulate their national FBDGs.

Assessing health effects of foods and food groups in NNR2023

During the last decades, nutritional sciences have revealed that foods contribute to health not only by contributing with the appropriate amounts of essential nutrients. The health effects of foods extend the effect on known essential nutrient, especially when it comes to chronic diseases. These health effects of foods are the major foundation for FBDGs. There has been a considerable development in recent methodologies to assess health effects of foods. To improve quality and reduce bias, health effects of foods are ideally considered through qualified SRs. Recent developments and harmonization of common principles and methodologies for synthesizing totality of evidence in qualified SR enable the NNR project to use qualified SRs developed from other national or international health authorities using similar methodologies. The list of qualified SRs that are the main foundation of the FBDGs in NNR is listed in Appendix 2.

First, it is essential to evaluate the causality of each individual food/food group and various relevant health outcome pair. This exercise may result in the identification of indicators that may be used to formulate FBDGs. If strength of evidence is graded above a certain predefined level, this indicator may be used for FBDG setting (3, 8, 9).

Then, a dose-response curve should be considered in a meta-analysis or qualified SR. If a dose-response curve can be established, a quantitative FBDG may be formulated. If no adequate dose-response curve can be established, a qualitative FBDG may be formulated (3, 8).

FBDGs are formulated more general than the DRVs, although the causal associations of foods and health outcomes can be stronger than for nutrients and health outcomes. There are seldom precise calculations, similar to those for DRVs, behind the quantitative FBDGs. The precise FBDGs are most often decided as consensus among expert groups. FBDGs are typically formulated for adults, not for all life-stage groups. Thus, when using the FBDGs for health guidance, care should be taken to consider the total amount foods and energy consumed. For example, the general FBDGs should be scaled down for adolescents and children, and others relevant populations such as elderly with low energy intake.

There is considerable uncertainty about health effects for some of some foods/food groups. If FBDGs cannot be formally defined, it does not necessarily mean that there are not any health effects of the foods/food groups. It simply means that the present scientific evidence is not strong enough to formulate a FBDG.

Assessing environmental effects of foods and food groups in NNR2023

In accordance with the scope and mandate from NCM we have assessed environmental effects of foods and food groups.

The assessment is based on the five sustainability background papers (summarized in the section "summary of background papers on environmental sustainability"). The sixth assessment reports from the Intergovernmental Panel on Climate Change (IPCC) (141, 142) and the Global Assessment Report on Biodiversity and Ecosystem Services from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (143) (IPBES) are pillars in the evaluation of environmental impact of food consumption in NNR2023. The most recent synthesis report from IPCC (2) concludes with "high confidence" that human activities have unequivocally caused global warming, with global surface temperature reaching 1.15°C above pre-industrial levels. Global GHG emissions continue to increase, with unequal historical and ongoing contributions arising from unsustainable energy use, land use and land-use changes, lifestyles and patterns of consumption and production across regions, and between and within countries. Global GHG emissions in 2030 implied by nationally determined contributions announced by October 2021 make it likely that warming will exceed 1.5°C within few years and make it much harder to limit warming below 2°C. Without strengthening of policies, global warming of 3.2°C [2.2-3.5] °C is projected by 2100 (*medium confidence).*

The IPCC report also concludes with "very high confidence" that climate change is a threat to human well-being and planetary health and that there is a rapidly closing window of opportunity to secure a liveable and sustainable future for all. Rapid and far-reaching transitions across all sectors and systems are therefore necessary. These system transitions involve a significant upscaling of a wide portfolio of mitigation and adaptation options across systems and regions.

IPCC estimates that the share of food systems in global anthropogenic GHG emissions is 21–37 % (144). While there are many options that may provide adaptation and mitigation benefits that could be up-scaled in the near-term across most regions, the demand-side measures, such as shifting to sustainable healthy diets and reducing food loss/waste, are essential parts of these adaptions and mitigations. As the five sustainability background papers, the report concludes with high confidence that a diet featuring plant-based foods, such as one based on coarse grains, legumes, fruits and vegetables, nuts and seeds, and animal-sourced food produced in resilient, sustainable, and low-GHG emission systems, present major opportunities for adaptation and mitigation while generating significant co-benefits in terms of human health.

The background papers contribute with science-based inputs on environmental (including climate) effects of foods and diets from a global and regional, as well as national perspectives. The background papers also provide status on the current FBDGs in the Nordic countries and suggestions for the approach to be used by the national authorities when developing or updating FBDGs integrating environmental sustainability. The present NNR2023 project initially considered recently developed optimization models for integration of environmental sustainability. While these are very useful tools, we conclude that is should not be used as the only methodology in the present NNR. Openness and transparency are essential, and it is always a “black box” in such modelling, and many complex assumptions that goes into the models. Also, optimization is a relatively new technology related to this integration and may need more development to really be useful. It is important to stress that we did not perform modelling in the NNR project.

We base our science advice on scientific evidence, and systematic reviews of available science. Therefore, we did not use optimization as an overarching principle for developing science advice for FBDGs in NNR. However, a number of different studies, also using optimization methodologies and referred in the background papers, feeds into the science advice.

Science advice for setting healthy and environmental-friendly FBDGs in Nordic and Baltic countries

Weighing of health versus environment when formulating FBDGs is essential, but difficult, and dependent on a number of factors and priorities. No formal mathematical weighing of health versus environment is performed in the science advice for developing FBDGs in the NNR report. We describe the considerations transparently and conclude by formulating quantitative or qualitative science advice for each individual food group.

Diet is a complex system of interacting components that cumulatively affect health. Foods are not consumed in isolation and decreasing the intake of one food group usually entails increasing the intake of another food group to make up for the reduction in energy and nutrients. Therefore, there is also a strong inter-connectivity between the science advice of different food groups (partially visible with cross-references). Food group-specific advice should always be interpreted in relation to the whole diet.

The FBDGs have an emphasis on plant-based sources of nutrients, based on health outcomes alone or in combination with the effort to reduce environmental impact of diets. Many new products have emerged on the market with the aim of replacing meat or dairy products in a meal. Such products may be part of a healthy diet, but the nutrient content of these products may vary considerably (68). The NNR2023 project has not evaluate the nutritional content of these products separately.

When developing a framework for integrating environmental sustainability into healthy FBDGs, we used the following strategy and principles:

1. First, we considered health effects of food groups. Health effects were given priority. The background papers of respective food groups were the main background for assessment. We focused primarily on evidence from qualified SRs on chronic disease outcomes. If significant and causal effect is established, we defined the range that is associated with low risk of diseases. The range spans a value larger than 0 up to the maximal intake. Alternatively, we set an upper level (in the case of adverse effect of high intakes) or a lower level (in the case of no relevant upper level).
2. Second, we considered whether the food group contributes significant amounts of essential nutrients in the general population in Nordic and Baltic countries. If significant contribution, the range spans a value larger than 0 up to the maximal intake. If no significant contribution, the range spans a value from 0 up to the maximal intake.
3. Third, we considered public health challenges related to health effects of the food group. Health effects related to prevalent chronic diseases were given priority.
4. Fourth, we considered the environmental impact of consumption of the food groups. We gave priority to changes in dietary patterns that reduce the environmental impact of the food group. We first considered whether narrowing the health defined ranges of intakes can contribute to reducing the environmental impact without compromising the beneficial health effects.

A short summary of these individual considerations and the main science advice from the NNR Committee is summarized in Table 16. The conclusions and advice, which is also summarized in the corresponding one-pagers in this report, builds mainly on the corresponding NNR2023 food group background papers as well as the NNR2023 background papers on food and diet intake, burden of diseases and environmental sustainability.

Adults in the general population is the target for the food based dietary guidelines in table 16.

Table 16. – Science advice for food groups for adults

Food group	Health effects on chronic diseases	Health effects on nutritional adequacy	Environmental impact of foods consumed	Advice to authorities in Nordic and Baltic countries
Beverages	Consumption of filtered coffee may reduce the risk of some cancers, CVD and T2D.	Negative health effects of caffeine more than 400 mg/d, and high consumption of SSB, energy drinks, unfiltered coffee and LNCSB.	High consumption of coffee may have a significant environmental impact. Negative impact is related to decreased biodiversity through monoculture crops.	Moderate consumption of coffee and tea may be part of a healthy diet. Consumption should be limited to maximum intake corresponding to 400 mg caffeine/day. Consumption of energy drinks, unfiltered coffee, LNCSB and SSB should be limited.
Cereals	High intake of whole grains reduces the risk of CVD, CRC, T2D and premature mortality.	Contribute with fibre and many essential nutrients.	Relatively low environmental impact, rice being an exception related to GHG emission and water use.	Intake equivalent of 90 g whole grain/day. Some further benefits of intakes up to 210 gram/day. Whole-grain cereals other than rice should preferentially be used. Cereals may contribute to reducing climate impact of current diets because they have a low GHG emissions.
Vegetables, fruits, berries	High consumption (500-800 g/day) reduce risk of several cancers, CVD, premature mortality	Contribute with fibre and many essential nutrients	In general, relatively low environmental impact. Negative environmental impact is mainly related to use of agriculture chemicals, and water stress issues of imported fruits from water scarce regions.	For adults it is recommended to consume a variety of vegetables, fruits and berries, at least 500-800 grams/day in total. At least half should be vegetables. Vegetables, fruits and berries may contribute to reduce the climate impact of current diets because they have a low GHG emissions.
Potatoes	No established health effects.	Common staple food, contribute with fibre and many essential nutrients. Negative health effects of potato products with	In general, relatively low environmental impact.	Potatoes can be part of a healthy and environment-friendly diet. Potatoes can be included as a significant part in the regular dietary pattern in the Nordic and Baltic countries. Potato products with added salt and fat should be limited.

		added salt and fat.		Potatoes may contribute to reducing climate impact of current diets because they have a low GHG emissions.
Fruit juice	No established health effects.	Contributes with many essential nutrients, may contribute with fibre. Fruit juices in large quantities, even with no added sugar, are likely to promote weight gain and caries in a similar way to sugar-sweetened drinks.	In general, low environmental impact. Negative environmental impact is mainly related to use of agriculture chemicals, and water stress issues of imported fruits from water scarce regions.	Fruit juice may be part of the fruit and vegetable recommendation. Fruit juice may contribute to maximum 100 g/day.
Legumes /pulses	No established health effects.	Contribute with protein, fibre and many essential nutrients.	In general, low environmental impact.	Legumes/pulses should be part of a healthy and environmental-friendly diet. Legumes/pulses should be included as a significant part in the dietary pattern in the Nordic and Baltic countries. In diets with limited amounts of meat, legumes/pulses are important providers of nutrients such as protein, iron and zinc.
Nuts and seeds	Reduced risk of CVD from intake of 20-30 gram/day.	High nutrient density. Contributes with specific fatty acids, protein and fibre.	Relatively low environmental impact. Environmental impact is related to land use and water stress issues of some nuts.	It is recommended to consume a daily serving of 20-30 grams, or more, unsalted nuts and seeds. Nuts and seeds may contribute to reduce the climate impact of current diets because they have low GHG emissions and high nutrient density.

Fish	Reduced risk of CVD, Alzheimer's disease, cognitive decline and premature mortality.	Contribute to n-3 fatty acids and essential nutrients such as vitamin D, vitamin B12 and iodine.	In general, consumption of fish has a lower environmental impact compared to consumption of meat. Negative impact mainly related to GHG emissions, decreased biodiversity, land use, freshwater use, spread of disease, and chemical pollution of feed ingredients and overfishing.	It is recommended to consume 300-450 g/week, at least 200 g/week should be fatty fish. It is recommended to consume fish from sustainably managed fish stocks.
Red meat	Intake above 350-500 gram/week increases the risk of CRC, CVD and T2D.	Contributes with many essential nutrients, such as iron and vitamin B12.	In general, high environmental impact. The high consumption of red meat is the most important contributor to GHG emissions from the diet in the Nordic and Baltic countries. Negative environmental impact is related to methane emissions from ruminants, imported fodder ingredients contribute through fertilizer, pesticide, water and land use.	For health reasons, consumption of red meat should be low and not exceed 350 gram/week (ready-to-eat weight). Processed red meat should be as low as possible. For environmental reasons, the consumption of red meat should be considerably lower than 350 grams/week (ready-to-eat). The reduction of red meat consumption should not result in an increase in white meat consumption. To minimize environmental impact, meat consumption should be replaced with increased consumption of plant foods such as legumes.
White meat (poultry)	No established health effects.	Contributes with many essential nutrients.	In general, lower environmental impact across many environmental metrics compared to red meat, but higher compared to plant foods. Negative	To minimize environmental impact, consumption of white meat should not be increased from current levels, and preferentially be lower. Processed white meat should be as low as possible. To minimize environmental impact,

			environmental impact is related to feed production and manure management.	meat consumption should be replaced by increased consumption of plant foods such as legumes.
Milk and dairy	Moderate consumption may reduce risk of CRC. High consumption of high-fat products may increase risk of CVD.	Contributes with many essential nutrients, such as calcium, iodine, riboflavin and vitamin B12.	In general, high environmental impact. The high consumption of milk and dairy is one of the most important contributors to GHG emissions from the diet in the Nordic and Baltic countries. Negative environmental impact is related to methane emissions from ruminants, imported fodder ingredients contribute through fertilizer, pesticide, water and land use. Positive environmental impact may be related to grazing and biodiversity.	250-500 gram/day of predominantly low-fat milk and dairy products (10 g cheese is similar to 100 g milk). If consumption of milk and dairy is lower than 250 gram/day, products may be replaced with other foods or fortified food equivalents.
Eggs	No significant health effects.	Contribute essential nutrients.	Contribute to GHG emission and loss of biodiversity, mainly through feed production. Lower GHG emission than most other animal food.	0-1 egg/day

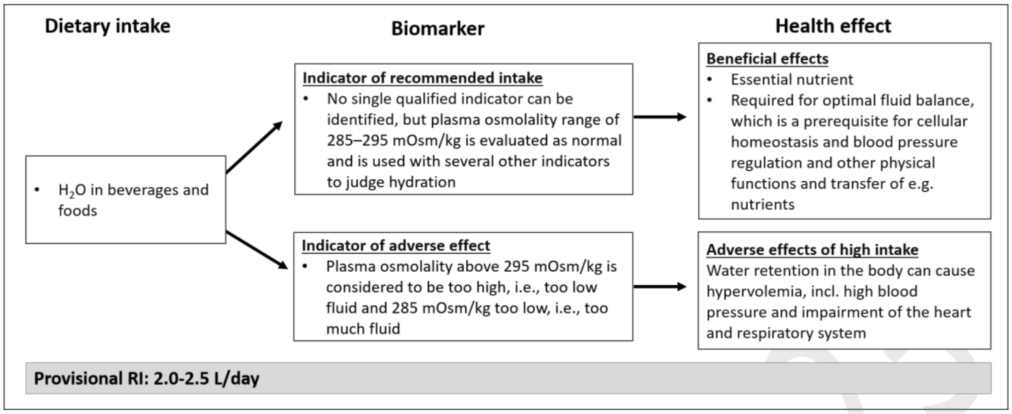
Fats and oils	No significant health effects.	Vegetable oils contribute with essential fatty acids. Fat quality affects risk of CVD. Replacing animal-based saturated fats (mainly butter) with non-tropical plant-based fats (unsaturated oils) may reduce the risk of CVD and mortality.	Variable environmental impact. Negative environmental impact related to high consumption of animal-based fats and GHG emissions, reduced biodiversity, and loss of nature. The different vegetable oils have variable environmental impact related to deforestation, GHG emissions, biodiversity, water and land use.	It is recommended to consume vegetable oils at a minimum of 25 g/day and limiting the consumption of butter and tropical oils.
Sweets	No significant health effects.	Sweets, cakes and biscuits contribute to high energy intake of sugar and fat, and have a positive and causal relationship with risk of chronic metabolic diseases such as obesity and dyslipidaemia, and caries.	High consumption of sweets may have a significant environmental impact. Negative environmental impact is related to decreased biodiversity through monocultures and land use change.	It is recommended to limit the consumption of sweets and other sugary foods.
Dietary patterns	Healthy dietary patterns are associated with beneficial health outcomes, such as reduced risk of CVD, T2D, obesity, cancer, bone health, and premature death.	Healthy dietary patterns are often micronutrient dense, including high intake of unsaturated fats and fibre, and low intake of saturated fats, added sugar and sodium.	In general, a healthy dietary pattern has a low environmental impact.	It is recommended to consume a predominantly plant-based diet high in vegetables, fruits, whole grains, fish, low-fat dairy, and legumes and low in red and processed meats, sugar-sweetened beverages, sugary foods, salt, and refined grains.

Abbreviations: CVD, cardiovascular disease; CRC, colorectal cancer; GHG, greenhouse gas; LNCSB, low- and no-calorie sweetened beverages; SSB, sugar-sweetened beverages; T2D, type 2 diabetes.

One-pagers of nutrients

All DRVs in the graphical abstracts for nutrients refer to the age group 25-50 years.

Fluid and water balance



Dietary intake. Main sources are drinking water, beverages, and solid foods. It has been estimated that solid foods provide an average of 600—800 mL of water per day (145) with water content in food items vary form ~5% in nuts to 90% or more in many fruits and vegetables. Intake from drinking water and beverages often provides between 700 to 1400 ML/day of water.

Main functions. Water is an essential nutrient needed to maintain normal physiological functions (e.g. blood pressure, pH, internal body temperature) and health (40). It is needed to transport essential substances (e.g., oxygen, carbon dioxide, water, and glucose) to and from cells, regulate body temperature and provide structure to cells and tissues, and to help preserve cardiovascular function.

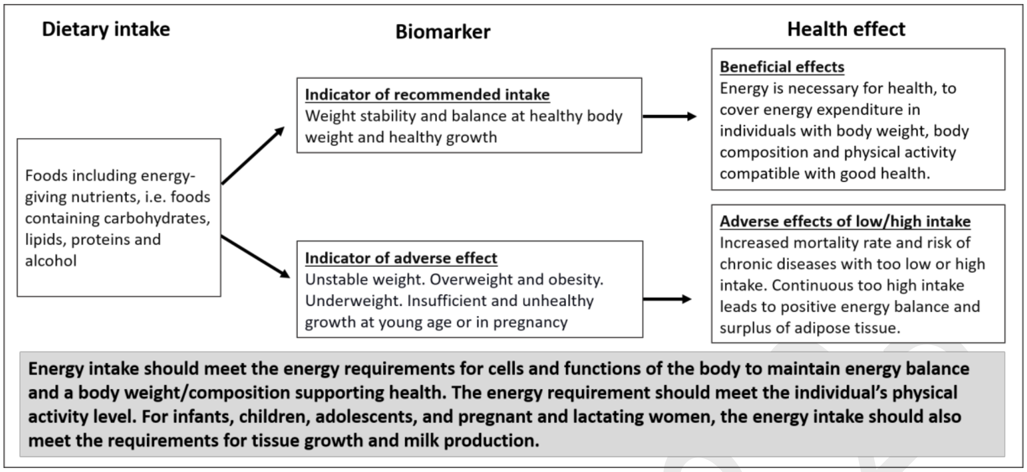
Indicator for recommended intake. Plasma osmolality in the range of 285 to 295 mOsm/kg

Main data gaps. Limited data on intake of drinking water intake in the Nordic or Baltic countries.

Deficiency and risk groups: Sick and frail older adults as well as those performing physical work/exercise, particularly at high environmental temperatures may be at risk of becoming dehydrated. Overhydration, i.e., too much water for body functions, may be seen as oedema or hyponatremia in certain conditions.

Recommendations. Provisional RI is set at 2.0 L/day for females and 2.5 L/day for males 14 years or older (97). The provisional RI is set on the basis of total water intake including water from beverages and from food moisture under moderate environmental temperatures and physical activity levels (PAL 1.6). Furthermore, the provisional RI is set to 0.8–1.0, 1.1–1.2, and 1.3, and 1.6 L per day for children aged 0.5–1, 1–2, 2–3, and 4–8 years, respectively. AI for 9–13-year-olds was set to 2.1 L for boys and 1.9 L for girls.

Energy



Dietary intake. Calculated mean energy intake of women and men in the Nordic and Baltic countries ranges from 6.5 MJ/d – 8.4 MJ/d and 8.7 MJ/d – 11.2 MJ/d, respectively (64). Percentage of energy (E%) from fat is 34.0-43.7, from total carbohydrates (including fibre, 16-26 g/d) 38.5-48.1, protein 15.0-18.6 and alcohol 0.7-5.3. Energy intake similarly calculated from available research on dietary intake of children in the Nordic and Baltic countries ranges from 5.5 to 10.6 MJ/d dependent on age and gender.

Main functions. Energy is needed for all cells in the body. It is stored as chemical energy and metabolised to ATP units of energy used for the functions of cells in the body. This should give energy balance of adults of healthy body weight and composition and a positive energy balance or building of energy containing tissue in growing infants, children and adolescents as well as pregnant and lactating women (33). Energy intake is in the form of energy giving nutrients in foods, i.e., carbohydrates and proteins giving 16.7 kJ/g (4 kcal/g) and lipids giving 37.7 kJ/g (9 kcal/g). The intake of the energy giving nutrients are recommended in intervals of E% with the sum of 100% i.e., the energy requirement (ER), but alcohol also yields energy of 29 kJ/g (7 kcal/g). ER of the body is composed of: The basal energy expenditure (BEE), proximately measured as resting energy expenditure (REE), which accounts for major part of the ER (up to 70-80% in adults) and is mainly based on the body's fat free mass (FFM); Energy expenditure for the physical activity level (PAL) which varies widely, most often 20-40%; The diet induced thermogenesis (DIT), approximately 10% of ER (33, 99). Additional energy intake and a positive energy balance is needed for tissue building etc. in growth and tissue building for infants, children, adolescents and pregnant women and for milk production in lactating women (33, 99). There is convincing evidence for high BMI and risk for cardiovascular disease and type 2 diabetes mellitus (33, 99, 146, 147), as well as for an increased risk of cancer in oesophagus (adenocarcinoma), pancreas, liver, colon, breast at postmenopausal age, endometrium and kidney, but there is probable evidence of an association between fatness in adulthood and lower risk for premenopausal breast cancer and between fatness in young adulthood and breast cancer in general (146).

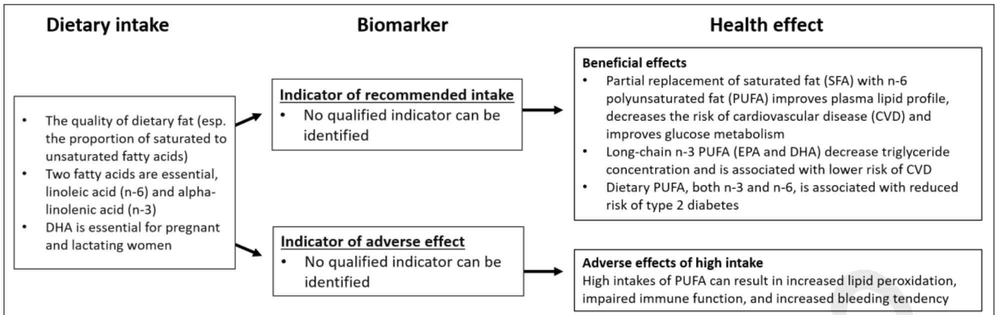
Indicator for recommended intake. Weight stability and balance at healthy body weight and healthy growth (99). Energy requirement covers energy expenditure in individuals with body weight, body composition and physical activity compatible with good health. In childhood, pregnancy and lactation energy requirement includes energy for growth and milk production.

Deficiency and risk groups. The food and social environment may increase the risk for too high energy intake and positive energy balance. Frail elderly is at risk of low energy intake.

Main data gaps. Studies to evaluate body weight stability over time and studies on methods to measure energy intake correctly, beside the DLW method, are needed. Studies on energy requirements of different age groups are needed.

Recommendations. Reference energy requirements for adult females and males are estimated from updated weight curves, the Henry equation, and a PAL value of 1.6. Reference height and weight for children 0-5 years old as well as height for those 6-17 years old are from five Nordic and Baltic countries (133-136, 148-150). For those 6-17 years old reference weight was calculated from the 50th percentile of BMI according to WHO growth reference curves for school-aged children and adolescents (151). The reference body heights for adults are values from seven recent Nordic and Baltic national dietary surveys (125-131), and reference weights for adults are calculated to BMI = 23 kg m^2.

Fat and fatty acids



RI, E%	**7-11 mo**	**12-23 mo**	**≥2 y**
Total fat	**30-45**	**30-40**	**25-40**
Saturated fat	**<10**	**<10**	**<10**
Monounsaturated fat	**10-25**	**10-20**	**10-20**
Polyunsaturated fat	**5-10**	**5-10**	**5-10**
of which n6/n3/ALA	**4/1/ND**	**3/0.5/ND**	**3/1/0.5**
Trans fat	**As low as possible**	**As low as possible**	**As low as possible**

ND; not determined

Dietary intake. In the Nordic countries and Estonia, the average intake of fat (E%) varies between 34 E% and 39 E% in men, and between 34 E% to 38 E% in women. In Lithuania (males: 43.7 E%, females: 42.1E %) and Latvia (males: 40.6 E%, females: 40.8 E%) total fat intake is higher. Average intake of saturated fat is above the recommendation (64).

Main functions. Fat is needed as a source of energy and essential fatty acids, and for the absorption of fat-soluble vitamins. A diet lower in total fat is associated with reductions in body weight and blood pressure compared with a diet higher in total fat in adults. Partial replacement of saturated fat (SFA) with n-6 polyunsaturated fat (PUFA) improves blood lipid profile, decreases the risk of cardiovascular disease (CVD) and improves glucose-insulin homeostasis. Long-chain n-3 PUFA (EPA and DHA) decrease triglycerides and is associated with lower risk of CVD. Dietary PUFA, both n-3 and n-6, is associated with reduced risk of type 2 diabetes (T2D).

Interaction with other nutrients. Diets low in total fat may compromise the intake and absorption of fat-soluble vitamins.

Indicator for recommended intake. There is no specific biological marker for recommended fat intake.

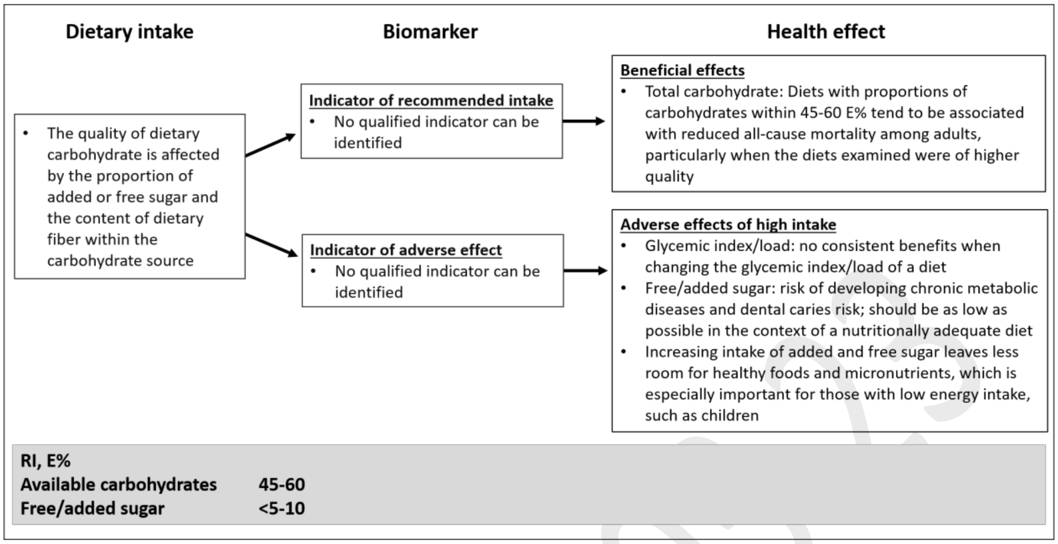
Main data gaps. The associations between ruminant trans fatty acids and odd-chain fatty acids and risk of type 2 diabetes and cardiovascular disease. The potential impact of dietary fat type on musculoskeletal- and mental health. The potential food source-specific effects of saturated fatty acids (SFA).

Deficiency and risk groups. Deficiency of the essential fatty acids linoleic acid (LA) and alpha-linolenic acid (ALA) in adults is very rare. Reported cases have been associated with chronic gastrointestinal diseases or prolonged parenteral or enteral nutrition either without fat or very low in fat. Clinical symptoms of deficiency (skin changes, neurological symptoms and growth retardation) have been found in healthy, new-born babies fed for 2 to 3 months with a diet low (<1 E%) in LA.

Recommendations. An extensive discussion on the recommendations for fats and fatty acids are described in the NNR2023 background papers (61, 75). The recommendations from NNR2012 are kept unchanged. Recommendations for fat are set based on health effects, the need for essential fatty acids and the requirement of fat-soluble vitamins. The minimum requirements of PUFA for adults are not known and the estimates are based on threshold intake data from children. Further, by limiting the intake of total fat, a beneficial increase in intake of micronutrients and dietary fibre is typically seen. No recommendation for the ratio of n-6 to n-3 can be set.

Intake of SFA should be less than 10 E% in the general population. The intake of trans fats should be as low as possible. The intake of MUFA should contribute between 10 and 20 E% in the diet. The intake of n-6 and n-3 PUFA in total should contribute 5–10 E%. N-3 should account for at least 1 E% of the diet. Intake of MUFA and PUFA should make up at least two thirds of the total fatty acids. The recommendation for essential fatty acids is 3 E%, of which at least 0.5 E% should be ALA.

Carbohydrates



Definitions and sources
The four main groups of carbohydrates are monosaccharides (1 monomer), disaccharides (2 monomers), oligosaccharides (3-9 monomers), and polysaccharides (10 or more monomers). The term “sugars” covers monosaccharides and disaccharides. The term “added sugars” refers to refined sugars such as sucrose, fructose, glucose, starch hydrolysates (glucose syrup, high-fructose syrup), and other isolated sugar preparations used as such or added during food preparation and manufacturing (1). Free sugars include added sugars plus sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates (1). There are two main classes of polysaccharides, starch and non-starch polysaccharides. Starch polysaccharides are included as a carbohydrate nutrient, while non-starch polysaccharides are included in the definition of dietary fibre.

Sources of carbohydrates are cereals and root and tuber vegetables, legumes, and corn. Sources of sugars are also fruit, vegetables, and milk (lactose), while the main sources of free/added sugars differ between countries: sugar, honey, syrups, candy, chocolate, cakes (fine bakery), biscuits, sweet desserts, milk and dairy, morning cereals, baby foods, sugar sweetened beverages, and for free sugars in addition fruit and vegetable juices.

Dietary intake In the Nordic and Baltic countries, the mean intake of available carbohydrates among adults varies between 41E% and 45E% in men and between 43E% to 48E% in women, highest in Estonia (64).

Main functions Dietary carbohydrates are a major source of energy. Evidence has not demonstrated health effects of carbohydrate intakes outside the current recommended range of 45-60E%. Diets with proportions of carbohydrates within this range tends to be associated with reduced all-cause mortality among adults, particularly when the diets examined were of higher quality (51).

In addition, there no consistent benefits on clinical outcomes have been demonstrated when changing the glycaemic index of a diet, and findings from prospective studies of diets characterized by glycaemic index or load are inconsistent.

The qualified SR from EFSA (152) concludes that available data do not allow the setting of an upper level of intake for free and added sugars. Based on the risk of developing chronic metabolic diseases and on dental caries risk, the EFSA Panel considers that the intake of added and free sugars should be as low as possible. The EFSA panel concluded that the available data cannot be used to conclude on a positive and causal relationship between the intake of free and added sugars, in isocaloric exchange with other macronutrients and risk of CVDs. However, EFSA reported a high level of certainty for a positive and causal relationship between the intake of sugar-sweetened beverages and risk of CVD. In the EFSA review, there is evidence from RCTs for a positive and causal relationship between the intake of free and added sugars and risk of dyslipidemia (moderate level of certainty). However, the relationship between the consumption of free and added sugars at levels of intake below 10 E% and risk of chronic metabolic diseases could not be adequately explored owing to the low number of RCTs available. Several studies show that with increasing intake of added and free sugar there is less room for healthy foods and micronutrients, which is especially important for those with low energy intake, such as children. The 2020 American Dietary Guidelines Advisory Committee suggested a recommendation on maximal intake of 6 E% from added sugar. The American report has performed dietary model-based estimations of energy after meeting nutrient requirements for different groups and find that adequate diets are difficult to attain with higher intakes of added sugar (153).

Interaction with other nutrients Diets high in free or added sugar may compromise the intake of dietary fibre, vitamins, and minerals.

Indicator for recommended intake There is no specific biological marker for recommended total carbohydrate intake or free or added sugar intake, nor for the intake.

Main data gaps

There is a lack of studies on carbohydrates and health effects in pregnancy and outcomes. There is further a lack of standardized definition for dietary sugars (free and added sugars). There is a lack of long-term studies measuring impact of reducing intake of free and added sugars (especially below 10 E%) on chronic metabolic diseases and surrogates. Because of the difficulties measuring carbohydrate quality in observational studies (including free/added sugar and glycaemic index/load) there is a need for further development and use of objective biomarkers.

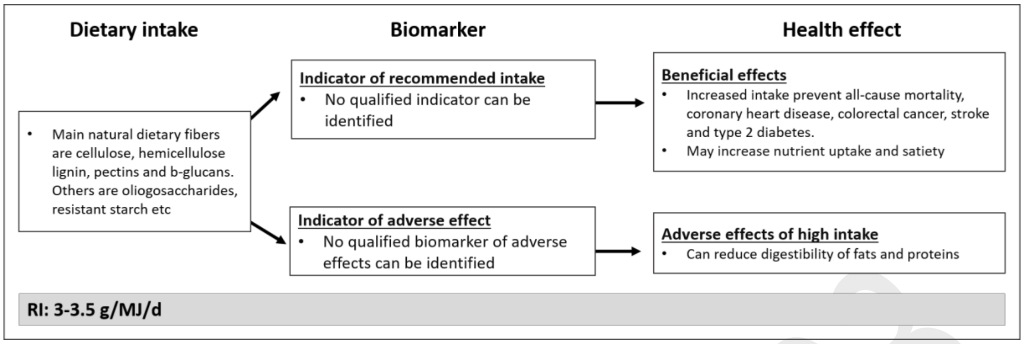
Deficiency and risk groups

No risk group is identified regarding total available carbohydrate intake, while the combinations of foods needed to achieve recommended intakes of key nutrients for ages 6 to 24 months leave virtually no remaining dietary energy for added sugars, apart from the very small amounts (less than 3 grams per day) already inherent in the foods used in modelling (153).

Recommendations

An extensive discussion on the recommendations for carbohydrates are described in the carbohydrates chapter (51). Recommendations for adults and children above 2 years: Available carbohydrates should provide 45-60E%. Intake of free/added sugar should be below 5-10E%. Avoid foods and beverages with added sugar and free sugar for children below two years.

Dietary fibre



Definitions and sources.
The latest definition from CODEX Alimentarius was proposed and largely adopted with minor modifications in most countries with the following definition (154):

Dietary fibre means carbohydrate (CHO) polymers with ten or more monomeric units[1] which are not hydrolyzed by the endogenous enzymes in the small intestine of humans and belong to the following categories:

- *Edible CHO polymers naturally occurring in the food as consumed*
- *CHO polymers, obtained from food raw material by physical, enzymatic, or chemical means[2]*
- *Synthetic CHO polymers[3]*

The European Food Safety Authority (EFSA) include lignin (branched aromatic alcohol), resistant oligosaccharides (3-9 monomeric units) and resistant starch in its definition. Chemical analyses of dietary fibres adhere to protocols from AOAC, and the latest protocol is AOAC 2017.16 (155). Main natural dietary fibres are cellulose, hemicellulose (fibres associated with cellulose, e.g., Arabinoxylans), Lignin, pectins and β-glucans. Other parts of the plant or grains contain oligosaccharides including galactoolisaccharides (GOS; raffinose, stachyose and verbacose from legumes), fructo-oligosaccharides (FOS)/ fructans (e.g., Inulin), or starch that may be inaccessible for digestion enzymes after ingestion because of either the food matrix preventing the access of enzymes or structural modifications of starch during processing of starch rich foods

The majority of dietary fibres derive from cell walls of all plants to provide mainly structural support for the cell. Main food sources are whole grains, fruits and berries, vegetables, nut/seeds and legumes. Additionally, several processed foods contain additives with fibre properties, including galactomannan from Guar gum, alginates from seaweed and methylcellulose (156).

Dietary intake. Daily mean intakes of dietary fibre vary within the range of 16 – 24 g/d among both men and women and are below the recommended minimum level of 25 g/d in all Nordic and Baltic countries, apart from Norwegian men whose intake is 26 g/d (64). Among children the intakes vary in the range of 13 - 21 g/d (32).

Main functions. Dietary fibre contributes to swelling and delayed gastric emptying leading to increased satiety and nutrient uptake in the small intestine. Dietary fibre through the effect on swelling, viscosity and so-called bulking caused by mixtures can optimize nutrient uptake, but also decrease gastrointestinal transit time. Viscosity, caused primarily by soluble fibres such as β-glucans from oats and barley, can also lead to a less penetrable barrier close to the epithelial cells and delay uptake of nutrients. This process leads to reduced postprandial glucose rise and lipids. Reduced uptake of bile acids molecules by β-glucans is now accepted as the main mechanism for the cholesterol reducing effects of fibre in blood (32). A huge body of evidence over many years consistently report on beneficial health effects of a higher intake of dietary fibres, and the conclusions from the NNR2012 is mainly unchanged. The strongest evidence is related to all-cause mortality followed by coronary heart disease and colorectal cancer (157). Evidence for a protective effect against stroke and type 2 diabetes is judged to be significant, but still weaker than for all-cause mortality and incidences of coronary heart disease and colorectal cancer. Effects on body weight is judged significant, but modest. For Inflammatory bowel diseases, dietary fibres may be protective, but too few studies have investigated this relationship to draw a firm conclusion. A new SR found no clear association between high intake of dietary fibre and growth or bowel function in young children living in affluent countries, albeit with only a limited number of studies (22).

Interaction with other nutrients. May increase nutrient uptake, and may reduce fat and protein digestibility. Phytate content related to dietary fibre content (depending on the source) can decrease availability of iron and zinc, see these one-pagers.

Indicator for recommended intake. No biomarker for intake.

Main data gaps. There is a lack of studies investigating health effects of high fibre intake in small children.

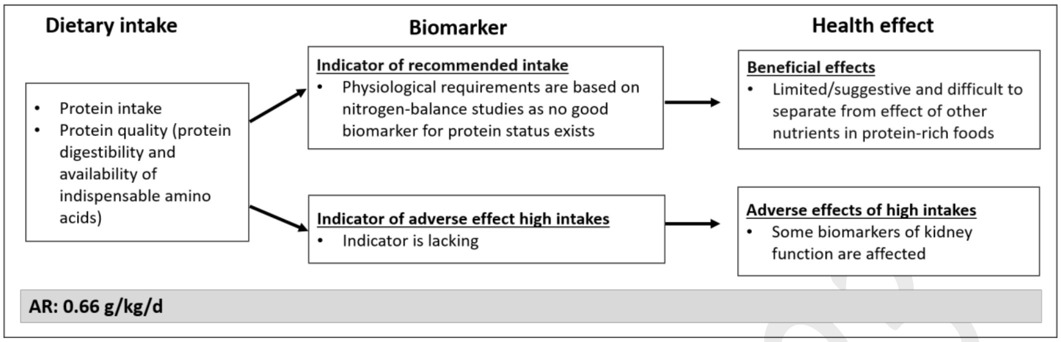
Deficiency and risk groups An intake of dietary fibre too high might cause of inadequate energy and nutrient density to cover needs of small children

Recommendations. An extensive discussion on the recommendations for dietary fibre are described in the NNR2023 background chapter (32). Recommended intake for adults: 3-3.5 g/MJ. Based on energy intake this corresponds to 25 g/d for females and 35 g/d for males. Wholegrain cereals, whole fruit, berries, vegetables, legumes/pulses, and nuts should be the major sources.

For children: An intake corresponding to 2–3 g/MJ or more is appropriate for children from 2 years of age. From school age the intake should gradually increase to reach the recommended adult level during adolescence.

[1]Allows international authorities to decide whether those compounds with DP of 3–9 would be allowed.
[2,3]For the isolated or synthetic fibres, they must show a proven physiological benefit to health as demonstrated by generally accepted scientific evidence to competent authorities.

Protein



Dietary intake. The average protein intake among adults is 15-18 E% in the Nordic and Baltic countries (64). Meat, fish, milk, and eggs are major animal protein sources while cereals, legumes, nuts, and seeds are the primary plant protein sources.

Main functions. Proteins provide indispensable amino acids, nitrogen, and energy. Severe protein deficiency results in oedema, muscle weakness, and changes to the hair and skin. Protein deficiency is often linked to deficiency of energy (protein-energy malnutrition), and deficiency of other nutrients.

The health effects of protein intake are difficult to separate from effects of other nutrients or ingredients in protein-rich foods. The results are inconclusive or seem neutral for the association between total protein intake and obesity cardiovascular disease, glycaemic control, bone health, kidney function, oesophageal cancer and prostate cancer in adults (57). A *de novo* SR (14) concluded that a high-protein diet in infancy was suggested as a risk factor for childhood overweight and obesity. There was probable evidence for a cause-and-effect association between total and animal protein intake and higher BMI in children up to 18 years of age. The evidence of substituting animal protein with plant protein to reduce the risk of cardiovascular disease mortality and type 2 diabetes incidence is *limited – suggestive* as evaluated in a de novo SR (16). Results from studies on protein sources and mortality are mixed.

Interaction with other nutrients and food components. Unprocessed plant protein sources often contain phytates, tannins, and protease inhibitors which interfere with the digestion of plant proteins, making them less well-digestible than animal-source proteins (158). In practice, the differences in quality between proteins might be less critical in diets containing a variety of protein sources such as in the average mixed diet in the Nordic and Baltic countries (64).

Indicator for recommended intake. While some biomarkers are used in the clinical setting, there is no specific biological marker to evaluate optimal protein status. On a long-term basis, intake and losses of nitrogen should be equal in healthy adults. Nitrogen-balance studies have been used to establish DRVs.

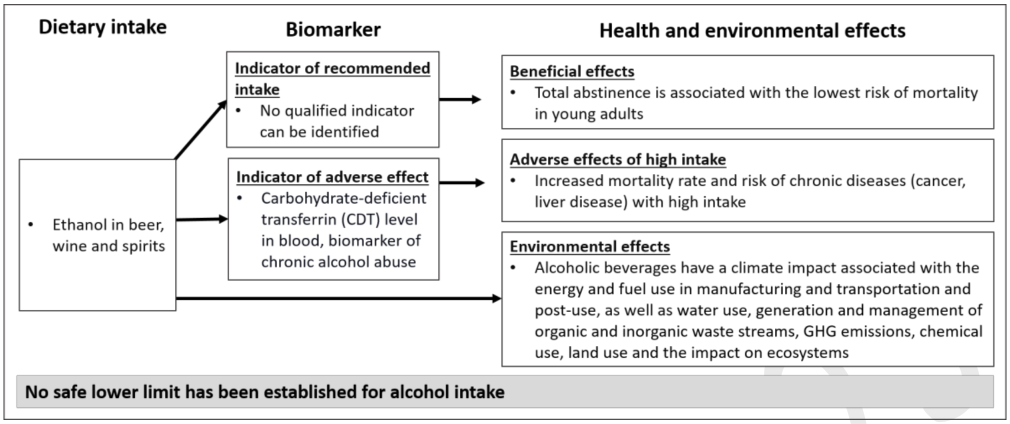
Main data gaps. The underlying assumptions to the nitrogen-to-protein conversion factor of 6.25 traditionally applied for measuring protein content in foods may lead to errors in the estimation. Evidence for associations between protein intakes and health outcomes are limited or suggestive.

Deficiency and risk groups. Proteins are required during active growth in late pregnancy, lactation and childhood. Older adults are at higher risk of inadequate protein intakes (57). Individuals with CKD syndrome are sensitive to high protein intakes (159, 160).

Recommendations. Based on the available evidence of nitrogen balance and isotope tracer studies, an AR was set to 0.66 g/kg BW per day for adults (161). This protein intake should also adequately meet the requirements for indispensable amino acids. For planning purposes, a range of 10–20 E% protein intake can be recommended. With energy intake below approx. 8 MJ (e.g., low body weight, low physical activity level or during intentional weight loss), the protein E% should increase accordingly. For frail older adults, several expert groups recommend 18 E% for planned diets (57). For young children it is advisable not to exceed a range of 10–15 E% protein intake.

Dietary proteins of animal origin or a combination of plant proteins from, for example, legumes and cereal grains, give a good distribution of indispensable amino acids. Replacing part of animal proteins in the current Nordic diet with plant proteins would lead to somewhat lower protein intake and lower bioavailability but still provide enough protein and indispensable amino acids at recommended protein intake levels (57).

Alcohol



Dietary intake. Alcohol (ethanol) is generally consumed as beer (about 2.5–6 vol% alcohol), wine (about 12 vol%), or spirits (about 40 vol%). There are also minor amounts of alcohol in foods (e.g., alcohol-free beer, yoghurt) usually not calculated in dietary surveys. The intake of alcohol in the Nordic countries as a percentage of total energy intake calculated from national dietary surveys on adults show 0.7-5.3 E% from alcohol (2.3-5.3 E% for males and 0.7-3.9 for females) (64). Intake of alcohol is unevenly distributed in the population (62).

Main functions. Alcohol is a toxic substance that affects all organs of the body. The energy from oxidation of alcohol in the body corresponds to 29 kJ (7 kcal) per gram, with a reduced energy efficiency at high alcohol consumption (62, 162). Alcohol is efficiently absorbed through passive diffusion, mainly in the small intestine, and is distributed throughout the total water compartment of the body.

Indicator for recommended intake. No qualified biological indicator for recommended intake exists. Blood Alcohol Level (BAL) can be measured and should be zero or close to zero for no alcohol effect in the body. Both acute and chronic alcohol-induced damage contribute significantly to morbidity and mortality (162-165). Alcohol consumption has been associated with cancer, convincing evidence exists for breast cancer and cancer sites in the gastrointestinal tract (166). The older population, e.g., above 50 years, have a higher cancer risk associated with alcohol (164). Chronic high consumption of alcohol, alcoholism, which may lead to liver cirrhosis and is associated to low quality of life and mortality (164, 165, 167).

Environmental effects. Consumption of alcoholic beverages contributes to negative environmental impact just as non-alcoholic beverages (see chapter on *Beverages* (77)). Alcoholic beverages have a climate impact associated with the energy and fuel used in manufacturing, transportation and post-use. Alcoholic beverages generated 3% of the dietary climate impact in a Swedish study (168). The crops used for alcohol production, barley and wheat, may be associated with monocultures. Concerns discussed on environmental impact of production of wine include water use and quality, the generation and management of organic and inorganic waste streams, energy use, GHG emissions, chemical use, land use and the impact on ecosystems. There is a lack of data for the evaluation of the quantitative environmental impact of alcoholic beverages.

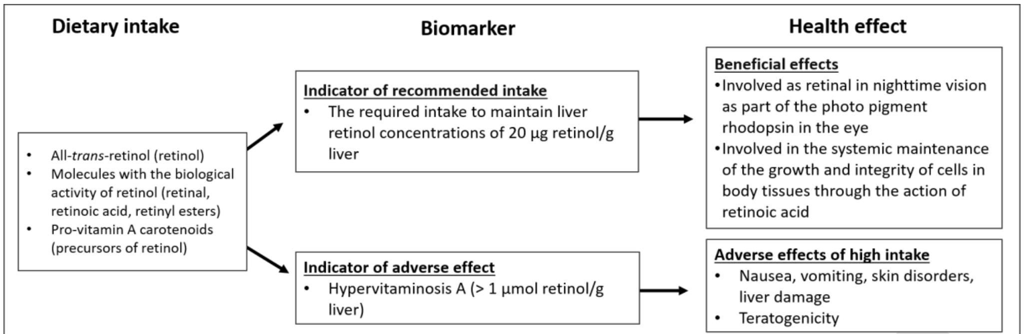
Main data gaps. Studies on methods on how to investigate amount and pattern of alcohol intake are scarce. Studies on health outcomes and genetic associations are needed (62).

Risk groups. Excessive alcohol intake increases the risk for low intake of nutrients and a lower bioavailability of nutrients. Risk groups especially vulnerable for adverse effects of alcohol intake are children, adolescents, pregnant women, and older people (62, 162, 164-167). Alcohol abuse is associated with negative socioeconomic effects both for individuals and for society (62, 162, 165, 167). Occasional intoxication with alcohol, binge drinking, may have detrimental effects such as violence and traffic accidents.

Recommendations

- **Based on health outcomes:** Based on the overall evidence, it is recommended to avoid or limit alcohol intake. Alcohol is not an essential nutrient, and from a nutritional point of view, energy contribution from high intake of alcoholic beverages affects diet quality negatively. Based on this and new systematic reviews and recommendations (165-167), and that no threshold for safe level of alcohol consumption has currently been established for human health, the NNR2023 recommends avoidance from alcohol. For children, adolescents and pregnant and lactating women abstinence from alcohol is advised.
- **Based on environmental effects**: The consumption of alcoholic beverages contributes to negative environmental impact.
- **Overall recommendation:** No safe lower limit for alcohol consumption has been established. For children, adolescents and pregnant and lactating women abstinence from alcohol is advised.

Vitamin A



RE/d	Women	Men
AR	450	630
RI	700	850

Dietary intake. Vitamin A is an essential fat-soluble vitamin that refer to several precursor and bioactive molecules. Precursors include all-*trans* retinol and pro-vitamin A carotenoids such as β-carotene. Vitamin A can be obtained from both animal and plant sources in the diet. In animal tissues, vitamin A exists predominantly as retinyl palmitate (a retinyl ester) whereas in plants only in the form of precursor compounds such as β-carotene (48). We convert all sources of vitamin A into a single unit with the term 'retinol equivalents' (RE). 1 RE is equal to: 1 µg of dietary or supplemental preformed vitamin A (retinol), 2 µg of supplemental β-carotene, 6 µg of dietary β-carotene, 24 µg of other dietary provitamin A carotenoids (e.g., α-carotene and β-cryptoxanthin) (48). Food rich in retinol include offal, meat, dairy products and eggs. Foods rich in β-carotene include vegetables and fruits, such as for example carrots, dark green leafy vegetables, red peppers, and melons (101). The daily mean intake range among adults in the Nordic and Baltic countries are 666-1556 RE/day depending on sex and nationality (64).

Main functions. Vitamin A acts through nuclear receptors in target cells. Activation of nuclear receptors requires that vitamin A is converted to all-*trans*-retinoic acid (ATRA). Vitamin A is involved in the visual cycle in the retina as part of the photopigment rhodopsin in the eye, where 11-cis retinal is the major bioactive component crucial for rhodopsin formation, and in the systemic maintenance of growth and integrity of cells in body tissues (48, 101).

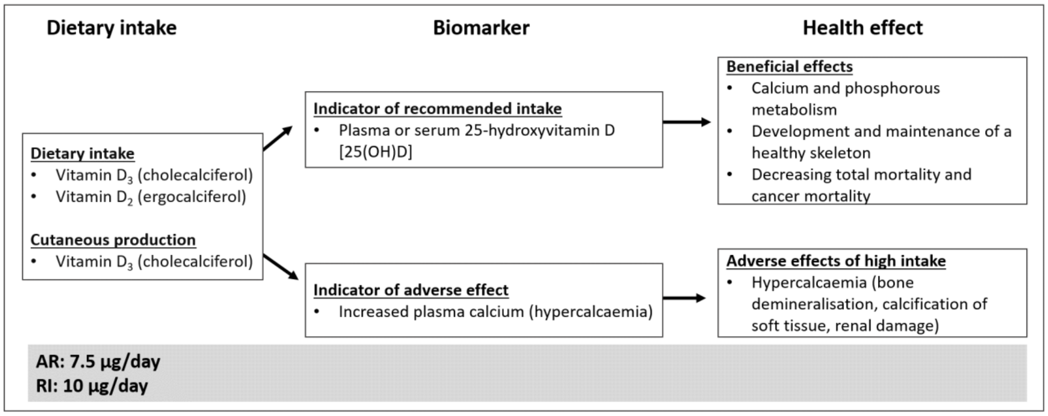
Indicator for recommended intake. The required intake to maintain liver retinol concentrations of 20 µg retinol/g liver (48, 101).

Main data gaps. There is a lack of simple screening tests to measure sub-clinical deficiency as plasma retinol is kept under tight homeostatic control. There is uncertainty in the variation of average requirements across populations. Little data is available on excessive intakes among children and adolescents. There is lack of consensus regarding the role vitamin A may have on the skeleton. Harmonization in estimating the conversion rates of β-carotene to retinol is missing (48).

Deficiency and risk groups. There is variability in the definitions of deficiency. Vitamin A deficiency is defined as liver stores of < 0.07 or < 0.10 µmol retinol/g liver depending on the publication, or alternatively serum/plasma retinol of < 0.7 µmol/L. Clinical vitamin A deficiency is characterized by several ocular features (xerophthalmia) and a generalized impaired resistance to infection and increased infectious disease mortality (48).

Recommendations. Requirements and recommended vitamin A intakes are based on the required intake to maintain liver retinol concentrations of 20 µg retinol/g liver. NNR2012 was based on the factorial methods of IOM 2001 (119). EFSA also uses factorial method but with more recent data on body/liver stores of vitamin A (48, 101), and NNR2023 have updated it with Nordic body weights for setting recommendations. The following factors are multiplied to arrive at average requirements that are in turn multiplied by coefficients of variation (0.15%) to yield final recommendations: target liver concentration (20 µg retinol/g), body/liver retinol stores (1.25), liver/body weight ratio (0.024), fractional catabolic rate (0.007%), 1/efficiency of body storage (2%), reference body weight (men 73.4 kg, women 62.9 kg), constant (10^3). RI were set to 700 RE/day (women) and 800-850 RE/day (men). AR: 450 RE/day (women) and 630 RE/day (men).

Vitamin D



Dietary intake. Vitamin D_3 (cholecalciferol) is a steroid-like molecule synthesised from 7-dehydro-cholesterol in the skin by ultraviolet B (UVB) light from the sun (wavelength 290-315 nm). The Nordic and Baltic countries are situated at latitudes (54–71°N) where the sun radiation is not sufficient part of the year for vitamin D_3 production in skin to occur. Food sources of vitamin D_3 are fish and seafood especially fatty fish like salmon, trout, mackerel, and herring, and egg yolk. Some products (incl. milk, butter and margarine) are fortified to a various degree in most of the Nordic countries (31) The daily mean intake range among adults in the Nordic and Baltic countries are 4.3-13 µg/day depending on gender and nationality (64).

Main functions. Vitamin D is an essential nutrient and a pro-hormone. It is first hydroxylated to 25-hydroxyvitamin D [25(OH)D] in the liver. Thereafter it is further hydroxylated to the active form of vitamin D, 1,25-dihydroxyvitamin D (calcitriol), predominantly in the kidneys but also in other tissues. Its role in calcium and phosphorous metabolism, and in the development and maintenance of a healthy skeleton are well documented.

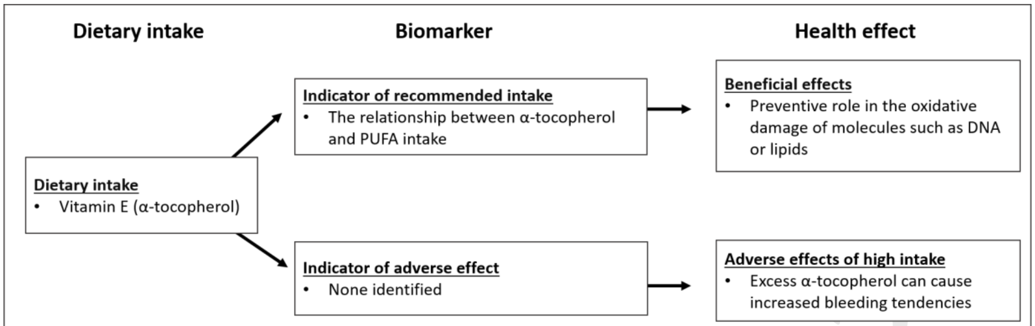
Indicator for recommended intake. Circulating 25(OH)D is considered as the most reliable biomarker for vitamin D status in humans as it captures both dietary intake and cutaneous vitamin D-production. Based on available evidence there is a growing agreement that circulating 25(OH)D above 50 nmol/l corresponds to sufficient level, and less than 25-30 nmol/l indicates deficiency. Due to method-related discrepancies between different laboratories analysing 25(OH)D; all measurements should be standardized by participating in a programme (31). Factors like UV-exposure, skin pigmentation and clothing habits are some of the determinants of 25(OH)D concentration. Different approaches have been used to analyse the dose-response relationship between vitamin D intake and 25(OH)D concentration. The different approaches are described in the Appendix 6.

Main data gaps. Despite the growing number of RCTs, weaknesses are calcium being administered together with vitamin D interventions, few studies conducted on participants with deficient 25(OH)D concentrations, and still lack of well-designed RCTs on some suggested vitamin D related health outcomes. More knowledge on vitamin D status being a *result of,* more than a *cause of* diseases and ill health, could have methodological implications on future study designs (31).

Deficiency and risk groups. Vitamin D deficiency leads to impaired mineralisation of bone due to an inefficient absorption of dietary calcium and phosphorus, and is associated with an increase in PTH serum concentration. Clinical symptoms of vitamin D deficiency manifest as rickets in children, and osteomalacia in adults (3). Skin pigmentation attenuate vitamin D production (31). Frail elderly, low sun exposure and individuals with dark skin pigmentation are at risk of vitamin D deficiency.

Recommendations. There is convincing evidence for recommendations to be set to prevent the population from being vitamin D deficient defined as 25(OH)D <30nmol/l. There is an increasing body of evidence showing that there is no additional health benefit from increasing the 25(OH)D levels above the suggested sufficient level at around 50nmol/l. Based on the totality of present available scientific evidence on vitamin D and health, the overall picture is in line with what was described in NNR2012. The strength of evidence has increased due to the large research activity within this field. Thus, there is stronger certainty now to conclude that increasing the recommendations will not have an effect in reducing disease risks in the population (31). RI for adult females and males: 10 µg/day. RI (≥75 years): 20 µg/day. AR is unchanged from NNR2012 (7.5 µg/day). The RI considers some contribution of vitamin D from outdoor activities during the summer season (late spring to early autumn), and this is compatible with normal, everyday life and is also in line with recommendations on physical activity. For people with little or no sun exposure, an intake of 20 µg/d is recommended.

Vitamin E



α-TE/day	Women	Men
Provisional AR	13	15
Provisional RI	15	12

Dietary intake. Vitamin E is used as a generic term for molecules that possess the biological effects of α-tocopherol, of which four tocopherols (α-, β-, γ-, and δ) and four tocotrienols (α-, β-, γ-, and γ) occur naturally. In NNR2023, vitamin E activity is confined to α-tocopherol, since α-tocopherol is the only form that is recognized to meet human requirements. The naturally occurring α-tocopherol in foods is the stereoisomer RRR-α-tocopherol (58). Food sources of vitamin E are vegetable oils, vegetable oil-based spreads, nuts, seeds, and egg yolk. The daily mean intake range among adults in the Nordic and Baltic countries are 7.8-14.9 mg/day depending on gender and nationality (64).

Main functions. Vitamin E is a liposoluble antioxidant that also exhibits non-antioxidant activities, such as modulation of gene expression, inhibition of cell proliferation and regulation of bone mass. The main biochemical function of α-tocopherol is antioxidant activity. α-tocopherol is present in cell membranes. It has a significant preventive role in the oxidative damage of molecules such as DNA or lipids by neutralizing free radicals and breaking the chain reaction in the oxidation of PUFA. Increased dietary intake of PUFA decrease vitamin E levels in plasma and tissues (58).

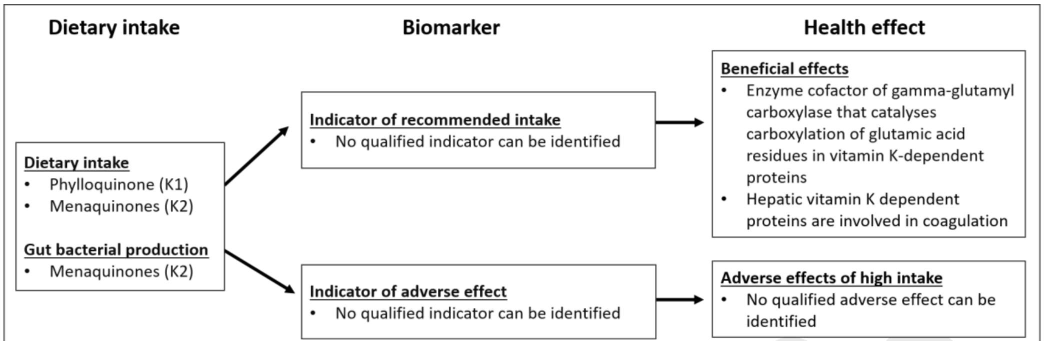
Indicator for recommended intake. EFSA finds that there is insufficient data on markers of α-tocopherol intake/status/function to derive the requirement and instead set AIs based on observed dietary intakes in healthy populations with no apparent α-tocopherol deficiency (102). The IOM based the adult requirements for vitamin E on prevention of hydrogen peroxide–induced hemolysis. The dietary PUFA intake is used to estimate the vitamin E requirement by considering a basal vitamin E requirement (3 mg for women, 4 mg for men) plus an additional requirement based on the dietary intake of PUFA. The average content of PUFA in human diets, mainly from linoleic acid, indicate that the additional vitamin E requirement ranges from 0.4-0.6 RRR-a-tocopherol/g of PUFA in the diet (58, 169). Example of formula: Vitamin E requirement for men (mg TE) = 4 + 0.5*M, where M= recommended amount of PUFA in grams.

Main data gaps. Some of the evidence related to chronic diseases relies on findings from observational studies, rather than RCTs. The effect of vitamin E cannot fully be separated from other nutritional factors. In addition, several studies suggest that besides α-tocopherol, other tocopherols and tocotrienols might have important functions and beneficial effects on various chronic disease outcomes.

Deficiency and risk groups. Vitamin E deficiency due to low dietary intake has not been described in healthy adults. However, deficiency can be caused by prolonged fat malabsorption due to genetic defects in lipoprotein transport or in the hepatic α-tocopherol transfer protein, or fat-malabsorption syndromes, such as cholestatic liver disease or cystic fibrosis. Vitamin E deficiency is more frequently found in children, likely due to limited stores and rapid growth. Specifically, premature and very low birth weight infants are at risk and symptoms such as haemolytic anaemia, thrombocytosis, and oedema have been reported.

Recommendations. Provisional RI: 13 α-TE/day (women), 15 α-TE/day (men), provisional AR: 10 α-TE/day (women), 12 α-TE/day (men).

Vitamin K



µg/d	Women	Men
Provisional AR	50	60
Provisional RI	65	75

Dietary intake. Vitamin K is the collective term for lipid-soluble compounds with the common 2-methyl-1,4-naphtoquinone ring structure. It occurs in foods as phylloquinone (vitamin K1) (2-methyl-3-phytyl-1,4-naphtoquinone) and menaquinones (vitamin K2) (multi-isoprenylquinones). Phylloquinone is plant-based and sources are leafy green vegetables, and certain vegetable oils (soybean, canola/ rapeseed, olive oils) and fat spreads made from the oils. Menaquinones-5 through -13 have bacterial origin and main sources are fermented foods, meat and dairy products. Sources of menaquinone-4 are meat and dairy products. Menaquinones are also produced by gut microbiota. Phylloquinone is regarded as the predominant form of in Western diet (46).

Main functions. Vitamin K function as an enzymatic cofactor in the gamma-carboxylation of vitamin K dependent proteins. Hepatic vitamin K dependent proteins are involved in coagulation. Extrahepatic vitamin K dependent proteins have a role e.g., in bone health and vascular calcification. The amount of vitamin K needed for optimal functioning of the different vitamin K dependent proteins is not known (46).

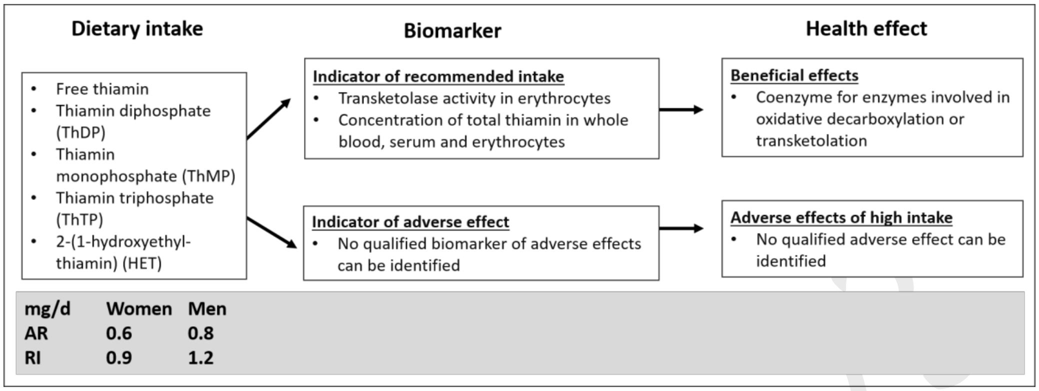
Indicator for recommended intake. There are several biomarkers that reflect vitamin K intake; however, none are considered sufficient to be used alone, and no qualified indicator can be identified (46).

Main data gaps. Data on vitamin K intake from nationally representative samples in Nordic and Baltic countries is missing. Is not known to which extent gut bacterial production plays a role in human physiology and health. In food composition databases vitamin K content data mostly include only phylloquinone, not menaquinones. The relative bioavailability of different forms of vitamin K is poorly known. More research is also needed on dose-response, optimal level of gamma-carboxylation, relationships with health outcomes and what biomarker to choose (46).

Deficiency and risk groups. Bleeding and haemorrhage are the classic signs of vitamin K deficiency affecting coagulation. Vitamin K deficiency in adults is rare and usually limited to people with malabsorption disorders or those taking drugs, e.g., vitamin K antagonists, which interfere with vitamin K metabolism. Breast-feed newborns can develop vitamin K deficiency (46).

Recommendations. For prevention of vitamin K deficiency bleeding, all newborn infants should receive vitamin K prophylaxis. In NNR2012 a provisional recommended intake of 1 µg phylloquinone/kg body weight per day was given for both children and adults. This level is maintained in NNR2023, since the limitations to set up a DRV have not been resolved, and data behind is limited. Similar recommendation on adequate intake of phylloquinone has been set by the EFSA (103). There is limited data available on the need of vitamin K during pregnancy and lactation and health outcomes during pregnancy, and the same provisional recommendation as for adult women applies to pregnant and lactating women (46, 103). Provisional AR: 50µg/day (females), 60µg/day (males). Provisional RI: 65 µg/day (females), 75 mg/day (males).

Thiamin



Dietary intake. Thiamin (vitamin B_1) is a water-soluble compound present in foods mainly as free thiamin and thiamin diphosphate (ThDP) (53, 104, 170). Thiamin monophosphate (ThMP), thiamin triphosphate (ThTP) and 2-(1-hydroxyethyl- thiamin) (HET) are also present. Main sources in Nordic and Baltic diets are cereal, meat and dairy products. Average dietary intakes are 1.4-2.0 mg/10 MJ and 1.2-1.4 mg/10 MJ in Nordic and Baltic countries, respectively (53).

Main functions. Free thiamin functions as the precursor for ThDP, which acts as a coenzyme for enzymes involved in carbohydrate and branched chain amino acid metabolism, and in energy-yielding reactions (53, 104, 170).

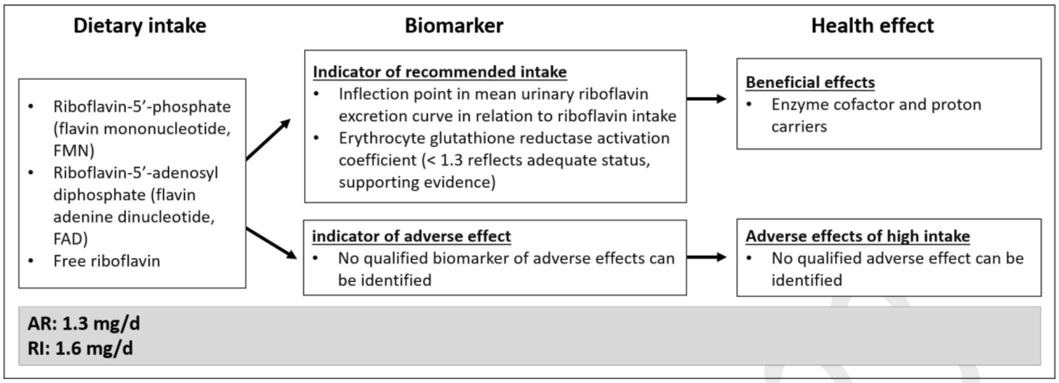
Indicator for recommended intake. The enzymatic activity of transketolase in the erythrocytes and blood, serum and erythrocyte concentration of total thiamin can be used as biomarkers of thiamin intake (53, 104, 170).

Main data gaps. Established cut-offs lack for the biomarkers (104).

Deficiency and risk groups. Thiamin deficiency leads to beriberi with mostly neurological and cardiovascular manifestations. Wernicke-Korsakoff syndrome is a condition of severe brain function impairment caused by thiamin deficiency related to chronic alcohol abuse. People with refeeding syndrome usually need additional thiamine administration for prevention of neurological, cardiac and pulmonary disturbances that can be fatal (53).

Recommendations. Based on data from depletion–repletion studies in adults on the amount of dietary thiamin intake associated with erythrocyte transketolase activity coefficient < 1.15 or with the restoration of normal activity, without a sharp increase in urinary thiamin excretion, AR is set as 0.072 mg/MJ. AR: 0.6 mg/day (females), 0.8 mg/day (males). RI: 0.9 mg/day (females), 1.2 mg/day (males). UL cannot be defined (53, 104).

Riboflavin



Dietary intake. Riboflavin (vitamin B2) is a water-soluble compound present in foods as riboflavin-5'-phosphate (flavin mononucleotide), riboflavin-5'-adenosyl diphosphate (flavin adenine dinucleotide) and free riboflavin (45, 105, 170). Main sources in Nordic and Baltic diets are dairy and meat products. Average dietary intakes are 1.8-2.3 mg/10 MJ and 1.4-1.7 mg/10 MJ in Nordic and Baltic countries, respectively (64).

Main functions. FAD and FMN act as cofactors of several flavoprotein enzymes, e.g., glutathione reductase and pyridoxamine phosphate oxidase, and as proton carriers in redox reactions involved in energy metabolism. Flavoproteins are involved in e.g., tricarboxylic acid cycle, fatty acid beta-oxidation, amino acid catabolism, electron transport chain, DNA repair/gene expression and cell signalling (45, 105, 170).

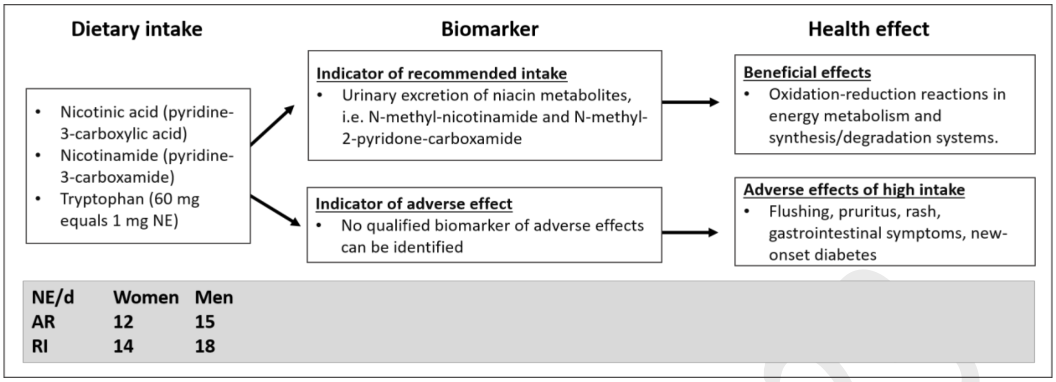
Indicator for recommended intake. The inflection point in mean urinary riboflavin excretion curve in relation to riboflavin intake reflects body saturation and is used as indicator for setting AR (45, 105, 170).

Main data gaps. Physical activity modifies riboflavin status, but there is lack of data on a quantitative relationship between riboflavin status biomarkers and energy expenditure. The role of MTHFR C677T polymorphism, which modifies riboflavin requirement, needs to be studied (45).

Deficiency and risk groups. Clinical signs of deficiency are unspecified and include stomatitis, seborrheic dermatitis, glossitis, cheilosis, sore throat, hyperaemia and edema of pharyngeal and oral mucous membranes, and normochromic normocytic anaemia. Risk groups for riboflavin deficiency include elderly people, hemodialysis patients, alcohol abusers, users of diuretics and people with severe malabsorption (45, 105, 170).

Recommendations. The weighted mean of riboflavin intake associated with the inflection point in the mean urinary excretion curve in relation to riboflavin intake was used to identify AR. Assuming that frequency distribution is normally distributed, AR is set as 1.3 mg/d (females and males). RI: 1.6 mg/day (females and males). UL cannot be defined (45).

Niacin



Dietary intake. Niacin (vitamin B_3) is the common term for nicotinic acid (pyridine-3-carboxylic acid), nicotinamide (pyridine-3-carboxamide) and derivatives that exhibit the biological activity of nicotinamide (34, 106, 170). Main sources in Nordic and Baltic countries are meat, eggs, fish, dairy, legumes (including peanuts), and cereals. Protein-rich foods contribute to the niacin intake through endogenous conversion from tryptophan, and 60 mg tryptophan is equivalent to 1 mg NE (34).

Main functions. Oxidation-reduction reactions in energy metabolism and various synthesis/degradation systems, DNA repair, transcriptional regulation, circadian rhythms, mitochondrial homeostasis and calcium signalling (34, 106, 170).

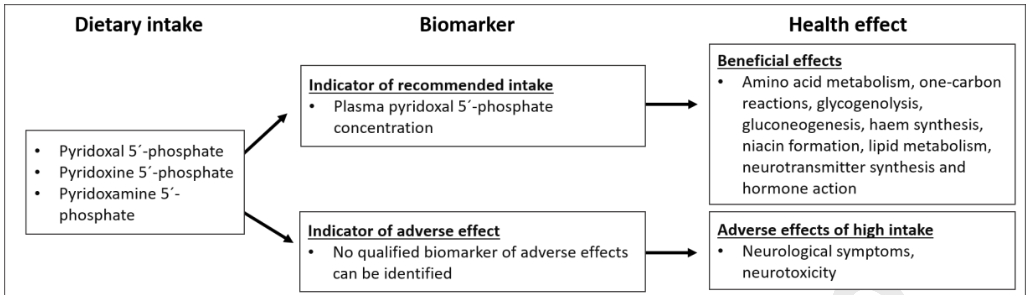
Indicator for recommended intake. The relationship between intake and urinary excretion of nicotinamide metabolites (34, 106, 170).

Main data gaps. Dose-response of niacin intake and health outcomes.

Deficiency and risk groups. The classical niacin deficiency disease is pellagra characterized with diarrhea, photosensitive dermatitis, dementia, and, if not treated, death. Pellagra is mainly observed in populations consuming predominantly a maize-based diet or a diet with other cereals with low protein content and low bioavailability of niacin (34).

Recommendations. Based on urinary excretion of niacin metabolites the AR is set at 12 NE/day (females) and 15 NE/day (males). RI is set at 14 NE/day (females) and 17 NE/day (males).

Vitamin B6



mg/d	Women	Men
AR	1.3	1.5
RI	1.6	1.8

Dietary intake. Pyridoxal 5´-phosphate (PLP) is the main form of vitamin B6 in animal tissue. Major sources of vitamin B6 in the Nordic diets are fish, meat, offal, potatoes, bread, cereals, milk, and dairy products. The bioavailability of vitamin B6 in animal foods is considered to be approximately 50%, whereas the bioavailability in plant-based foods varies from 0 to 80% (28).

Main functions. PLP functions as a coenzyme for more than 160 different enzymatic reactions in the metabolism of amino acids, one-carbon reactions, glycogenolysis and gluconeogenesis, haem synthesis, niacin formation, and also in lipid metabolism, neurotransmitter synthesis and hormone action (28, 108, 170).

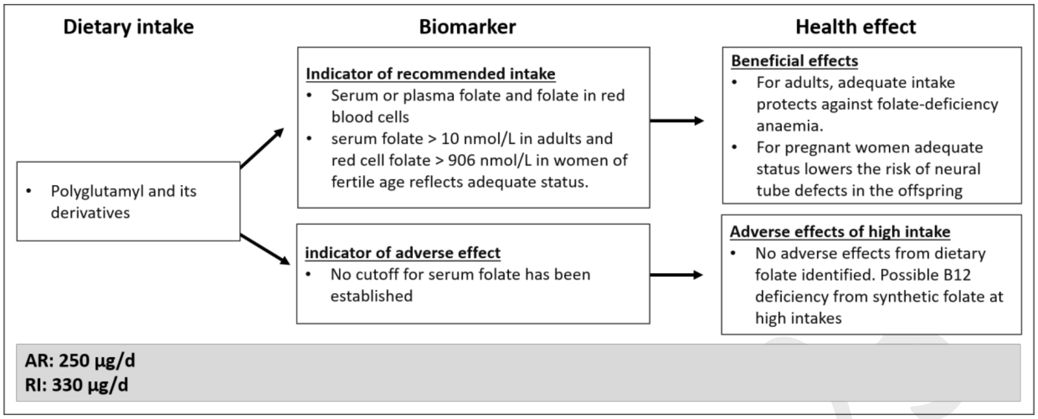
Indicator for recommended intake. Plasma PLP concentration reflects the tissue stores of vitamin B6 (biomarker of status) and has a defined cut-off value for an adequate vitamin B6 status (28, 108, 170).

Main data gaps. There are limitations in biomarkers of vitamin B6 intake and status, and information on the variability in the requirement is absent (108).

Deficiency and risk groups. Prolonged vitamin B6 deficiency is reported to cause peripheral neuropathy that leads to weakness, decreased reflexes, sensory loss, and ataxia, particularly in the lower limbs. Seizures, migraine, cognitive decline, and depression have also been linked to vitamin B6 deficiency (28). Mean values below 30 nmol/l are associated with perturbations of amino acid, lipid, and organic acid profiles in plasma (108).

Recommendations. Plasma PLP concentration is considered as the biomarker of status; it has a defined cut-off value for an adequate vitamin B6 status. ARs derived from one group to the other, an allometric scaling was applied. AR is set as 1.3 mg/day (females) and 1.5 mg/day (males). RI is set at 1.6 mg/day (females) and 1.8 mg/day (males). UL is defined at 25 mg/d for both men and women (108).

Folate



Dietary intake. Folate is present in most foods with higher concentrations found in liver, green vegetables, and legumes. Dietary folate is sensitive to light and oxidation and is partly degraded by cooking. Synthetic folic acid is mainly found in supplements. Mean daily intakes of folate the Nordic and Baltic countries vary from 164 µg in women in Estonia to 370 µg in men in Denmark.

Main functions. Folate is an essential micronutrient for normal development and metabolic function (29).

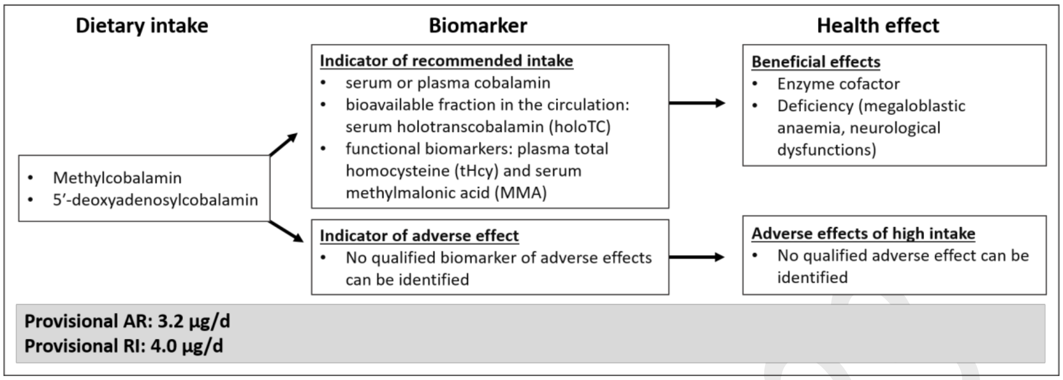
Indicator for recommended intake. Serum or plasma folate and folate in red blood cells are the primary biomarker of dietary intake.

Main data gaps. Lack of biomarker cut-offs for adverse health effects.

Deficiency and risk groups. People with low folate intake, malabsorption or increased folate requirements have a risk of developing folate deficiency. Chronic alcoholism is associated with severe folate deficiency linked to poor dietary intake, intestinal malabsorption, impaired hepatic uptake with reduced storage of folates, and increased renal excretion. Children and pregnant and lactating women have an increased demand for folate.

Recommendations. The AR for adults was derived based on the level of intake required to maintain serum and red blood cell folate concentrations of ≥ 10 and 340 nmol/L, respectively. The provisional AR for pregnant females was derived from the AI value set by EFSA 2014 (110). The lower intake level is derived on the basis of estimated amount needed to prevent megaloblastic anemia. AR is set at 250 µg/day (females) and 250 µg/day (males). RI is set at 330 µg/day (females and males). Provisional AR for pregnant females are set at 480 µg/day. Provisional RI for pregnant females are set at 600 µg/day. Females of reproductive age are recommended to take a supplement of 400 µg/day from planned pregnancy and throughout the first trimester of pregnancy.

Vitamin B12



Dietary intake. Vitamin B12 is a water-soluble vitamin that is naturally present in animal-based foods. Main sources in Nordic and Baltic diets are meat, liver, dairy products, fish, and shellfish. The average B12 intake ranges from 4.0 (Lithuania) to 6.4 (Norway) in Nordic and Baltic women and 3.3 (Lithuania) – 8.9 (Norway) µg/d in men, respectively (64).

Main functions. Vitamin B12 is a cofactor for two enzymes in the human metabolism (2-5). Methylcobalamin is a cofactor for methionine synthase, the enzyme that catalyses the conversion of homocysteine to methionine. Adenosylcobalamin is a cofactor for methylmalonyl-CoA mutase in the isomerization of methylmalonyl-CoA to succinyl-CoA. An adequate supply of vitamin B12 is essential for normal development, neurological function, and blood formation.

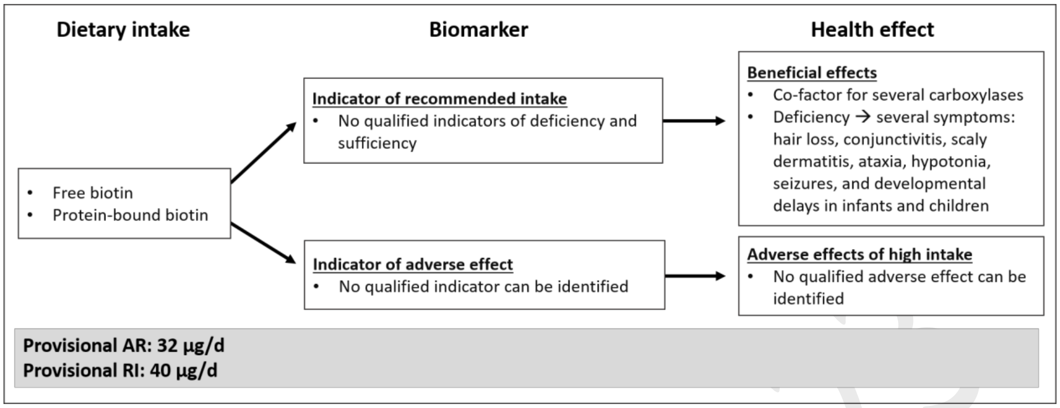
Indicator for recommended intake. Biomarkers of vitamin B12 status include serum and plasma B12 and holoTC (bioavailable fraction in the circulation), and the functional biomarkers total tHcy and MMA. All four B12 biomarkers have limitations as standalone markers, and a combination of biomarkers is the most suitable approach to derive DRVs for vitamin B12 (30, 111, 170, 171). Because vitamin B12 is essential for folate metabolism, it is also important to consider folate status.

Main data gaps. Data are needed to improve the definition of deficiency. In addition, there are insufficient data to derive an AR for infants and children.

Deficiency and risk groups. The ones who omit or restrict animal products in their diets, as vegetarians and vegans, are destined to become vitamin B12 deficient. Frequent causes of a decline in cobalamin status in older adults are malabsorption of cobalamin bound to food as a consequence of atrophic gastritis. The neonatal period is a period of special vulnerability to cobalamin insufficiency and deficiency.

Recommendations. The *de novo* NNR2023 systematic review concluded that there is not enough evidence to say if usual or experimental intake of vitamin B12 is sufficient in children, pregnant and lactating women, young adults, older adults, and vegetarians or vegans (18). In the NNR2023, the values based on EFSA were used for AIs and the provisional ARs were derived from them. Provisional AR is set at 3.2 µg/day (females and males). Provisional RI is set at 4.0 µg/day (females and males).

Biotin



Dietary intake. Biotin, also referred to as vitamin B7, is a water-soluble vitamin. Most foods, such as milk, liver, grain, egg yolk, and some vegetables, contain biotin at low concentrations. Protein-bound biotin requires to be released by biotinidase before absorption. The dietary intake of biotin is not estimated in any of the Nordic national surveys. In Latvia, the average intake of biotin in adults was between 34 and 45 μg/day (109).

Main functions. Biotin functions as a cofactor for several carboxylases that are involved in fatty acid synthesis, gluconeogenesis, and catabolism of branched-chained amino acids. Biotin may also have a role in cellular processes, including gene regulation.

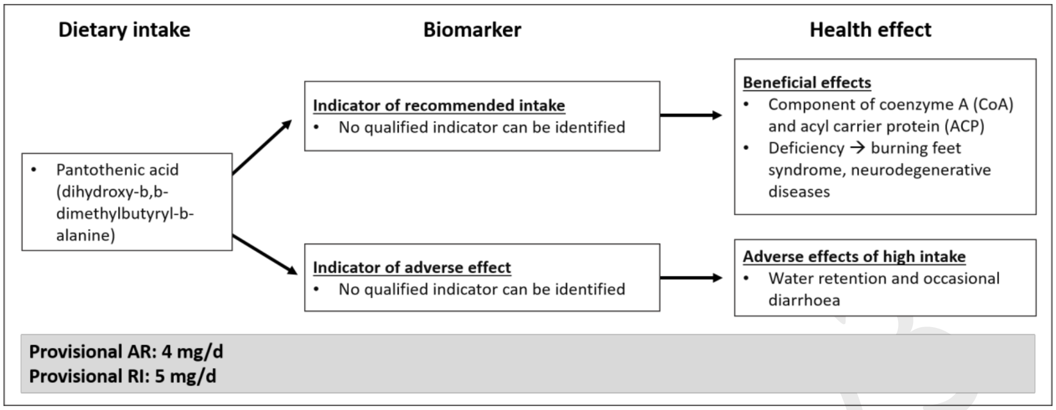
Indicator for recommended intake. No qualified indicator can be identified (50, 172). Biomarkers sensitive to biotin depletion, including urinary biotin excretion and biomarkers of biotin function, have been identified. Dose-response relationships between biotin intakes and these biomarkers have not been established.

Main data gaps. The concentration of biotin in foods should be analysed and incorporated into the Nordic and Baltic food composition tables to estimate dietary intakes and requirements in different age groups.

Deficiency and risk groups. A common deficiency is unlikely in the general population. Biotin deficiency has been demonstrated in cases of inherited biotinidase deficiency. Symptoms of biotin deficiency include hair loss, conjunctivitis, scaly dermatitis, ataxia, hypotonia, seizures, and developmental delays in infants and children

Recommendations. Population-level data on biotin biomarkers are lacking, and no cut-off values for biotin adequacy or insufficiency can be established. In Nordic and Baltic countries, intake data is available only from Latvia (109). Based on dietary intake data with no sign of deficiency, AIs have been set by EFSA (109) and were used as AIs for the NNR2023, and as the basis for provisional ARs (173). Provisional AR is set at 32 μg/day (females and males). Provisional RI is set at 40 μg/day (females and males).

Pantothenic acid



Dietary intake. Pantothenic acid, *dihydroxy-b,b-dimethylbutyryl-b-alanine*, is a water-soluble vitamin that belongs to the group of B vitamins. Pantothenic acid is widely distributed in foods of both animal and vegetable origin, rich sources including organ meats, eggs, seafood, cheese, mushrooms, legumes, whole grains, vegetables and nuts. Pantothenic acid is not part of food composition tables in most Nordic and Baltic countries and information on intake is limited. In Latvia, the average intake of pantothenic acid was estimated to be 3.2-6.3 mg/d in adult men and women (107).

Main functions. As a component of coenzyme A (CoA) and acyl-carrier protein (ACP), pantothenic acid plays a central role in both catabolism and anabolism as a carrier of acyl groups. ACP is needed in fatty acid synthesis.

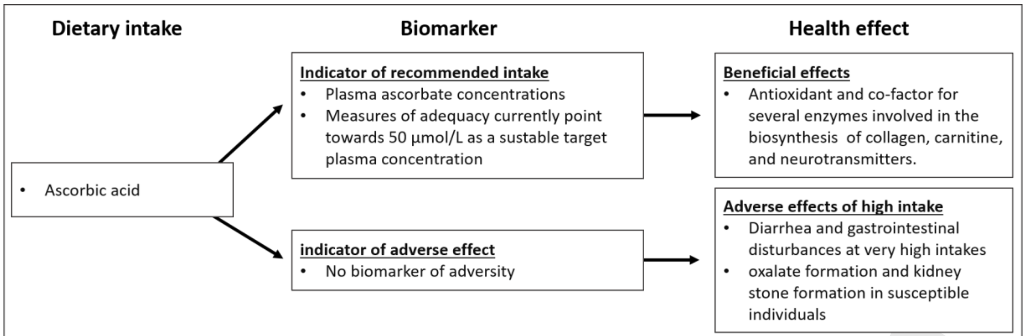
Indicator for recommended intake. No qualified indicator can be identified. Urinary pantothenic acid excretion reflects recent pantothenic acid intake and is considered the most reliable indicator of vitamin status (35, 107).

Main data gaps. The concentration of pantothenic acid in foods should be analysed and incorporated into the Nordic and Baltic food composition tables to estimate dietary intakes and requirements.

Deficiency and risk groups. A common deficiency is unlikely in the general population. It is most likely to occur in conjunction with multiple nutrient deficiencies.

Recommendations. Population-level data on pantothenic acid biomarkers are lacking, and no cut-off values for pantothenic acid adequacy or insufficiency can be established. In Nordic and Baltic countries, intake data is available only from Latvia. Based on dietary intake data with no sign of deficiency, AIs have been set by EFSA (107), and were used as AIs for NNR2023, and as the basis for provisional ARs (173). Provisional AR is set at 4 mg/day (females and males). Provisional RI is set at 5 mg/day (females and males).

Vitamin C



mg/d	**Women**	**Men**
AR	**75**	**90**
RI	**95**	**110**

Dietary intake. The major sources of vitamin C in the diet are fresh fruit and vegetables. Potatoes have a relatively low content of vitamin C but relatively high intake in the Nordic countries they can be an important source. Mean daily intake of vitamin C in the Nordic and Baltic counties varies from 72 µg in men in Estonia to 132 µg in women in Latvia (64).

Main functions. Vitamin C is low-molecular weight electron donor that has the capacity to reduce any biologically relevant oxidant species as well as regenerate other antioxidants, such as vitamin E, from their oxidized forms. It is a cofactor for several enzymes involved in the biosynthesis of collagen, carnitine, and neurotransmitters.

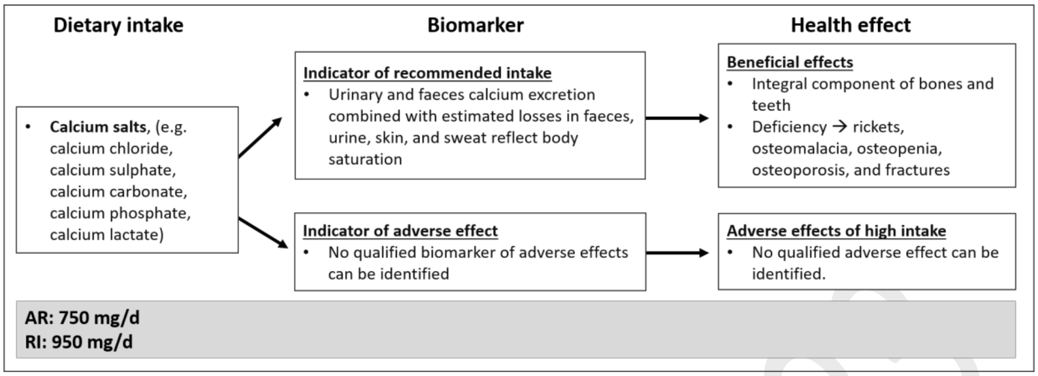
Indicator for recommended intake. Plasma ascorbate concentrations is a marker of vitamin C status (44, 112).

Main data gaps. Lack of dose-response data from controlled studies for solid clinical endpoints which could be used to target plasma concentrations ascorbate.

Deficiency and risk groups. Low intake of fruits and vegetables (including fruit juices). Several studies have reported lower vitamin C status and a higher prevalence of deficiency in smokers relative to non-smokers.

Recommendations. AR is set at 75 mg/day (females) and 90 mg/day (males). RI is set at 95 mg/day (females) and 110 mg/day (males). The values are based on AR set by EFSA (112).

Calcium



Dietary intake. Calcium (Ca) is present in foods as calcium salts which are generally water-soluble, with a few exceptions. Most of the dietary Ca intake is provided by dairy products. Other rich food sources include dark green vegetables, legumes, water, and calcium-fortified foods. Average dietary intakes are 1016-1370 mg/10 MJ and 628-966 mg/10 MJ in Nordic and Baltic countries, respectively (64).

Main functions. Most (99%) of total body Ca is found in bones and teeth as Ca hydroxyapatite ($Ca_{10}[PO_4]_6[OH]_2$), where it has a structural role. In soft tissues and body fluids Ca (< 1%) serves as an essential regulator of several body functions, such as muscle contraction, the functioning of the nervous system, and blood clotting.

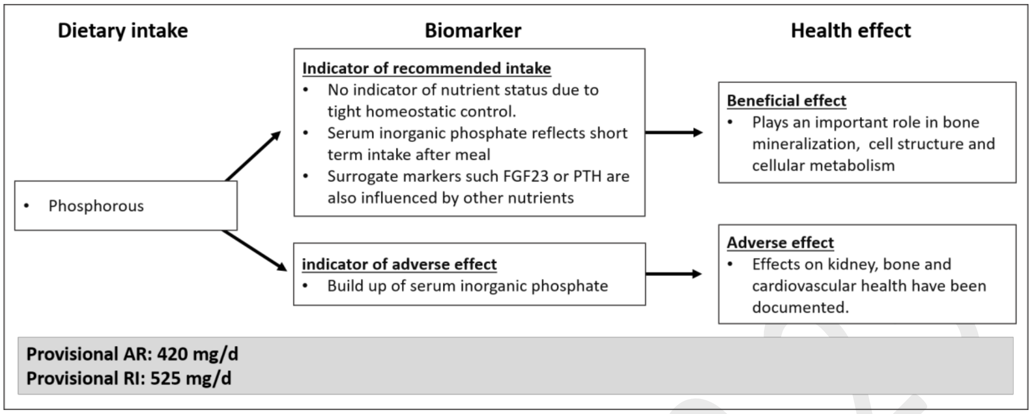
Indicator for recommended intake. Urinary and faeces Ca excretion combined with estimated losses in faeces, urine, skin, and sweat reflects body saturation and may be used as an indicator for setting AR (55).

Main data gaps. There is a lack of data on the efficacy of Ca with or without vitamin D. In terms of a whole diet, more prospective research is needed to clear the impact of plant-based diets on bone health (55, 174, 175).

Deficiency and risk groups. Clinical signs of deficiency include rickets, osteomalacia, osteopenia, osteoporosis, and fractures. Risk groups for Ca deficiency include children, adolescents and young adults accumulating Ca in bones, postmenopausal women, and people of all ages following the diet, e.g., vegan, with no rich Ca and/or vitamin D sources (55, 64, 175).

Recommendations. The AR and RI are based on data from balance studies and on epidemiological and clinical studies on the role of Ca in maintaining a healthy skeleton and preventing fractures. For children and adolescents, the AR is derived using factorial approach based on estimates of Ca retention in the skeleton during growth in addition to the requirement for losses and adjusted for the percentage of absorption (113, 176). The recommended intake of adolescents is extended to young adults, noting that some bone mass is still accreted (113). The foetal need for Ca is met by maternal physiological changes. LI is set to 400 mg/d and UL 2500 mg/d (113). The UL for Ca for adults is based on the evidence of intervention studies in which Ca intakes of 2500 mg/d were tolerated without adverse effects (177). Groups with no or low consumption of dairy products should use Ca fortified foods or Ca supplementation. AR is set to 750 mg/day (females and males). RI is set to 900-1100 mg/day (females and males). The values are based on EFSA (113).

Phosphorus



Dietary intake. Phosphorus occurs widely in foodstuffs, but the highest contents are in protein-rich foods, including meat, fish, eggs, dairy, legumes, whole-grain cereals, nuts and seeds. Various phosphate compounds are also used as food additives.

Main functions. Phosphorus-containing compounds are involved in e.g., ATP synthesis, signal transduction, cell structure, cellular metabolism, regulation of subcellular processes, acid-base homeostasis and in bone mineralization (39).

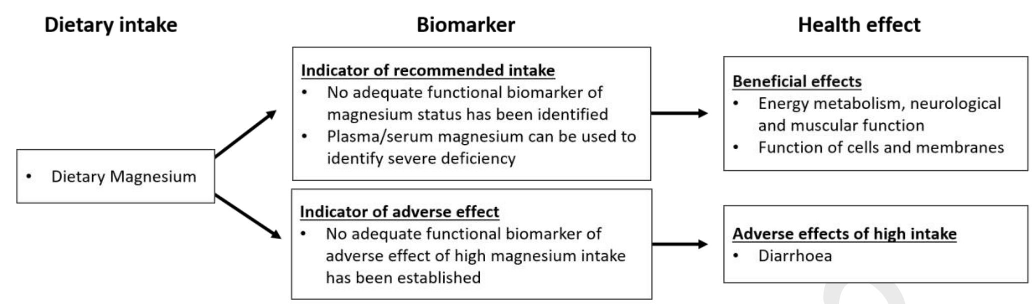
Indicator for recommended intake. Due to tight homeostatic control no reliable indicator for recommended intake is available.

Main data gaps. Effects of phosphorus on health may depend on the source from which it is ingested but methods by which phosphorus bioavailability can be taken into account are lacking.

Deficiency and risk groups. Phosphorus deficiency is generally related to metabolic disorders. Although vitamin D deficiency or resistance decreases phosphorus absorption, hypophosphatemia due to low intestinal absorption is rare and only becomes apparent when phosphorus deprivation has continued for a long time, such as in the case of diarrhoea (39).

Recommendations. Provisional AR is set to 420 mg/day (females and males). Provisional RI is set to 525 mg/day (females and males). Values are based on EFSA (114).

Magnesium



mg/d	Women	Men
Provisional AR	240	280
Provisional RI	300	350

Dietary intake. Dietary sources of magnesium are for example milk, whole grain cereals, starchy roots, vegetables and legumes while magnesium concentrations are especially high in dark chocolate, nuts, and coffee. Drinking water can also contribute to intakes. The average dietary intake in Nordic and Baltic countries ranges from 260– 350 mg/d in females and in 330-440 in males (64). Magnesium is used as a therapeutic agent for specific conditions.

Main functions. Magnesium is a cofactor of many enzymes and thus necessary in a large number of biochemical and physiological processes such as energy metabolism, glucose transport, electrical potential in nerves and cell membranes and transmission of neuromuscular impulses (37).

Interaction with other nutrients. Inorganic forms of magnesium appear to be less bioavailable than organic ones. A diet high in phytic acid and phosphate reduces absorption, but the clinical relevance is uncertain (37). Plasma magnesium concentrations are regulated by kidney excretion which is increased by hypernatremia, metabolic acidosis, unregulated diabetes, and alcohol consumption (37).

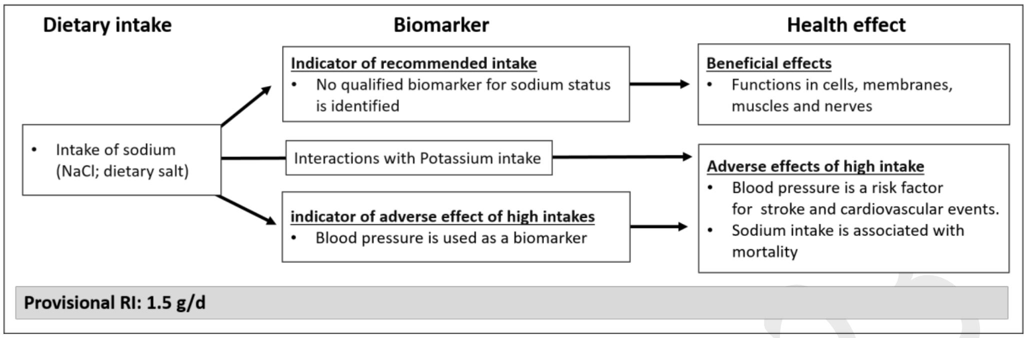
Indicator for recommended intake. No adequate functional biomarker of magnesium status has been identified (117). Plasma or serum levels can be used to identify severe deficiency. The available evidence suggests a causal relationship between magnesium intake and reduced risk for CVD, hypertension, metabolic syndrome and improvement of glucose tolerance but limitations of the makes it impossible to identify an optimal magnesium intake based on those studies (37).

Main data gaps. The lack of an appropriate biomarker of status and the limitations in the dietary assessment of magnesium prevents a conclusion on the role of magnesium in chronic disease.

Deficiency and risk groups. Magnesium depletion is uncommon and usually secondary to a disease or to the use of a therapeutic agent.

Recommendations. In NNR2012 Mg recommendations were based on balance studies. However, in the most recent review of the evidence of magnesium and health it was concluded that the lack of a functional biomarker of magnesium status makes it impossible to conclude on an average requirement (117). EFSA set an AI based on the average Magnesium intakes of the EU population and NNR2023 adopts these values. UL is set to 250 mg/day based on the health outcome mild diarrhoea, and it applies only to magnesium in dietary supplements (178). Provisional AR is set at 240 mg/day (females) and 280 mg/day (males). Provisional RI is set at 300 mg/day (females) and 350 mg/day (males).

Sodium



Dietary intake. The main sources of sodium chloride (NaCl) are bread and other bakery products, cheese, meat and fish products and ready meals such as pizza, pie and soups. Sodium is usually found in very low concentrations in unprocessed foods. One gram of salt corresponds to about 0.4 g sodium, and 1 g sodium is equivalent to 2.5 g salt. Estimates of sodium intakes have been made with differences in methodology, and ranges from about 5.1 g/d to 1.8 g/d in adults Nordic and Baltic countries (64).

Main functions. The volume of the extracellular fluid and the equilibrium between intracellular and extracellular osmolality is controlled by systems transporting sodium into the cell and by the energy-dependent sodium pump (Na+/K+-ATPase) that pumps sodium out of the cell in exchange for potassium.

Interaction with other nutrients. Renal sodium excretion is closely related to potassium intake, whereas sodium intake normally does not influence potassium excretion (54).

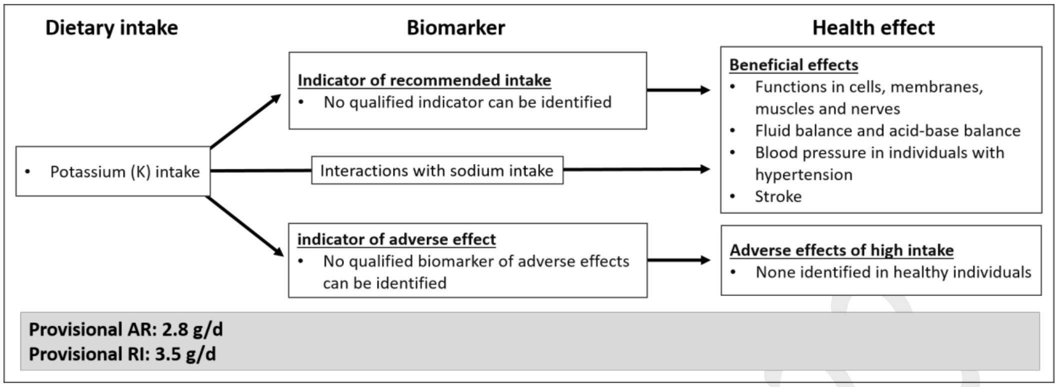
Indicator for recommended intake. There is no sensitive and specific biomarker for estimating sodium status. The impact of sodium on blood pressure is an important indicator of the health impact of sodium as elevated blood pressure is a leading global and Nordic risk factor for premature death and disability (63).

Main data gaps. A limitation of the current evidence is the lack of a robust biomarker and the limited evidence of health effects of intakes below 1.5 g sodium per day. The low agreement between the currently often used proxy indicator spot urine as a measure of sodium intake and the golden standard method 24-h urinary sodium is also a limitation (41).

Deficiency and risk groups. Sodium deficiency due to low dietary intake is rare. Risk for elevated blood pressure due to high sodium intake increase with increasing age. Acute toxicity with fatal outcomes has been reported with single doses ranging from about 7 grams but smaller amounts may be detrimental for subjects with heart failure, renal failure or decompensated liver cirrhosis (41).

Recommendations. Sodium balance can be maintained at intakes of about 10 mmol (230 mg) per day in adults, corresponding to about 0.6 g of salt (41). An intake of 25 mmol (575 mg) per day, corresponding to about 1.5 g salt, is set as the estimated lower intake level and accounts for variations in physical activity and climate (179). Sodium reduction decreases blood pressure linearly by a dose-response manner down to a sodium intake level of less than 2 g/d (41). Prospective cohort studies indicate that higher sodium intake is associated with an increased risk of stroke and cardiovascular events and mortality among the general adult population. Intervention studies confirm the efficiency and safety of reducing blood sodium intake to a level of less than 2 g/d (41). The EFSA Panel considered 2.0 g sodium/day to be a safe and adequate intake for the general EU population of adults (137). In the U.S the reference level of sodium intake of adults was set to 1.5 g/d due to limited evidence on health effects of sodium intakes lower than that (116). Based on an overall evaluation of the available data in the recent reviews (116, 137), the provisional RI in NNR2023 is set at 1.5 g sodium per day (adult (females and males), which corresponds to 3,75 g salt per day. NNR2023 adapt the reasoning from NASEM to recommend limiting intake above 2.3 g/d.

Potassium



Dietary intake. Potassium is widely available in different types of foods and about 90% of the ingested potassium is absorbed. The most important dietary sources are potatoes, fruits, vegetables, cereal and cereal products, milk and dairy products, and meat and meat products. Average dietary intakes are 2300-3400 mg/day in women and 3000-4400 g/day in men in the Nordic and Baltic countries.

Main functions. Potassium is essential to normal cell- and membrane function, for maintenance of fluid balance and acid-base balance and for normal excitation in nerves and muscles. Results from observational studies have shown that a potassium intake above 3.5g /day is associated with a reduced risk of stroke. Intervention studies provide evidence that potassium intakes at that level have a beneficial effect on blood pressure, particularly in individuals with high blood pressure or high sodium intakes (>4 g/day) (54). Increased potassium intake from dietary supplements reduces blood pressure in adults with prehypertension or hypertension but not in adults with normal blood pressure (116). Elevated blood pressure is very common in the adult population in Nordic and Baltic population and a leading risk factor for premature death and disability (63).

Interaction with other nutrients. The metabolism of potassium is strongly related to that of sodium due to the Na^+/K^+-ATP-ase pump that maintain the extracellular/intracellular concentration. Potassium is also interrelated with calcium and with magnesium.

Indicator for recommended intake. The plasma concentration of potassium is strictly regulated within narrow limits by homeostasis and can thus not be used to assess status. No sensitive or specific biomarker to determine potassium status is currently proposed (116).

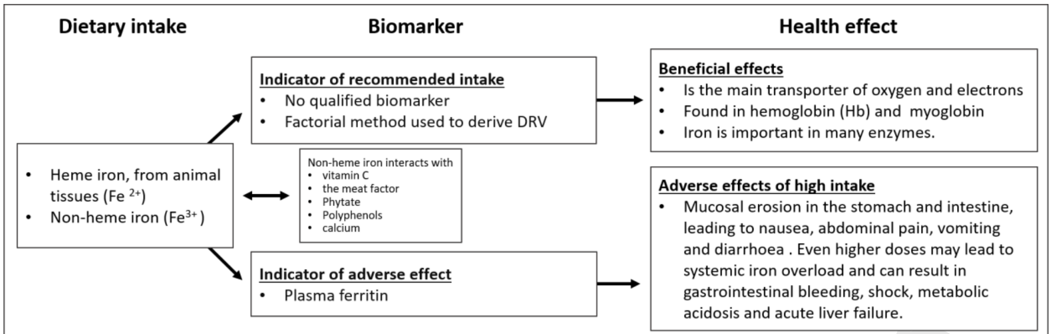
Main data gaps. The lack of biomarkers for potassium status and the uncertainties of the data relating potassium intake to chronic outcomes are the main data gaps. The estimation of potassium requirements during lactation is uncertain.

Deficiency and risk groups. Potassium deficiency due to low dietary intake is rare. High intakes are regulated via renal excretion or cellular uptake and release. There is no evidence of adverse effects of high dietary potassium intake in healthy individuals.

Recommendations. The links between potassium intakes and chronic disease was recently evaluated but data was insufficient to set a reference value based on chronic disease outcomes according to set criteria (116, 180). Instead, NASEM set AI based on highest median intake in American dietary surveys (2600 mg/day for women and 3400 mg/day for men). In the case of potassium, EFSA set a health-based

AI, as the evidence was not strong enough to set an AR (115). The EFSA AI is based on the associations between potassium and normal blood pressure and the risk of stroke. The NNR2022 committee finds the link between potassium intakes and normal blood pressure well-established and supports the EFSA AI of 3500 mg/day for both men and women, including pregnant women. EFSA set an AI of 4000 mg/d for lactating women by adding the requirements of production of breastmilk corresponding to about 400 mg potassium /day (115). The NNR committee notes that the evidence for such a high requirement during lactation is limited, and recommends 3500 mg of potassium also during lactation. No UL was set for potassium. Provisional AR is set to 2.8 g/day (females and males). Provisional RI is set to 3.5 g/day (females and males).

Iron



mg/d	Women	Men
AR	9	6
RI	12	8

Background information. Iron (Fe) is the most abundant trace element in the body.

Dietary intake. Meat, poultry and fish as well as cereals are the main iron sources in a mixed diet. In vegetarian diets, legumes and processed products, wholegrain cereals and dark green vegetables are important iron sources. Dietary iron consists of heme (from animal tissues) and non-heme iron. Mean average dietary intake in the Nordic and Baltic countries ranged between 9.4 mg and 14.5 mg (64).

Main functions. The most important biological characteristic of iron is the ability to alternate between two oxidation states – ferrous iron (Fe^{2+}) and ferric iron (Fe^{3+}) – that can donate or accept one electron, respectively. Iron is found in hemoglobin (Hb) that transports oxygen from the lungs to the tissues and in myoglobin, the oxygen-binding protein in muscle fibre. Iron is important in many enzymes throughout the body, including the brain. Iron is recycled in the body and humans have no pathway for excretion. There is a strict homeostatic regulation of iron absorption in order to avoid both deficiency and iron overload (56).

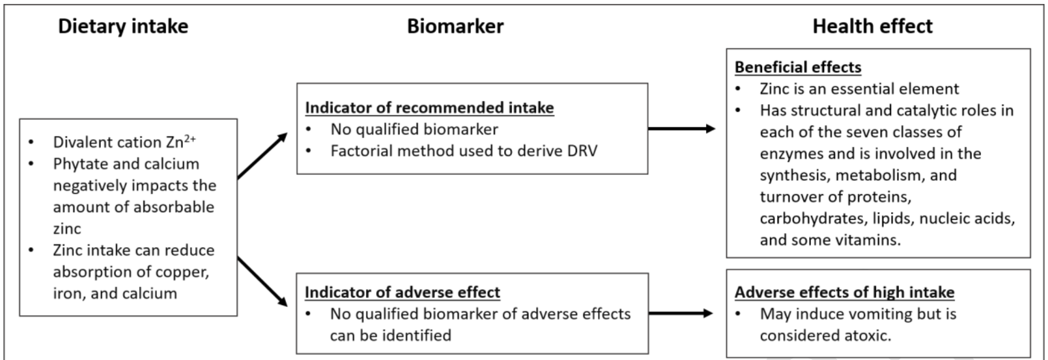
Interaction with other nutrients. Heme iron is generally more efficiently absorbed than non-heme iron and generally not affected by other food components. Absorption of non-heme is enhanced by ascorbic acid and muscle tissue (meat/poultry/fish) and inhibited by phytate, polyphenols and calcium. Calcium also affects absorption of heme iron. Iron absorption is more efficient when body stores are low. Iron absorption from foods is generally lower than that of most other nutrients, typically around 10-15 % from a mixed diet. Heme iron absorption is usually estimated to be at least 25 %.

Indicators for recommended intake. There is no indicator that can be used for setting DRVs. Serum ferritin is considered to be the best indicator of iron status and there are several other available biomarkers. The combination of ferritin and hemoglobin is usually recommended for basic screening of iron deficiency anemia. For setting DRVs, the factorial approach was used (56, 181).

Deficiency and risk groups. Iron deficiency is one of the most common micronutrient deficiencies globally, and is the most common cause of nutritional anemia. Large population groups in the Nordic and Baltic countries are at risk of iron deficiency, including infants, young children, menstruating females, pregnant women as well as vegetarians.

Recommendations for setting DRV. DRVs was set based on factorial calculations considering the following factors: 1) iron losses, 2) iron absorption and 3) iron requirements for growth (in children and pregnant women), see Appendix 5. Upper ranges are based on the 97.5th percentile of the variation in requirements, when not otherwise specified. A CV of 15% has been used in the absence of data. There is very limited information on iron absorption in children and like EFSA, a 10 % absorption for children up to 11 years was used. For the other population groups, 15 % absorption was used as in the previous edition of NNR. EFSA calculated the AR based on factorial methods as well, but used a CV of 20 %. AR is set to 9 mg/day (females) and 6 mg/day (males). RI is set to 12 mg/day (pre-menopausal females) and 8 mg/day (males) For post-menopausal females, the RI is 8 mg/day.

Zinc



µg/d	**Women**	**Men**
AR	**7**	**8**
RI	**8**	**10**

Background information. Zinc is a widespread element which exists as a stable divalent cation (Zn^{2+}). It has a wide range of vital physiological functions and is present in every cell of the human body.

Dietary intake. Meat, dairy products, legumes, eggs, grains, and grain-based products are rich dietary zinc sources. Average dietary intake in the Nordic and Baltic countries ranged between 7.2 mg and 14.1 mg (64).

Main functions. Zinc has a structural and catalytic role in each of the seven classes of enzymes and is involved in the synthesis, metabolism, and turnover of proteins, carbohydrates, lipids, nucleic acids, and some vitamins. An essential structural role of zinc is zinc motifs (zinc fingers) for transcription factors and account for a significant part of the zinc requirement. Zinc acts as a cofactor for key enzymes for reducing oxidative stress. Strong homeostatic mechanisms keep the zinc content of tissues and fluids constant over a wide range of intakes through changes in excretion and absorption (52).

Interaction with other nutrients. The luminal content of phytate and calcium negatively impacts the amount of zinc available for absorption. Zinc intake can also reduce the absorption of other divalent cations such as copper, iron, and calcium.

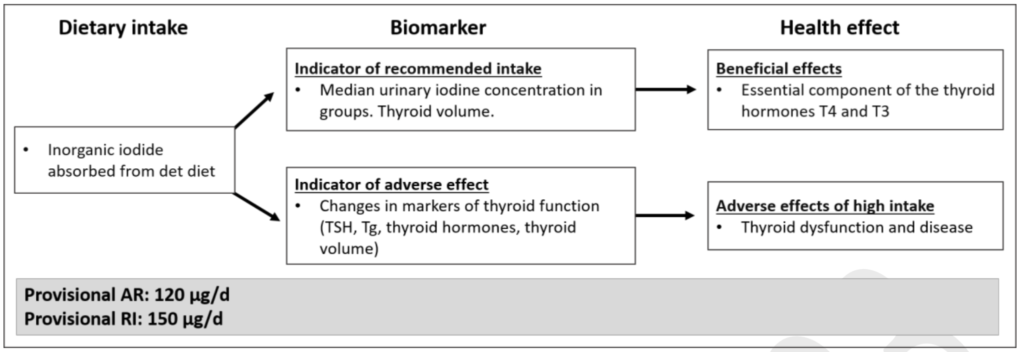
A more plant-based diet with a higher content of chelating substances such as phytic acid and tannins increase zinc requirements. In 2014, EFSA updated their population reference intake (PRI) for zinc adjusted for the intake of phytic acid (118). The scenario with the lowest phytate intake (300 mg per day) gave a population reference intake close to the RIs in NNR 2012. In EFSA, the ARs for adults were estimated as the zinc requirement at the 50th percentile of reference body weights for European men and women, and for levels of phytate intake of 300, 600, 900 and 1 200 mg/day. Data on population intake of phytate is scarce, but according to the EFSA opinion this ranged between 300 to 1 400 mg/day, depending on diet composition (118).

Main data gaps. The consequences of mild or moderate zinc deficiency and the identification of reliable biomarkers for zinc status are important knowledge gaps. Furthermore, it is expected that the intake of animal-source foods will decrease, and how this will influence zinc status and the risk for zinc deficiency is important to study.

Deficiency and risk groups. Zinc deficiency is rare in the Nordic and Baltic countries. Although it may induce vomiting, zinc is not considered to be toxic even in relatively high doses. Excess zinc in the diet is not absorbed and stored in the body for later use.

Recommendations for setting DRV. Recommendations are set based on factorial methods based on daily losses through the kidneys, skin, semen, or menses, and the gastrointestinal tract (feces) (118). The dietary requirement is also dependent on the fraction of zinc absorbed from the diet, which is dependent on zinc content and on diet composition. In NNR2023, AR and RI are based on phytate intake of 300 mg/day. The DRVs set by EFSA for a diet with a higher phytate content (600, 900 or 1200 mg per day) can be used to fit a population following a diet higher in unrefined cereal grain products and legumes. For children there is an extra need for zinc for growth. The extra need during pregnancy is smaller (mg) than for lactating women that have an additional need due to a decline of zinc in breast milk after 4 month (2.5 to 0.7 mg/L). AR is set to 7 µg/day (females) and 8 µg/day (males). RI is set to 8 µg/day (females) and 10 µg/day (males).

Iodine



Dietary intake. The only naturally rich source of iodine is lean fish. The main sources of iodine in the Nordic and Baltic countries include cow's milk, saltwater fish, eggs, iodized table salt and products containing iodized salt, such as bread (36).

Main functions. Iodine is an essential component of the thyroid hormones thyroxine (T4, a pro-hormone) and triiodothyronine (T3, the active hormone), which are involved in metabolic regulation throughout life. During the foetal stage, infancy and childhood, these hormones are crucial for growth and numerous processes of neural and cognitive development, e.g., myelinization, neural migration and differentiation, and gene expression.

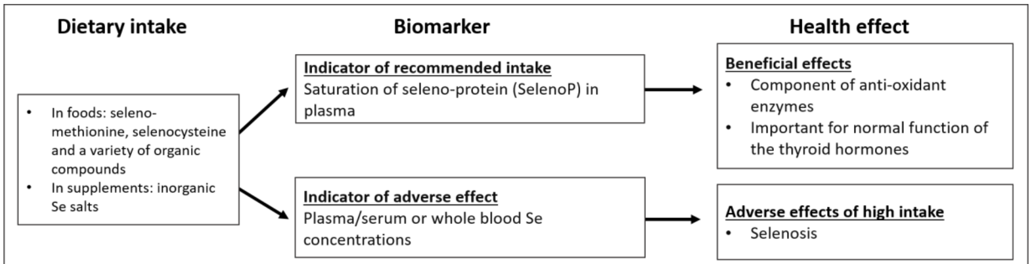
Indicator for recommended intake. There is no good indicator for adequate iodine intake at the individual level. Median urinary iodine concentration (UIC) is a valid marker of iodine intake at the group level (36).

Main data gaps. There is a need to re-evaluate the risk of iodine intakes above the current UL of 200 µg/day for 1 to 2- year-old children versus the benefit of implementing universal salt iodization to increase iodine intake in women of childbearing age. More nationally representative data on iodine status in infants, toddlers and breastfeeding women is warranted.

Deficiency or risk groups. Risk groups for iodine deficiency in the Nordic and Baltic countries include all women with low or no intake of milk/milk products and lean fish. Children at particular risk of iodine deficiency include breastfed and weaning infants in countries with no or voluntary salt iodization or fed by mothers on a restrictive diet. Seaweed users may risk excess intake.

Recommendations. Based on a recent balance study in infants and subsequent review-paper of iodine nutrition in lactating women and infants, **t**he recommended intake for children <2 years has been adjusted to 80-90 µg/day for infants up to 11 months and 90 µg/day children 1-3 years (182). The provisional RI is set at 90 µg/day 4-6-year-olds, 90 µg/day for children 7-10 years and 120 µg/day for adolescents from the age of 10. The provisional RI for pregnant women and lactating women is 200 µg/day. Based on AI set by EFSA (120), provisional AR for adolescents is set at 120 µg/day (females and males). Provisional RI for adults is set at 150 µg/day (females and males).

Selenium



µg/d	Women	Men
Provisional AR	60	70
Provisional RI	75	90

Dietary intake.
Selenium concentrations in foods are highly dependent on soil content and availability. The Nordic and Baltic countries have low soil selenium content followed by low concentrations in locally grown foods. Finland has amended this by adding Se to fertilizers while the other Nordic countries add Se to fodder. The main food sources are cereals (if imported from countries with higher soil Se), fish, meat, dairy and eggs. Dietary intake in the Nordic and Baltic area vary from 39 to 88 µg/day in men and 22 to 68 µg/day in women, Lithuania having the lowest and Finland the highest intake (64).

Main functions. The physiological functions of selenium are mediated by its presence in selenoproteins (27). Five of these are the antioxidant enzyme group of glutathione peroxidases of which one is also a structural protein in sperm. The three iodothyronine deiodinases converting T4 to T3, the active thyroid hormone, are also Se-dependent. Three Se-containing thioredoxin reductases play key roles in cellular redox regulation. The function of several selenoproteins have not yet been fully characterized. Selenoprotein P (SelenoP) in plasma has a dual role; it transports selenium to peripheral tissue, has antioxidative properties and appears to play a role in protecting circulating lipoproteins against oxidation to more toxic species.

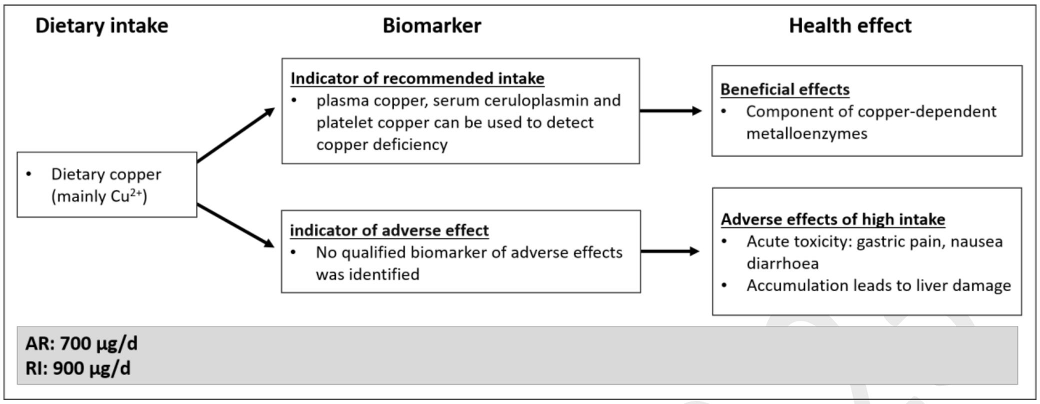
Indicator for recommended intake. Saturation of SelenoP in plasma. This is obtained at plasma selenium concentrations of approx. 110 µg/L (183). The selenium intake needed to achieve a plasma concentration of about 110 µg/L is dependent on the selenium compound given, e.g., Se-methionine has higher bioavailability than most other forms of Se. Based on a Chinese study (184), an average daily intake of dietary selenium of about 1.2 µg/kg bw would be sufficient to achieve an adequate selenium concentration and maximized expression of SelenoP in plasma (27).

Main data gaps. More studies are needed on the relationship between selenium status and health outcomes, in populations low in selenium. Health outcomes include: developmental effects in humans, e.g., neurodevelopment, immune function, cardiovascular diseases, cancer, immune function, ageing etc.

Deficiency and risk groups. Persons with a high intake of locally grown plant foods, like vegans and vegetarians, might have very low Se intakes, especially if the foods are grown organically (185).

Recommendations. SelenoP in plasma represents a saturable pool of selenium and is maximised at a selenium concentration in plasma of about 110µg/L or an intake of about 1.2 µg/kg bw. At intakes above 330 to 450 ug/day selenium may cause toxic effects affecting liver, peripheral nerves, skin, nails and hair. NNR2023 adopt EFSA's new UL of 255 µg/day (186). Provisional AR is set to 60 µg/day (females) and 70 µg/day (males). Provisional RI 75 µg/day (females) and 90 µg/day (males).

Copper



Dietary intake. Copper is found in a variety of foods. Cereals and meat contribute the most in Nordic and Baltic diets where intake ranges from 1.1 mg/d to 2.1 mg/d (64)

Main functions. Copper functions as a structural component in many proteins involved in energy and iron metabolism, production of neurotransmitters, formation of connective tissue, and endogenous antioxidant defense. Copper imbalances and copper deficiency have been linked to the pathogenesis of several chronic inflammatory diseases, but study design limits conclusions about causality in these associations (59). Intake of high doses of copper leads to acute toxicity, which includes symptoms of gastric pain, nausea, vomiting, and diarrhea. High chronic intakes of copper, for example in drinking water, can lead to gastro-intestinal disorders in children(59).

Interactions with other nutrients. Copper absorption is inhibited by the presence of other minerals like zinc and iron and compounds like phytates and oxalates that bind to Cu^{2+} in the gastrointestinal tract (59).

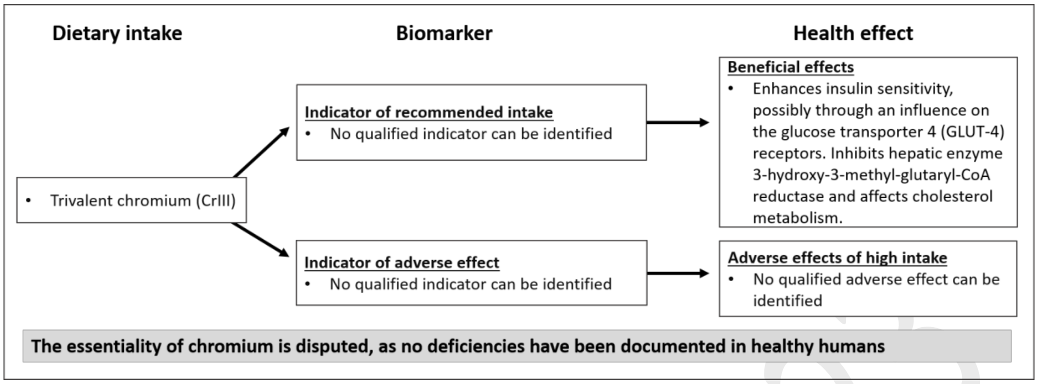
Indicator for recommended intake. Diets low in copper reduce the activity of several copper-dependent metalloenzymes. Plasma copper, serum ceruloplasmin and platelet copper has been used to indicate adequate copper status (119).

Main data gaps. A single sensitive and reliable biomarker of copper status is currently lacking (187). The role of copper imbalances in inflammatory and chronic disease needs further investigation.

Deficiency and risk groups. There are no risk groups for copper deficiency, but infants are sensitive to high intakes.

Recommendations. An intake of approximately 0.7–0.8 mg/d will maintain adequate copper status (119) and no new balance studies have been published since NNR 2012 (59). The requirement for extra copper during pregnancy is estimated to be met by adaptation through increased fractional absorption while a calculation of the copper content of human breast milk is the basis of a recommendation on additional copper during lactation. UL is set to 5 mg for adults corresponding to the ADI of 0.07 mg/kg based on probability for retention in liver (188). AR is set to 700 µg/day (adult females and males). RI is set to 900 µg/day (adult females and males). The values are set based on IOM (119).

Chromium



Background information. Trivalent chromium (CrIII) is the principal form of chromium which is ubiquitous in nature and exisists in the air, water, soil, and biological materials. Hexavalent chromium (CrVI) forms chromates and dichromates which are strong oxidizers and can traverse biological membranes. CrVI compounds are used in different industrial processes.

Dietary intake. CrIII is found in foods and dietary supplements. EFSA has estimated the intake to be between 57-84 µg/day. The emission of chromium from industry to the environment has steadily declined in the Nordic countries during the last 20 years, but oral exposure to CrVI by drinking water may affect parts of the population.

Interaction with other nutrients. Simultaneous ascorbate administration increases chromium uptake in humans and animals, and chromium absorption is also higher in zinc- and iron-deficient animals.

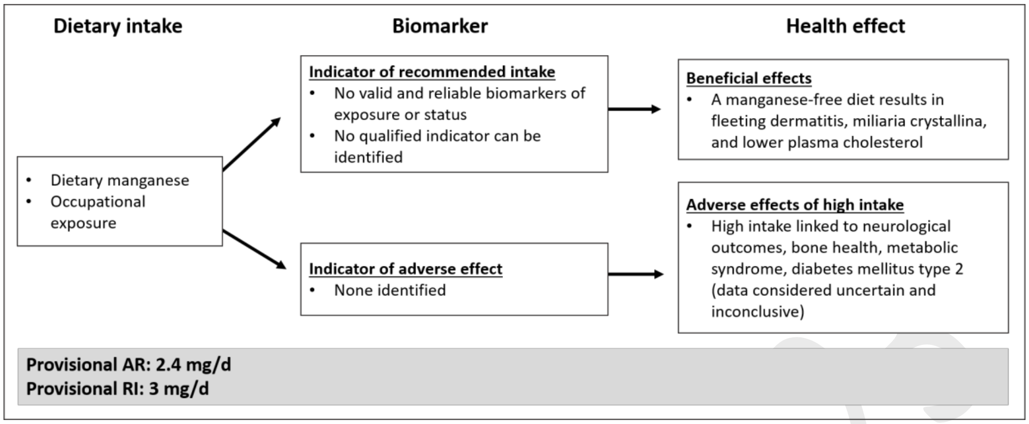
Main functions. About 0.5 % of the dietary intake of chromium is absorbed by the body via passive diffusion, and the remainder is excreted in the feces. The exact biological function of chromium has not yet been determined (38). CrIII is considered to enhance insulin sensitivity, possibly through an influence on the glucose transporter 4 receptors. Chromium inhibits the cholesterol biosynthesis enzyme HMG-CoA reductase and thereby affects cholesterol metabolism.

Data gaps. Biomarkers for evaluating chromium status should be explored in balance studies, where a given amount of chromium is given. Furthermore, long-term effects of increased chromium intake in physiological dosages need to be assessed by clinical trials.

Indicator for recommended intake. There are no reliable biomarkers for chromium status.
Deficiency and risk groups. The essentiality of chromium is disputed, as no deficiencies have been documented in healthy humans. Toxicity of chromium is generally low and achieved at very high doses.

Recommendations. There is no evidence of beneficial effects associated with increased chromium intake in healthy subjects (38). This is also in line with EFSA's review of the topic (189). The Institute of Medicine (US) set an AI for chromium in 2001 based on the mean intakes of the population (119). In NNR2023, the AI set by IOM (13 µg/1000 kcal) for adults is adapted and extrapolated to children and adolescents.

Manganese



Dietary intake. Manganese is ubiquitous (incl. occupational exposure) but main dietary sources are cereal-based products, nuts, chocolate, shellfish, pulses, fruits, and beverages (coffee, tea, alcoholic beverages, drinking water). Intake in Nordic populations is typically around 4 mg/d, but ranges from 3 to 7 mg/d. Breastmilk contains approx. 3 µg/L, and with an average milk intake of 0.8 L/day, the mean intake of exclusively breast feed infants up to 6 months of age would range between 2.4 to 24 µg/day. There are no valid and reliable biomarkers of manganese intake or status (42).

Main functions. Essential trace element for mammals. Found in all tissues. Involved in synthesis and activation of enzymes. Cofactor for metalloenzymes. Required for normal metabolism of proteins, amino acids, lipids, and carbohydrates. Important for maintenance of mitochondria by scavenging of free radicals. Involved in reproduction, bone formation, immune function, regulation of blood glucose and cellular energy, digestion, and in in blood clotting.

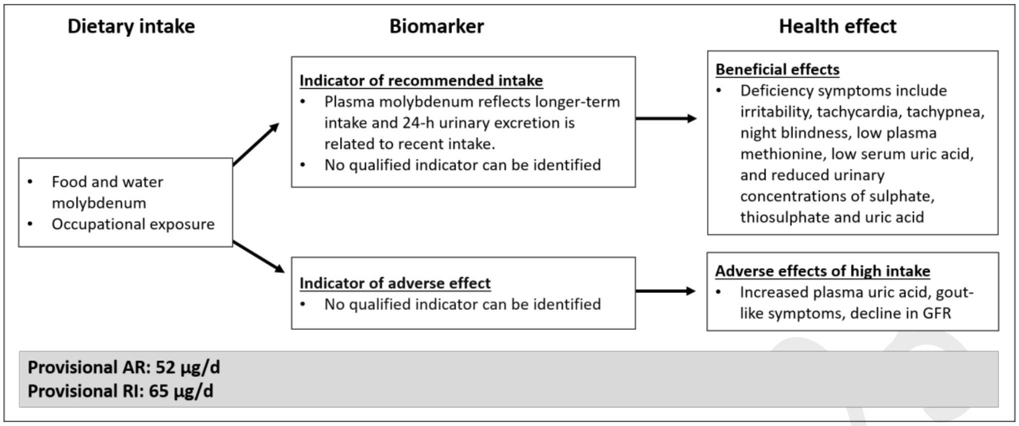
Indicator for recommended intake. No indicator was identified for setting any DRV. For AR, under experimental conditions (depletion-repletion studies), a manganese-free diet results in fleeting dermatitis, miliaria crystallina, and lower plasma cholesterol, which normalizes during repletion. For UL, high intakes linked to neurological outcomes, bone health, metabolic syndrome, diabetes mellitus type 2 (epi-studies), but data is considered uncertain and inconclusive.

Main data gaps. Biomarkers of intake and status. Limited information concerning the relationship between manganese intake or status and health-related endpoints or disease prevention, especially high exposure levels and neurodevelopment in infants, children and adolescents. No studies from the Nordic or Baltic countries (42).

Deficiency and risk groups. Deficiency is not characterized in free-living people. No specific risk groups established, although unclear if bottle-fed infants are exposed to low or high levels.

Recommendations. IOM (2001) (119) and EFSA (2013) (123) provided age and sex-specific AI values from approx. 0.003 mg/d before 6 months age to approx. 2-3 mg/d in adulthood. A provisional AR is set to 2.4 mg/day (adult females and males). Provisional RI is set to 3 mg/day (adult females and males). Values are based on EFSA (123).

Molybdenum



Dietary intake. Molybdenum is ubiquitous in food and water as soluble molybdates. The main dietary sources of molybdenum are cereal products, vegetables and dairy products (49). Few published studies on the dietary intake in the Nordic countries. Dietary intake approx. 30 µg/day in children, and 60-172 µg/day in adults. Plasma molybdenum reflects longer-term intake and 24-h urinary excretion is related to recent intake.

Main functions. Cofactor for enzymes involved in oxidation of purines to uric acid, metabolism of aromatic aldehydes and heterocyclic compounds and in the catabolism of sulfur amino acids.

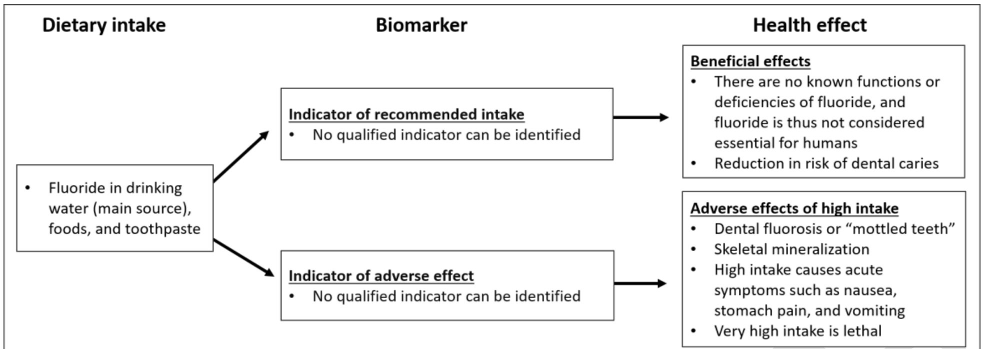
Indicator for recommended intake. No indicator was identified for setting any DRV. For AR, TPN with no molybdenum results in signs of clinical deficiency, incl. irritability, tachycardia, tachypnea, night blindness, low plasma methionine, low serum uric acid, and reduced urinary concentrations of sulphate, thiosulphate and uric acid (normalized after 30 days treatment with 300 300 µg/day of ammonium molybdate) (49). For UL, little data available, but intake of 10-15 mg/d and occupational exposure may be related to increased plasma uric acid and gout-like symptoms, and high plasma levels may accelerate the decline in GFR.

Main data gaps. Indicators for AR and UL based on health outcomes in humans.

Deficiency and risk groups. Even though considered an essential element, there are no reports on clinical signs of dietary molybdenum deficiency in healthy humans (49).

Recommendations. The Institute of Medicine set AR (34 µg/d) and RI (45 µg/d) for adults, and RI and AI for certain other life-stage groups (119). EFSA set only an AI for adults only (15-65 µg/d) due to limited evidence (124). For NNR2023, a provisional AR is set to 52 µg/day (females and males). Provisional RI is set to 65 µg/day (females and males), based the AI set by EFSA (124).

Fluoride



mg/d	Women	Men
Provisional AR	2.6	3.0
Provisional RI	3.2	3.7

Dietary intake. Drinking water is the dominant source of fluoride. Fluoride levels in foods are generally low, with a few exceptions, like seafood and tea. There is also a lack of fluoride in food composition tables. Toothpaste contributes in small children. The World Health Organization has categorized bone and teeth fluoride content as historical biomarkers, nails and hair as recent biomarkers, and urine, plasma and saliva as contemporary biomarkers of fluoride exposure.

Main functions. There are no known functions or deficiencies of fluoride, and fluoride is thus not considered essential for humans (43). However, fluoride can bind to calcium in the skeleton and tooth tissues creating complexes that replace the hydroxyl ions in hydroxyapatite crystals thereby making the crystals less acid-soluble which prevents dental caries.

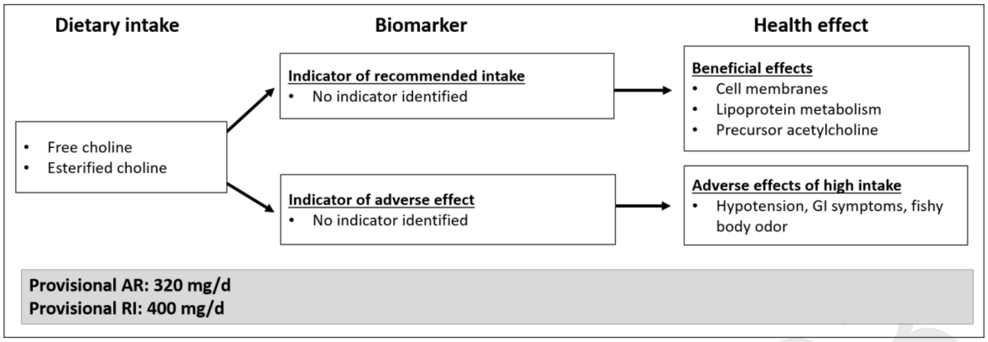
Indicator for recommended intake. No indicator was identified for setting AR and RI. For AI, selected indicator was reduction in risk of dental caries (observational studies). An intake of 2.2 g/kg bodyweight is lethal in adults. In children, 15 mg/ kg bodyweight is lethal, and 5 mg/kg bodyweight causes acute symptoms such as nausea, stomach pain, and vomiting. Chronic high intakes of fluoride via drinking water can affect skeletal mineralization. The most common side effect of high fluoride intake is dental fluorosis or "mottled teeth".

Main data gaps. The main challenge for setting recommended intake in the Nordic and Baltic countries, are lack of food composition data reporting fluoride content in food, and lack of data on fluoride status for the population.

Deficiency and risk groups. There are no known deficiencies for low/zero fluoride exposure (43).

Recommendations. IOM set an AI for adults to 3 mg/d and 4 mg/d for females and males, respectively; for infants and children (> 6 months), 0.05 mg/kg/d (190). EFSA set AI to 0.05 mg/kg/d for both children and adults (122). Provisional AR is set to 2.6 mg/day (females) and 3 mg/day (males). Provisional RI is set to 3.2 mg/day (females) and 3.7 mg/day for males). Values are based on EFSA (122).

Choline



Dietary intake. Choline is found in foods as free choline or esterified forms (phosphatidylcholine, phosphocholine, glycerophosphocholine and sphingomyelin). Ubiquitous in foods, but high in liver, eggs and wheat germ. Main sources are meat, dairy, eggs and grains. Dietary intake data from Nordic and Baltic populations is scarce. Average choline intake was 317-468 mg/day (men) and 317-404 mg/day (women) in adults aged 18 to ≥75 y, and 171-180 mg/day (1-3 y), 256–285 mg/day (3-10 y), and 292–373 mg/day (10-18 y) in children.

Main functions. Choline has roles in one-carbon metabolism, as a component of cell membranes (phospholipids such as phosphatidylcholine, the main storage form of choline), in lipoprotein metabolism (VLDL assembly and secretion from the liver), and as a precursor for the neurotransmitter acetylcholine (47).

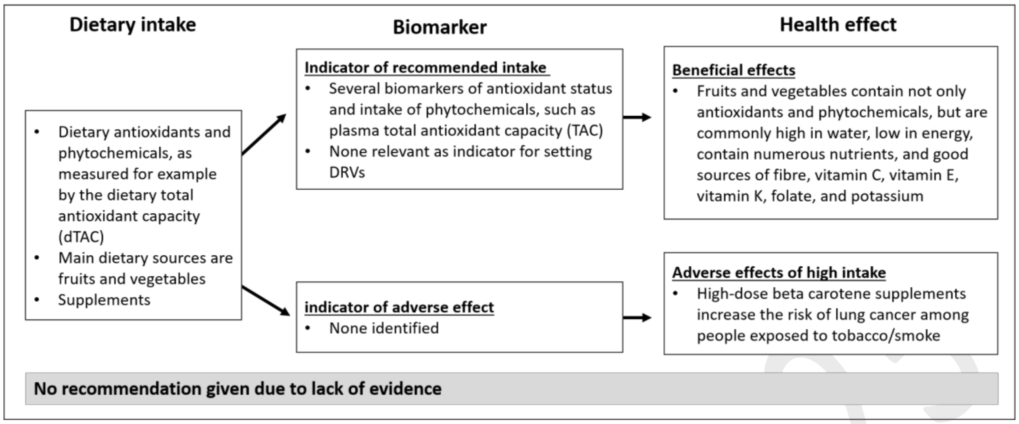
Indicator for recommended intake. No indicator was identified for setting AR and RI. For AI, selected indicator was liver damage and average intake across European populations (191). For UL, selected indicators included hypotension, GI symptoms and fishy body odour.

Main data gaps. Dietary intake data for Nordic and Baltic populations, including assessment of choline content of foods in this region, and databases. Surrogate markers or a combination of markers that reflect long-term average choline intake from the diet. Impact of genetic variation in choline metabolism.

Deficiency and risk groups. A choline-free diet results in liver damage (corrected by 500 mg choline/d). No specific risk groups established, although pregnant women and children are likely more vulnerable.

Recommendations. Provisional AR is set to 320 mg/day (females and males). Provisional RI is set to 400 mg/day (females and males), based on EFSA (191). LOAEL was 7.5 g/d, and with an uncertainty factor of 2 the UL was set to 3.5 g/d for adults, and then scaled to 1-3 g/d for children.

Phytochemicals and antioxidants



Dietary intake. Fruits and vegetables are the main contributors to dietary total antioxidant capacity (dTAC). Only a few studies have assessed dTAC in Nordic and Baltic countries. Estimated dTAC (assessed by oxygen radical absorbance capacity [ORAC] assay) from foods in Swedish men and women were median 14 025 and 12 353 µmol Trolox equivalents/day, respectively. For Swedish girls and boys age 8 y, estimated median dTAC was 10 397 and 9611 µmol Trolox equivalents/day, respectively. Plasma TAC is considered a valid and reproducible biomarker of dietary intake. Fruits and vegetables contain not only antioxidants and phytochemicals, but are commonly high in water, low in energy, contain numerous nutrients, and good sources of fibre, vitamin C, vitamin E, vitamin K, folate, and potassium. See other chapters for further discussions related to antioxidants and phytochemicals specific to specific foods (vegetables, fruits and berries) or nutrients with antioxidant capacity (vitamin C, vitamin E, b-carotene, and selenium).

Main functions. In plants, phytochemicals protect against pathogens and UV radiation, and provide color and flavor. In humans, phytochemicals may affect biological functions via regulation of redox reactions, including antioxidant (scavenge free radicals, induce endogenous antioxidants), anti-apoptosis, anti-carcinogen, anti-inflammation, and anti-atherosclerotic properties, and modification of endothelial function and angiogenesis (60).

Indicator for recommended intake. No indicator was identified for setting any DRV. WCRF considered high-dose beta-carotene supplements to convincingly increase the risk of lung cancer among people exposed to tobacco/smoke (192).

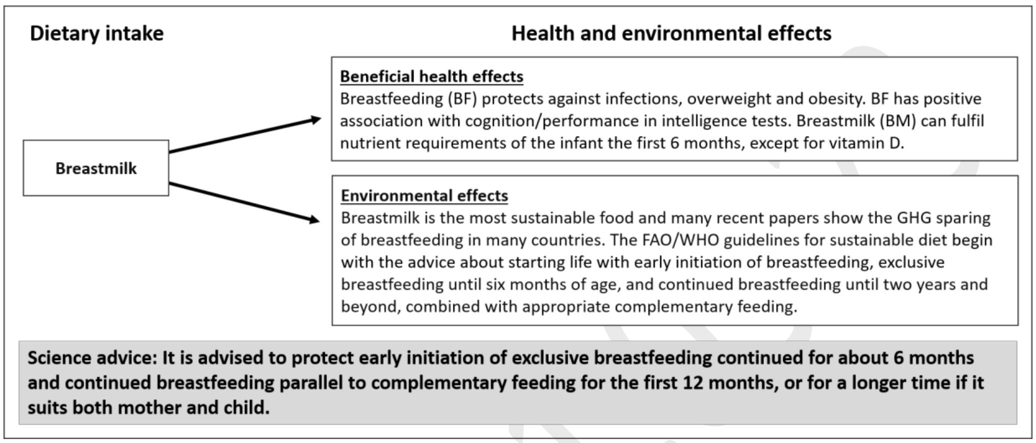
Main data gaps. None identified in chapter.

Deficiency and risk groups. There are no known deficiencies or risk groups.

Recommendations. Recommendations for specific antioxidants or phytochemicals beyond the ordinary dietary recommendations for vitamin C, vitamin E, b-carotene, and selenium cannot be given at this time. High intake of supplements with antioxidant properties, such as b-carotene, increase the risk of total mortality, and is therefore not recommended.

Two-pagers of food groups, meal and dietary patterns

Breastfeeding



Food and nutrient intake. The Nordic countries have relatively high breastfeeding rates. Almost all mothers start breastfeeding (BF) their infants (82). Exclusive BF rates at 4-months is 40-50%, with a rapid decline thereafter. Breastfeeding is commonly continued together with the addition of solids and other fluids than breastmilk, i.e., complementary foods. About 60-80% of infants are still breastfeed at 6 months, and 30-60% at 12 months. Breastfeeding rates seem similar in the Baltic countries with 50-70% of infants breastfed at 6 months.

Health effects. Numerous studies have indicated immediate as well as long-term beneficial health effects of BF for both the infant and the mother, for all income levels (82, 193-195). BF protects against infectious diseases in childhood, decreases mortality and malnutrition including overweight and obesity in toddlers, childhood and adolescence and has positive effects on cognition and performance in intelligence tests (82). There is also evidence, of varying strength between studies, for BF decreasing blood pressure and triglycerides in childhood and adolescence and reducing blood cholesterol levels in overweight, obesity and diabetes (T2DM) in adulthood (82). Women who have breastfed have decreased risk of breast and ovarian cancer (strong, probable evidence) (196). Adverse effects of too long EBF, i.e., longer than 6 months may be difficulties in learning to eat variable diet and may increase risk of food allergies in children in risk population (82). The risk of worsening iron status may also increase after a long duration of EBF. Within the recommended levels of EBF and BF these effects are not expected.

Environmental effects. Breastmilk is the most environmental-friendly food for infants and recent papers demonstrates lower GHG emissions of breastfeeding compared for formula feeding in many countries (25). The FAO/WHO guidelines for sustainable diet begin on the advice about starting early in life with early initiation of breastfeeding, exclusive breastfeeding until six months of age, and continued breastfeeding until two years and beyond, combined with appropriate complementary feeding (197).

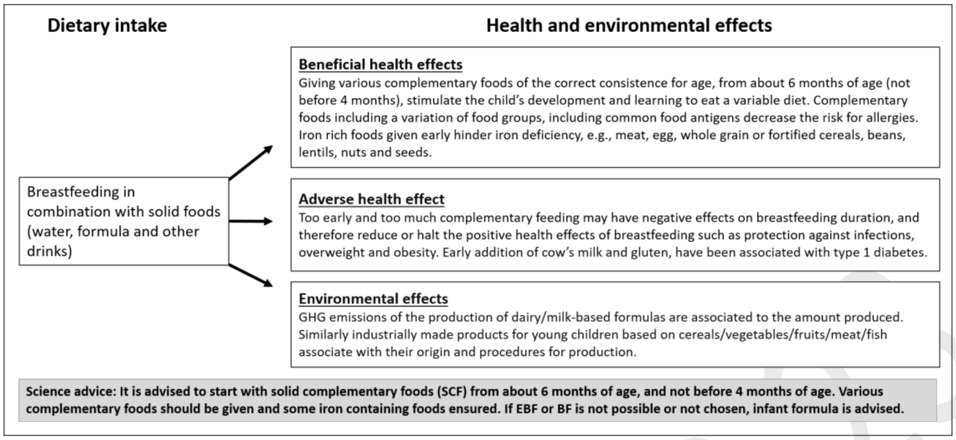
Main data gaps. More knowledge about varying duration of EBF and partial BF is needed as well as knowledge about complementary feeding and foods for young children. Further, the evidence for associations between infant nutrition and health effects is needed.

Risk groups. Limited possibilities for maternity leaves may influence breastfeeding.

Science advice:

- **Based on health outcomes:** From a health perspective it is important to protect, support and promote breastfeeding. For full-term, normal weight infants, breast milk is sufficient as the only form of nutrition for the first 4-6 months; except for vitamin D which needs to be given as supplement (82). The world's official bodies recommend exclusive breastfeeding (EBF) for the first 6 months and some for 4-6 months (82, 176, 194). EBF is advised for about 6 months, and continued breastfeeding parallel to giving complementary foods from that age until 12 months of age, or longer if it suits mother and child. For nutritional reasons, the majority of infants need complementary feeding from around 6 months of age (198). Breastmilk substitutes or infant formula is recommended instead of breastmilk the first 4 months if exclusive breastfeeding is not possible.
- **Based on environmental effects**: Longer duration of breastfeeding has been shown to decrease the environmental impact of the consumption of other foods, e.g., industrially prepared and processed foods, in infancy. Breastmilk is the most environment-friendly food as compared to formula and industrially made foods for infants.
- **Overall science advice:** It is advised to protect early initiation of exclusive breastfeeding continued for about 6 months and continued breastfeeding parallel to complementary feeding for the first 12 months, or for a longer time if it suits both mother and child.

Complementary feeding



Food and nutrient intake. At 4 month of age, approximately 40-40% of infants in the Nordic countries are still exclusively breastfed. A further 15-30% are still breastfed together with complementary foods (semi-solids and/or infant formula). About 15-30% have are not being breastfed. At 12 months of age, about 30-60% of infants are still being breastfed together with complementary foods (82).

Health effects. Giving various complementary foods of the correct consistence for age, from 6 months of age, stimulate the child's development and learning to eat variable diet (198). Complementary foods given to infants from 4-6 months of age (not before 4 months) decrease the risk of allergies when incl. common antigens in foods, especially for those children at high risk of food allergy (82). For nutritional reasons, the majority of infants need complementary feeding from around 6 months of age (198). Iron rich foods given early, e.g., meat, egg, whole grain or fortified cereals, beans, lentils, nuts and seeds, hinder iron deficiency. Too early and too much complementary feeding reduces the positive health effects of breastfeeding for mother and child, such as protection of the child against infections, overweight and obesity. Adding cow's milk and gluten early to the infant's diet, have been associated with Type 1 diabetes (82).

Environmental effects. The GHG impact of infant formulas, breast milk substitutes, are twice that of breastmilk. The environmental impact of four months exclusive feeding with infant formula was 35–72% higher than that of four months exclusive breastfeeding, depending on the impact category, i.e., global warming potential, terrestrial acidification, marine and freshwater eutrophication, and land use (25). Similarly, industrial products for young children based on cereals/vegetables/fruits/meat/ fish associate with their origin and procedures for production.

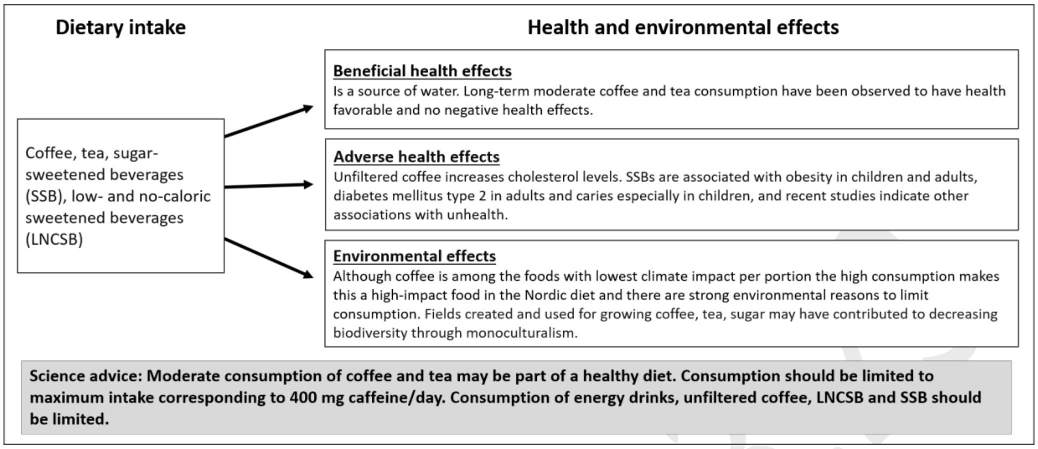
Main data gaps. More knowledge about complementary feeding is needed as well as about foods for young children. Further evidence on associations between infant nutrition and health effects is also needed. Studies and innovation to explore the possibilities and challenges with a vegan or mainly plant-based diet is necessary.

Risk groups. The market of special foods for the youngest citizens is large and evolving and needs to be explored by experts regularly.

Science advice:

- **Based on health outcomes**: If EBF or BF is not possible or not chosen, infant formula is advised. It is advised to start with various solid foods from about 6 months of age, and not before 4 months of age. Various complementary foods should be given and iron containing foods ensured.
- **Based on environmental effects:** GHG emissions of the production of dairy/milk-based formulas are associated to the amount produced (25). The GHG impact of infant formulas, breast milk substitutes, are twice that of breastmilk, and this difference might be larger with a more environmental-friendly diet of the mother.
- **Overall science advice:** It is advised to start with solid complementary foods (SCF) from about 6 months of age, and not before 4 months of age. Various complementary foods should be given and some iron containing foods ensured. If EBF or BF is not possible or not chosen, infant formula is advised (82).

Beverages (coffee, tea, sugar sweetened and artificially sweetened drinks)



Dietary intake. Intake of coffee in the Nordic and Baltic countries is 252 g/day - 706 g/day. Intake of tea is 40 g/day - 240 g/day. Intake of soft drinks is 24 g/day - 282 g/day (64). The added sugar in sugar sweetened beverages (SSB) accounts for 1 to 7E% in the countries. Among the groups with very high intake of added sugar (i.e., the 95th percentile), the added sugar in SSB contribute with up to 24 E% (152).

Health effects. Consumption of coffee may reduce the risk of some cancers, cardiovascular diseases and type 2 diabetes (77). Long-term moderate coffee consumption has been observed to have some health favorable effects and hardly any negative effects of moderate amounts of coffee and tea have been observed (77). The negative health effects of high intake of coffee, tea, SSB and LNCSB, may be mediated through their ingredients, such as caffeine, added sugar or other sweeteners. Boiled coffee increases cholesterol levels. High caffeine intake in pregnancy is associated with higher risk of pregnancy loss, pre-term birth, and low birth weight. SSB are associated with obesity and caries especially in children and have also been associated with increased risk of type 2 diabetes, hypertension, and cardiovascular mortality. Consumption of LNCSB may result in a small reduction in body weight in adults, likely mediated through the effect of reduced energy intake (77).

Environmental effects. Coffee has a lower environmental footprint compated to other food groups per portion (199). However, the high consumption can contribute to a higher total environmental footprint in the Nordic and Baltic diet and consumption should therefore be limited. For environmental reasons tap water should be the preferred choice before SSB, LNCSB and bottled water. Fields created and used for growing coffee, tea, sugar may have contributed to decreasing biodiversity through monoculture of crops (200).

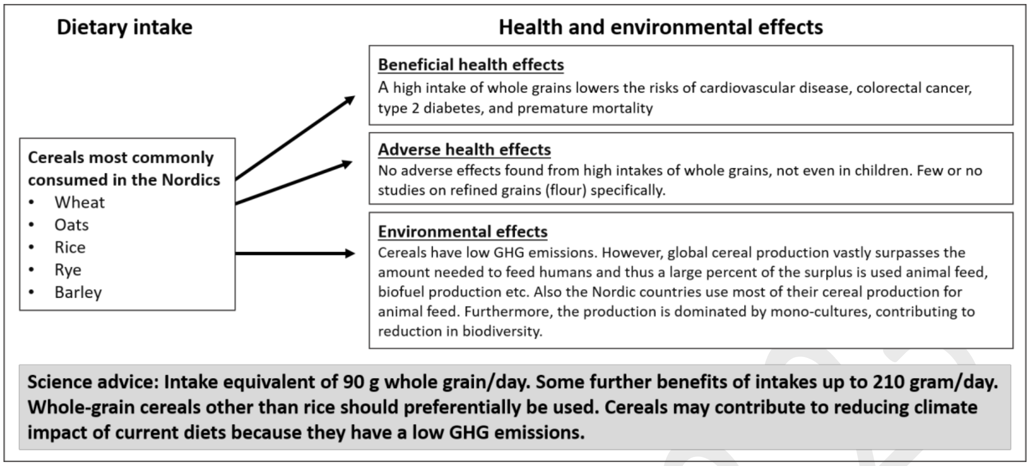
Main data gaps. Further research on health effect and safe intake levels are needed.

Risk groups. Children and pregnant women are more sensitive to high caffeine intakes. Adolescents and children are a risk group as they are targeted in marketing of, e.g., energy drinks, which may have multiple adverse health consequences. Overweight and obese people are at risk due to high intake of SSB and energy drinks with or without caffeine.

Science advice:

- **Based on health outcomes:** Consumption from 0 to a maximum of 400 mg/d of caffeine is considered a safe level for adults. Caffeine concentration of tea is generally lower than in coffee and varies from highest content in black tea to the lowest in herbal tea, with green tea in between. Many energy drinks contain high amounts of caffeine. Consumption of energy drinks, boiled/unfiltered coffee, LNCSB and SSB should be limited (see chapter about sweets for SSB (80)).
- **Based on environmental effects:** Coffee has a lower environmental footprint compared to other food groups per portion. However, the high consumption can contribute to a higher total environmental footprint in the Nordic and Baltic diet and consumption should therefore be limited. For SSB, see *Sweets*. High-quality tap water should be the preferred choice before SSB, LNCSB and bottled water.
- **Overall science advice:** Moderate consumption of filtered coffee and tea may be part of a healthy diet. Consumption should be limited to maximum intake corresponding to 400 mg caffeine/day. Consumption of energy drinks, boiled coffee, LNCSB and SSB should be limited. EFSA recommends that single doses of caffeine up to 200mg and total intake up to 400mg per day from all sources do not raise safety concerns for the general healthy adult population. For children, current recommendation on a safety level of caffeine intake is 3mg per kilogram of body weight per day. For pregnant and lactating women, the recommendation for total caffeine intake is set to maximum 200mg per day.

Cereals (grains)



Whole grains are defined as intact grains or processed grains (e.g., ground, cracked or flaked) where the three fractions endosperm, germ and bran are present in the same relative proportion as in the intact grains. The definition includes commonly eaten seeds from species from the grass family, i.e., wheat, rye, oat, barley, maize, rice, millet, sorghum/durra, teff and wild rice (201). In addition, the global consensus definition includes 'pseudo-cereals' (amaranth, buckwheat and quinoa). The WholeEUGrain-report suggests that whole grain should be the main ingredient in whole grain food products, i.e., whole grain should constitute more than 50 % of the dry matter (96). The word "cereals" also encompasses refined grains, i.e., flour derived from whole grains, but where the germ and bran most often has been removed. In many whole grain products, refined grains are also added for better taste and baking properties. Cereals and cereal products have traditionally been staple foods in the Nordic and Baltic countries.

Food and nutrient intake. Cereals are an important source of energy, carbohydrate and protein, and a key source of vitamin B1, folate, vitamin E, iron and fibre in the Nordic and Baltic countries. If cereals have been grown in selenium-rich soils, cereals are also an important source of this element. Average intakes in Nordic/Baltic countries range from approx. 270 g/day in Norwegian men to 110 g/day in Finnish women (64). Thus, cereal consumption is high, mostly consumed as bread, but also as breakfast cereals or porridge. Wheat dominates among the types of cereals.

Health effects. There is a convincing dose-response association between whole grain intake and reduced risk of coronary heart disease, colorectal cancer, type 2 diabetes incidence, and premature mortality (76). There is less evidence for refined grains, but available evidence does not indicate similar beneficial associations as for whole grains.

Environmental effects. Most modern grain varieties have relatively high yields, and except for large methane emissions from traditional rice paddies and nitrous oxide from excess nitrogen fertilizer, GHG emissions from grain production are low. Fertilizer utilization is variable but can be high. Thus, grain-based foods can be produced with a relatively modest environmental footprint. However, the production is dominated by monocultures, where long term sustainability may be difficult to ensure and contributing to reduced biodiversity. Global cereal production vastly surpasses the amount needed to feed humans (202). The surplus is used for animal feed, biofuel production etc. The large demand generated by such uses may contribute to adverse environmental effects of grain production.

Main data gaps. There is more information available for whole grain than for the health effects of refined grains. Papers analysing how substitution of refined grains with whole grains influence health outcomes are sparse. There are few studies on specific cereals.

Risk groups. Gluten-intolerant people are at risk of low cereal intakes, but can instead consume millet, rice, maize, quinoa or buckwheat products to cover energy needs. Gluten-free oats are also an option.

Science advice:

- **Based on health outcomes:** It is recommended to consume the equivalent of 90 g wholegrains/day, e.g., from bread, with likely further benefits of intakes up to 210 g/day. Such further intake has no adverse effects and may contribute to a healthy, plant-based diet. At high energy requirements and when portion size needs to be small to meet energy needs (as in small children and frail elderly) refined grains also have a role. This justifies also allowing some refined cereals in the diet (76).
- **Based on environmental effects:** Due to the low climate impact of cereals and cereal-based foods, rice being an exception, they are key foods in the transition to a lower climate impact diet. There is room for more cereals and cereal based foods as long as the whole grain foods make up the most part of it.
- **Overall science advice:** It is recommended to have an intake equivalent of 90 g wholegrains/day, e.g., from bread, with likely further benefits of intakes up to 210 g/day. Whole-grain cereals other than rice should preferentially be used.

Vegetables, fruits, and berries

Dietary intake

Culinary defined into
- Vegetables, excl. potatoes and pulses
- Fruits excl. fruit juice
- Berries

Health and environmental effects

Beneficial health effects
- Contributes to appropriate supply of some nutrients in different types of diets, e.g. vitamin C,E and K, folate and potassium, some vegetables provides minerals as iron and selenium e.g. dark green leaves, which also provides beta-carotene (pro vitamin A) as other vegetables such as carrots.
- Increasing intakes positive effect on lowering cancer in the gastric system and lung, cardiovascular disease and overall mortality.

Adverse health effects
Available evidence does not indicate any significant adverse health effects

Environmental effects
General low sustainability impacts. Low climate impact, relatively low land use. Environmental impacts are mainly related to pesticide uses and impacts on biodiversity, locally and globally.

Science advice: It is recommended to consume a variety of vegetables, fruits and berries, at least 500-800 grams/day in total. At least half should be vegetables. Vegetables, fruits and berries may contribute to reduce the climate impact of current diets because they have a low GHG emissions.

Products within this food group are culinary defined as vegetables, fruits and berries. Based on culinary practices and nutrient content, potatoes and pulses are not included in vegetables as a food group. Although botanically defined as legumes, green beans and green peas, may be included in the vegetable food group due to their culinary use being more similar to vegetables in general than to pulses – also the protein and mineral content is lower than in pulses in general (even by cooked weight). Fruit juices derived from fruits and berries also constitute a separate food group.

Vegetable subgroups are cruciferous vegetables (Brassica), such as broccoli, brussels sprouts, cabbage, cauliflower, kale, and turnips, which also are a source of calcium and selenium and have gained increased attention due to their high content of organosulfur compounds and their possible health effects(74). Leafy green vegetables such as spinach, Swiss chard, and lettuce, comprise another subgroup characterised by their content of vitamin K, iron, zinc, calcium and magnesium as well as nitrate, carotenoids and flavonoids, with particularly high concentrations of carotenoids in dark green leafy vegetables. Yellow-orange-red vegetables, such as tomato, carrot, pumpkin, and yellow and red pepper, comprise yet another subgroup rich in carotenoids, while allium vegetables, such as onion, garlic and leek, are characterised by a high content of organosulfur compounds and flavonoids. Due to the higher content of starch, some tubers and roots, such as potatoes, sweet potatoes and cassava, are classified as starchy vegetables, separated from non-starchy root vegetables, such as carrots, beets, parsnips, turnips, and swedes (203). Fruit subgroups are citrus fruits (e.g., oranges, lemon, lime, grape fruit), high in vitamin C , stone fruit (e.g., cherries, plums) and pome fruit (e.g., apples, pears).

Food and nutrient intake. The mean intake of vegetables, fruits, and berries ranges between around 200 and 400 g per day among females and males in the Nordic and Baltic countries, with lowest intakes seen in Iceland and highest intakes in Denmark (64). The mean intake of vegetables (potatoes not included) is generally ranging between around 150 to 200 grams per day. The mean intake of fruits and berries is generally ranging between 100 and 200 g per day. In all eight countries, the intakes of fruit and berries are higher in women than in men, while the differences between the sexes are generally smaller and inconsistent regarding the intake of vegetables (64).
Vegetables, fruits and berries are commonly high in water, low in energy, contain numerous nutrients, and good sources of dietary fibre, vitamin C, vitamin E, vitamin K, folate, and potassium. They also

contain other bioactive compounds, or phytochemicals, and the synergistic effects of these are still not fully understood.

Health effects. Current evidence supports the role of consuming vegetables, fruits, and berries for preventing chronic diseases. Most robust evidence is found for cancer in the gastric system and lung cancer (203), cardiovascular disease, and all-cause mortality (74). Steeper risk reductions are generally seen at the lower intake ranges, but further reductions have been seen for higher intakes for cardiovascular disease, the highest corresponding to intakes of 800 g of fruit and vegetables per day. Inverse associations are also seen for all-cause mortality, with the maximum risk reductions plateauing at around 5-6 servings of fruit and vegetables per day, or around 2-3 servings of fruits per day and around 3-4 servings of vegetables per day, with no apparent increased risk reduction at intakes above this in the most recent meta-analysis. Also, of relevance for vegetables and fruits consumption of foods containing dietary fibre probably protects against colorectal cancer (203). Mixed results are seen for association to type 2 diabetes, associations are weaker and further studies are needed to reach conclusive results.

Environmental effects. Vegetables, fruits and berries have in general low environmental footprints per weight unit, although impacts vary between products (25). Estimations of the footprint of the whole diets also show low footprints from the food group “vegetables, fruits and berries” in the current diets as well as in modelled plant rich diets (25).

The supply of vegetables, fruits and berries in the Nordic and Baltic countries is based on a combination of local grown products and imported product from different regions of the world. The footprints of individual types of vegetables, fruits and berries vary mainly due to different horticultural production practices, but also ways of transportation, transportation length and processing have climate impact. Products in season and locally grown in Nordic countries seem to be among the products with the lower impact, due to less waste during transport and storing. This is the case, in particular for salad vegetables and for berries. The more robust types of fruit and vegetables like apples, pears and citrus fruits and root vegetables, onions and leek, and brassica can be most easily stored, with relatively small energy use and little waste and seem to be the types with the lower impact also when imported. Apples, pears, cherries, currants and plums may provide additional benefits, such as carbon sequestration and storage through photosynthesis during tree growth.

Production in climate-controlled greenhouses based on renewable energy sources may have low climate and environmental impact and increase the length of the season. However, greenhouse grown vegetables might have a higher GHG emission depending on the heating source, while greenhouse production in general might lower the land use and the pesticide use.

Transportation contributes to GHGE, in particular when the supply is dependent on imported products from long distances. Transportation by flight increases the GHGE of products, as has been seen for some types of fruits and vegetables.

In general, more chemical plant protection products are used in the production of fruits and vegetables than other types of agricultural production (in terms of per hectare and kg of harvested product), and tends to be higher in intensive fruit and berry production (e.g., monoculture plantations) compared with vegetables (25). While pesticide use is mostly concentrated during the production stage, for some fruits it is also applied at other stages e.g., fungicides applied to bananas for transportation, and some are applied to the soil e.g., soil disinfectant for strawberries to prevent mould. Production in warmer locations can also require higher levels of pesticide application. Both fertilizers and pesticides are used in conventional vegetable and fruit production. However, the total impact is substantially lower compared to impact from animal food production. This is also the case for impact on biodiversity through increase in land use and increased use of pesticide and fertilizers (25).

Organic production of vegetables, fruits and berries within the Nordic countries might have higher land use but similar GHGE while contributing to lower pesticide use.

There are currently no major water stress issues in Nordic countries. Considerations could also be extended to imported supplies – for example, decreasing imports from water-scarce regions (e.g., in Spain) and regions that are likely to become water stressed.

Main data gaps. Possible health effects of different subgroups of fruit and vegetables need further investigation, including the role of phytochemicals. Nutrient and phytochemical bioavailability and interactions, including effects of different preparation methods, might also be an area for further research. Studies on children and chronic diseases are limited. More research on environmental and climate impact of vegetables, fruits and berries are needed to provide valid data for sustainability assessment of foods and diets.

Risk groups. Available evidence does not indicate any significant adverse health effects.

Science advice:

- **Based on health outcomes:** For adults it is recommended to consume at least 500-800 g per day of vegetables, fruits and berries in total. At least half should be vegetables. Include a variety of different types of vegetables and fruits (incl. berries) with emphasis on dietary fibre contribution (potatoes and pulses are not included). Limit intake of -products with high content of added sugar.
- **Based on environmental effects**: Vegetables fruits and berries have in general low climate and environmental impact/footprints per weight unit, although impacts also varies between products in this food group. Environmental impacts are mainly related to pesticide uses and impacts on biodiversity, locally and globally. Fruits and vegetables that store well will reduce waste and thereby reduce negative impacts.
- **Overall science advice:** For adults it is recommended to consume a variety of vegetables, fruits, and berries, at least 500-800 grams/day in total. At least half should be vegetables. Vegetables, fruits and berries may contribute to reduce the climate impact of current diets because they have a low GHG emissions.

Potatoes

Dietary intake	Health and environmental effects
Potatoes (*Solanum tuberosum*), fat content depending on different cooking methods	**Beneficial health effects** Contributes to appropriate supply of some nutrients in different types of diets, e.g., vitamin C, vitamin B6, niacin, folate, potassium, calcium, phosphorous, iron and magnesium and they also contain dietary fibre, protein of high quality and phytochemicals such as phenolics and carotenoids.
	Adverse health effects Current available evidence indicates that potatoe consumption is not associated with cardiovascular disease and all-cause mortality. Intake of French fries but not boiled potatoes is associated to increased risk of hypertension. The association between a high intake of potatoes and overall cancer and certain cancer types remains unclear. Regarding both type 2 diabetes and weight gain evidence was non-conclusive.
	Environmental effects Like vegetables and in particular root vegetables, potatoes are among the food products with the lowest climate and environmental impacts. Environmental impacts are mainly related to pesticide uses and impacts on biodiversity, locally and globally.

Science advice: Potatoes can be part of a healthy and environment-friendly diet. Potatoes can be included as a significant part in the regular dietary pattern in the Nordic and Baltic countries. Potato products with added salt and fat should be limited. Potatoes may contribute to reducing climate impact of current diets because they have a low GHG emissions.

Potatoes (*Solanum tuberosum*) comprise a commonly consumed staple food. Potatoes are not included in the vegetable food group, because of the central role of boiled potatoes in many hot meals, and as provider of starch in exchange of bread, rice or pasta in the Nordic and Baltic countries.

Food and nutrient intake. The mean intake of potatoes is ranging between approximately 50 and 130 g/day among females and males in the Nordic and Baltic countries with large individual variations within the countries (64). Highest intakes are seen in Sweden, Denmark, Estonia, and Latvia, and in all countries higher intakes are seen in males than in females. Potatoes contribute to the supply of e.g., vitamin C, vitamin B6, niacin, folate, potassium, calcium, phosphorous, iron and magnesium and they also contain dietary fibre, protein of high quality and phytochemicals such as phenolics and carotenoids. However, potatoes are also often consumed in processed forms with added fat and salt, such as French fries.

Health effects. Recent studies have reported no association between total intake of potatoes and cardiovascular disease and all-cause mortality (73). For overall cancer and different cancer types, the evidence is inconclusive. Regarding type 2 diabetes, the evidence was considered limited-suggestive for total potatoes, and limited-no conclusive for boiled potatoes, using the World Cancer Research Fund criteria. Regarding body weight, the evidence was inconclusive.

However, some studies have indicated that isoenergetic portions of potatoes, particularly boiled potatoes, generates a higher satiation compared with other starchy carbohydrates when consumed in isolation. An association between the intake of French fries and an increased risk of hypertension has been reported in a dose-response analysis, while this was not seen for boiled/baked/mashed potatoes. The quality of evidence was considered moderate.

A qSR on dietary patterns indicated that French fries/fried potatoes, as well as total potatoes as components of a dietary pattern were associated with an increased risk of colorectal cancer in adults; the evidence was graded as moderate (153, 204).

Environmental effects. Like vegetables and in particular root vegetables, potatoes are among the food products with the lowest climate and environmental impacts. Potatoes can be easily stored, with relatively small inputs and little waste (25). The difference in GHGE between organic and conventional production is relatively small. Pesticide use is low, however, yield can be substantially lower in organic production, and thereby increasing the land use. In conventional production fungicides are applied to control potato blight and increase the yield. Monocultures of potatoes decrease biodiversity. Crop rotation and genetic diversity within the crop itself is important for reducing disease and increasing yield of potatoes. In the diet, potatoes often replaces grains with potentially larger environmental impacts (e.g. rice) and potato can be grown widely in the region (25).

Modelling studies taken nutritional adequacy into account suggest intakes of around 100 g per day can contribute to a nutritionally adequate and varied plant rich diet.

Main data gaps. There is in general a need for further research regarding the intake of potatoes, including different cooking methods, and health.

Risk groups. No risk groups identified

Science advice:

- **Based on health outcomes:** Potatoes comprise a common staple food in the Nordic and Baltic countries, they provide vitamins, minerals, dietary fibre, protein and phytochemicals, and may be part of a healthy diet. The intake of French fries/deep fried potatoes (high in fat and salt) should be limited.
- **Based on environmental effects:** The environmental impacts are among the lowest among food products, supporting potatoes as part of a plant rich healthy diet.
- **Overall science advice:** Potatoes can be part of a healthy and environmental-friendly diet. Potatoes should be included as a significant part in the regular dietary pattern in the Nordic and Baltic countries. Potato products with added salt and fat should be limited. Potatoes may contribute to reducing climate impact of current diets because they have a low GHG emissions.

Fruit juices

Dietary intake

- Juice 100% based on fruits and berries
- Components such as preservatives, sugars, sweeteners, colourants, cannot be added or remove

Health and environmental effects

<u>Beneficial health effects</u>
In general, fruit juice has a similar nutritional value as whole fruit – except dietary fibre, and maybe vitamin C. Nutrients up to the level as the original fruits can be added. No added sugar, but a natural sugar content.
Low to moderate consumption of fruit juice is not associated with an apparent risk of chronic diseases

<u>Adverse health effects</u>
A possible increased risk of excess energy intake might be of particular concern in people with overweight and obesity and in young children.
Possible effect on tooth erosion remains to be further investigated.

<u>Environmental effects</u>
Environmental impacts are in general low, although somewhat higher than the for the original fruits or berries. As for fruit and berries environmental concerns are mainly related to pesticide uses and impacts on biodiversity, locally and globally.

Science advice: Fruit juice may be part of the fruit and vegetable recommendation. Fruit juice may contribute to maximum 100 g/day.

Fruit juice can be defined as the liquid obtained from the edible part of fruit, or berries, which is ripe and fresh or preserved by chilling or freezing**.** Flavour, pulp, and cells that are separated from the juice during the process may be restored to the juice. This also corresponds to the definition of 100% fruit juice, with no added sugar.

Food and nutrient intake. The mean intake of juice (the type of juice is not specified) is ranging between 35 and 114 g/day among females and males in the Nordic and Baltic countries with large individual variations within the countries (no data was available for Lithuania). Highest intakes are seen in Norway and Iceland and lowest in Estonia and Latvia. In all countries, the intake of juice was higher in males than in females (150). Nutrient content might be similar to nutrient content of the fruits (or berries), although, some juices contain no or a lower level of dietary fibre. Due to relatively high sugar content, fruit juice and concentrated fruit juice has been used as sweetener for example in baby foods. Therefore, sugars from fruit juices and fruit juice concentrates are included in the definition of free sugars.

Health effects. Fruit juices in large quantities, even with no added sugar, are likely to promote weight gain in a similar way to sugar-sweetened drinks (205). Suggested beneficial effects on cardiovascular disease as well as adverse effects on weight gain and tooth erosion remains to be further investigated. Avoiding drinking fruit juice between meals may also be relevant to prevent possible tooth erosion due to fruit juice consumption.

Environmental effects. Considerations regarding the climate and the environmental impact of fruit juice are similar to the original fruits and berries (25). The impact from production also varies, since the juice yield of the original fruit in general varies depending on the type of juice. For oranges it is typically around 50 % and for apples 66 to 75 %, resulting in environmental impacts of fruit juices being around twice the impact of oranges and one third to two thirds higher than the impact of apples. However, the impacts are still relatively low. As for fruit and berries, environmental concerns are mainly related to pesticide uses and impacts on biodiversity, locally and globally.

Main data gaps. More data on environmental impact of juice are warranted.

Risk groups. A possible increased risk of excess energy intake might be of particular concern in people with overweight and obesity and in young children.

Science advice:

- **Based on health outcomes:** A low to moderate intake of fruit juice, corresponding to 0-100 grams per day, may contribute to nutrients and be part of a healthy diet for adults.
- **Based on environmental effects:** The climate and environmental impacts are relatively low although in general somewhat higher than the impacts from the whole fruit.
- **Overall science advice:** Fruit juice may be part of the fruit and vegetable recommendation. Fruit juice may contribute to maximum 100 g/day.

Pulses (legumes)

Dietary intake

The terms legumes or pulses are used interchangeably. For the dietary guidance pulses include the ripened (or dried) form of peas and beans, include lentils, but exclude green beans and green peas.

Health and environmental effects

Beneficial health effects
Contributes to appropriate supply of some nutrients in different types of diets, e.g., protein, dietary fibre, starch, vitamins and minerals, such as thiamine, potassium, magnesium, iron and zinc. Increased intake of legumes is associated with decreased risk of mortality and gastric, colorectal, breast, and lung cancer. Protective effects in RCTs on established risk factors for CVD and type2 diabetes.

Adverse health effects
Hormonal effect of soy products on young children might be a risk
Correct preparation methods are important, due to the content of lectins in raw form of most dry beans.

Environmental effects
Among the food product with the lowest climate and environmental impacts.

Science advice: Legumes/pulses should be part of a healthy and environmental-friendly diet. Legumes/pulses should be included as a significant part in the dietary pattern in the Nordic and Baltic countries. In diets with limited amounts of meat, legumes/pulses are important providers of nutrients such as protein iron and zinc.

A culinary definition of legumes including peas, and lentils, and beans (but excluding coffee and cacao beans). Peanuts are included in the nut and seed food group, as they are culinary considered as a nut. The terms legumes and pulses are often used interchangeably. Legumes are a collective term for plants under the *Fabaceae* botanical family and include various types of beans, lentils, peas, and soybeans (78). Peanuts classify botanically as legumes but are usually classified as nuts in nutrition science in line with their culinary definition. Pulses are often used as the term for the ripened (or dried) form of peas and beans, include lentils, but exclude green beans and green peas. This definition of the food group legumes/pulses is used when giving science advice.

Food and nutrient intake. In the Nordic and Baltic countries, the intake of legumes is generally relatively low, with mean consumption among adults ranging from 1-3 g/day for adults in Denmark and Norway to 17-18 g in Latvia (64). Pulses are good sources of protein and essential amino acids, complex carbohydrates, dietary fibre, and are low in fat and saturated fatty acids. The content of micronutrients differs between varieties, but several legumes are rich in folate, potassium, magnesium, iron, zinc, and thiamine, as well as bioactive compounds such as phytochemicals (78). Correct preparation methods are important, due to the content of lectins in raw form of most dry beans.

Health effects. Increasing consumption of legumes/pulses is associated with a decreased risk of mortality from gastric, colorectal, breast, endometrial, and lung cancers (78). A high consumption of legumes is associated with reduced mortality (78). A new qSR and meta-analysis on legume consumption in adults and risk of cardiovascular disease and type 2 diabetes concluded that findings were mixed (15). Legume consumption was not found to influence risk of CVD and type 2 diabetes in healthy adult populations with generally low legume consumption. However, protective effects on risk factors, seen in RCTs, support recommending legume consumption as part of diverse and healthy dietary patterns. The evidence from observational studies, generally with low legume consumption, was suggestive of null associations. However, protective effects are seen in RCTs on established risk factors for CVD and type2 diabetes, with amounts of legumes commonly being higher in RCTs (>120-150 g/d legumes) than the mean in the highest intake category in cohort studies. The SR conclude that since legume interventions were suggested to have protective effects on blood lipids and glycemic markers, the evidence is not considered strong enough to support a convincing absence of a causal relationship. However, the direction of effect in observational studies was not considered consistent enough to be suggestive of an association (as in the grading *limited - suggestive*) (15).

Based on meta-analyses and data from the Global Burden of Disease study, one modelling study showed sustained change in the consumption of legumes from none to 100 grams per day is associated with an increase in life expectancy of approximately 1 year for male and female adults in the age range 30 to 50 years (78).

Allergies and related adverse reactions to legumes are not among the most common, except for reactions to soy

One concern has been related to hormonal effects of soy products. However, an extensive review of potential endocrine disruption, does not support such concerns (78). Hormonal effect of soy products on young children might be a risk (206).

Pulses also contain anti-nutritional compounds such as amylase inhibitors, phytate and tannins, which are considerably lowered or eliminated during preparation such as soaking and cooking. Also, of relevance for pulses, consumption of foods containing dietary fibre probably protects against colorectal cancer (203).

Environmental effects. Pulses and legumes have among the lowest relative climate and environmental impacts, and have much lower impacts across the board in comparison to meat for example, whether the pulses/legumes are domestically produced or imported. Only 7 % of global soy production is used to produce products directly for human consumption, with most soy (77 %) being used as farmed animal feed – largely for chickens and pigs. Growing practices greatly influence the environmental impacts of pulses and legume production, in terms of both scale and type. Grown as part of crop rotations with cereals, for example, can provide benefits including increasing the yield of cereal crops (as they use the nitrogen supplied by the pulses and legumes), and less requirement for plant protection products, as well as increasing landscape-scale heterogeneity and its associated biodiversity benefits. As legumes and pulses fix nitrogen in the soil, they do not require nitrogen fertilizers. Despite their nitrogen fixing properties, there are production practices that use high amounts of nitrogen fertilizer to increase yields e.g., cultivating soya beans in monocultures. requires the use of chemical plant protection products.

Monocultures with fertilizer and pesticide application can adversely impact the landscape and surrounding biodiversity (25).

Modelling studies taken nutritional adequacy into account suggest intakes of around 100 g per day can contribute to a nutritionally adequate and varied plant rich diet.

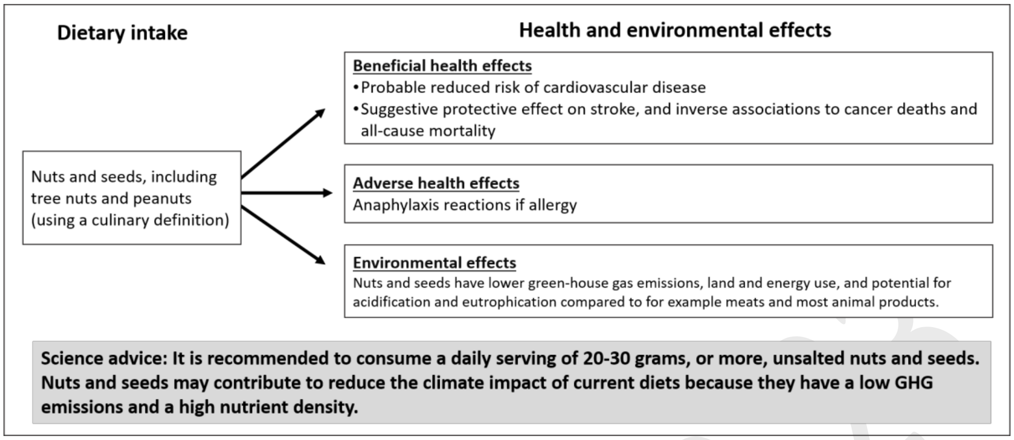
Main data gaps. Intervention trials exploring effects of lower consumption levels on cardiometabolic biomarkers would be of public health relevance.

Risk groups. No risk groups identified.

Science advice:

- **Based on health outcomes:** Overall, the current health evidence and supply of nutrients supports an increasing legume consumption.
- **Based on environmental effects:** Pulses and legumes in general have low environmental impacts. Pulses are important providers of nutrients such as protein iron and zinc in plant rich diets, with limited amounts of meat.
- **Overall science advice:** Legumes/pulses should be part of a healthy and environmental-friendly diet. Legumes/pulses should be included as a significant part in the regular dietary pattern in the Nordic and Baltic countries. In diets with limited amounts of meat, legumes/pulses are important providers of nutrients such as protein iron and zinc.

Nuts and seeds



A culinary definition of nuts is used, including nuts including tree nuts, peanuts, and seeds. Peanuts, almonds, walnuts, hazelnuts, cashew, Brazil nuts, macadamias, pistachio, sesame, and sunflower seeds, are some of the frequently consumed nuts and seeds (69).

Food and nutrient intake. In Sweden, Denmark, and Estonia, mean consumption among adults is 3-5 g/day for adults, while the estimates were 5-9 g/day for Finland, Latvia and Norway (64). Tree nuts and seeds have hard shells covering the seed composed of macronutrients including fats, proteins and fibres, minerals and micronutrients such as magnesium, selenium, vitamin E, and a range of other active metabolites such as phenolic compounds. Nuts are nutrient-dense and contain mostly mono- and polyunsaturated fatty acids (69).

Health effects. Consumption of nuts and seeds is linked with a probable dose-response relationship with a reduced risk of cardiovascular disease (CVD), mostly driven by a reduction in coronary heart disease (CHD), possibly in part through effects on blood lipids (21). There is also suggestive evidence for a protective effect of nut consumption on stroke, and inverse associations to cancer deaths and all-cause mortality. There was no evidence for stronger associations for nut intake beyond 30 grams per day (21, 69). In the de novo SR it was not possible to separate nuts from seeds in the body of the cohort studies, and all RCTs were based on nuts alone, not seeds (21).

Environmental effects. Nuts and seeds have lower green-house gas emissions, land use, and potential for acidification and eutrophication compared to for example meats and most animal products (25). Nuts and seeds production contribute to overall high land use compared to other plant-based foods due to a relatively low yield of the edible nuts when the shields are removed, but land use varies widely (207). High land use also has an impact on biodiversity, especially for nuts and seeds grown in areas with high biodiversity values (207). Current nut production contributes to and is affected by water stress in many regions (25). Groundnuts generally have less water footprint per kg and per g of protein than tree nuts such as almonds.

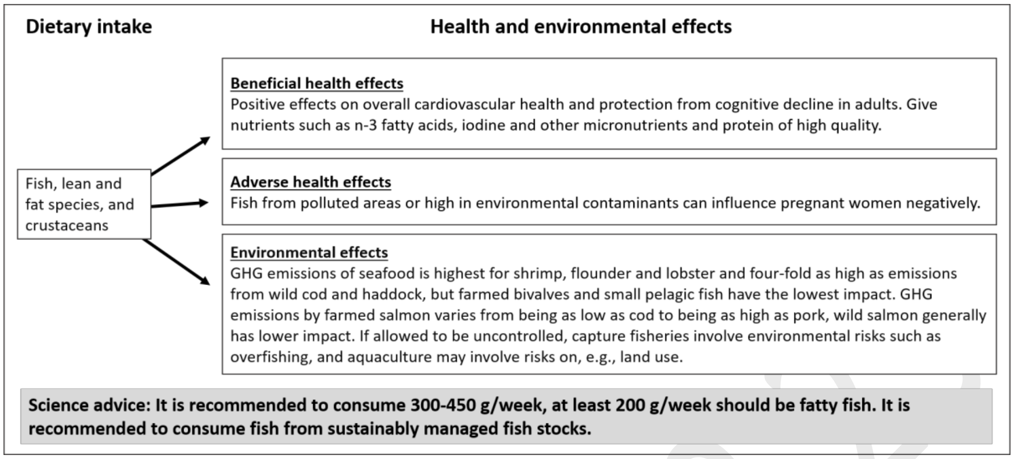
Main data gaps. Effect of individual types of nuts and seeds, and on seeds separately on health outcomes.

Risk groups. People with allergies and related adverse reactions to nuts (1-2% of adult populations). For some people such allergies could cause severe anaphylaxis reactions that can be life-threatening if not handled promptly and properly.

Science advice:

- **Based on health outcomes:** It is recommended to consume a daily serving of 20-30 grams unsalted nuts and seeds (a handful). Intake amounts can be adapted to the age and the youngest children generally needs less energy, however recommending a handful will result in an age-adjustment.
- **Based on environmental effects:** Nuts and seeds may contribute to reducing climate impact of current diets because they have a low GHG emissions and a high nutrient density. However, when increased consumption is achieved, more detailed recommendations are warranted to avoid the potential water stress and biodiversity loss associated with nut and seed consumption.
- **Overall science advice:** It is recommended to consume a daily serving of 20-30 grams unsalted nuts and seeds. Nuts and seeds may contribute to reducing climate impact of current diets because they have a low GHG emissions and a high nutrient density.

Fish and seafood



Food and nutrient intake. Fish is an important source of nutrients such as n-3 fatty acids, vitamin D, iodine and protein of high quality. Among the Nordic and Baltic countries, the fish and fish product consumption on average is about 150 – 500 g/week (64).

Health effects. Health effects of fish have mainly been associated with its lipid contents, n-3 fatty acids, but fish proteins may also be important. Fish consumption has beneficial effect on health (2). It is associated with lower risk of cardiovascular diseases (CVD) such as coronary heart disease (CHD), myocardial infarction (MI) and stroke, as well as total mortality (79, 208). Fish consumption reduces the risk of cognitive decline in adults (e.g., Alzheimer's dementia) (79). Fish intake may be beneficial to prevent metabolic syndrome by reducing plasma triglyceride levels and increasing high density lipoprotein cholesterol (HDL-C) levels (79, 208). Too low intake of n-3 fatty acids is considered a considerable dietary risk, especially in the Baltic countries (63). Requirements for n-3 fatty acids can be reached by consuming fatty fish and fish-oil. qSRs (208) conclude that the benefits from increasing fish intake to the recommended two to three dinner courses per week (corresponding to 300-450 grams, including at least 200 grams fatty fish in adults) outweigh the risks for all age groups.

Environmental effects. Greenhouse gas (GHG) emissions per kg edible seafood varies; emissions associated with commonly consumed species such as wild cod and pollock are considerably lower than any meat alternative (141). The GHG emissions per kg edible part for farmed salmon varies from being similar to cod to be as high impact pork, while wild salmon, e.g., pink salmon, has the lowest impact. In terms of GHG, the main impact from capture fisheries is fossil fuel use for fishing vessels, while the main impact of aquaculture comes from feed production. Farmed fish and seafood now contribute 53 % to total global production, which is expected to increase due to limited growth potential in the capture sector. Overfishing of fish stocks is minimized through check surveillance and governmental rules of fishing. Another environmental stressor associated with capture of wild fish is bottom trawling; when used across large areas, bottom trawling can negatively impact biodiversity. Aquaculture may put pressure on the environment, for example due to land use, freshwater use, spread of disease, and chemical pollution (25). To efficiently use fish without unnecessary waste, the inclusion of some processed fish products is justified from an environmental perspective.

Main data gaps. More information is needed about health-enhancing constituents and health effects of fish. More knowledge is needed about sustainable fish production, especially fish farming.

Risk groups. Pregnant women are advised to avoid certain fish that may be polluted by environmental toxins. Large fresh-water fish from certain areas may contain methyl mercury, and fish from the Baltic Sea or fjords may contain pollutants. Lean fish generally contain lower levels of persistent organic pollutants (POPs).

Science advice:

- **Based on health outcomes:** It is recommended to consume 300-450 g/week (2-3 times/week), at least 200g/week should be fatty fish. Limit intake of fish from polluted areas or high in environmental contaminants, especially during pregnancy and lactation.
- **Based on environmental effects:** Fish and seafood from sustainably managed stocks should be prioritized and consumption of species with high environmental impact should be limited (e.g., GHG emissions).
- **Overall science advice:** It is recommended to consume 300-450 g/week, at least 200g/week should be fatty fish. It is recommended to consume fish from sustainable managed fish stocks.

Red meat

Dietary intake

Health and environmental effects

Ruminants
- Cattle
- Sheep
- Goats
- Game: Moose, deer, reindeer

Non-ruminant
- Pigs

Beneficial health effects
Provider of high-quality protein, iron, zinc and vitamins A, B1, B2, B6, B12

Adverse health effects
- Major source of saturated fatty acid
- Processed red meat: Increased risk of colorectal cancer, cardiovascular diseases and type 2 diabetes + include red meat

Environmental effects
- Ruminants are main contributors to methane emissions from agriculture
- Pigs' GHG footprint is lower than for ruminant meat, but their demand on cereals for feed is high

Science advice: For health reasons, consumption of red meat should be low and not exceed 350 gram/week (ready-to-eat). Processed red meat should be as low as possible. For environmental reasons the consumption of red meat should be considerably lower than 350 grams/week (ready-to-eat). The reduction of red meat consumption should not result in an increase in white meat consumption. To minimize environmental impact, meat consumption should be replaced by increased consumption of plant foods, such as legumes.

Food and nutrient intake. Red meat contributes with high-quality protein, monounsaturated fatty acids, iron (with high bioavailability), zinc, vitamin A and vitamins B1 (thiamine), B2 (riboflavin), B6 and B12 in a regular diet, but is also a major source of saturated fatty acids. Average dietary intakes in the Nordic and Baltic countries varies from 49 g/d in Estonia to 136 g/d in Denmark (64).

Health effects. Despite being a good source of nutrients, regular intake of more than 350-500 grams red meat per week, especially processed meat, may increase the risk of colorectal cancer, cardiovascular diseases and type 2 diabetes (71, 209, 210).

Environmental effects. High production and consumption of ruminant meat is a major contributor to GHG emissions, especially methane (25, 199), in total being approx. 4- and 7-fold higher on a protein basis compared to pork and poultry, respectively (211). Meat from dairy cows has a lower GHG emissions than meat from sucker cows. Although Nordic/European ruminant meat production has relatively low GHG emissions per kg meat produced compared to other world regions (211), the high consumption of red meat is the most important contributor to GHG emissions from the diet in the Nordic and Baltic countries. Imported fodder ingredients contribute to the environmental footprint through fertilizer, pesticide, water and land use, and high feed concentrate demand may also run contrary to more sustainable agricultural practices in the Nordics. Their ability to utilize grass make ruminants important for resource utilization (including outfields), and if well managed and avoiding overgrazing, grazing ruminants may contribute to biodiversity and keeping cultural landscapes open in some settings in the Nordics (212-214). The largest proportions of overall environmental impacts from pig meat production tend to be a result of the cereals and soy in feed production and manure management (25). To efficiently use meat and meat products without unnecessary waste, the inclusion of some processed meat products is justified from an environmental perspective.

The major route to reduce the overall environmental impact of the diet is to reduce the consumption of animal products, while simultaneously increase the consumption of whole grain, pulses, and legumes. Reducing the absolute amount of pork and chicken production could reduce the substantial environmental impacts of soybean production, including deforestation.

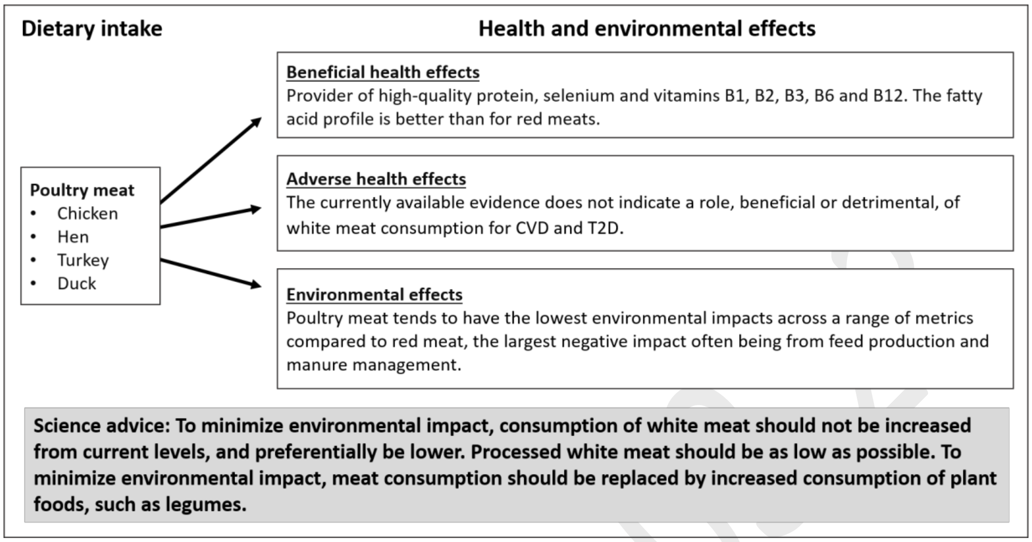
Main data gaps. We lack studies on the health effects of different types of red meat. Little is known about the nutritional impact of how they are reared, e.g., fatty acid profile of meat from feedlot cows versus grassland herds. Data are still lacking on the health effects of substances formed when meat is processed.

Risk groups. High-consumers of red meat, especially processed red meat, have an increased risk of non-communicable diseases. Red meat, especially beef and blood products, are rich in iron and important contributors of iron especially for children and women of fertile age who are at increased risk of developing iron deficiency.

Science advice:

- **Based on health outcomes:** Red meat is nutrient dense and key providers of iron and zinc in the diet. Based on meta-analysis of RCTs and observational studies on red meat and health outcomes, it is recommended to consume no or a limited amount of red meat in the diet, with a maximum intake of 350 grams of red meat per week.
- **Based on environmental effects:** In general, high environmental impact. The high consumption of red meat is the most important contributor to GHG emissions from the diet in the Nordic and Baltic countries. Negative environmental impact is related to methane emissions from ruminants, imported fodder ingredients contribute through fertilizer, pesticide, water and land use, and high feed concentrate. Positive environmental impact may be related to grazing and biodiversity. GHG emission from pigs is lower than ruminants, but demands for feed is high.
- **Overall science advice:** For health reasons, consumption of red meat should be low and not exceed 350 gram/week (ready-to-eat). Processed red meat should be as low as possible. For environmental reasons the consumption of red meat should be considerably lower than 350 grams/week (ready-to-eat). The reduction of red meat consumption should not result in an increase in white meat consumption. To minimize environmental impact, meat consumption should be replaced by increased consumption of plant foods, such as legumes.

White meat



Food and nutrient intake. White meat provides high-quality protein and many B vitamins in addition to having a better fatty acid profile than red meats. The dietary intake of white meat has increased the last decades and is the main driver of increased total meat intake. Intake in the Nordics and Baltics ranges from 20 g/day in Estonia to 43 g/day in Latvia (64). Mean intake of white meat across the Nordic and Baltic countries corresponds to about 175 g/week.

Health effects. A recent *de novo* qSR developed within the NNR2023 project concluded that the currently available evidence does not indicate a role, beneficial or detrimental, of white meat consumption for CVD and T2D (19).

Environmental effects. Across a range of metrics, including GHG, poultry tend to have the lowest environmental impact within the meat food group, however, in general, the environmental impact is higher than plant-foods. Feed production (mostly cereals and soy) and manure management, has an environmental impact which cannot be neglected (25, 215). To efficiently use poultry without unnecessary waste, the inclusion of some processed poultry products in the diet is justified from an environmental perspective. The amount of animal waste in the poultry industry should be minimized to reduce the climate impact.

Of environmental reasons, reduction in red meat consumption, as suggested above, should not be countered with an increase in white meat consumption, but rather increased intake of plant-based foods (25, 26, 68).

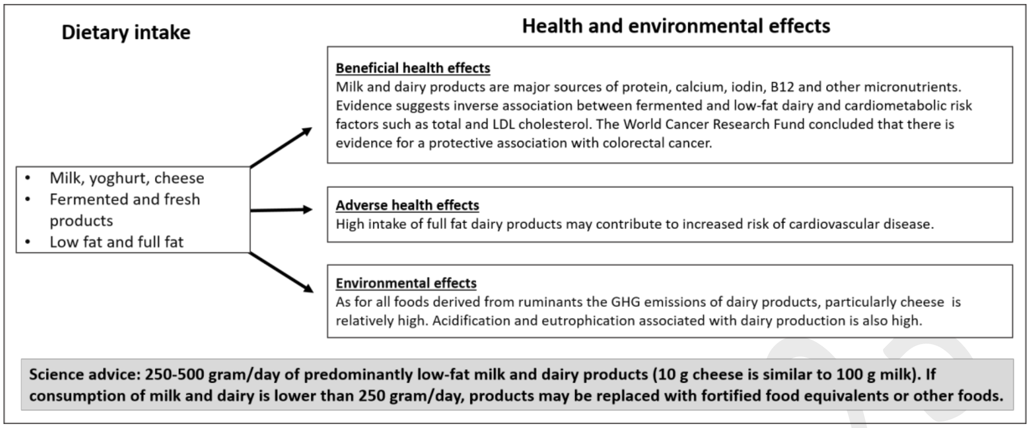
Main data gaps. Few long-term intervention studies on risk factors and disease endpoints. Little data on potentially differential effects of processed vs. unprocessed white meat, different subgroups of white meat, and preparation methods. It is also difficult to determine effects of white meat per se, rather than as substitutes for red meat or fish.

Risk groups. Low- or no-consumers have an increased risk of vitamin B12 deficiency.

Science advice:

- **Based on health outcomes:** Based on meta-analysis of RCTs and observational studies, white meat is considered relatively neutral when it comes to health outcomes.
- **Based on environmental effects**: In general, lower environmental impact across many environmental metrics compared to red meat. Negative environmental impact is related to feed production and manure management. Due to negative environmental impacts, it is not desirable to increase white meat consumption from current levels.
- **Overall science advice**: To minimize environmental impact, consumption of white meat should not be increased from current levels, and preferentially be lower. Processed white meat should be as low as possible. To minimize environmental impact, meat consumption should be replaced by increased consumption of plant foods, such as legumes.

Milk and dairy products



Food and nutrient intake: National dietary surveys in the Nordic and Baltic countries show that milk and dairy consumption ranges between ~100 and ~500 g/day across countries, while intake of cheese ranges from ~20 to 50 g/day (64). Milk and dairy products are rich in calcium, iodine, riboflavin, B-12 and other nutrients.

Health effects: Dairy protein has been used as a reference for high quality protein because of its content and composition of essential amino acids. Evidence suggests an inverse association between fermented and low-fat dairy and cardiometabolic risk factors such as total and LDL cholesterol.

Milk or dairy is generally not associated with increased risk of cardiovascular risk and some suggestions of inverse association, especially with low-fat products and fermented dairy products, were found with respect to cardiovascular disease and type 2 diabetes (70). The World Cancer Research Fund concluded that there is evidence for a protective association with colorectal cancer (209).

Environmental effects: As for all foods derived from ruminants, the GHG emissions of dairy products, particularly cheese and butter, are relatively high. On a protein basis dairy has somewhat lower (~1/3) carbon footprint compared to ruminant meat. Acidification and eutrophication potential of dairy production is also high compared to many other foods. It has been estimated that ~7% of the Earth´s land surface is currently being used to feed dairy animals. This has been a major driver for deforestation and habitat loss to create arable land for feed production. If demand for dairy continuous to increase, dairy products will be one of the key contributors to the adverse environmental impacts of food production. Although conditions to produce dairy in the Nordic countries may, in some cases be somewhat favourable, substantial part of the feed used, including soy, is imported thereby contributing to environmental stress outside the Nordic countries (25, 26, 66, 68).

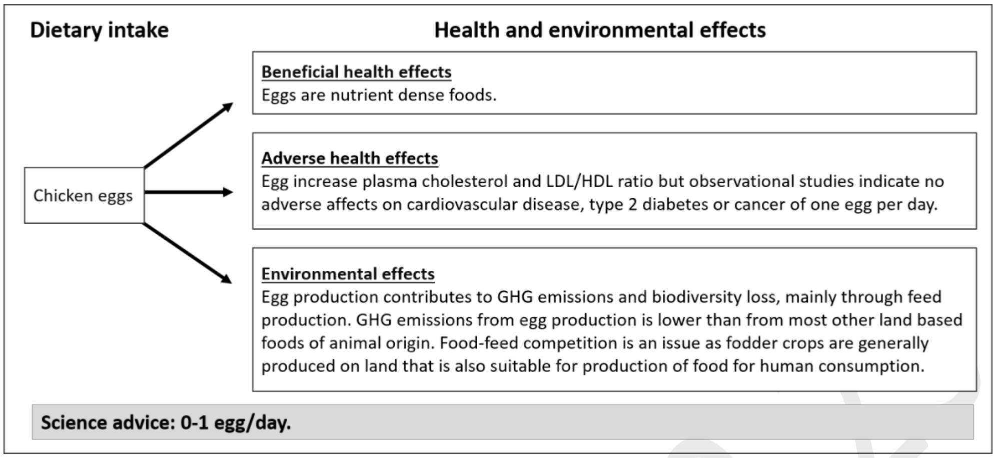
Main data gaps: Different dairy products may possess different effects dependent on fermentation, matrix and composition, therefore more studies on the effect of the different dairy products are needed (70). Moreover, little focus has been on systematically comparing the effect of low- versus high fat dairy because most studies compare different dairy products to other foods. Studies using objective biomarkers of dairy consumption are lacking. Because of an increasing focus on plant-based diets, more studies focusing on alternatives to dairy to meet dietary requirements for calcium, iodin and other nutrients are needed (70).

Risk groups: Those with lactose intolerance and milk protein allergy.

Science advice:

- **Based on health outcomes:** It is recommended to consume 250-500 grams milk and dairy products/day with reference to fulfilling recommended intake for calcium and iodine. Milk and dairy products are also major dietary sources of saturated fatty acids. Therefore, replacing full-fat dairy products with low-fat products is considered more beneficial for health.
- **Based on environmental effects**: In general, high environmental impact. The high consumption of milk and dairy is the most important contributor to GHG emissions from the diet in the Nordic and Baltic countries. Negative environmental impact is related to methane emissions from ruminants, imported fodder ingredients contribute through fertilizer, pesticide, water and land use, and high feed concentrate. Positive environmental impact may be related to grazing and biodiversity.
- **Overall science advice:** 250-500 gram/day of predominantly low-fat milk and dairy products (10 g cheese is similar to 100 g milk). If consumption of milk and dairy is lower than 250 gram/day, products may be replaced with fortified food equivalents or other foods.

Eggs



Food and nutrient intake. Egg is a source of high-quality protein. This food contains all essential vitamins except vitamin C, all minerals and several bioactive compounds such as carotenoids. Reported mean egg intakes in Nordic and Baltic countries are 10-40 g/day with large standard deviation and methodological differences of the studies.

Health effects. Randomized controlled trials show that higher egg intake may increase serum total cholesterol concentration and the ratio of low-density lipoprotein (LDL) to high-density lipoprotein (HDL) cholesterol, but there is substantial heterogeneity in the response. Observational studies indicate no adverse effects of up to one egg per day on the risk of CVD. Observational studies indicate no association between egg consumption and mortality or Type 2 diabetes (81).

Environmental effects. Egg consumption in the Nordic diets is not considered to have a major environmental impact in general (25, 26). Environmental issues related to egg consumption are land use, nutrient pollution of surrounding ecosystems from manure and urea, and resource use on farm including water and energy (25). Egg production produces GHG emissions, which are lower than those of other land animal sourced foods but considerably higher than for root vegetables and legumes (26). Feed for laying-hens may contribute to biodiversity loss when produced in monocultures, for example soy. Another aspect is lack of a comprehensive system of poultry and chicken production. In intensive and efficient egg production, male chickens and most of the laying-hens post-production are considered waste.

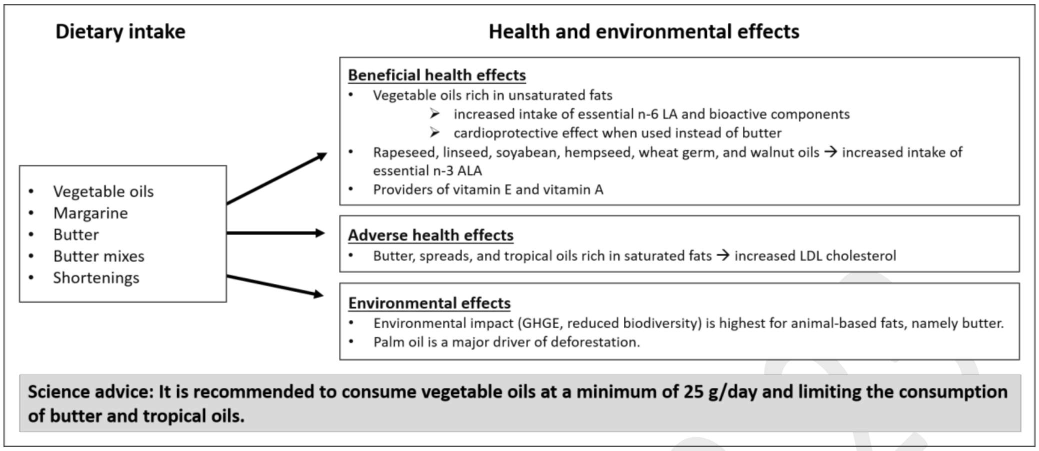
Main data gaps. There are limited data on health effects of > 1 egg per day (81).
Risk groups. There are no population groups especially vulnerable to positive or negative health effects of egg consumption up to one egg per day.

Science advice:

- **Based on health outcomes:** Eggs are nutrient dense and can be part of a healthy diet at current level of consumption in Nordic and Baltic countries, although evidence on health outcomes from intakes of more than one egg per day is limited. Consumption of 0-1 eggs per pay can be part of a healthy diet.
- **Based on environmental effects**: Egg consumption is associated with lower GHG emissions than other land animal sourced foods, but as feed production demands land and may contribute negatively to biodiversity, environmental considerations points towards an egg consumption in the lower end of 0-1 egg per day.

- **Overall science advice:** It is recommended to consume 0-1 egg/day.

Fats and oils



Food and nutrient intake. Fats and oils contribute with essential fatty acids, fat-soluble vitamins, and bioactive components in a regular diet. In Nordic countries, average dietary intakes vary between ~15g/d in Iceland women and 53g/d in Finnish men, and in Baltic countries between 9 g/d in Lithuanian women and 26g/d in Estonian men, respectively (64).

Health effects. The degree of saturation is the primary mediator in terms of the health effects of dietary fats and oils together with different contents of bioactive components and degree of processing (75). Replacing animal-based saturated fats (mainly butter) with plant-based fats (unsaturated oils) may reduce the risk of cardiovascular diseases and mortality. The average daily intake of 25 g/10MJ would secure the recommended intake of essential fatty acids (61, 75).

Environmental effects. The high production and consumption of animal-based fats contribute to GHGE, reduced biodiversity, and loss of nature (25, 26, 68). Palm oil is a major driver of deforestation and has the highest carbon and biodiversity footprint of all vegetable oils, followed by soybean oil (3,6). Among the main fat sources, sunflower and rapeseed oil have the lowest GHGE. Land and water use are highest for olive oil and sunflower oil, while rapeseed oil requires high fertilizer and pesticide inputs. Rapeseed oil is a preferable source of added fat due to its nutritional profile (most balanced n-6 to n-3 ratio) and low GHGE.

Main data gaps. The studies on health effect of margarines and butter mixes, commonly used products in the Nordic countries, is scarce (75). In addition, further studies of different consumption levels of vegetable oils, rapeseed oil in particular, in relation to disease outcomes, mortality, blood lipids, overweight, and obesity in different age groups are needed.

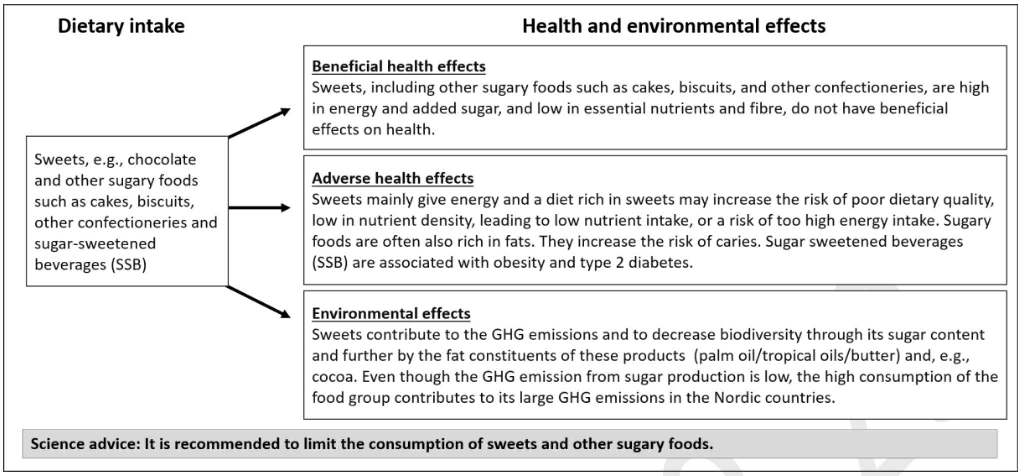
Risk groups. From the perspective of weight management, it is advisable to use fats and oils in moderate amounts.

Science advice:

- **Based on health outcomes:** To secure the intake of essential fatty acids, it is recommended to consume vegetable oils rich in unsaturated fatty acids a minimum of 25 g/day paying attention to a sufficient intake of ALA (minimum of 1.5 g/day per the total energy intake of 10 MJ/day). For cardioprotective effects, vegetable oils rich in unsaturated fatty acids and margarines produced therefrom should be preferred over butter and butter-mixes, hard margarines, and tropical oils (palm- and coconut oil).

- **Based on environmental effects:** A shift from animal to plant-based fats its recommended to contribute to lower GHGE and it is recommended to avoid oils that contribute to deforestation.
- **Overall science advice:** It is recommended to consume vegetable oils at a minimum of 25 g/day and limiting the consumption of butter and tropical oils.

Sweets and confectioneries



Food and nutrient intake. Sweets, chocolate and other sugary foods contains high amount of energy and added sugar, and low amount of essential nutrients and fibre. The consumption of sweets is high in the Nordic countries (64). Adults consume on average 61g/d to 282g/d of soft drinks (including cordials), and 43 g/d to 90 g/d of sweets, cakes and biscuits (64). Values for intake among children and adolescents are missing.

Health effects. Sweets contributes mainly to energy intake. A high intake of sweets may therefore increase the risk of poor dietary quality and low nutrient density (80, 216). Sweets, cakes and biscuits further contribute to high energy intake as they often contain a high amount of fat. Qualified systematic reviews on sweets have found a positive and causal relationship with risk of chronic metabolic diseases such as obesity and dyslipidemia (216). Consumption of sugars is associated with increased risk of dental caries (80). It has been estimated that overconsumption of energy-dense foods contributes to half of the adult population and one in seven children being overweight or obese (26).

Environmental effects. Sugar cane is produced in higher quantities than any other crop (25, 217). The food group of sweets also include ingredients such as fats and oils (see one-pager *Fats and oils*) and cocoa, which has an impact on biodiversity through deforestation. On a kg basis, beet sugar has lower environmental impact than sugar canes. Sugar cane is generally grown in tropical and subtropical regions. Sugar beet production is concentrated in temperate regions of the northern hemisphere (25). Because of high consumption of discretionary foods, such as sugar, sweets, and beverages, in the Nordic countries they have a large contribution to GHG emissions (68), even though the emission from sugar production is low (199). Production of sugar and fats on deforested land may have contributed to decreased biodiversity (26).

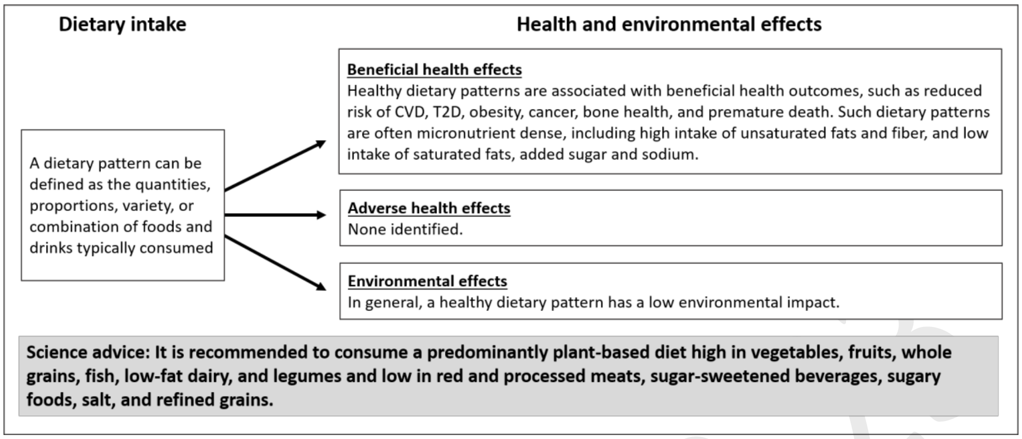
Main data gaps. More information is needed about how to improve diet and decrease the intake of sweets, cakes and biscuits, especially among children.

Risk groups. Children and adolescents are risk groups for high intake of sweets, cakes and biscuits, as well as sugar-sweetened beverages (218-220). People of relatively low energy requirement is at risk of low nutrient intake if the diet is rich of sweets and confectioneries.

Science advice:

- **Based on health outcomes:** It is recommended to limit the intake of sweets, including other sugary foods such as cakes, biscuits, and other confectioneries, as well as SSB. This advice is based on the risk of lower quality of a diet including these sugar containing foods, as well as on the risk of hyperlipidemia, obesity, and caries.
- **Based on environmental effects:** Even though the GHG emission from sugar production is low, the high consumption of the food group contributes to the relatively high GHG emissions in the Nordic countries. Sweets contribute to decreased biodiversity through monocultures and land use change, e.g. tropical oils and butter(see one-pager for *Fats and oils*) and cocoa.
- **Overall science advice:** Limited consumption of sweets and other sugary foods is recommended.

Dietary patterns



Food and nutrient intake. A dietary pattern can be defined as the quantities, proportions, variety, or combination of foods and drinks typically consumed. The dietary pattern approach aims to place the emphasis on the total diet as a long-term health determinant, instead of focusing on separate foods and nutrients, which may interact or confound each other. The Nordic and Baltic countries do not routinely monitor dietary patterns.

Health effects. A healthy diet can be characterized as follows: high in vegetables, fruits, whole grains, fish, low-fat dairy, and legumes and low in red and processed meats, sugar-sweetened beverages, sugary foods, and refined grains. Such dietary patterns are often micronutrient dense, including high intake of unsaturated fats and fibre, and low intake of saturated fats, added sugar and sodium. Healthy dietary patterns are associated with beneficial health outcomes, such as reduced risk of cardiovascular disease, type 2 diabetes, obesity, cancer, bone health, and premature death (85).

Environmental effects. The current average Nordic diets exceed multifold the planetary boundaries related to GHGE, cropland use, biodiversity, nitrogen use, and phosphorus use (25, 68). The water footprint is mainly located outside the Nordics. In Nordic dietary patterns, the majority of the GHGE and other environmental impacts are from ruminant meat and dairy with some country- and gender-specific differences (25, 68, 221). Transitioning from the current Nordic diets to the national FBDGs would reduce GHGE somewhat. More drastic changes are needed to stay within the limits of planetary boundaries.

Main data gaps. Lack of a comprehensive, structured information on pre-defined and explicit dietary patterns over time in the Nordic and Baltic countries. There is a need for more studies in certain subgroups, such as children, adolescents, and the elderly.

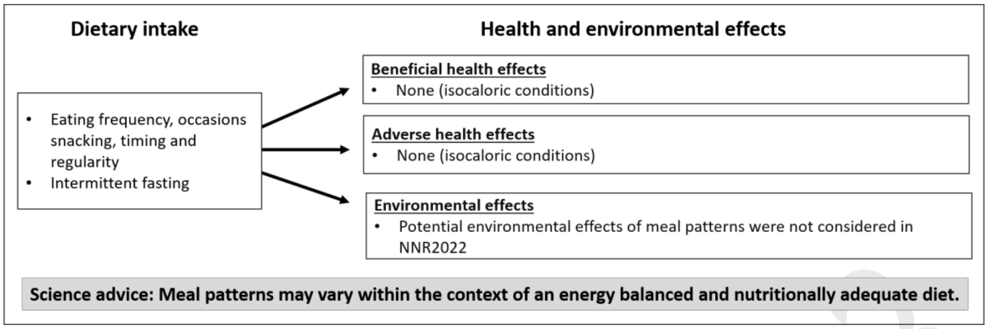
Risk groups. People of relatively low energy requirement and those with low appetite (e.g., frail elderly people) is at risk of low nutrient intake even when eating a healthy and sustainable diet.

Science advice:

- **Based on health outcomes**: To decrease the risk of diet-related chronic diseases and premature death, consume a dietary pattern characterized by high intakes of vegetables, fruits, whole grains, fish, low-fat dairy, and legumes and low in red and processed meats, sugar-sweetened beverages, sugary foods, and refined grains.

- **Based on environmental effects**: Transitioning towards more plant-based dietary patterns will reduce several negative environmental effects of the diet.
- **Overall science advice**: Dietary patterns high in plant-based foods and low in animal-based foods would benefit health and have the lowest environmental impacts. Food group specific considerations are essential to simultaneously reduce the environmental impacts and achieve nutritional adequacy of dietary patterns.

Meal patterns



Food and nutrient intake. Studies considered investigated eating frequency, occasions of eating, snacking, timing and regularity of food consumption under isocaloric conditions.

Health effects: Given the overall low to critically low quality of the reviews, the evidence is too limited and inconclusive to set recommendations for meal patterns (84). Updating the Dietary Guidelines for Americans, 2020-2025 (222) six systematic reviews on the relationship between frequency of eating and chronic disease as well as gestational weight gain during pregnancy and postpartum weight loss during lactation were conducted (153). It was concluded that there was insufficient evidence to draw firm conclusions.

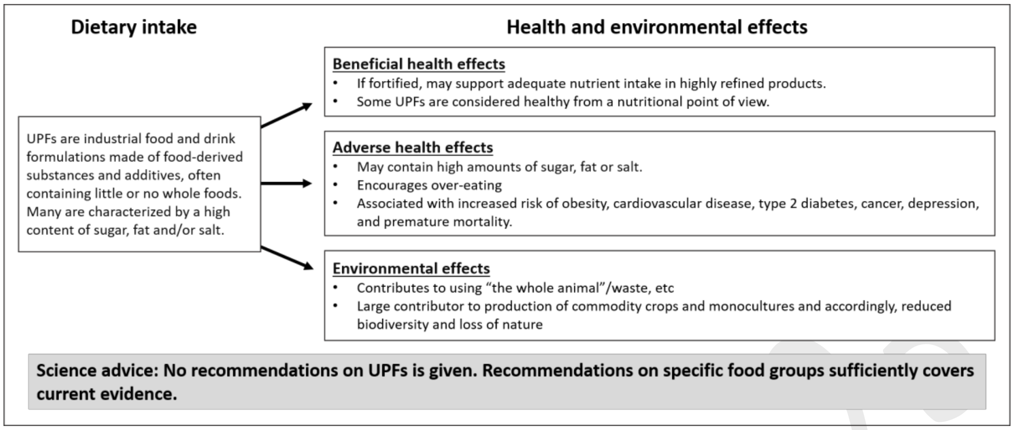
Environmental effects. NNR2023 did not evaluate the potential environmental impact of different meal patterns.

Main data gaps. Limited number of studies and low quality of studies.

Risk groups. No risk groups for adverse effects were identified in (84) but some population groups are more vulnerable to inadequate energy and/or nutrient intake and more dependent on meal regularity. For example, frail elderly and young and growing children, may have to eat more frequently than the general population as they may otherwise be unable to eat adequately sized portions of food to cover energy and nutrient needs. This was out of scope of the chapter on meal patterns (84), but some information was included in the infant feeding chapter (82).

Science advice: There is not enough evidence to set dietary guidelines on meal patterns based on health effects, based on studies of isocaloric intake. Meal patterns may vary within the context of an energy balanced and nutritionally adequate diet.

Ultra-processed foods



There is currently no consensus on classification of processing of foods, including UPFs. The dominating UPF classification (NOVA classification group 4) contains a variety of unhealthy foods, but also a number of foods with beneficial health effects.

Food and nutrient intake. There is currently no good, coherent way to estimate intake, but a number of studies indicate that the intake is increasing and might be around 40- 60 percent in the Nordic and Baltic countries (83). According to the NOVA classification, UPF include SSBs, sweet and savoury packaged snacks, ice cream, potato chips, pizza, and hamburgers, all of which are foods associated with an unfavourable dietary pattern (Chapter on dietary patterns). Other potentially more nutrient dense foods also classified as UPF include factory-produced whole grain bread, many breakfast cereals, and fish products.

Health effects. Regular intake of UPF encourages over-eating and intake of foods in the UPF category of the NOVA classification has been suggested associated with increased risk of obesity, cardiovascular disease, type 2 diabetes, cancer, depression, and premature mortality (83). However, no qSRs support these suggestions.

Environmental effects. Environmental impact of UPFs as such has not been evaluated in NNR2023. In general, processing of foods may have a positive environmental impact by reducing waste and utilization of by-products.

Negative environmental impacts of UPF are related to content of sugar and fats. Environmental impact of sugar is related to decreased biodiversity through monocultures and land use change. Fats and oils have a negative environmental impact related to high consumption of animal-based fats and GHGE, reduced biodiversity, and loss of nature. The different vegetable oils have variable environmental impact related to deforestation, GHGE, biodiversity, water and land use. For more details, please see one-pagers on sweets and fats and oils.

Main data gaps. The mechanisms for the role of degree or type of processing on health outcomes are unknown but may involve overconsumption of energy (223). The term processing is a broad concept and not easily captured (224). There is currently no evidence of health impacts of a diet high in highly processed but healthy foods. There are methodological issues making it difficult to classify UPF with the NOVA classification using FFQs as a basis for information on food consumption.

Risk groups. No risk groups identified.

Science advice.
In many cases, a less processed product has a higher content of nutrients and more fibre, and FAO/WHO recommend a diet based on a great variety of unprocessed or minimally processed foods, balanced across food groups, while restricting highly processed food and drink products (197). There are however several reasons for not making a dietary guideline on UPF in NNR2023. The NOVA classification captures discretionary foods, and this category is usually overlapping with foods known to be associated with adverse effects (high in sugar, fat, high energy density and low nutrient density). UPF is however a heterogenous group of foods and a mix of foods with various nutrient quality and it has not been possible to assess causality on the type of processed foods and health outcomes. A guideline on UPF would introduce conflicting messages about some foods, for example some ready-made foods, wholegrain bread, and granola. The concept is difficult for the consumers to understand, for example why pasta with or without filling is classified differently. Time to prepare foods, and the accessibility to foods does not make it easy to leave out highly processed foods from the diet (225).

No recommendations on UPFs are given. Recommendations on specific food groups sufficiently covers current evidence.

Appendix 1. Experts

Authors and referees of nutrient and food group background papers

Chapter	Lead author	Co-author	Referee	Referee	Referee
Fluid and water balance	Per Ole Iversen, UiO, NO	Mikael Fogelholm, UoH, FI	Robert G Hahn, KI, SE	Sofia Enhôrning, LU, SE	
Energy	Liselotte Cloetens, LU, SE	Lars Ellegård, GU, SE	Mette Svendsen, UiO, NO	Hilde Brekke, UiO, NO	
Fat and fatty acids	Kjetil Retterstøl, UiO, NO	Fredrik Rosqvist, UoU, SE	Matti Uusitupa, UoEF, FI	Maria Lankinen, UoEF, FI	
Carbohydrates	Emily Sonestedt, LU, SE	Nina Øverby, UiA, NO	Bryndis Eva Birgisdottir, UoI, IS	Niina Kaartinen, FIHW, FI	
Dietary fibre	Harald Carlsen, NMBU, NO	Anne-Maria Pajari, UoH, FI	Bryndis Eva Birgisdottir, UoI, IS	Nina Øverby, UiA, NO	
Protein	Olof Gudny Geirsdottir, SHS, IS	Anne-Maria Pajari, UoH, FI	Elisabet Rothenberg, KU, SE	Lise Madsen, UiB, NO	
Alcohol	Dag S. Thelle, UiO, NO	Morten Grønbæk, NIPH, DK	K Leander, SE	Dena Alavi, UiO, NO	
Vitamin A	Thomas Olsen, UiO, NO	Ulf H Lerner, UoG, SE	Thomas Lind, UU, SE	Harald Carlsen, NMBU, NO	
Vitamin D	Magritt Brustad, UiT, NO	Haakon Meyer, FHI, NO	Christel Lamberg-	Inger Öhlund,UO, SE	

			Allardt, UH, FI		
Vitamin E	Essi Marjatta Hantikainen, ER, IT	Ylva Trolle Lagerros, KI, SE	Asim Duttaroy, UiO, NO	Jette Jakobsen, DTU, DK	
Vitamin K	Arja Lyytinen, UEF, FI	Allan Linneberg, GUH, DK	Kyla Shea, Tufts, US	Sara L Booth, US	
Thiamin	Hanna Sara Strandler, SLV, SE	Tor A Strand, UoB, NO	Fredrik Jernerén, UU, SE	David Smith, UoO, UK	
Riboflavin	Vegard Lysne, UiB, NO	Hanna Sara Strandler, SLV, SE	Riitta Freese, UoH, FI	Fredrik Jernerén, UU, SE	
Niacin	Riitta Freese, UoH, FI	Vegard Lysne, UiB, NO	Hanna Sara Strandler, SFA, SE	Fredrik Jernerén, UU, SE	
Vitamin B6	Anne-Lise Bjørke Monsen, UoB, NO	Per Magne Ueland, UoB, NO	Riitta Freese, UoH, FI	Fredrik Jernerén, UU, SE	
Folate	Anne-Lise Bjørke Monsen, UoB, NO	Per Magne Ueland, UoB, NO	Cornelia Witthöft, LU, SE	David Smith, OoO, UK	
Vitamin B12	Anne-Lise Bjørke Monsen, UoB, NO	Vegard Lysne, UiB, NO	A David Smith, UoO, UK	Ebba Nexø, AaU, DK	
Biotin	Beate Stokke Solvik, UiB, NO	Tor A Strand, UoB, NO	Dena Alavi, UiO, NO	Inge Tetens, UoC, DK	
Pantothenic acid	Riitta Freese, UoH, FI	Tonje Aarsland and Maja Bjorkevoll, UoB, NO	Dena Alavi, UiO, NO	Inge Tetens, UoC, DK	

Choline	Rima Obeid, AaU, DK	Therese Karlsson, GU, SE	Anthea Van Parys, UiB, NO	Sari Hantunen, FI	
Vitamin C	Jens Lykkesfeldt, UoC, DK	Anitra Carr, OU, NZ	mari myhrstad, NO, OsloMet	Mikael Fogelholm, OoH, FI	
Calcium	Kirsti Uusi-Rasi, UKK, Fi	Johanna E Torfadottir, UoI, IS	Lars Rejnmark, ÅU, DK	Emelie Helte, KI, SE	
Phosphorus	Suvi T. Itkonen, UoH, FI	Christel Lamberg-Allardt, UoH, FI	Lars Rejnmark, ÅU, DK	Hilde Brekke, UiO, NO	
Magnesium	Christine Henriksen, UiO, NO	Jan Olav Aaseth, IH, NO	Emelie Helte, KI, SE	Mikael Fogelholm, UoH, FI	
Sodium and salt	Antti Jula, fimnet, FI		Per Ole Iversen, UiO, NO	Veronica Öhrvik, NFA, SE	
Potassium	Ulla Toft, FH, DK and Nanna Louise Riis, FH, DK	Antti Jula, fimnet,FI	Per Ole Iversen, UiO, NO	Inger Lise Steffensen, FHI, NO	
Iron	Magnus Domellöf, UU, S	Agneta Sjöberg, UoG, SE	Lena Hulthén, GU, SE	Gry Hay, NDH, NO	
Zinc	Tor A Strand, UoB, NO	Maria Mathisen, VVH, NO	Lisbeth Dahl, IMR, NO	Liv Elin Torheim, NIPH, NO	
Iodine	Ingibjörg Gunnarsdottir, UoI, IS	Anne Lise Brantsæter	Sigrun Henjum,	Iris Erlund, THL, FI	

			OsloMet, NO		
Selenium	Jan Alexander, NIPH, NO	Ann-Karin Olsen, FHI, NO	Jan Olav Aaseth, IH, NO	Inge Tetens, UoC, DK	
Copper	Christine Henriksen, UiO, NO	Erik Kristoffer Arnesen, UiO, NO	Jan Olav Aaseth, IH, NO	Frode A Norheim, UoO, NO	
Chromium	Christine Henriksen, UiO, NO	Susanne Bügel, UoC, DK	Jan Olav Aaseth, IH, NO	Anette Hjartåker, UoO, NO	
Manganese	Maria Kippler, KI, SE	Agneta Oskarsson, SLU, SE	Inge Tetens, UoC, DK	Monica Hauger Carlsen, UoO, NO	
Molybdenum	Agneta Oskarsson, SLU, SE	Maria Kippler, KI, SE	Inge Tetens, UoC, DK	Anette Hjartåker, UoO, NO	
Fluoride	Marian Kjellevold, IMR, NO	Maria Kippler, KI, SE	Emelie Helte, KI, SE	Monica Hauger Carlsen, UoO, NO	
Phytochemicals and antioxidants	Mari Myhrstad, OsloMet, NO	Alicja Wolk, KI, SE	Anna Bergstrøm, KI, SE	Harald Carlsen, NMBU, NO	
Beverages (Coffee, tea, sugar sweetened and artificially-sweetened drinks)	Anna S Olafsdottir, UoI, IS	Emily Sonestedt, LU, SE	Trine Husøy, NIPH, NO	Josefin Edvall Löfvenborg, SFA, SE	
Cereals (grains)	Guri Skeie, UiT, NO	Lars T Fadnes, UiB, NO	Liselotte Cloetens, LU, SE	Liv Elin Torheim, NIPH,NO	
Vegetables, fruits, and berries	Magdalena Rosell, KI, SE	Lars T Fadnes, UiB, NO	Suvi Virtanen, FIHW, FI	Cornelia Witthöft, LU, SE	

Potatoes	Magdalena Rosell, KI, SE	Christine Delisle, KI, SE	Suvi Virtanen, FIHW, FI	Cornelia Witthöft, LU, SE	
Fruit Juice	Magdalena Rosell, KI, SE	Christine Delisle, KI, SE	Suvi Virtanen, FIHW, FI	Cornelia Witthöft, LU, SE	
Pulses (legumes)	Liv Elin Torheim	Lars T Fadnes, UiB, NO	Niina Kaartinen, THL, FI	Cornelia Witthöft, LU, SE	
Nuts	Lars T Fadnes, UiB, NO	Magdalena Rosell, KI, SE	Mette Svendsen, UiO, NO	Suvi Virtanen, FIHW, FI	
Fish, fish products and seafood	Stine Ulven, UiO, NO	Johanna E Torfadottir, UoI, IS	Kirsi Laitinen, FIHW, FI	Lise Madsen, UiB, NO	
Meat and meat products	Jelena Meinilä, UoH, FI	Jyrki K. Virtanen, UEF, FI	Liv Elin Torheim, NIPH, NO	Alicja Wolk, KI, SE	
Milk and dairy products	Kirsten Holven, UiO, NO	Emily Sonestedt, LU, SE	Johanna E Torfadottir, UoI, IS	Suvi Virtanen, FIHW, FI	
Eggs	Jyrki K. Virtanen, UEF, FI	Susanna C Larsson, KI, SE	Fredrik Rosqvist, UU, SE	Vibeke Telle-Hansen, OMU, NO	
Fats and oils	Fredrik Rosqvist, UU, SE	Sari Niinistö, FIHW, FI	Vibeke Telle-Hansen, OMU, NO	Maria Lankinen, UEF, FI	

Sweets and confectionaries	Henna Vepsäläinen, UoH, FI	Emily Sonestedt, LU, SE	Stina Ramne, LU, SE	Anna Karin Lindroos, SFA, SE	
Breastfeeding	Agneta Hörnell, UU, SE	Hanna Lagström, TUH, FI	Gry Hay, NDH, NO	Anna Bergstrøm, KI, SE	Kirsi Laitinen, FIHW, FI
Dietary patterns	Henna Vepsäläinen, UoH, FI	Jaana Lindström, THL, FI	Matti Uusitupa, UEF, FI	Ulrika Ericson, LU, SE	
Meal patterns, intermittent fasting, fasting	Mette Svendsen, UiO, NO	Helene Bertheus Forslund, GU, SE	Anna Karin Lindroos, SFA, SE	Noora Kanerva, UoH, FI	
Ultraprocessed foods	Filippa Juul, KI, SE	Elling Bere, UiA, NO	Marit Kolby, ONH, NO	Nina Cecilie Øverby, UiA, NO	Marjaana Lahti-Koski, UoH, FI

Experts involved in background articles

Title	**Authors**	**Other involved experts**
Assessing the environmental sustainability of diets – an overview of approaches and identification of 5 key considerations for comprehensive assessments	Tim Benton, Helen Harwatt, Helle Margrete Meltzer, Ellen Trolle, Rune Blomhoff	**Reference group members are listed below.** Anne Maria Pajari, Åsa Svenfeldt, Bob van Oort, Ellinor Hallström, Klaus Mittenzwei, Mikael Fogelholm, Minna Kaljonen, Piia Jallinoja, Sirpa Sarlio, Stefan Einarsson
Overview of food consumption and environmental sustainability – considerations in the Nordic and Baltic region	Helen Harwatt, Tim Benton, Jan Bengtsson, Rune Blomhoff, Bryndis Eva Birgisdottir, Kerry Ann Brown, Corné van Dooren, Maijaliisa Erkkola,	**Workshop participants are listed below.**

	Morten Graversgaard, Jelena Meinilä, Thorhallur Halldorsson, Michael Hauchild, Anne Høyer, Bob van Oort. Merja Saarinen, Hanna Tuomisto, Ellen Trolle, Olafur Ögmundarson	NNR2023 Committee members, Tim Benton, Helen Harwatt, Erik Arnesen, Eirin Bar, Jan Bengtsson, Bryndis Eva Birgisdottir, Kerry Ann brown, Morten Graversgaard, Hannah Karlsson, Audun Korsæth, Olafur Ögmundarson, Sirli Pehme, Merja Saarinen, Hanna Tuomisto, Bob van Oort, Elin Röös, Davy Vanham, Amanda Wood, Bruna Miguel, Hanna Karlsson Potter, Johanna Tikamem. Klas Wetterberg, Mija Ceruka, Davy Vanham, Richard King
Integrating sustainability into Food Based Dietary Guidelines – how far are we in investigating environmental sustainability of the Nordic diets	Ellen Trolle, Maijaliisa Erkkola, Hanna Eneroth, Thorhallur Ingi Halldorsson, Inga Thorsdottir, Helle Margrete Meltzer, Jelena Meinilä	
Challenges and opportunities when incorporating sustainability into food-based dietary guidelines in the Nordics	Hanna Eneroth, Maijaliisa Erkkola, Thorhallur Ingi Halldorsson, Inga Thorsdottir, Ellen Trolle, Helle Margrete Meltzer	**Resource group are listed below. Some might be included as authors after finalization of paper.** Peter Fantke, Jørgen E. Olesen, Juha Helenius, Merja Saarinen, Olafur Ögmundarson, Trond Arild Ydersbond, Hanne Fjerdingby Olsen, Ola Hedstein, Åge Klepp, Max Troell, Elin Röös and Amanda Wood
Social and economic dimensions of food sustainability – summary of the SAPEA report	Peter Jackson and Lotte Holm	
Physical activity: associations with health and summary of guidelines	Katja Borodulin and Sigmund Anderssen	
The burden of diet related diseases and dietary risk factors in the Nordic and Baltic countries 1990-2021: a systematic analysis of the global burden of diseases, injuries, and risk factors study 2021 for the Nordic Nutrition Recommendations	GBD – NNR collaboration group to be announced.	
Human body weight, nutrients, and foods: a scoping review	Jøran Hjelmesæth and Agneta Sjöberg	

The Nordic Nutrition Recommendations 2022 – food consumption and nutrient intake in the adult population of the Nordic and Baltic countries	Eva Warensjö Lemming and Tagli Pitsi	
The Nordic Nutrition Recommendations 2022 - Principles and methodologies	NNR Committee	
The Nordic Nutrition Recommendations 2022 - handbook for qualified systematic reviews	NNR Committee	
The Nordic Nutrition Recommendations 2022 – structure and rationale for qualified systematic reviews	NNR Committee	
The Nordic Nutrition Recommendations 2022 – prioritisation of topics for *de novo* systematic reviews	NNR Committee	
Nine *de novo* systematic reviews	All SR Centre members. Please see section "NNR SR Centre" and section "Selection of topics for *de novo* SRs".	

Appendix 2. List of qualified systematic reviews

Topic	Year	Authors/organization (country)	Exposure(s)	Outcome(s)	Risk of bias assessment tool	SoE/evidence quality grading
Sodium and Potassium intake	2018	AHRQ (USA) (226)	Dietary Sodium (sodium reduction), Potassium	Blood pressure, risk for cardiovascular diseases, all-cause mortality, renal disease and related risk factors, adverse events	Cochrane RoB / NOS. Some nutrition-specific items added (e.g. Sodium intake assessment)	"High", "Moderate", "Low" or "Insufficient". Based on: 1) Study limitations, 2) consistency, 3) directness, 4) precision, 5) reporting bias. Observational studies may be upgraded if very strong effects, a strong dose-response-relationship or if effects cannot be explained by uncontrolled confounding.
Vitamin D and Calcium	2014	AHRQ (USA) (174)	Vitamin D and/or Calcium	Bone health, cardiovascular health, cancer, immune function, pregnancy, all-cause mortality, vitamin D status	CONSORT statement for RCTs, own checklist based on STROBE and nutrition-specific items	Grade A-B
Omega-3 Fatty Acids	2016	AHRQ (USA) (227)	Omega-3 Fatty Acids	Cardiovascular Disease, risk factors	Cochrane RoB / NOS. Some nutrition-specific items added.	"High", "Moderate", "Low" or "Insufficient". Based on: 1) Study limitations, 2) consistency, 3) directness, 4) precision, 5) reporting bias, 6) number of studies
Omega-3 Fatty Acids	2016	AHRQ (USA) (228)	Omega-3 Fatty Acids	Maternal and Child Health: Gestational length, risk for preterm birth, birth weight, risk for low birth weight, risk for peripartum depression, risk for gestational hypertension/preeclampsia; postnatal growth, visual acuity, neurological development, cognitive development, autism spectrum disorder, ADHD, learning disorders, atopic dermatitis, allergies and respiratory disorders, adverse events	Cochrane RoB / NOS. Some nutrition-specific items added.	"High", "Moderate", "Low" or "Insufficient". Based on: 1) Study limitations, 2) consistency, 3) directness, 4) precision, 5) reporting bias, 6) number of studies
Vitamin, Mineral, and Multivitamin Supplementation	2021	AHRQ (USA)	Multivitamin and single nutrient supplements	Risk of cardiovascular disease, cancer, and mortality, other harms	Similar to Cochrane RoB	"High", "Moderate", "Low" or "Insufficient". Based on: 1) Study limitations, 2) consistency, 3) precision, 4) reporting bias

Nutrient Reference Values for Sodium	2017	Australian Government Department of Health/New Zealand Ministry of Health (229)	Dietary sodium/sodium reduction	Blood pressure, cholesterol levels, stroke, myocardial infarction, total mortality	Cochrane RoB, modified	GRADE and NHMRC level of evidence (from I to IV)
Alcohol	2023	Canadian Centre on Substance Use and Addiction (Health Canada) (165)	Alcohol	Physical and mental health, and social impact	AMSTAR 2.0	GRADE
Dietary Patterns	2020	DGAC (USA) (86)	Dietary patterns; macronutrient distribution	Growth, Size, Body Composition, and/or Risk of Overweight or Obesity	Cochrane RoB 2.0 / Rob-Nobs*	Strength of Evidence: "Strong", "Moderate", "Limited" or "Not Assignable"; based on 1) risk of bias, 2) consistency, 3) directness, 4) precision, 5) generalizability
Dietary Patterns (update of 2015 DGAC review)	2020	DGAC (USA) (230)	Dietary patterns	Cardiovascular disease, CVD risk factors (blood pressure, blood lipids)		
Dietary Patterns and Risk of Type 2 Diabetes (update of 2015 DGAC review)	2020	DGAC (USA) (231)	Dietary patterns	Type 2 Diabetes		
Dietary Patterns (update of 2015 DGAC review)	2020	DGAC (USA) (204)	Dietary patterns	Breast cancer, colorectal cancer, lung cancer, prostate cancer		
Dietary Patterns (update of 2015 DGAC review)	2020	DGAC (USA) (232)	Dietary patterns	Bone health, e.g. risk of hip fracture, bone mineral density		
Dietary Patterns (update of 2015 DGAC review)	2020	DGAC (USA) (233)	Dietary patterns	Neurocognitive health; age-related cognitive impairment, dementia		
Dietary Patterns	2020	DGAC (USA) (234)	Dietary patterns	Sarcopenia		
Dietary Patterns	2020	DGAC (USA) (235)	Dietary patterns	Mortality		
Dietary Patterns during Pregnancy	2020	DGAC (USA) (236)	Dietary patterns	Gestational weight gain		
Dietary Patterns during Lactation	2020	DGAC (USA) (237)	Dietary patterns	Human milk composition and quantity		
Folic Acid from Fortified Foods and/or Supplements during Pregnancy and Lactation	2020	DGAC (USA) (238)	Folic acid	Micronutrient status; gestational diabetes; hypertensive disorders during pregnancy; human milk composition; developmental milestones in child		

Omega-3 fatty acids from Supplements Consumed before and during Pregnancy and Lactation	2020	DGAC (USA) (239)	Omega-3 from supplements	Risk of Child Food Allergies and Atopic Allergic Disease		
Maternal Diet during Pregnancy and Lactation	2020	DGAC (USA) (240)	Dietary patterns, food allergen (e.g. Cow milk, eggs, fish, soybean, wheat, nuts etc.)	Risk of Child Food Allergies and Atopic Allergic Diseases (e.g. Atopic dermatitis, allergic rhinitis, asthma)		
Exclusive Human Milk and/or Infant Formula Consumption	2020	DGAC (USA) (241)	Human milk and/or infant formula	Overweight and Obesity		
Exclusive Human Milk and/or Infant Formula Consumption	2020	DGAC (USA) (242)	Human milk and/or infant formula	Nutrient Status (e.g. Iron, zinc, iodine, vitamin B12 status)		
Iron from Supplements Consumed During Infancy and Toddlerhood	2020	DGAC (USA) (243)	Iron from supplements	Growth, Size, and Body Composition		
Vitamin D from Supplements Consumed during Infancy and Toddlerhood	2020	DGAC (USA) (244)	Vitamin D from supplements/fortified foods	Bone Health (e.g biomarkers, bone mass rickets, fracture) up to age 18 years		
Beverage Consumption	2020	DGAC (USA) (245)	Beverages (milk, juice, sugar-sweetened beverages, low and no-calorie beverages vs. water)	Growth, Size, Body Composition, and Risk of Overweight and Obesity		
Beverage Consumption During Pregnancy	2020	DGAC (USA) (246)	Beverages (Milk, Tea, Coffee, Sugar-Sweetened/Low- or no-calorie sweetened beverages, water)	Birth weight		
Alcohol Consumption	2020	DGAC (USA) (162)	Alcoholic beverages (type and drinking pattern)	Mortality		
Added Sugars (update of 2015 DGAC review)	2020	DGAC (USA) (247)	Added sugars; sugar-sweetened beverages	Cardiovascular Disease, CVD mortality, CVD risk factors		
Types of Dietary Fat	2020	DGAC (USA) (248)	Types of fatty acids, individual fatty acids (e.g. ALA, DHA), dietary cholesterol or food sources of types of fat (e.g. Olive oil for MUFA, butter for SFA)	Cardiovascular Disease outcomes, intermediate outcomes (blood lipids and blood pressure)		
Seafood consumption during pregnancy and lactation	2020	DGAC (USA) (249)	Maternal seafood/fish intake (e.g. Fish, Salmon, tuna, trout, tilapia; shellfish: shrimp, crab, oysters)	Neurocognitive development (e.g. Cognitive and language development; behavioral development; attention deficit disorder, autism spectrum disorder) In the child		

Seafood consumption during childhood and adolescence (up to 18 years of age)	2020	DGAC (USA) (250)	Seafood (e.g. Fish, Salmon, tuna, trout, tilapia; shellfish: shrimp, crab, oysters)	Neurocognitive development (e.g. Cognition, depression, dementia, psychomotor performance, behavior disorders, autism spectrum disorder, mental health ... Academic achievment)		
Seafood consumption during childhood and adolescence (up to 18 years of age)	2020	DGAC (USA)(251)	Seafood (e.g. Salmon, tuna, trout, tilapia; shellfish: shrimp, crab, oysters)	Cardiovascular Disease (and blood lipids or blood pressure)		
Frequency of eating	2020	DGAC (USA) (252)	Eating frequency	Overweight and Obesity		
Frequency of eating	2020	DGAC (USA) (253)	Eating frequency	Cardiovascular Disease		
Frequency of eating	2020	DGAC (USA)(254)	Eating frequency	Type 2 Diabetes		
Dietary patterns	2015	DGAC (USA) (204)	Dietary patterns	Cancer	NEL Bias assessment tool	"Strong", "Moderate", "Limited", "Expert opinion only", "Not assignable"; based on 1) risk of bias, 2) consistency, 3) quantity, 4) impact, 5) generalizability
Dietary patterns	2015	DGAC (USA)(255)	Dietary patterns	Congenital anomalities		
Dietary patterns	2015	DGAC (USA)(255)	Dietary patterns	Neurological and psychological illness		
Dietary patterns and	2015	DGAC (USA)(255)	Dietary patterns	Bone health		
Dietary patterns and long-term food sustainability and related food security	2015	DGAC (USA)(255)	Dietary patterns	Environmental impact		
Sodium intake in children	2015	DGAC (USA)(255)	Dietary sodium	Blood pressure		
Sodium intake	2015	DGAC (USA)(255)	Dietary sodium	Cardiovascular disease		
Added sugars	2015	DGAC (USA)(255)	Added sugars & sugar-sweetened beverages	CVD, CVD mortality, hypertension, blood pressure, cholesterol, triglycerides		

Carbohydrates	2012	DGE (Germany)(220)	Total carbohydrates, sugars, sugar-sweetened beverages, dietary fibre, whole-grain, glycaemic index/load	Obesity, type 2 diabetes, dyslipidaemia, hypertension, metbolic syndrome, coronary heart disease, cancer	WHO level of evidence (Ia-Ic, IIa-IIb) based on study design	WHO/WCRF (convincing, probable, possible, insufficient)
Fatty acids	2015	DGE (Germany)(256)	Dietary fats	Adiposity, type 2 diabetes, dyslipidaemia/hyperlipidaemia, blood pressure, cardiovascular diseases, metabolic syndrome, cancer		
Dietary Reference Values for Sodium	2019	EFSA (137)	Sodium intake, as 24 hr sodium excretion (i.e. not self-reported)	Blood pressure, CVD, bone mineral density, osteoporotic fractures, sodium balance	OHAT/NTP Risk of bias tool (based on AHRQ, Cochrane, CLARITY etc.): selection, performance, attrition, detection and selective reporting bias	"Uncertainty analysis" based on consistency, precision, internal and external validity, etc.
Dietary References Values for Copper	2012	EFSA, review by ANSES (France)(257)	Copper	Copper status, bioavailability, cardiac arrythmia, cancer, arthritis, cognitive function, respiratory disease, cardiovascular mortality	EURRECA system (high, moderate, low or unclear), partly based on Cochrane	Consistency, strength, and quality of the studies (see Dhonukshe-Rutten et al. 2013 (258) & EFSA, 2010 (principles) (259))
Dietary Reference Values for Riboflavin	2014	EFSA, review by Pallas Health Research (Netherlands)(260)	Riboflavin	Riboflavin status, biomarkers; cancer; mortality; bone health, infant health etc		
Dietary Reference Values for Phosphorus, Sodium and Chloride	2013	EFSA, review by Pallas Health Research (Netherlands)(261)	Phosphorus, sodium, chloride	Status, adequacy, health outcomes including cancer, CVD, kidney disease, all-cause and CVD mortality		
Dietary Reference Values for Niacin, Biotin and Vitamin B6	2012	EFSA, review by Pallas Health Research (Netherlands)(172)	Niacin	Niacin/biotin/vitamin B6 status, adequacy, bioavailability, cancer, CVD, cognitive decline, infant health, all-cause mortality etc.		
Tolerable upper intake level for dietary sugars	2022	EFSA (152)	Sugars (total/added/free), fructose, sources of sugars	Chronic metabolic diseases, pregnancy-related endpoints and dental caries	OHAT/NTP risk of bias (RoB) tool	"Uncertainty analysis" based on consistency, precision, internal and external validity, etc.
Tolerable upper intake level for selenium	2023	EFSA (186)	Selenium	Clinical effects, potential biomarkers of effect, risk of chronic diseases and impaired neuropsychological development in humans	OHAT/NTP risk of bias (RoB) tool	"Uncertainty analysis" based on consistency, precision, internal and external validity, etc.
Milk and dairy consumption during pregnancy	2012	NNR: Brantsæter et al. (262)	Milk and dairy products	Birth weight, fetal growth, large for gestational age, small for gestational age	NNR quality assessment tool (rated A, B or C)	WCRF (convincing, probable, limited - suggestive, limited - no conclusion)
Dietary iron	2013	NNR: Domellof et al. (263)	Iron intake at different life stages	Requirements for adequate growth, development and maintenance of health (anemia, cognitive/behavioral function, cancer, cardiovascular disease)		

Dietary macronutrients	2012	NNR: Fogelholm et al. (264)	Dietary macronutrient consumption	Primary prevention of long-term weight/WC/body fat changes, or changes after weight loss		
Weight loss before conception	2012	NNR: Forsum et al. (265)	Weight loss before conception in overweight or obese women	Birth outcomes, childhood obesity/BMI obstetric risk, preeclampsia, postpartum weight retention, gestational diabetes mellitus, hypertension, postpartum depression, lactation, infant growth		
Iodine	2012	NNR: Gunnarsdottir et al. (266)	Iodine status	Requirements for adequate growth, development and maintenance of health (pregnancy, childhood development, thyroid function, metabolism		WCRF
Protein intake from 0 to 18 years of age	2013	NNR: Hörnell et al. (195)	Protein intake in infancy and childhood	Functional/clinical outcomes, risk factors (including serum lipids, glucose and insulin, blood pressure, body weight, bone health)		
Breastfeeding, introduction of other foods and effects on health	2013	NNR: Hörnell et al. (193)	Breastfeeding and introduction of other foods	Growth in infancy, overweight and obesity, atopic disease, asthma, allergy, health and disease outcomes including infectious disease, cognitive and neurological development, CVD, cancer, diabetes, blood pressure, glucose tolerance, insulin resistance)		
Vitamin D	2013	NNR: Lamberg-Allardt et al.(267)	Vitamin D	Dietary reference values, vitamin D status, requirements for adequate growth, development and maintenance of health, upper limits, pregnancy outcomes, bone health, cancer, diabetes, obesity, total mortality, CVD, infections		
Protein intake in elderly populations	2014	NNR: Pedersen et al.(268)	Protein intake in elderly populations	Dietary requirements (nitrogen balance), muscle mass, bone health, physical training, potential risks		
Protein intake in adults	2013	NNR: Pedersen et al.(269)	Protein intake, protein sources	Dietary requirements, markers of functional or clinical outcomes (including serum lipids, glucose and insulin, blood pressure), pregnancy or birth outcomes, CVD, body weight, cancer, diabetes, fractures, renal function, physical training, muscular strength, mortality		
Dietary fat	2014	NNR: Schwab et al.(270)	Types of dietary fat	Body weight, diabetes, CVD, cancer, all-cause mortality, risk factors (including serum lipids, glucose and insulin, blood pressure, inflammation)		
Sugar consumption	2012	NNR: Sonestedt et al.(271)	Sugar intake; sugar-sweetened beverages	Type 2 Diabetes, CVD, metabolic risk factors (including glucose tolerance, insulin sensitivity, dyslipidaemia, blood pressure, uric acid, inflammation), all-cause mortality		
Calcium	2013	NNR: Uusi-Rasi et al. (175)	Calcium	Calcium requirements, upper intake level, adequate growth, development and maintenance of health; bone health, muscle strength, cancer, autoimmune diseases, diabetes, obesity/weight control, all-cause mortality, CVD		

Health effects associated with foods characteristic of the Nordic diet	2013	NNR: Åkesson et al. (272)	Potatoes, berries, whole grains, dairy products, red meat/processed meat	CVD incidence and mortality, Type 2 diabetes, inflammatory factors, colorectal, prostate and breast cancer, bone health, iron status	NNR quality assessment tool	WCRF
Carbohydrates	2015	SACN (UK) (219)	Total carbohydrates, sugars, sugar-sweetened food/beverages, starch, starchy foods, dietary fibre, glycemic index/load	Obesity, cardio-metabolic health, energy intake, colorectal health (cancer, IBS, constipation), oral health	Cochrane RoB; observational studies: no formal grading, but markers of study quality = cohort size, attrition, follow-up time, sampling method and response rate, participant characteristics, dietary intake assessment	"Adequate", "moderate", "limited" (own grading system based on study quality, study size, methodological considerations, and specific criteria to upgrade, e.g. dose-response relationship)
Fish	2022	VKM (Norway), Scientific Committee for Food and Environment (208)	Fish/fish products, nutrients and contaminants in fish	CVD-outcomes, mortality, neurodevelopmental outcomes, birth outcomes, type 2 diabetes, bone health, dental enamel changes, overweight and obesity, immunological diseases, male fertility	NNR quality assessment tool (rated A, B or C), AMSTAR version 1	WCRF
Alcohol	2018	WCRF (166)	Alcoholic drinks (beer, wine, spirits, fermented milk, mead, cider)	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, skin)	Cochrane RoB / NOS	WCRF
Body fatness & weight gain	2018	WCRF (273)	Body fatness: BMI, waist circumference, W-H ratio; adult weight gain	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)		
Energy balance	2018	WCRF (147)	Dietary patterns, foods, macronutrietns, energy density, lactation, physical activity	Weight gain, overweight and obesity	From NICE (2014) report (low, moderate, high quality) (ref. Obesity: Identification, Assessment and Management of Overweight and Obesity in…)	
Height and birthweight	2018	WCRF (274)	Attained height, growth, birthweight	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)	Cochrane RoB / NOS	
Lactation	2018	WCRF (196)	Lactation	Cancer (including of breast, ovary, etc.) in the mother who is breastfeeding		
Meat, fish, dairy	2018	WCRF (209)	Meat, fish and dairy products, heam iron, diets high in calcium	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)		
Non-alcoholic drinks	2018	WCRF (275)	Non-alcoholic drinks: water/arsenic in drinking water, coffee, tea, mate	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)		

Other	2018	WCRF (276)	Dietary patterns, macronutrients, micronutrients in foods or supplements, glycemic load	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)		
Physical activity	2018	WCRF (277)	Physical activity, types of physical activity, intensity.	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)		
Preservation and processing	2018	WCRF (278)	Salting, curing, fermentation, smoking; processed meat and fish	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)		
Wholegrains, fruit, vegetables	2018	WCRF (203)	Wholegrains, pulses (legumes), vegetables, fruits, dietary fibre, aflatoxins, beta-carotene, carotenoids, vitamin C, isoflavones	Cancer (including of mouth, pharynx and larynx, esophagus, liver, colorectal, breast, kidney, stomach, lung, pancreas, gallbladder, ovary, prostate etc.)		
Sugars	2015	WHO (218)	Total, added or free sugars, sugar-sweetened beverages, fruit juice	Body weight, body fatness, dental caries	Cochrane RoB / cohort studies: own	GRADE
Sodium	2012	WHO (279)	Sodium intake/reduced sodium intake, sodium excretion	Cardiovascular diseases, all-cause mortality, blood pressure, renal function, blood lipids, potential adverse effects	Cochrane RoB	
Potassium	2012	WHO (280)	Potassium intake, 24 h urinary potassium excretion	Blood pressure, cardiovascular diseases, all-cause mortality, cholesterol, noradrenaline, creatinine, side effects	Cochrane RoB	
Trans-fats	2016	WHO (de Souza et al. 2015 (281); Brouwer et al. 2016 (282); Reynolds et al. 2022 (283)	Trans fatty acids	All-cause mortality, cardiovascular disease, type 2 diabetes; blood lipids	Cochrane RoB (for TFA and blood lipids) / NOS	
Saturated fats	2016	WHO (Hooper, 2015; Mensink, 2016; Te Morenga 2017; Reynolds 2022) (283-286)	Saturated fat reduction	Cardiovascular disease, mortality, blood lipids, other risk factors, growth (children)	Cochrane RoB, other potential sources of bias, e.g. compliance	
Carbohydrate quality	2019	WHO (Reynolds et al.) (157)	Markers of carbohydrate quality, i.e. dietary fibre, glycaemic index/load, whole grains	All-cause mortality, coronary heart disease, stroke, type 2 diabetes, colorectal cancer, adiposity-related cancers, adiposity, fasting glucose/insulin/insulin sensitivity/HbA1c, blood liipids, blood pressure	Cochrane RoB / NOS / ROBIS	
Omega-3, Omeg- 6 and polyunsaturated fat	2020	Brainard et al 2020 (287)	Higher vs lower omega-3, omega-6, or polyunsaturated fats	New neurocognitive illness, newly impaired cognition, and/or continuous measures of cognition	Cochrane RoB	GRADE

Appendix 3. NNR2023 modified AMSTAR2

As explained in the background paper (Shea et al., 2017), the reviewers should agree on how AMSTAR 2 should be used. It also emphasize that the “critical” domains are suggestions, and that reviewers add or substitute other critical domains. Further, their criteria for overall rating of reviews are “advisory”. These aspects are often overlooked.

To harmonize the quality appraisal, we have created a modified version of AMSTAR 2 that conforms better to the research questions for NNR 2023, instructions for scoping reviews, as well as the “Handbook” for de novo systematic reviews. We have also tried to make it more focussed on sources of bias in the review methodology.

It is emphasized that this tool also applies to systematic reviews including only observational studies. Of major changes, we have removed question 3, “Did the review authors explain their selection of the study designs for inclusion in the review?”, while question 12 and 13 have been combined into one question (question 11 in this version).

For the list of “critical” domains, we have changed question 7 (now 6), “Did the review authors provide a list of excluded studies and justify the exclusions?” to a non-critical domain, as it does not clearly address the internal validity of the review, and as it may have been subject to the journals’ space limitations. The Cochrane handbook also states that “The list of excluded studies should be as brief as possible”. We do still acknowledge that it is good practice to report excluded studies with justifications (and in line with the NNR 2022 “Handbook”), and have therefore not removed the item itself.

Finally, we have developed an “algorithm” for making the overall rating:

	Critical domains	Non-critical domains
High confidence	All YES, ***and***	0-2 NO
Moderate confidence	All YES, ***and***	3 or more NO
Low confidence	1 NO, ***and***	0-2 NO
Critically low confidence	1 NO, ***and***	3 or more NO
Critically low confidence	2 or more NO	

Thus, for “high” or “moderate” ratings, all critical domains must be fulfilled. If there are 2 or more critical domains lacking, it will receive a “critically low” rating regardless of the number of non-critical domains fulfilled.

The modified AMSTAR 2 form is available at the official NNR2023 web-page: (https://www.helsedirektoratet.no/english/nordic-nutrition-recommendations-2022#updatingchaptersofnnr).

Appendix 4. Growth curves and energy requirement estimations

Appendix will be finalized in the NNR2023 report available in June 2023.

Appendix 5. Principles and calculations of DRVs

Appendix will be finalized in the NNR2023 report available in June 2023.

Appendix 6. Vitamin D intake and serum 25OHD concentrations: Approaches to dose–response analyses

Rikke Andersen and Inge Tetens

Serum or plasma 25-hydroxyvitamin D (25OHD) concentration serves as a biomarker of total vitamin D exposure (D2 and D3) from oral sources (foods, fortification, supplements) and cutaneous synthesis. When obtained during periods of low exposure to UV-B irradiation from sunlight serum or plasma 25OHD concentration can be used as a biomarker of oral vitamin D intake.

A 25OHD concentration of 25 or 30 nmol/l represents a cut-of below which the risk of clinical vitamin D deficiency increases, manifested as nutritional rickets in children and osteomalacia in adults. Most expert agencies consider a 25OHD concentration of 50 nmol/l to reflect a sufficient vitamin D status concerning bone health.

In setting DRVs, different approaches have been used to analyse the dose-response relationship between vitamin D intake and 25OHD concentration. In this Appendix the different approaches are described.

<u>Institute of Medicine</u>

Regression analyses of the relationship between serum 25OHD concentrations and log-transformed total intake of vitamin D were undertaken by Institute of Medicine (IOM) in 2011 [1]. In this approach total vitamin D intake from diet and supplements are included in the analyses.

The analyses included results from randomized controlled (RCT) intervention trials with the following inclusion criteria:

- using total vitamin D intake (from food and supplements)
- carried out at latitudes above 49.5°N in Europe or Antarctica
- conducted during winter with limited sun exposure

In the first step in the dose-response analysis the analyses were performed separately on:

- children and adolescents (1-18 years), based on 3 studies
- young and middle-aged adults (19-60 years), based on 3 studies
- older adults (>61 years), based on 5 studies

In total 11 RCTs were included.

The response of serum 25OHD concentration to vitamin D intake was found to be non-linear, the rise being steeper below 25 µg/day and flattening above 25 µg/day. Regression analysis (n = 1376), was preceded by a log transformation of the total vitamin D intake data, since the log transformation was the best curvilinear fit. A significant association between dose and serum 25OHD levels was found. Baseline 25OHD concentrations and age was found to have no significant effect in the response of 25OHD concentration to total vitamin D intake.

Given the lack of an age effect, the second step included a single, combined regression analysis with study as a random effect. Besides, an analysis for latitudes 40–49°N during winter found that achieved 25OHD concentration was around 24% higher for a given total intake compared to that achieved in the previous analysis at higher latitudes, besides it explained less variability than the model at higher latitudes. Therefore, IOM decided to focus on latitude above 49.5°N to set DRVs for vitamin D.

IOM selected the estimated intakes needed to reach the targeted serum 25OHD values of 40 and 50 nmol/l. Using the dose-response curve and the lower limit of 95% CI, it was found that at a total intake of 10 µg/day, the predicted mean 25OHD concentration was 59 nmol/l in children and adolescents, young and middle-aged adults, and older adults with a lower limit of the CI of about 52 nmol/l. With the same approach it was found that at a total intake of 15 µg/day, the predicted mean 25OHD concentration was 63 nmol/l with a lower limit of the CI of 56 nmol/l. These results were used to set EARlike and RDAlike for vitamin D, respectively, which take into account the uncertainties in these analyses.

Nordic Council of Ministers

Regression analyses estimating the overall dose-response relationship between intake and serum 25OHD concentrations were undertaken by the Nordic Council of Ministers (NCM) in 2014 [2].

The analyses included results from RCTs with the following inclusion criteria:

- using vitamin D supplements at various levels
- carried out at latitudes covering the Nordic region or just south of (latitudes 50°-61° N)
- conducted during winter with limited sun exposure
- administered doses of vitamin D ≤ 30 µg/day.

The analyses were performed separately on:

- children and adults (up to about 60 years of age), based on 7 RCT studies
- older adults and elderly (above 65 years of age), based on 4 studies.

In total of 10 different RCTs conducted in the Nordic countries were included. However, due to the limited number of RCTs with elderly above 65 y, a repeated cross-sectional study with 8 sub-groups was also included.

The relationship between vitamin D supplementation intake and serum 25OHD concentrations (log transformed) was analysed using fitted line plot. The outcome was displayed by graphs.

Using the lower 95% confidence interval in the graph, an intake of about 10 µg/d was considered to be sufficient to ensure a serum 25OHD concentration about 50 nmol/l in the majority of the population. The AR was set as the intake maintaining a mean serum 25OHD concentration in half of the subjects of about 50 nmol/l. Using the lower 95% confidence interval in the graph, intakes sufficient to ensure a serum 25OHD concentration in the majority of the population were estimated, and used to set RI.

Scientific Advisory Committee on Nutrition

Meta-regression analyses and modelling of data on dose-response between vitamin D intake and 25OHD concentration from vitamin D RCTs in adults and adolescent girls were undertaken by Scientific Advisory Committee on Nutrition (SACN) in 2016 [3] by use of two different approaches: A meta-regression approach based on group means and an approach using data from individual participant data in vitamin D RCTs. The relationship between vitamin D intake and serum 25OHD concentration was explored during winter in various age-groups.

In the meta-regression approach, group mean or median serum 25OHD data from the intervention arms from selected RCTs were used together with an estimate of total vitamin D intake (from foods and supplements). The resulting regression line and its 95% confidence intervals were used to estimate average requirements (EAR) at group level.

In the approach using individual participant data from three vitamin D RCTs covering three different age groups [4–6], inter-individual variability estimates were obtained with the possibility to estimate the distribution of individual intakes required to achieve what SACN considered estimations of the distribution of intakes required to achieve specified serum 25OHD concentrations at the individual level. The mean serum 25OHD concentration was modelled as a linear function of vitamin D intake and 95% confidence intervals were calculated.

The inclusion criteria for the RCTs were that studies were conducted during winter with limited sun exposure.

The modelling exercise estimated average daily vitamin D intake required to maintain serum 25OHD concentration ≥25 nmol/l in winter by 97.5% of the population based on different analytical methods to measure 25OHD concentration.

Applying a precautionary basis, a serum 25OHD concentration of 25 nmol/l was selected as the target concentration to protect all individuals from the risk of poor musculoskeletal health. This concentration was considered to be a 'population protective level'; i.e., the concentration that 97.5% of individuals in the UK should be above, throughout the year, in terms of protecting musculoskeletal health.

The next step in estimating DRVs for vitamin D was translation of the serum 25OHD concentration of 25 nmol/l into a dietary intake value that represents the RNI for vitamin D; i.e., the average daily vitamin D intake that would be sufficient to maintain serum 25OHD concentration ≥ 25 nmol/l in 97.5% of individuals in the UK. The average vitamin D intake refers to the mean or average intake over the long term and takes account of day-to-day variations in vitamin D intake. The RNI was estimated by modelling data from individual RCTs in adults (men & women, 20-40 y and 64+ y) and adolescent girls (11 y). The RCTs had been conducted in winter so that dermal production of vitamin D was minimal.

The modelling exercise of individual data indicated that the estimated average daily vitamin D intake needed to maintain serum 25OHD concentration ≥ 25 nmol/l in winter by 97.5% of individuals in the population was 12 µg/d based on serum 25OHD analysis by LC-tandem MS or 9 µg/d based on analysis of the same sera by immunoassay. Since the target threshold serum 25OHD concentration of 25 nmol/l was based on studies which had used a range of different assays to measure serum 25OHD concentration, the RNI (safe level) was set between these 2 estimates, at 10 µg/d.

The work with Individual participant data (IPD) meta-regression analysis were continued years later among light-skin participants in RCTs with vitamin D fortified foods [7] and among dark-skinned participants in RCTs with supplements or vitamin D fortified foods [8]. One-stage IPD meta-analysis was performed in both studies.

The analyses included results from randomized controlled (RCT) intervention trials. The inclusion criteria were [7,8]:

- Age ≥2 years
- Latitudes ≥40°N
- Endpoint in winter
- Duration ≥6 weeks
- In [7]: Light-skinned participants (Fitzpatrick skin types V or VI was excluded)
- In [8]: Dark-skinned participants of Black or South Asian descent

In total 11 [7] and 10 [8] (6 studies on Blacks, 3 in South Asians and 1 mixed group dark-skinned) RCTs were included.

In [7] a log-log model was judged to be the best fit, and the analysis included an unadjusted model and a model adjusted for covariates (mean values for baseline 25OHD, age and BMI). In [8] a linear mixed regression model with vitamin D intake as the independent variable (a fixed effect) and square root-transformed 25OHD concentration as the dependent variable was used, and the analysis included an unadjusted model, as well as a model adjusted for covariates (mean values for baseline 25OHD, age and BMI). In both studies, the results are presented as vitamin D intake estimates required to maintain serum 25OHD above 25, 30 and 50 nmol/l.

<u>European Food Safety Authority</u>

Meta-analyses, meta-regression analyses and dose-response models estimating the dose-response relationship between total vitamin D intake and serum/plasma 25OHD concentration were undertaken by the European Food Safety Authority (EFSA) in 2016 [9]. As preparatory work, a comprehensive literature review was performed to identify and summarise studies that could be used to assess the dose-response relationship [10]. Data from prospective observational studies were analysed but not included in the meta-regression dose-response model, which was based on RCTs.

Meta-analyses:

- Inclusion criteria were:

o Young and older adults as well as children

o Vitamin D3 only

o Summary data available or possible to estimate/impute

o Dose of supplemented vitamin D ≤ 100 µg/day

After applying the inclusion criteria to the 57 RCTs from the review, the final data set included 83 arms from 35 RCTs, 4 of the RCTs (9 arms) were carried out on children. Absolute achieved mean values and mean differences were analysed to check for the inclusion of trials/arms in the dose-response analysis and to complement the results from the dose-response models. Mean differences in achieved mean 25OHD concentration were calculated for 30 RCTs (5 did not have control group).

Meta-regression and dose-response models:

The final data set included 83 arms from 35 RCTs, 4 of the RCTs (9 arms) were carried out on children. Weighted linear meta-regression analyses of total vitamin intake (habitual plus supplemental intake) vs. mean achieved serum or plasma 25OHD concentration measured at the end of the winter sampling points

- Two model constructs were explored:

  - o Non-linear (log linear): total vitamin D intake was transformed to the natural log (ln) before regression analysis

  - o Linear: mean achieved 25OHD concentrations were regressed to total vitamin D intake on its original scale (for doses > 35 µg/day)

- The log linear model was retained to better describe the dose-response shape and to be able to include results from higher dose trials.

- The models were adjusted and a detailed description of the regression analysis including handling of model fitting, baseline measurements, inter-individual variability on dietary intake, model checking diagnostics and influencing factors is described in EFSA 2016.

- Interpretation of the intervals drawn around the meta-regression lines:

  - o Confidence Intervals (CI): illustrates the uncertainty about the position of the line, i.e. across-study conditional means.

  - o Prediction Intervals (PI): illustrates the uncertainty about the true mean that would be predicted in a future study, i.e. the dispersion of the true effects around the mean.

The same equations were used both to predict the achieved mean serum 25OHD concentrations conditional to total vitamin D intakes of 5, 10, 15, 20, 50, 100 µg/day and to estimate the total vitamin D intakes that would achieve serum 25OHD concentrations of 50, 40, 30, 25 nmol/l and applied to all and to adults and children separately, respectively.

EFSA concludes that based on the available data, ARs and PRIs for vitamin D cannot be derived, and therefore defines AIs for all population groups and that the dietary intake of vitamin D estimated to achieve a serum 25OHD concentration of 50 nmol/l should be used for all age and sex groups.

Setting the AI was based on the prediction interval in the adjusted model of the meta-regression analysis of serum 25OHD concentration according to total vitamin D intake (natural log of the sum of habitual diet, and fortified foods and supplements using vitamin D3).

<u>Summary</u>

The different approaches that were used by different agencies [1–3,9] to define the relationship between vitamin D intake and serum 25OHD concentrations included meta-regression or regression analyses based at group mean (aggregate data) level. Also, an approach based on meta-regression analyses based on individual participant data (IPD) has been applied [3]. All approaches applied data from RCT studies conducted during the wintertime with no or little UV expose.

Using mean group level data for dose-response relationship follows the conventional approach used by IOM and NCM [1,2] in setting DRVs, using the mean findings from a group of individuals in a (meta)-regression line to estimate the AR value to achieve a specific and pre-defined serum 25OH concentration and its lower 95% confidence intervals to estimate the RI which theoretically covers the majority – or 97.5% of the population - at group level to reach a certain pre-defined threshold. This threshold is set based on separate analysis on the relationship between 25OHD concentration and health outcomes, which is also based on mean group level. The advantage of this approach is that it follows the conventional approach to set DRVs (AR and RI) [11] at group level, which is in accordance with the approach used setting the thresholds of sufficiency in the relationship between status and health outcomes. However, this group mean level does not take into account the inter-individual variability.

SACN used the dose-response relationship data to identify a safe level or RNI of vitamin D intake to maintain a 25OHD concentration above 25 nmol/l for 97.5% of the population. EFSA concluded that the available evidence does not allow the setting of ARs and PRIs for vitamin D, and therefore defines adequate intake (AI) for all population groups and that the dietary intake of vitamin D estimated to achieve a serum 25OHD concentration of 50 nmol/l should be used.

Using individual data from RCTs studying the dose-response relationship has the advantage that it takes into account the inter-individual variability. The available data from the IPD-papers [7,8] would allow the possibility to identify the intakes of vitamin D needed at the individual level to reach a certain threshold for 25OHD concentration. However, this approach requires that the threshold for sufficiency for the relationship between 25OHD concentration and health outcomes, which is up to now set based on mean group levels, is reconsidered.

References for Appendix 6

1. Dietary Reference Intakes for Calcium and Vitamin D; A. Catharine Ross, Christine L. Taylor, Ann L. Yaktine, Heather B. Del Valle, Committee to Review Dietary Reference Intakes for Vitamin D and Calcium; Food and Nutrition Board; Institute of Medicine, Eds.; National Academies Press, 2011; ISBN 978-0-309-16394-1.

2. Nordic Nutrition Recommendations 2012. Integrating Nutrition and Physical Activity. Nordic Council of Ministers 2014, Nord 2004:002, doi:http://dx.doi.org/10.6027/Nord2014-002.

3. Vitamin D and Health. Scientific Advisory Committee on Nutrition (SACN); 2016;

4. Cashman, K.D.; FitzGerald, A.P.; Viljakainen, H.T.; Jakobsen, J.; Michaelsen, K.F.; Lamberg-Allardt, C.; Mølgaard, C. Estimation of the Dietary Requirement for Vitamin D in Healthy Adolescent White Girls. American Journal of Clinical Nutrition 2011, 93, 549–555, doi:10.3945/ajcn.110.006577.

5. Cashman, K.D.; Wallace, J.M.W.; Horigan, G.; Hill, T.R.; Barnes, M.S.; Lucey, A.J.; Bonham, M.P.; Taylor, N.; Duffy, E.M.; Seamans, K.; et al. Estimation of the Dietary Requirement for Vitamin D in Free-Living Adults ≥64 y of Age. American Journal of Clinical Nutrition 2009, 89, 1366–1374, doi:10.3945/ajcn.2008.27334.

6. Cashman, K.D.; Hill, T.R.; Lucey, A.J.; Taylor, N.; Seamans, K.M.; Muldowney, S.; FitzGerald, A.P.; Flynn, A.; Barnes, M.S.; Horigan, G.; et al. Estimation of the Dietary Requirement for Vitamin D in Healthy Adults. American Journal of Clinical Nutrition 2008, 88, 1535–1542, doi:10.3945/ajcn.2008.26594.

7. Cashman, K.D.; Kiely, M.E.; Andersen, R.; Grønborg, I.M.; Madsen, K.H.; Nissen, J.; Tetens, I.; Tripkovic, L.; Lanham-New, S.A.; Toxqui, L.; et al. Individual Participant Data (IPD)-Level Meta-Analysis of Randomised Controlled Trials with Vitamin D-Fortified Foods to Estimate Dietary Reference Values for Vitamin D. European Journal of Nutrition 2021, 60, 939–959, doi:10.1007/s00394-020-02298-x.

8. Cashman, K.D.; Kiely, M.E.; Andersen, R.; Grønborg, I.M.; Tetens, I.; Tripkovic, L.; Lanham-New, S.A.; Lamberg-Allardt, C.; Adebayo, F.A.; Gallagher, J.C.; et al. Individual Participant Data (IPD)-Level Meta-Analysis of Randomised Controlled Trials to Estimate the Vitamin D Dietary Requirements in Dark-Skinned Individuals Resident at High Latitude. European Journal of Nutrition 2022, 61, 1015–1034, doi:10.1007/s00394-021-02699-6.

9. Bresson, J.L.; Burlingame, B.; Dean, T.; Fairweather-Tait, S.; Heinonen, M.; Hirsch-Ernst, K.I.; Mangelsdorf, I.; McArdle, H.; Naska, A.; Neuhäuser-Berthold, M.; et al. Dietary Reference Values for Vitamin D. EFSA Journal 2016, 14, doi:10.2903/j.efsa.2016.4547.

10. Elske M. Brouwer-Brolsma; Agnes A. M. Berendsen; Anouk M.M. Vaes; Carla Dullemeijer; Lisette C.P.G.M. de Groot; Edith J.M. Feskens EFSA Supporting Publications - Collection and Analysis of Published Scientific Information as Preparatory Work for the Setting of Dietary Reference Values for Vitamin D. EFSA supporting publication 2016:EN-766 2016.

11. Christensen, J.J.; Arnesen, E.K.; Andersen, R.; Eneroth, H.; Erkkola, M.; Høyer, A.; Lemming, E.W.; Meltzer, H.M.; Halldórsson, Þ.I.; Þórsdóttir, I.; et al. The Nordic Nutrition Recommendations 2022 – Principles and Methodologies. Food and Nutrition Research 2020, 64, 1–15.

REFERENCES

1. Nordic Council of Ministers. Nordic nutrition recommendations 2012: integrating nutrition and physical activity. Copenhagen: Nordic Council of Minsters; 2014.
2. IPCC. AR6 Synthesis Report (SYR). IPCC; 2023. https://www.ipcc.ch/report/sixth-assessment-report-cycle/.
3. Christensen JJ, Arnesen EK, Andersen R, Eneroth H, Erkkola M, Høyer A, et al. The Nordic Nutrition Recommendations 2022 – Principles and methodologies. Food Nutr Res. 2020; 64:4402. doi: 10.29219/fnr.v64.4402
4. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med. 2009;6(7):e1000100. doi: 10.1371/journal.pmed.1000100
5. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi: 10.1136/bmj.n71
6. Lundh A, Lexchin J, Mintzes B, Schroll JB, Bero L. Industry sponsorship and research outcome. Cochrane Database Syst Rev. 2017;2(2):MR000033. doi: 10.1002/14651858.MR000033.pub3
7. Hansen C, Lundh A, Rasmussen K, Hrobjartsson A. Financial conflicts of interest in systematic reviews: associations with results, conclusions, and methodological quality. Cochrane Database Syst Rev. 2019;8(8):MR000047. doi: 10.1002/14651858.MR000047.pub2
8. Arnesen EK, Christensen JJ, Andersen R, Eneroth H, Erkkola M, Høyer A, et al. The Nordic Nutrition Recommendations 2022 – Structure and rationale of systematic reviews. Food Nutr Res. 2020; 64:4403. doi: 10.29219/fnr.v64.4403
9. Arnesen EK, Christensen JJ, Andersen R, Eneroth H, Erkkola M, Høyer A, et al. The Nordic Nutrition Recommendations 2022 – Handbook for systematic reviews. Food Nutr Res. 2020;64 4404 doi: 10.29219/fnr.v64.4404
10. Høyer A, Christensen JJ, Arnesen EK, Andersen R, Eneroth H, Erkkola M, et al. The Nordic Nutrition Recommendations 2022 - prioritisation of topics for de novo systematic reviews. Food Nutr Res. 2021;65. doi: 10.29219/fnr.v65.7828
11. Sterne JA, Savovic J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898. doi:
12. Sterne JA, Hernan MA, Reeves BC, Savovic J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016;355:i4919. doi: 10.1136/bmj.i4919
13. Nutrition Evidence Systematic Review. Risk of Bias for Nutrition Observational Studies (RoB-NObs) Tool 2019. https://nesr.usda.gov/sites/default/files/2019-07/RiskOfBiasForNutritionObservationalStudies-RoB-NObs.pdf.
14. Arnesen EK, Thorisdottir B, Lamberg-Allardt C, Barebring L, Nwaru B, Dierkes J, et al. Protein intake in children and growth and risk of overweight or obesity: A systematic review and meta-analysis. Food Nutr Res. 2022; 66. doi: 10.29219/fnr.v66.8242
15. Thorisdottir B, Arnesen EK, Bärebring L, Dierkes J, Lamberg-Allardt C, Ramel A, et al. Legume consumption in adults and risk of cardiovascular disease or type 2 diabetes: A systematic review and meta-analysis. In press.
16. Lamberg-Allardt C, Bärebring L, Arnesen EK, Nwaru BI, Thorisdottir B, Ramel A, et al. Animal versus plant-based protein and risk of cardiovascular disease and type 2 diabetes: A systematic review of randomized controlled trials and prospective cohort studies. Food Nutr Res. 2023;67:9003. doi: 10.29219/fnr.v67.9003

17. Nwaru BI, Dierkes J, Ramel A, Arnesen EK, Thorisdottir B, Lamberg-Allardt C, et al. Quality of dietary fat and risk of Alzheimer's disease and dementia in adults aged >/=50 years: a systematic review. Food Nutr Res. 2022;66. doi: 10.29219/fnr.v66.8629
18. Bärebring L, Lamberg-Allardt C, Thorisdottir B, Ramel A, Arnesen EK, Nwaru BI, et al. Intake of vitamin B12 in relation to vitamin B12 status in groups susceptible to deficiency: A systematic review. In press.
19. Ramel A, Nwaru BI, Lamberg-Allardt C, Thoristdottir B, Bärebring L, Söderlund F, et al. White meat consumption and risk of cardiovascular disease and type 2 diabetes: a systematic review and meta-analysis. In press.
20. Bärebring L, Nwaru BI, Lamberg-Allardt C, Thorisdottir B, Ramel A, Soderlund F, et al. Supplementation with long chain n-3 fatty acids during pregnancy, lactation, or infancy in relation to risk of asthma and atopic disease during childhood: a systematic review and meta-analysis of randomized controlled clinical trials. Food Nutr Res. 2022;66. doi: 10.29219/fnr.v66.8842
21. Arnesen EK, Thorisdottir B, Barebring L, Soderlund F, Nwaru BI, Spielau U, et al. Nuts and seeds consumption and risk of cardiovascular disease, type 2 diabetes and their risk factors: a systematic review and meta-analysis. Food Nutr Res. 2023;67. doi: 10.29219/fnr.v67.8961
22. Dierkes J, Nwaru BI, Ramel A, Arnesen EK, Thorisdottir B, Lamberg-Allardt C, et al. Dietary fiber and growth, iron status and bowel function in children 0–5 years old: a systematic review. Food Nutr Res. 2023(67):9011. doi: 10.29219/fnr.v67.9011
23. Nordic Nutrition Recommendations 2022. Instructions to authors of chapter. https://www.helsedirektoratet.no/english/nordic-nutrition-recommendations-2022.
24. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 2018;169(7):467-73. doi: 10.7326/M18-0850
25. Harwatt H, Benton TG, Bengtsson J, Blomhoff R, Birgisdóttir BE, Brown KA, et al. Overview of food consumption and environmental sustainability – considerations in the Nordic and Baltic region. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
26. Eneroth H, Erkkola M, Halldorsson TI, Thorsdóttir I, Trolle HM. Challenges and opportunities when incorporating sustainability into food-based dietary guidelines in the Nordics. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
27. Alexander J, Olsen A-K. Selenium. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
28. Bjørke-Monsen A-L, Ueland PM. Vitamin B6. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022
29. Bjørke-Monsen A-L, Ueland PM. Folate. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022
30. Bjørke-Monsen AL, Lysne V. Vitamin B12. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
31. Brustad M, Meyer HE. Vitamin D. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
32. Carlsen H, Pajari A-M. Dietary fibre. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
33. Cloetens L, Ellegård L. Energy. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022/.

34. Freese R, Lysne V. Niacin (Vitamin B3). 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
35. Freese R, Aarsland T, Bjørkevoll M. Pantothenic acid. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
36. Gunnarsdóttir I, Brantsæter AL. Iodine. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
37. Henriksen C, Aaseth JO. Magnesium. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
38. Henriksen C, Bügel S. Chromium. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
39. Itkonen ST, Lamberg-Allardt C. Phosphorus. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022
40. Iversen PO, Fogelholm M. Fluid and Water Balance. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
41. Jula A. Sodium. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
42. Kippler M, Oskarsson A. Manganese. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
43. Kjellevold M, Kippler M. Fluoride. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
44. Lykkesfeldt J, Carr A. Vitamin C. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
45. Lysne V, Strandler HS. Riboflavin. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
46. Lyytinen A, Linneberg A. Vitamin K. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
47. Obeid R, Karlsson T. Choline. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022
48. Olsen T, Lerner UH. Vitamin A. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
49. Oskarsson A, Kippler M. Molybdenum. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
50. Solvik BS, Strand TA. Biotin. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
51. Sonestedt E, Øverby N. Carbohydrates. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
52. Strand TA, Mathisen M. Zinc. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
53. Strandler HS, Strand TA. Thiamin (Vitamin B1). 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
54. Toft U, Riis NL, Jula A. Potassium. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.

55. Uusi-Rasi K, Torfadóttir JE. Calcium. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
56. Domellöf M, Sjöberg A. Iron. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
57. Geirsdóttir OG, Pajari A-M. Protein. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
58. Hantikainen EM, Lagerros YT. Vitamin E. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
59. Henriksen C, Arnesen EK. Copper. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
60. Myhrstad M, Wolk A. Antioxidants and Phytochemicals. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
61. Retterstøl K, Rosqvist F. Fat and fatty acids. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
62. Thelle DS, Grønbæk M. Alcohol. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
63. Clarsen B, et al. The burden of diet-related diseases and dietary related diseases and dietary risk factors in the Nordic and Baltic countriesrisk factors in the Nordic and Baltic countries: A systematic analysis of the Global Burden of Diseases, Injuries, and Risk Factors Study 2021 for the Nordic Nutrition Recommendations. In press.
64. Lemming EW, Pitsi T. The Nordic Nutrition Recommendations 2022 - food consumption and nutrient intake in the adult population of the Nordic and Baltic countries. Food Nutr Res. 2022;66. doi: 10.29219/fnr.v66.8572
65. Borodulin K, Anderssen S. Physical activity: associations with health and summary of guidelines. In press.
66. Benton TG, Harwatt H, Høyer A, Meltzer HM, Trolle E, Blomhoff R. Assessing the environmental sustainability of diets – an overview of approaches and identificantion of 5 key considerations for comprehensive assessments. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
67. Jackson P, Holm L. Social and economic dimensions of sustainability. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
68. Trolle E, Erkkola M, Eneroth H, Halldorsson TI, Thorsdóttir I, Meltzer HM. Integrating sustainability into Food Based Dietary Guidelines – how far are we in investigating environmental sustainability of the Nordic diets? 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
69. Fadnes LT, Balakrishna R. Nuts and seeds. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
70. Holven K, Sonestedt E. Milk and dairy products. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
71. Meinilä J, Virtanen JK. Meat and meat products. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
72. Rosell M, Delisle C. Fruit juice. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.

73. Rosell M, Deslisle C. Potatoes. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
74. Rosell M, Fadnes LT. Vegetables, fruits, and berries. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
75. Rosqvist F, Niinistö S. Fats and oils. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
76. Skeie G, Fadnes LT. Cereals and cereal products. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
77. Sonestedt E, Lukic M. Beverages. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022
78. Torheim LE, Fadnes LT. Legumes/pulses. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
79. Ulven S, Torfadóttir JE. Fish, fish products and seafood. 2023. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
80. Vepsäläinen H, Sonestedt E. Sweets and other sugary foods. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
81. Virtanen JK, Larsson SC. Eggs. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
82. Hörnell A, Lagström H. Infant feeding. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
83. Juul F, Bere E. Ultra-processed foods. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
84. Svendsen M, Forslund HB. Meal patterns, including intermittent fasting. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
85. Vepsäläinen H, Linström J. Dietary patterns. 2022. Nordic Nutrition Recommendations 2023. Available from: https://www.helsedirektoratet.no/horinger/nordic-nutrition-recommendations-2022-nnr2022.
86. Boushey C, Ard J, Bazzano L, Heymsfield S, Mayer-Davis E, Sabate J, et al. Dietary Patterns and Growth, Size, Body Composition, and/or Risk of Overweight or Obesity: A Systematic Review. 2020. In: Dietary Patterns and Growth, Size, Body Composition, and/or Risk of Overweight or Obesity: A Systematic Review [Internet]. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35129906.
87. World Health Organization. WHO European Regional Obesity Report 2022. Copenhagen: WHO Regional Office for Europe; 2022.
88. Hjelmesæth J, Sjöberg A. Human body weight, nutrients, and foods: a scoping review. Food Nutr Res. 2022;66. doi: 10.29219/fnr.v66.8814
89. United Nations. Transforming our world: The 2030 Agenda for sustainable development. A/RES/70/1. New York, NY; 2015. https://sdgs.un.org/2030agenda.
90. Nordic Council of Ministers. The Nordic Region – towards being the most sustainable and integrated region in the world: Action Plan for 2021 to 2024 Copenhagen: Nordic Council of Ministers; 2020. https://pub.norden.org/politiknord2020-728/.
91. FAO, WHO. Sustainable healthy diets. Guiding principles. Rome, Italy; 2019. https://www.fao.org/3/ca6640en/ca6640en.pdf.

92. Sachs J, Lafortune G, Kroll C, Fuller G, Woelm F. Sustainable development report 2022. 2022. Contract No.: ISBN 978-1-009-21003-4 https://dashboards.sdgindex.org/.
93. Kinnunen P, Guillaume JHA, Taka M, D'Odorico P, Siebert S, Puma MJ, et al. Local food crop production can fulfil demand for less than one-third of the population. Nature Food. 2020;1(4):229-37. doi: 10.1038/s43016-020-0060-7
94. Daugbjerg C, Sønderskov KM. Environmental policy performance revisited: Designing effective policies for green markets. Political Studies. 2012;60:399-418. doi: 10.1111/j.1467-9248.2011.00910.x
95. Šūmane S, Kunda I, Tisenkopfs T, Pilvere I, Stokmane I, Zēverte-Rivža S. Small Farms' Development Strategies (Latvia). RETHINK Case Study Report. Riga, Latvia; 2015.
96. WholEUGrain. Whole Grain: definition, evidence base review, sustainability aspects and considerations for a dietary guideline. Copenhagen; 2021.
97. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for water. EFSA Journal. 2010;8(3). doi: 10.2903/j.efsa.2010.1459
98. National Academies of Sciences, Engineering and Medicine,. Guiding Principles for Developing Dietary Reference Intakes Based on Chronic Disease. Washington (DC): National Academies Press; 2017.
99. National Academies of Sciences, Engineering, and Medicine. Dietary Reference Intakes for Energy. Washington (DC): The National Academies Press; 2023.
100. Trolle E, et al. The Nordic Nutrition Recommendation 2022 – Use of Dietary Reference Values. In press.
101. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for vitamin A. EFSA Journal. 2015;13(3). doi: 10.2903/j.efsa.2015.4028
102. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for vitamin E as α ‐ tocopherol. EFSA Journal. 2015;13(7). doi: 10.2903/j.efsa.2015.4149
103. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA), Turck D, Bresson JL, Burlingame B, Dean T, Fairweather ‐ Tait S, et al. Dietary reference values for vitamin K. EFSA Journal. 2017;15(5). doi: 10.2903/j.efsa.2017.4780
104. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA), Turck D, Bresson JL, Burlingame B, Dean T, Fairweather ‐ Tait S, et al. Dietary reference values for thiamin. EFSA Journal. 2016;14(12). doi: 10.2903/j.efsa.2016.4653
105. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA), Turck D, Bresson JL, Burlingame B, Dean T, Fairweather ‐ Tait S, et al. Dietary Reference Values for riboflavin. EFSA Journal. 2017;15(8). doi: 10.2903/j.efsa.2017.4919
106. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for niacin. EFSA Journal. 2014;12(7). doi: 10.2903/j.efsa.2014.3759
107. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for pantothenic acid. EFSA Journal. 2014;12(2). doi: 10.2903/j.efsa.2014.3581
108. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Dietary Reference Values for vitamin B6. EFSA Journal. 2016;14(6). doi: 10.2903/j.efsa.2016.4485
109. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for biotin. EFSA Journal. 2014;12(2). doi: 10.2903/j.efsa.2014.3580
110. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for folate. EFSA Journal. 2014;12(11). doi: 10.2903/j.efsa.2014.3893
111. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for cobalamin (vitamin B12). EFSA Journal. 2015;13(7). doi: 10.2903/j.efsa.2015.4150
112. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for vitamin C. EFSA Journal. 2013;11(11). doi: 10.2903/j.efsa.2013.3418

113. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Scientific Opinion on Dietary Reference Values for calcium. EFSA Journal. 2015;13(5). doi: 10.2903/j.efsa.2015.4101
114. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for phosphorus. EFSA Journal. 2015;13(7). doi: 10.2903/j.efsa.2015.4185
115. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Dietary reference values for potassium. EFSA Journal. 2016;14(10). doi: 10.2903/j.efsa.2016.4592
116. National Academies of Sciences, Engineering, and Medicine. Dietary Reference Intakes for Sodium and Potassium. Washington, DC: National Academies Press; 2019. https://www.ncbi.nlm.nih.gov/books/NBK538102.
117. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for magnesium. EFSA Journal. 2015;13(7). doi: 10.2903/j.efsa.2015.4186
118. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for zinc. EFSA Journal. 2014;12(10). doi: 10.2903/j.efsa.2014.3844
119. Institute of Medicine Panel on Micronutrients. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington (DC): National Academies Press; 2001.
120. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Scientific Opinion on Dietary Reference Values for iodine. EFSA Journal. 2014;12(5). doi: 10.2903/j.efsa.2014.3660
121. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for selenium. EFSA Journal. 2014;12(10). doi: 10.2903/j.efsa.2014.3846
122. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for fluoride. EFSA Journal. 2013;11(8). doi: 10.2903/j.efsa.2013.3332
123. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for manganese. EFSA Journal. 2013;11(11). doi: 10.2903/j.efsa.2013.3419
124. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for molybdenum. EFSA Journal. 2013;11(8). doi: 10.2903/j.efsa.2013.3333
125. Amcoff E, Edberg A, Barbieri HE, Lindroos AK, Nälsén C, Pearson M, et al. Riksmaten – vuxna 2010-11: Livsmedels- och näringsintag bland vuxna i Sverige (Riksmaten- Adults 2010-11: Food and nutrition intakes among adults in Sweden). Uppsala; 2012. https://www.livsmedelsverket.se/globalassets/publikationsdatabas/rapporter/2011/riksmaten_2010_20111.pdf.
126. Pedersen AN, Christensen T, Matthiessen J, Kildegaard Knudsen V, Rosenlund Sørensen M, Biltoft-Jensen AP, et al. Danskernes kostvaner 2011-2013. Søburg; 2015.
127. Nurk E, Nelis K, Saamel M, Martverk M, Nelis L. National Dietary Survey among 11 - 74 years old individuals in Estonia. EFSA Supporting Publications. 2017;14(4). doi: 10.2903/sp.efsa.2017.EN-1198
128. Valsta L, Kaartinen N, Tapanainen H, Männistö S, Sääksjärvi K. Ravitsemus Suomessa – FinRavinto 2017 -tutkimus (Nutrition in Finland – The National FinDiet 2017 Survey). Helsinki; 2018.
129. Grīnberga D, Velika B, Pudule I, Gavare I, Villeruša A. Latvijas iedzīvotāju veselību ietekmējošo paradumu pētījums, 2020 (Health Behaviour among Latvian Adult Population, 2020). Riga; 2020. https://www.spkc.gov.lv/lv/media/16574/download.
130. Abel MH, Totland TH. Kartlegging av kostholdsvaner og kroppsvekt hos voksne i Norge basert på selvrapportering – Resultater fra Den nasjonale folkehelseundersøkelsen 2020 (Self reported dietary habits and body weight in adults in Norway – Results from the National Public Health Survey 2020). Oslo; 2020. https://www.fhi.no/globalassets/dokumenterfiler/rapporter/2021/rapport-nhus-2020.pdf.
131. Gunnarsdottir S, Gudmannsdottir R, Thorgeirsdottir H, Torfadottir JE, Steingrimsdottir L, Tryggvadottir EA, et al. Hvað borða Íslendingar? Könnun á mataræði Íslendinga 2019-2021 (What do Icelanders eat? Survey of the diet of Icelanders 2019-2021). Reykjavik; 2022. https://maturinnokkar.hi.is/wp-content/uploads/2022/03/Hvadbordaislendingar_vefur_endanlegt.pdf.

132. World Health Organization. Growth reference data for 5-19 years 2007. https://www.who.int/tools/growth-reference-data-for-5to19-years.
133. Juliusson PB, Roelants M, Nordal E, Furevik L, Eide GE, Moster D, et al. Growth references for 0-19 year-old Norwegian children for length/height, weight, body mass index and head circumference. Ann Hum Biol. 2013;40(3):220-7. doi: 10.3109/03014460.2012.759276
134. Saari A, Sankilampi U, Hannila ML, Kiviniemi V, Kesseli K, Dunkel L. New Finnish growth references for children and adolescents aged 0 to 20 years: Length/height-for-age, weight-for-length/height, and body mass index-for-age. Ann Med. 2011;43(3):235-48. doi: 10.3109/07853890.2010.515603
135. Tinggaard J, Aksglaede L, Sorensen K, Mouritsen A, Wohlfahrt-Veje C, Hagen CP, et al. The 2014 Danish references from birth to 20 years for height, weight and body mass index. Acta Paediatr. 2014;103(2):214-24. doi: 10.1111/apa.12468
136. Wikland KA, Luo ZC, Niklasson A, Karlberg J. Swedish population-based longitudinal reference values from birth to 18 years of age for height, weight and head circumference. Acta Paediatr. 2002;91(7):739-54. doi: 10.1080/08035250213216
137. EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA), Turck D, Castenmiller J, de Henauw S, Hirsch‐Ernst KI, Kearney J, et al. Dietary reference values for sodium. EFSA Journal. 2019;17(9). doi: 10.2903/j.efsa.2019.5778
138. Food-based dietary guidelines [Internet]. 2023. Available from: https://www.fao.org/nutrition/education/food-based-dietary-guidelines.
139. World Health Organization. Food based dietary guidelines in the WHO European Region. Copenhagen: WHO Regional Office for Europe; 2003.
140. FAO/WHO. Preparation and use of food-based dietary guidelines. Geneva: World Health Organization; 1996.
141. IPCC. Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK; 2022.
142. IPCC. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK; 2022.
143. IPBES. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn; 2019.
144. IPCC. IPCC Special Report on Climate Change and Land. Geneva; 2019. https://www.ipcc.ch/srccl/.
145. Guelinckx I, Tavoularis G, Konig J, Morin C, Gharbi H, Gandy J. Contribution of Water from Food and Fluids to Total Water Intake: Analysis of a French and UK Population Surveys. Nutrients. 2016;8(10). doi: 10.3390/nu8100630
146. World Cancer Research Fund/American Institute for Cancer Research. Body fatness and weight gain and the risk of cancer. London; 2018.
147. World Cancer Research Fund/American Institute for Cancer Research. Diet, nutrition and physical activity: Energy balance and body fatness. London; 2018.
148. National Institute for Health Development. Health Statistics and Health Research Database for Estonia 2021. https://statistika.tai.ee/pxweb/en/Andmebaas/Andmebaas__01Rahvastik/.
149. Salm E, Käärik E, Kaarma H. The growth charts of Estonian schoolchildren. Comparative analysis. Papers on Anthropology. 2013;22. doi: 10.12697/poa.2013.22.19
150. Pitsi T. Eesti toitumis- ja liikumissoovitused 2015. Tallinn; 2017.
151. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ. 2007;85(9):660-7. doi: 10.2471/blt.07.043497
152. EFSA Panel on Nutrition, Novel Foods and Food Allergens. Tolerable upper intake level for dietary sugars. EFSA J. 2022;20(2):e07074. doi: 10.2903/j.efsa.2022.7074

153. Dietary Guidelines Advisory Committee. Scientific Report of the 2020 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Agriculture and the Secretary of Health and Human Services. Washington, DC.; 2020. https://doi.org/10.52570/DGAC2020.
154. Jones JM. CODEX-aligned dietary fiber definitions help to bridge the 'fiber gap'. Nutr J. 2014;13:34. doi: 10.1186/1475-2891-13-34
155. McCleary BV, Sloane N, Draga A. Determination of total dietary fibre and available carbohydrates: A rapid integrated procedure that simulates in vivo digestion. Starch - Stärke. 2015;67(9-10):860-83. doi: 10.1002/star.201500017
156. Gill SK, Rossi M, Bajka B, Whelan K. Dietary fibre in gastrointestinal health and disease. Nat Rev Gastroenterol Hepatol. 2021;18(2):101-16. doi: 10.1038/s41575-020-00375-4
157. Reynolds A, Mann J, Cummings J, Winter N, Mete E, Te Morenga L. Carbohydrate quality and human health: a series of systematic reviews and meta-analyses. Lancet. 2019;393(10170):434-45. doi: 10.1016/S0140-6736(18)31809-9
158. Sarwar Gilani G, Wu Xiao C, Cockell KA. Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. Br J Nutr. 2012;108 Suppl 2:S315-32. doi: 10.1017/S0007114512002371
159. Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Washington, DC: National Academies Press; 2005.
160. Joint WHO/FAO/UNU Expert Consultation. Protein and amino acid requirements in human nutrition. World Health Organ Tech Rep Ser. 2007(935):1-265. doi:
161. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Scientific Opinion on Dietary Reference Values for protein. EFSA Journal. 2012;10(2). doi: 10.2903/j.efsa.2012.2557
162. Mayer-Davis E, Leidy H, Mattes R, Naimi T, Novotny R, Schneeman B, et al., editors. Alcohol Consumption and All-Cause Mortality: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews,; 2020.
163. Wild C, Weiderpass E, Stewart B, editors. World Cancer Report: Cancer research for cancer prevention. Lyon: International Agency for Research on Cancer; 2020.
164. GBD Alcohol Collaborators. Alcohol use and burden for 195 countries and territories, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet. 2018;392(10152):1015-35. doi: 10.1016/S0140-6736(18)31310-2
165. Canadian Centre on Substance Use and Addiction, Paradis C, Butt P, Shield K, Poole N, Wells S, et al. Canada's Guidance on Alcohol and Health: Final Report. Ottawa: Canadian Centre on Substance Use and Addiction; 2023.
166. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Alcoholoic drinks and the risk of cancer. 2018. dietandcancerreport.org
167. World Health Organization. Global status report on alcohol and health 2018. Geneva; 2018. https://www.who.int/publications/i/item/9789241565639.
168. Hallström E, Davis A, Woodhouse A, Sonesson U. Using dietary quality scores to assess sustainability of food products and human diets: A systematic review. Ecological Indicators. 2018;93:219-30. doi: j.ecolind.2018.04.071
169. Raederstorff D, Wyss A, Calder PC, Weber P, Eggersdorfer M. Vitamin E function and requirements in relation to PUFA. Br J Nutr. 2015;114(8):1113-22. doi: 10.1017/S000711451500272X
170. Institute of Medicine. Dietary Reference Intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline. Washington, DC: National Academies Press; 1998.
171. Allen LH, Miller JW, de Groot L, Rosenberg IH, Smith AD, Refsum H, et al. Biomarkers of Nutrition for Development (BOND): Vitamin B-12 Review. J Nutr. 2018;148(suppl_4):1995S-2027S. doi: 10.1093/jn/nxy201
172. Pallas health research and consultancy, Eeuwijk J, Oordt A, Terzikhan N, Noordegraaf.Schouten MV. Literature search and review related to specific preparatory work in the establishment of Dietary Reference Values for Niacin, Biotin and Vitamin B6. Supporting Publications. 2012;9(12):474. doi: 10.2903/sp.efsa

173. Allen LH, Carriquiry AL, Murphy SP. Perspective: Proposed Harmonized Nutrient Reference Values for Populations. Adv Nutr. 2020;11(3):469-83. doi: 10.1093/advances/nmz096
174. Newberry SJ, Chung M, Shekelle PG, Booth MS, Liu JL, Maher AR, et al. Vitamin D and Calcium: A Systematic Review of Health Outcomes (Update). Evid Rep Technol Assess (Full Rep). 2014(217):1-929. doi: 10.23970/AHRQEPCERTA217
175. Uusi-Rasi K, Karkkainen MU, Lamberg-Allardt CJ. Calcium intake in health maintenance - a systematic review. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.21082
176. Nordic Council of Ministers. Nordic Nutrition Recommendations 2012 – Integrating nutrition and physical activity. Copenhagen: Nordic Council of Ministers; 2014.
177. EFSA Panel on Dietetic Products NaAN. Scientific Opinion on the Tolerable Upper Intake Level of calcium. EFSA Journal. 2012;10(7). doi: 10.2903/j.efsa.2012.2814
178. Scientific Committee on Food, Scientific Panel on Dietetic Products, Nutrition and Allergies. Tolerable Upper Intake Levels for Vitamins and Minerals. Parma; 2006.
179. Scientific Committee for Food (SCF). Nutrient and energy intakes for the European Community. Luxembourg: Commission of the European Communities; 1993.
180. Newberry SJ, Chung M, Anderson CAM, et al. Sodium and Potassium Intake: Effects on Chronic Disease Outcomes and Risks (Comparative Effectiveness Review, No. 206). Rockville (MD): Agency for Healthcare Research and Quality; 2018.
181. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Scientific Opinion on Dietary Reference Values for iron. EFSA Journal. 2015;13(10). doi: 10.2903/j.efsa.2015.4254
182. Dold S, Zimmermann MB, Baumgartner J, Davaz T, Galetti V, Braegger C, et al. A dose-response crossover iodine balance study to determine iodine requirements in early infancy. Am J Clin Nutr. 2016;104(3):620-8. doi: 10.3945/ajcn.116.134049
183. Hurst R, Collings R, Harvey LJ, King M, Hooper L, Bouwman J, et al. EURRECA-Estimating selenium requirements for deriving dietary reference values. Crit Rev Food Sci Nutr. 2013;53(10):1077-96. doi: 10.1080/10408398.2012.742861
184. Xia Y, Hill KE, Li P, Xu J, Zhou D, Motley AK, et al. Optimization of selenoprotein P and other plasma selenium biomarkers for the assessment of the selenium nutritional requirement: a placebo-controlled, double-blind study of selenomethionine supplementation in selenium-deficient Chinese subjects. Am J Clin Nutr. 2010;92(3):525-31. doi: 10.3945/ajcn.2010.29642
185. Kristensen NB, Madsen ML, Hansen TH, Allin KH, Hoppe C, Fagt S, et al. Intake of macro- and micronutrients in Danish vegans. Nutr J. 2015;14:115. doi: 10.1186/s12937-015-0103-3
186. EFSA Panel on Nutrition, Novel Foods and Food Allergens, Turck D, Bohn T, Castenmiller J, de Henauw S, Hirsch-Ernst KI, et al. Scientific opinion on the tolerable upper intake level for selenium. EFSA J. 2023;21(1):e07704. doi: 10.2903/j.efsa.2023.7704
187. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Scientific Opinion on Dietary Reference Values for copper. EFSA Journal. 2015;13(10). doi: 10.2903/j.efsa.2015.4253
188. EFSA Scientific Committee, More SJ, Bampidis V, Benford D, Bragard C, Halldorsson TI, et al. Re‐evaluation of the existing health‐based guidance values for copper and exposure assessment from all sources. EFSA Journal. 2023;21(1). doi: 10.2903/j.efsa.2023.7728
189. EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA). Scientific Opinion on Dietary Reference Values for chromium. EFSA Journal. 2014;12(10). doi: 10.2903/j.efsa.2014.3845
190. Institute of Medicine. Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington (DC): National Academies Press; 1997.
191. EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA). Dietary Reference Values for choline. EFSA Journal. 2016;14(8). doi: 10.2903/j.efsa.2016.4484
192. World Cancer Research Fund/American Institute of Cancer Research. Diet, Nutrition, Physical Activity and Cancer: A Global Perspective. . London; 2018. dietandcancerreport.org.
193. Hörnell A, Lagstrom H, Lande B, Thorsdottir I. Breastfeeding, introduction of other foods and effects on health: a systematic literature review for the 5th Nordic Nutrition Recommendations. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.20823

194. National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, Food and Nutrition Board, Committee on Scoping Existing Guidelines for Feeding Recommendations for Infants and Young Children Under Age 2. Feeding Infants and Children from Birth to 24 Months: Summarizing Existing Guidance. Harrison M, Dewey K, editors. Washington (DC): National Academies Press; 2020.
195. Hörnell A, Lagström H, Lande B, Thorsdottir I. Protein intake from 0 to 18 years of age and its relation to health: a systematic literature review for the 5th Nordic Nutrition Recommendations. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.21083
196. World Cancer Research Fund/American Institute for Cancer Research. Lactation and the risk of cancer. London; 2018. dietandcancerreport.org.
197. FAO/WHO. Sustainable healthy diets - guiding principles. Rome; 2019. https://www.fao.org/3/ca6640en/ca6640en.pdf.
198. EFSA Panel on Nutrition, Novel Foods, Allergens a, Castenmiller J, de Henauw S, Hirsch-Ernst KI, Kearney J, et al. Appropriate age range for introduction of complementary feeding into an infant's diet. EFSA J. 2019;17(9):e05780. doi: 10.2903/j.efsa.2019.5780
199. Poore J, Nemecek T. Reducing food’s environmental impacts through producers and consumers. Science. 2018;360(6392):987-92. doi: 10.1126/science.aaq0216
200. Ahlgren S, Morell K, Hallström E. Mapping of biodiversity impacts and hotspot products in Nordic food consumption. Uppsala; 2022. http://urn.kb.se/resolve?urn=urn:nbn:se:ri:diva-59111.
201. Christensen LM, Biltoft-Jensen A. Scientific background for updating the recommendation for whole-grain intake. Copenhagen; 2022.
202. Bahadur KC K, Dias GM, Veeramani A, Swanton CJ, Fraser D, Steinke D, et al. When too much isn't enough: Does current food production meet global nutritional needs? PLoS One. 2018;13(10):e0205683. doi: 10.1371/journal.pone.0205683
203. World Cancer Research Fund/American Institute for Cancer Research. Wholegrains, vegetables and fruit and the risk of cancer. London; 2018. dietandcancerreport.org.
204. Boushey C, Ard J, Bazzano L, Heymsfield S, Mayer-Davis E, Sabate J, et al. Dietary Patterns and Breast, Colorectal, Lung, and Prostate Cancer: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020.
205. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Report. Judging the evidence. World Cancer Research Fund; 2018. Available from dietandcancerreport.org.
206. Nordic Council of Ministers. Soy intake and possible adverse health effects in Nordic children and pregnant women (unborn children). Copenhagen; 2020. https://www.norden.org/en/publication/soy-intake-and-possible-adverse-health-effects-nordic-children-and-pregnant-women.
207. Karlsson Potter H, Lundmark L, Röös E. Environmental impact of plant-based foods – data collection for the development of a consumer guide for plant-based foods. Lund; 2020. https://res.slu.se/id/publ/107935.
208. Norwegian Scientific Committee for Food and Environment (VKM), Lene Frost Andersen, Paula Berstad, Barbara Bukhvalova, Monica Carlsen, Lisbeth Dahl, et al. Benefit and risk assessment of fish in the Norwegian diet. Scientific Opinion of the Scientific Steering Committee of the Norwegian Scientific Committee for Food and Environment. VKM Report 2022:17. Oslo; 2022.
209. World Cancer Research Fund/American Institute for Cancer Research. Meat, fish, and dairy products and the risk of cancer. London; 2018. dietandcancerreport.org.
210. International Agency for Research on Cancer. IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. Red Meat and Processed Meat. Lyon: International Agency for Research on Cancer,; 2018.
211. FAO. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Rome; 2013.
212. Olff H, Ritchie ME. Effects of herbivores on grassland plant diversity. Trends in Ecology & Evolution. 1998;13:261-65. doi:

213. Norwegian Institute of Bioeconomy Research (NIBIO), Sickel H, et al. Biologisk mangfold i utmarkas kulturbetingete naturtyper - hvilken rolle spiller beitedyrene? . Oslo; 2021.
214. Collins SL, et al. Modulation of diversity by grazing and mowing in native tallgrass prairie. Science. 1998;280(5364):745-7. doi:
215. Vinnari E, M. V. Making the invisibles visible: Including animals in sustainability (and) accounting. Critical Perspectives on Accounting. 2022;82:102324. doi:
216. EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA), Turck D, Bohn T, Castenmiller J, de Henauw S, Hirsch-Ernst KI, et al. Tolerable upper intake level for dietary sugars. EFSA J. 2022;20(2):e07074. doi: 10.2903/j.efsa.2022.7074
217. FAO. Agricultural production statistics 2000–2020. FAOSTAT Analytical Brief Series No. 41. Rome; 2022. https://www.fao.org/3/cb9180en/cb9180en.pdf.
218. WHO. Guideline: Sugars intake for adults and children. Geneva, Switzerland; 2015.
219. Scientific Advisory Committee on Nutrition (SACN). Carbohydrates and Health. London: TSO; 2015.
220. Hauner H, Bechthold A, Boeing H, Brönstrup A, Buyken A, Leschik-Bonnet E, et al. Evidence-based guideline of the German Nutrition Society: carbohydrate intake and prevention of nutrition-related diseases. Ann Nutr Metab. 2012;60 Suppl 1:1-58. doi: 10.1159/000335326
221. Meltzer HM, et al. Country-specific challenges when aiming to incorporate sustainability into food-based dietary guidelines – the Nordics (and Baltics) as an example. In press.
222. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025. Washington, D.C.: USDA; 2020. Available from: www.DietaryGuidelines.gov.
223. Forde CG, Decker EA. The Importance of Food Processing and Eating Behavior in Promoting Healthy and Sustainable Diets. Annu Rev Nutr. 2022;42:377-99. doi: 10.1146/annurev-nutr-062220-030123
224. Sadler CR, Grassby T, Hart K, Raats M, Sokolović M, Timotijevic L. Processed food classification: Conceptualisation and challenges. Trends in Food Science & Technology. 2021;112:149-62. doi: 10.1016/j.tifs.2021.02.059
225. Tobias DK, Hall KD. Eliminate or reformulate ultra-processed foods? Biological mechanisms matter. Cell Metabolism. 2021;33(12):2314-5. doi: 10.1016/j.cmet.2021.10.005
226. Newberry SJ, Chung M, Anderson CAM, Chen C, Fu Z, Tang A, et al. Sodium and Potassium Intake: Effects on Chronic Disease Outcomes and Risks. Comparative Effectiveness Review No. 206. (Prepared by the RAND Southern California Evidence-based Practice Center under Contract No. 290-2015-00010-I.). Rockville, MD: Agency for Healthcare Research and Quality; 2018 June 2018.
227. Balk EM, Adam GP, Langberg V, Halladay C, Chung M, Lin L, et al. Omega-3 Fatty Acids and Cardiovascular Disease: An Updated Systematic Review. Evidence Report/Technology Assessment No. 223. (Prepared by the Brown Evidence-based Practice Center under Contract No. 290-2012-00012-I.). Rockville, MD: Agency for Healthcare Research and Quality; 2016 August 2016. www.effectivehealthcare.ahrq.gov/reports/final.cfm.
228. Newberry SJ, Chung M, Booth M, Maglione MA, Tang AM, O'Hanlon CE, et al. Omega-3 Fatty Acids and Maternal and Child Health: An Updated Systematic Review. Evidence Report/Technology Assessment No. 224. (Prepared by the RAND Southern California Evidence-based Practice Center under Contract No. 290-2012-00006-I.). Rockville, MD: Agency for Healthcare Research and Quality; 2016 October 2016. www.effectivehealthcare.ahrq.gov/reports/final.cfm.
229. Australian Government Department of Health. Australian and New Zealand Nutrient Reference Values for Sodium: Supporting Document 1: Systematic Literature Review. 2017. https://www.nrv.gov.au/resources.
230. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns and Risk of Cardiovascular Disease: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.

231. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns and Risk of Type 2 Diabetes: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
232. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns and Bone Health: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
233. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns and Neurocognitive Health: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
234. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns and Sarcopenia: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
235. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns and All-Cause Mortality: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
236. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns during Pregnancy and Gestational Weight Gain: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
237. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Dietary Patterns during Lactation and Human Milk Composition and Quantity: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
238. Donovan S, Dewey K, Novotny R, Stang J, Taveras E, Kleinman R, et al. Folic Acid from Fortified Foods and/or Supplements during Pregnancy and Lactation and Health Outcomes: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35289987.
239. Donovan S, Dewey K, Novotny R, Stang J, Taveras E, Kleinman R, et al. Omega-3 fatty acids from Supplements Consumed before and during Pregnancy and Lactation and Developmental Milestones, Including Neurocognitive Development, in the Child: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35289988.
240. Donovan S, Dewey K, Novotny R, Stang J, Taveras E, Kleinman R, et al. Maternal Diet during Pregnancy and Lactation and Risk of Child Food Allergies and Atopic Allergic Diseases: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35289989.
241. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. The Duration, Frequency, and Volume of Exclusive Human Milk and/or Infant Formula Consumption and Overweight and Obesity: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service,

Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
242. Dewey K, Bazzano L, Davis T, Donovan S, Taveras E, Kleinman R, et al. The Duration, Frequency, and Volume of Exclusive Human Milk and/or Infant Formula Consumption and Nutrient Status: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35315997.
243. Dewey K, Bazzano L, Davis T, Donovan S, Taveras E, Kleinman R, et al. Iron from Supplements Consumed During Infancy and Toddlerhood and Growth, Size, and Body Composition: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35324134.
244. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Vitamin D from Supplements Consumed during Infancy and Toddlerhood and Bone Health: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
245. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Beverage Consumption and Growth, Size, Body Composition, and Risk of Overweight and Obesity: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion, July 2020; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
246. Mayer-Davis E, Leidy H, Mattes R, Naimi T, Novotny R, Schneeman B, et al. Beverage Consumption During Pregnancy and Birth Weight: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35349234.
247. Mayer-Davis E, Leidy H, Mattes R, Naimi T, Novotny R, Schneeman B, et al. Added Sugars Consumption and Risk of Cardiovascular Disease: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35353466.
248. Snetselaar L, Bailey R, Sabate J, Van Horn L, Schneeman B, Bahnfleth C, et al. Types of Dietary Fat and Cardiovascular Disease: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35436064.
249. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Seafood Consumption during Pregnancy and Lactation and Neurocognitive Development in the Child: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
250. Snetselaar L, Bailey R, Sabate J, Van Horn L, Schneeman B, Spahn J, et al. Seafood Consumption during Childhood and Adolescence and Neurocognitive Development: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020. Available from: https://www.ncbi.nlm.nih.gov/pubmed/35436066.
251. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Seafood Consumption during Childhood and Adolescence and Cardiovascular Disease: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
252. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Frequency of Eating and Growth, Size, Body Composition, and Risk of Overweight and Obesity: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S.

Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
253. Heymsfield S, Boushey C, Leidy H, Mattes R, Kleinman R, Callahan E, et al. Frequency of Eating and Cardiovascular Disease: A Systematic Review. Alexandria (VA): USDA Nutrition Evidence Systematic Reviews; 2020.
254. 2020 Dietary Guidelines Advisory Committee and Nutrition Evidence Systematic Review Team. Frequency of Eating and Type 2 Diabetes: A Systematic Review. 2020 Dietary Guidelines Advisory Committee Project. Alexandria, VA: U.S. Department of Agriculture, Food and Nutrition Service, Center for Nutrition Policy and Promotion; 2020 July 2020. https://nesr.usda.gov/2020-dietary-guidelines-advisory-committee-systematic-reviews.
255. Dietary Guidelines Advisory Committee. Scientific Report of the 2015 Dietary Guidelines Advisory Committee: Advisory Report to the Secretary of Health and Human Services and the Secretary of Agriculture. Washington, DC; 2015. https://health.gov/our-work/food-nutrition/2015-2020-dietary-guidelines/advisory-report.
256. Wolfram G, Bechthold A, Boeing H, Ellinger S, Hauner H, Kroke A, et al. Evidence-Based Guideline of the German Nutrition Society: Fat Intake and Prevention of Selected Nutrition-Related Diseases. Ann Nutr Metab. 2015;67(3):141-204. doi: 10.1159/000437243
257. Bost M, Houdart S, Huneau JF, Kalonji E, Margaritis I, Oberli M. Literature search and review related to specific preparatory work in the establishment of Dietary References Values for Copper (Lot 3). . EFSA; 2012. Report No.: EN-302. [63 pp.]. www.efsa.europa.eu/publications.
258. Dhonukshe-Rutten RA, Bouwman J, Brown KA, Cavelaars AE, Collings R, Grammatikaki E, et al. EURRECA-Evidence-based methodology for deriving micronutrient recommendations. Crit Rev Food Sci Nutr. 2013;53(10):999-1040. doi: 10.1080/10408398.2012.749209
259. EFSA Panel on Dietetic Products N, Allergies. Scientific Opinion on principles for deriving and applying Dietary Reference Values. EFSA Journal. 2010;8(3):1458. doi: https://doi.org/10.2903/j.efsa.2010.1458
260. Buijssen M, Eeuwijk J, Noordegraaf-Schouten MV. Literature search and review related to specific preparatory work in the establishment of Dietary Reference Values for Riboflavin. EFSA; 2014. Report No.: EN-591, 245 pp. . www.efsa.europa.eu/publications.
261. Eeuwijk J, Oordt A, Noordergraaf-Schouten MV. Literature search and review related to specific preparatory work in the establishment of Dietary Reference Values for Phosphorus, Sodium and Chloride. EFSA; 2013. Report No.: 2013:EN-502, 388 pp. . www.efsa.europa.eu/publications.
262. Brantsæter AL, Olafsdottir AS, Forsum E, Olsen SF, Thorsdottir I. Does milk and dairy consumption during pregnancy influence fetal growth and infant birthweight? A systematic literature review. Food Nutr Res. 2012;56. doi: 10.3402/fnr.v56i0.20050
263. Domellöf M, Thorsdottir I, Thorstensen K. Health effects of different dietary iron intakes: a systematic literature review for the 5th Nordic Nutrition Recommendations. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.21667
264. Fogelholm M, Anderssen S, Gunnarsdottir I, Lahti-Koski M. Dietary macronutrients and food consumption as determinants of long-term weight change in adult populations: a systematic literature review. Food Nutr Res. 2012;56. doi: 10.3402/fnr.v56i0.19103
265. Forsum E, Brantsaeter AL, Olafsdottir AS, Olsen SF, Thorsdottir I. Weight loss before conception: A systematic literature review. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.20522
266. Gunnarsdottir I, Dahl L. Iodine intake in human nutrition: a systematic literature review. Food Nutr Res. 2012;56. doi: 10.3402/fnr.v56i0.19731
267. Lamberg-Allardt C, Brustad M, Meyer HE, Steingrimsdottir L. Vitamin D - a systematic literature review for the 5th edition of the Nordic Nutrition Recommendations. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.22671
268. Pedersen AN, Cederholm T. Health effects of protein intake in healthy elderly populations: a systematic literature review. Food Nutr Res. 2014;58. doi: 10.3402/fnr.v58.23364

269. Pedersen AN, Kondrup J, Borsheim E. Health effects of protein intake in healthy adults: a systematic literature review. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.21245
270. Schwab U, Lauritzen L, Tholstrup T, Haldorssoni T, Riserus U, Uusitupa M, et al. Effect of the amount and type of dietary fat on cardiometabolic risk factors and risk of developing type 2 diabetes, cardiovascular diseases, and cancer: a systematic review. Food Nutr Res. 2014;58. doi: 10.3402/fnr.v58.25145
271. Sonestedt E, Øverby NC, Laaksonen DE, Birgisdottir BE. Does high sugar consumption exacerbate cardiometabolic risk factors and increase the risk of type 2 diabetes and cardiovascular disease? Food Nutr Res. 2012;56. doi: 10.3402/fnr.v56i0.19104
272. Åkesson A, Andersen LF, Kristjansdottir AG, Roos E, Trolle E, Voutilainen E, et al. Health effects associated with foods characteristic of the Nordic diet: a systematic literature review. Food Nutr Res. 2013;57. doi: 10.3402/fnr.v57i0.22790
273. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Body fatness and weight gain and the risk of cancer 2018. dietandcancerreport.org
274. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Height and birthweight and the risk of cancer. 2018. dietandcancerreport.org
275. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Non-alcoholic drinks and the risk of cancer 2018. dietandcancerreport.org
276. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Other dietary exposures and the risk of cancer. 2018. dietandcancerreport.org
277. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Physical activity and the risk of cancer. 2018. dietandcancerreport.org
278. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report 2018. Preservation and processing of foods and the risk of cancer. 2018. dietandcancerreport.org
279. WHO. Guideline: Sodium intake for adults and children. Geneva; 2012.
280. Aburto NJ, Hanson S, Gutierrez H, Hooper L, Elliott P, Cappuccio FP. Effect of increased potassium intake on cardiovascular risk factors and disease: systematic review and meta-analyses. BMJ. 2013;346:f1378. doi: 10.1136/bmj.f1378
281. de Souza RJ, Mente A, Maroleanu A, Cozma AI, Ha V, Kishibe T, et al. Intake of saturated and trans unsaturated fatty acids and risk of all cause mortality, cardiovascular disease, and type 2 diabetes: systematic review and meta-analysis of observational studies. BMJ. 2015;351:h3978. doi: 10.1136/bmj.h3978
282. Brouwer IA. Effect of trans-fatty acid intake on blood lipids and lipoproteins: a systematic review and meta-regression analysis. Geneva: World Health Organization; 2016.
283. Reynolds A, Hodson L, R. dS, Tran Diep Pham H, Vlietstra L, Mann J. Saturated fat and trans-fat intakes and their replacement with other macronutrients: A systematic review and meta-analysis of prospective observational studies. Geneva: World Health Organization; 2022.
284. Hooper L, Martin N, Abdelhamid A, Davey Smith G. Reduction in saturated fat intake for cardiovascular disease. Cochrane Database Syst Rev. 2015(6):Cd011737. doi: 10.1002/14651858.Cd011737
285. Mensink RP. Effects of saturated fatty acids on serum lipids and lipoproteins: a systematic review and regression analysis. Geneva: World Health Organization; 2016.
286. Te Morenga L, Montez JM. Health effects of saturated and trans-fatty acid intake in children and adolescents: Systematic review and meta-analysis. PLoS One. 2017;12(11):e0186672. doi: 10.1371/journal.pone.0186672

287. Brainard JS, Jimoh OF, Deane KHO, Biswas P, Donaldson D, Maas K, et al. Omega-3, Omega-6, and Polyunsaturated Fat for Cognition: Systematic Review and Meta-analysis of Randomized Trials. J Am Med Dir Assoc. 2020;21(10):1439-50.e21. doi: 10.1016/j.jamda.2020.02.022