

Carbohydrate intake for adults and children

WHO guideline summary



World Health
Organization

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ISBN 978-92-4-008335-6 (electronic version)

ISBN 978-92-4-008336-3 (print version)

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Cataloguing-in-Publication (CIP) data. CIP data are available at <https://iris.who.int/>.

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Note

This document is a summary of a WHO guideline, the full version of which is available only in English and can be accessed at <https://www.who.int/publications/i/item/9789240073593>. This summary document does not contain all of the information found in the full guideline, but what it does contain has been extracted directly from the full guideline and is therefore identical to the information found in the full guideline. Anywhere in this summary document where “this guideline” or “the guideline” is used in the text, it refers to the full guideline document.

Guideline summary

Background

Noncommunicable diseases (NCDs) are the world's leading cause of death, responsible for an estimated 41 million of the 55 million deaths in 2019 (1). Nearly half of these deaths were premature (i.e. in people aged less than 70 years) and occurred in low- and middle-income countries (LMICs). Obesity is a risk factor for diet-related NCDs and is linked to millions of deaths globally (2, 3). In 2016, more than 1.9 billion adults aged 18 years and older were overweight (4) and, of these, more than 600 million were obese. The spotlight on prevention and management of NCDs and obesity has intensified recently as a result of the COVID-19 pandemic, as there is increasing recognition that those with obesity or certain NCDs are at increased risk of adverse outcomes associated with COVID-19 (5–9). Modifiable risk factors such as unhealthy diets, physical inactivity, tobacco use and harmful use of alcohol are major risk factors for NCDs and obesity. The quality of carbohydrates in the diet has been extensively explored as a potential modulator of NCD and obesity risk.

Carbohydrates are found in a wide variety of primarily plant-based foods and are the principal source of energy (i.e. calories) in the diets of many people. Metabolism of carbohydrates produces glucose, which is the primary source of metabolic “fuel” for the brain, and other organs and tissues of the body. Carbohydrates can be grouped in many different ways and referred to using a variety of terms. At the most basic level, carbohydrates comprise monosaccharide building blocks and can be categorized based on the degree of polymerization (i.e. number of connected monosaccharides) as either sugars (mono- and disaccharides), oligosaccharides (short-chain carbohydrates) or polysaccharides (i.e. starch) (10).

The concept of carbohydrate “quality” refers to the nature and composition of carbohydrates in a food or in the diet, including the proportion of sugars, how quickly polysaccharides are metabolized and release glucose into the body (i.e. digestibility), and the amount of dietary fibre (11–13). Carbohydrates that are slowly digested in the small intestine or pass through undigested are generally considered “high quality”, and rapidly digested carbohydrates such as sugars are considered “low quality”. Dietary fibre, in particular, is an important element of carbohydrate quality. It can be defined in various ways, although virtually all definitions share the concept that dietary fibre is resistant to digestion by enzymes in the small intestine of humans (10). Consumption of low-quality carbohydrates is often associated with poor overall dietary quality and may have a negative health impact, whereas consumption of high-quality carbohydrates is often associated with high overall dietary quality and has been shown to have a positive health impact (14). A high intake of free sugars, for example, is associated with increased risk of obesity and diet-related NCDs. Consequently, the World Health Organization (WHO) has previously issued guidance on limiting intake of free sugars (15). Conversely, high intakes of dietary fibre and consumption of foods generally containing high-quality carbohydrates – such as whole grains, fruits, vegetables and pulses – have been shown to broadly improve health (16–20).

The inclusion of dietary fibre and high-quality carbohydrates in the diet from whole grains, vegetables, fruits and pulses has long been recommended to improve and maintain cardiometabolic and overall health. Although current intakes of these nutrients and foods are highly variable across and within populations in different settings, they are generally low at the global level relative to recommended intakes in this guideline, and other national reference values (21–28). Low vegetable and fruit intake in LMICs is of particular concern: recent estimates suggest that less than 20–30% of individuals in many LMICs meet WHO recommendations for vegetable and fruit consumption (29, 30).

Objective, scope and methods

The objective of this guideline is to provide guidance on carbohydrate intake, including intake of dietary fibre and healthy food sources of carbohydrates, to be used by policy-makers, programme managers, health professionals and other stakeholders to promote healthy diets. The guideline was developed by the WHO Nutrition Guidance Expert Advisory Group (NUGAG) Subgroup on Diet and Health following the WHO guideline development process, as outlined in the *WHO handbook for guideline development* (31). This process includes a review of systematically gathered evidence by an international, multidisciplinary group of experts; assessment of the quality of that evidence via the Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework¹; and consideration of additional, potentially mitigating factors² when translating the evidence into recommendations. The guideline was reviewed by a group of external experts and feedback was solicited from interested stakeholders during public consultations. The guidance in this guideline replaces previous WHO guidance on carbohydrate intake, including that from the 1989 WHO Study Group on Diet, Nutrition and the Prevention of Chronic Diseases (32) and the 2002 Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases (33).

The evidence

Evidence from systematic reviews of randomized controlled trials (RCTs) and prospective observational studies conducted in adults (18, 34-39) found that higher dietary fibre intake may lead to small reductions in various measures of body fatness (*moderate to high* certainty evidence), and is associated with reduced risk of developing and/or dying from cardiovascular diseases (CVDs), type 2 diabetes and cancer (all *moderate* certainty evidence). Higher consumption of whole grains, vegetables, fruits and pulses is also associated with reduced risk of developing and/or dying from CVDs (*moderate* certainty evidence). Higher consumption of whole grains, vegetables and fruits is further associated with reduced risk of developing and/or dying from cancer (*moderate* certainty evidence). Higher consumption of whole grains (*moderate* certainty evidence) and pulses (*very low* certainty evidence) is associated with reduced risk of developing type 2 diabetes. Although evidence from studies assessing effects or associations of low glycaemic index and/or low glycaemic load foods and diets was reviewed, little consistency was seen in benefit on mortality or NCDs from observational studies (*very low to moderate* certainty evidence), and little to no improvement in cardiometabolic risk factors was seen in RCTs (*very low to high* certainty evidence). Direct evidence for health effects of dietary fibre, whole grains, vegetables, fruits and pulses in children was limited but was consistent with results observed for adults (40).

Interpreting the evidence

Several observations were made in interpreting the results of the systematic reviews, some based directly on data from the review and others supported by background questions and information that helps to establish the context for the recommendations (31). They are summarized below.

Impact on measures of body fatness. Evidence of minor weight loss was observed with higher intakes of dietary fibre, whole grains, vegetables, fruits and pulses³ in short-term RCTs of generally less than 6 months. Evidence for longer-term associations with body weight from prospective observational studies was consistent with effects observed in RCTs and generally suggestive of benefit (20, 41-43); however, the evidence from prospective observational studies is much more limited than the evidence from RCTs and was not formally included in the evidence base. Because the evidence for long-term impact on body weight is limited but consistent with both observed short-term effects on body weight assessed in RCTs and associations with disease outcomes observed in prospective cohort studies, and the evidence for disease outcomes was so robust and therefore sufficient on its own to justify the formulation of recommendations, emphasis was placed on the evidence for associations with disease outcomes in formulating the recommendations.

¹ <http://www.gradeworkinggroup.org/>

² These include desirable and undesirable effects of the intervention, priority of the problem that the recommendation addresses, values and preferences related to the recommendation in different settings, the cost of the options available to public health officials and programme managers in different settings, feasibility and acceptability of implementing the recommendation in different settings, and the potential impact on equity and human rights.

³ The 2019 systematic review (34) included a limited number of RCTs assessing the effects of pulse intake on measures of body fatness in the context of their dietary fibre content and found no significant effect on body weight. Evidence from a 2016 systematic review not formally included in the evidence base and more broadly assessing the effects of pulses on body weight with a larger number of trials reported a reduction in body weight with consumption of pulses (44).

Impact on intermediate markers and risk factors for cardiometabolic disease. Evidence of favourable changes in some intermediate markers and risk factors for cardiometabolic disease – including LDL cholesterol and fasting glucose levels was observed with higher intakes of dietary fibre in short-term RCTs of generally less than 6 months. However, when subgrouped by different sources of fibre (i.e. from whole grains, vegetables, fruits and pulses), evidence was less consistent, with little evidence of effects on intermediate markers and risk factors observed. This was somewhat unexpected, given the strong associations between intake of dietary fibre, whole grains, vegetables, fruits and pulses, but may reflect methodological considerations in the RCTs, including variation in trial duration and nature of the interventions employed. Nevertheless, the results are not inconsistent with results observed for disease outcomes in prospective cohort studies – that is, there is no evidence of unfavourable effects on intermediate markers or risk factors for cardiometabolic disease with higher intakes of dietary fibre, whole grains, vegetables, fruits or pulses.

Oral health outcomes. Lesser emphasis was placed on the results from the systematic review on oral health outcomes (35) when formulating recommendations because the data were limited, came from many different study types, were based on exposures not strictly consistent with the PICO questions, and were generally consistent with results from the other systematic reviews. Consequently, the results from this review are not reported in the GRADE evidence profiles found in the full guideline.

Glycaemic index and glycaemic load. In interpreting the results observed for lower glycaemic index and glycaemic load, the NUGAG Subgroup on Diet and Health noted that there was a lack of consistent benefit from diets with lower glycaemic index or glycaemic load in observational studies, and little to no improvement in cardiometabolic risk factors in RCTs associated with lower glycaemic index and glycaemic load. In addition, because the recommendations on carbohydrate intake were formulated in the context of other WHO guidance on healthy diets, a key consideration for the NUGAG Subgroup on Diet and Health is that glycaemic index and glycaemic load only provide information about how a food affects postprandial glucose levels; they do not take into consideration other potentially undesirable components of the food that may contribute to a reduction in diet quality. Because more robust, consistent evidence was available for the health benefits of foods containing dietary fibre and whole carbohydrate, the NUGAG Subgroup on Diet and Health concluded that providing guidance on dietary fibre and food sources of carbohydrate was the most effective means of addressing carbohydrate quality. Recommendations on glycaemic index and glycaemic load were therefore not made.

Identifying recommended levels of intake. Data from the dose–response analyses suggested additional benefits with dietary fibre intakes greater than 30 g per day, and vegetable and fruit intakes up to 800 g per day. However, the data on intakes at these levels were more limited and precluded definitive conclusions. Additionally, from a practical standpoint, it was considered prudent to identify recommended intakes at levels that had both robust evidence for health benefit and a likelihood that the intakes could be achieved in most, if not all, settings. Recommended intakes for dietary fibre, and vegetables and fruits were formulated accordingly.

A dose–response relationship was also observed between intake of whole grains and several outcomes. However, the NUGAG Subgroup on Diet and Health concluded that quantitative recommendations for whole grains would likely be more challenging to implement than those for dietary fibre or vegetables and fruits. This is because, unlike vegetables and fruits, whole grains are often not consumed directly but are consumed as part of prepared foods such as bread or pasta. As well, unlike dietary fibre, whole grains are generally not included in nutrient declarations and labels on packaged foods. Results for the dose–response relationships can be found in the 2019 systematic review by Reynolds et al. (34).

Adverse effects. Very few adverse effects were observed with higher intakes of dietary fibre, whole grains, vegetables, fruits or pulses. However, higher intake of dietary fibre or whole grains was associated with increased risk of endometrial cancer and prostate cancer, respectively, in prospective cohort studies. The certainty in the evidence for these two outcomes was *very low* and *low*, respectively, and there are no clear biological mechanisms that would explain these potential relationships. Additional evidence from case–control studies not formally included in the evidence review shows reduced risk of endometrial cancer with higher fibre intake (45) and reduced risk of prostate cancer with higher intake of whole grains (46). Consequently, the NUGAG Subgroup on Diet and Health did not feel that these observed associations

outweighed the robust associations observed between intake of dietary fibre and whole grains and reduced risk of cardiometabolic disease, other types of cancer and mortality. They further noted that additional research is needed to explore the observed associations. Additionally, consuming a diet with lower glycaemic load was associated with increased risk of cancer mortality; however, the evidence comes from a single prospective cohort study of *very low* certainty. As noted above, there is no clear biological mechanism that would explain this potential relationship, but given the limitations of glycaemic index and glycaemic load as described in bullet 4 above, it is difficult to make any firm conclusions about this observation.

Evaluating the evidence for children. Evidence for the health effects in children of consuming dietary fibre, whole grains, vegetables, fruits and pulses is limited, but is consistent with results observed in studies conducted in adults. Consequently, the NUGAG Subgroup on Diet and Health concluded that it would be appropriate to extrapolate the results obtained for adults to children. The calculations used in deriving the quantitative levels of intake of dietary fibre, and vegetables and fruit are described in the Annex.

Recommendations and supporting information

All recommendations should be considered in the context of other WHO guidelines on healthy diets, including those on sugars (15), sodium (47), potassium (48), total fat (49), saturated fatty acids and *trans*- fatty acids (50), polyunsaturated fatty acids (32)¹ and non-sugar sweeteners (51). An explanation of the strength of WHO recommendations can be found in Box 1.

WHO recommendations

1. WHO recommends that carbohydrate intake should come primarily from whole grains, vegetables, fruits and pulses (*strong recommendation*; relevant for all individuals 2 years of age and older).
2. In adults, WHO recommends an intake of at least 400 g of vegetables and fruits per day (*strong recommendation*).
3. In children and adolescents, WHO suggests the following intakes of vegetables and fruits (*conditional recommendation*):
 - 2–5 years old, at least 250 g per day
 - 6–9 years old, at least 350 g per day
 - 10 years or older, at least 400 g per day.
4. In adults, WHO recommends an intake of at least 25 g per day of naturally occurring dietary fibre as consumed in foods (*strong recommendation*).
5. In children and adolescents, WHO suggests the following intakes of naturally occurring dietary fibre as consumed in foods (*conditional recommendation*):
 - 2–5 years old, at least 15 g per day
 - 6–9 years old, at least 21 g per day
 - 10 years or older, at least 25 g per day.

Rationale and remarks

The following provides the reasoning (rationale) behind the formulation of the recommendations, as well as remarks designed to provide context for the recommendations and facilitate their interpretation and implementation.

¹ WHO guidance on polyunsaturated fatty acids is currently being updated.

Box 1. Strength of WHO recommendations

WHO recommendations can either be *strong* or *conditional*, based on a number of factors including overall certainty in the supporting scientific evidence, balance of desirable and undesirable consequences, and others as noted elsewhere in this summary.

Strong recommendations are those recommendations for which the WHO guideline development group is confident that the desirable consequences of implementing the recommendation outweigh the undesirable consequences. *Strong* recommendations can be adopted as policy in most situations.

Conditional recommendations are those recommendations for which the WHO guideline development group is less certain that the desirable consequences of implementing the recommendation outweigh the undesirable consequences or when the anticipated net benefits are very small. Therefore, substantive discussion amongst policy-makers may be required before a *conditional* recommendation can be adopted as policy.

The reasoning behind the strength of the recommendation(s) in this guideline is provided in the rationale for the recommendation(s). Additional information on assessing the strength of WHO recommendations can be found in the *WHO handbook for guideline development* (31).

Rationale for recommendation 1

- ▶ Recommendation 1 is based on evidence from seven systematic reviews that assessed the effects of higher compared with lower intakes of whole grains, vegetables and fruits, or pulses (18, 34–39). These systematic reviews found that higher intake of these foods reduced the risk of all-cause mortality and several NCDs. The overall certainty in the evidence for recommendation 1 was assessed as *moderate*.

For adults, findings supporting the recommendation include the following.

- Evidence of *moderate* certainty overall came from a systematic review of prospective observational studies demonstrating associations between higher intakes of whole grains and reduced risk of all-cause mortality, CVDs, coronary heart disease, type 2 diabetes and colorectal cancer (34).
- Evidence of *moderate* certainty overall came from a systematic review of prospective observational studies demonstrating associations between higher intakes of vegetables and fruits and reduced risk of all-cause mortality, CVDs, stroke, coronary heart disease, type 2 diabetes and cancer (19).
- Evidence of *moderate* certainty overall came from a systematic review of prospective observational studies demonstrating associations between higher intakes of pulses and reduced risk of CVDs, coronary heart disease and type 2 diabetes (38, 39).

For children and adolescents, findings supporting the recommendation include the following.

- Direct evidence for health effects of consumption of whole grains, vegetables, fruits and pulses by children and adolescents is limited. Because the health benefits of consuming these foods observed in adults are expected to also be relevant for children and adolescents, and the benefits observed in adulthood are likely to begin accruing in childhood, the recommendation as it pertains to children and adolescents is based on extrapolation of adult data without downgrading the strength of the recommendation. Limited evidence from a systematic review of prospective observational studies of intake of dietary fibre, whole grains, vegetables, fruits and pulses by children and adolescents (40) is consistent with that observed for adults. Results from studies included in this review were not amenable to meta-analysis. Although several studies suggested benefit from consumption of whole grains, vegetables, fruits or pulses in terms of body weight, blood lipids and glycaemic control, results from some studies suggested no effect, and results from a very small number of studies suggested increased body weight with increased vegetable intake (*very low* certainty evidence for all outcomes).
- ▶ Recommendation 1 was assessed as *strong* because evidence for benefit was observed directly for a number of critical health outcomes, and indirectly in the results for dietary fibre; the main dietary

sources of dietary fibre were whole grains, vegetables, fruits and pulses. Although assessed in adults, this evidence was also considered to be highly relevant for children and adolescents. With the exception of a small increase in risk of prostate cancer with higher whole grain intake (*low* certainty evidence), no undesirable effects were identified, and no mitigating factors were identified that would argue against including whole grains, vegetables, fruits and pulses as the primary sources of carbohydrates in the diet.

Rationale for recommendations 2 and 3

- ▶ Recommendations 2 and 3 are based on evidence of *moderate* certainty overall from a systematic review of prospective observational studies conducted in adults that assessed the health effects of higher compared with lower intake of vegetables and fruits (19). The systematic review found that higher intakes of vegetables and fruits were associated with reduced risk of all-cause mortality, CVDs, stroke, coronary heart disease, type 2 diabetes and cancer.
- ▶ The threshold of at least 400 g of vegetables and fruits per day was selected because a dose–response relationship was observed in the observational studies: risk for all outcomes except cancer decreased with intakes of vegetables and fruits up to 800 g per day, and the greater the intake, the greater the benefit. Evidence for intakes more than 800 g per day was limited. Although the greatest benefit was observed at intakes of 800 g per day, the steepest reduction in risk was up to 400 g per day, after which the effect levelled off for some outcomes. Furthermore, intakes of more than 400 g per day may be difficult to achieve in many settings. The threshold of 400 g per day was therefore selected as a feasible minimal level that would provide significant health benefits.
- ▶ Because evidence from studies conducted in children and adolescents is insufficient to derive quantitative recommendations on intakes for children, and the observed health benefits of consuming vegetables and fruits in studies of adults are expected to be relevant for all age groups, intakes for children and adolescents are extrapolated from values for adults, based on the different levels of energy intake at different stages of childhood and adolescence. Limited evidence from a systematic review of prospective observational studies in children and adolescents suggested that higher vegetable and fruit intakes are generally associated with improvements in body weight, blood lipids and glycaemic control (*very low* certainty evidence for all outcomes), with no evidence of undesirable effects (40). This further supports the recommended levels of vegetable and fruit intake for children.
- ▶ Recommendation 2 was assessed as *strong* because evidence for benefit was observed for a number of critical health outcomes across a wide range of intakes. The minimal value selected for vegetable and fruit intake was both associated with a significant benefit and an amount that many should be able to achieve. No undesirable effects were identified with consuming 400 g per day or more of vegetables and fruits, and no mitigating factors were identified that would argue against consuming vegetables and fruits at this level.
- ▶ Recommendation 3 was assessed as *conditional* because, although the evidence observed for benefit in adults is robust and is expected to also be relevant for children and adolescents, the values were calculated based on extrapolation of adult values. Because the values are based both on extrapolated data and mean reference energy expenditures, a conservative approach was taken, leading to a *conditional* recommendation.

Rationale for recommendations 4 and 5

- ▶ Recommendations 4 and 5 are based on evidence of *moderate* certainty overall from a systematic review of randomized controlled trials and prospective observational studies conducted in adults that assessed higher compared with lower intakes of dietary fibre (34). This systematic review found that higher intakes of dietary fibre led to favourable improvements in obesity and NCDs risk factors, and were associated with reduced risk of all-cause mortality, CVDs, stroke, coronary heart disease, type 2 diabetes and cancer.
- ▶ The threshold of at least 25 g per day was selected based on the dose–response relationship seen in the observational studies between dietary fibre intake and reduced risk for several NCD and mortality outcomes. This relationship was observed at intakes up to 40 g per day, but the number of studies reporting data began to taper off at 30 g or more per day. Evidence for intakes more than 40 g per day

was scarce. In studies comparing individuals with the lowest fibre intakes with those consuming discrete ranges of increasing intake, the range that demonstrated greatest benefit for the largest number of health outcomes was 25–29 g per day.

- ▶ Because evidence from studies conducted in children and adolescents is insufficient to derive quantitative recommendations on intakes for children, and the observed health benefits of consuming dietary fibre in studies of adults are expected to be relevant for all age groups, intakes for children and adolescents are extrapolated from values for adults, based on the different levels of energy intake and energy expenditure at different stages of childhood and adolescence. Limited evidence from a systematic review of prospective observational studies in children and adolescents suggested that higher dietary fibre intake is generally associated with improvements in body weight, blood lipids and glycaemic control (*very low* certainty evidence for all outcomes), with no evidence of undesirable effects (40). This further supports the recommended levels of dietary fibre intake for children.
- ▶ Recommendation 4 was assessed as *strong* because evidence for benefit was observed for a number of critical health outcomes across a wide range of intakes. The minimal value selected for dietary fibre intake was both associated with a significant benefit and an amount that many should be able to achieve. With the exception of increased risk of endometrial cancer with higher intakes of dietary fibre (*very low* certainty evidence), no undesirable effects were identified with dietary fibre intakes of at least 25 g per day, and no mitigating factors were identified that would argue against dietary fibre intake at this level.
- ▶ Recommendation 5 was assessed as *conditional* because, although the evidence observed for benefit in adults is robust and is expected to also be relevant for children and adolescents, the values were calculated based on extrapolation of adult values. Because the values are based both on extrapolated data and mean reference energy expenditures, a conservative approach was taken, leading to a *conditional* recommendation.

Remarks

- ▶ One of the original aims of updating the guidance on carbohydrate intake was to provide guidance on carbohydrate quality. Having considered the available evidence relating to food sources of carbohydrate and dietary fibre, starch digestibility and glycaemic response, as measured by glycaemic index and glycaemic load, the WHO NUGAG Subgroup on Diet and Health concluded that providing guidance on dietary fibre and food sources of carbohydrate with consistently demonstrated benefit in terms of important health outcomes was the most effective means of addressing carbohydrate quality.
- ▶ This guideline provides guidance on dietary fibre intake, and also updates the prior WHO recommendation on intakes of vegetables and fruits (32). The scope of this guideline does not include an update to the previously published range of carbohydrate intake as a percentage of total energy intake, which was determined largely by the energy intake remaining after defining amounts of dietary fat and protein intake (32). Consequently, this guideline does not include recommendations on the amount of carbohydrate that should be consumed, and carbohydrate intake should continue to be based on recommended levels of protein (32) and fat intake (49). Results from a 2018 meta-analysis suggest that a range of total carbohydrate intake appears to be compatible with a healthy diet (52). Intakes of approximately 40–70% of total energy intake as carbohydrate are associated with reduced risk of mortality compared with lower (<40%) or higher (>70%) intakes. This is largely consistent with the range of carbohydrate intakes resulting from current WHO guidance on protein intake (32) and recently updated guidance on total fat intake (49).
- ▶ In addition to the benefits of dietary fibre from whole grains, vegetables, fruits and pulses, these foods may also contain other compounds that have been associated with health benefits (53–55).
- ▶ The recommendations included in this guideline cover all types of whole grains, vegetables, fruits and pulses, with caveats relating to processing and preparation, as noted in the following remarks. A variety of such foods should be consumed, where possible.
- ▶ Although fresh vegetables and fruits are a good choice when and where they are available, in some settings they present a significant risk for foodborne illness. In areas where risk of foodborne illness is high, selecting vegetables and fruits with hard skins or peels that can be removed, thoroughly washing them with potable water, or consuming cooked or canned varieties can reduce the risk of illness (56).

- ▶ The recommendations covering vegetable and fruit intake are not limited to fresh vegetables and fruits. Evidence from the systematic reviews suggests health benefits from a wide range of vegetables and fruits, including those that are fresh, cooked, frozen or canned. However, an increased risk of all-cause mortality and CVDs was observed for tinned fruits in a small number of studies. Specific evidence for dried fruits and fruit juices in the systematic reviews is very limited, and results are inconsistent; however, both can be significant sources of sugars, as can fruit concentrates and fruit sugars (i.e. sugars and syrups obtained from whole fruits). All should therefore be consumed in accordance with WHO recommendations on free sugars intake (15). Similarly, although no specific evidence was identified for canned vegetables, some canned vegetables contain added sodium and should therefore be consumed in accordance with WHO recommendations on sodium intake (47).
- ▶ The method of preparation and the level of processing should be considered when consuming whole grains, vegetables, fruits and pulses, and should be compatible with other WHO macronutrient recommendations as indicated in the next point. For example, frying and addition of sauces or condiments can significantly increase the amount of fat, sugars or salt. Therefore, fresh foods, or foods that are minimally processed or modified beyond the treatment necessary to ensure edibility, without added fat, sugars or salt, are preferred.
- ▶ Whole grains contain the naturally occurring components of the kernel (i.e. bran, germ and endosperm). Some processed foods are labelled whole grain if these three components of the grain are included, regardless of the extent to which the grains have been processed, and highly processed products labelled as whole grain are becoming increasingly available (e.g. products containing flour from milled whole grains with added fat, sugar or salt). Because there is evidence to suggest that the naturally occurring structure of intact whole grains contributes to its observed health effects (57-59), minimal processing of whole grains beyond that necessary to ensure edibility is preferred.
- ▶ The source of dietary fibre in the prospective cohort studies included in the systematic reviews, upon which recommendations 4 and 5 are largely based, is fibre naturally occurring in foods and not extracted or synthetic fibre added to foods or consumed on its own (e.g. fibre supplements, capsules, powders). Although there was limited evidence for a reduction in total cholesterol with use of extracted or synthetic fibre, further research on disease outcomes associated with extracted or synthetic fibre is needed before conclusions on potential health benefits can be drawn. Therefore, the recommendations specifically cover dietary fibre that occurs naturally in foods.
- ▶ Plant-based foods – including whole grains, vegetables, fruits and pulses – contain some compounds that have been shown to inhibit absorption of certain nutrients, most notably minerals such as iron, zinc and calcium (60). These “antinutrients” include lectins, oxalates, phytates, goitrogens, phytoestrogens, tannins, saponins and glucosinolates, and many of these have also been shown to have health benefits unrelated to their impact on nutrient absorption. The extent to which an impact on nutrient absorption occurs varies from person to person. The inhibitory effect is generally observed only at very high intakes and in individuals with existing nutritional deficiencies; in the context of adequate, diverse diets, it is generally not significant. In addition, some simple methods of preparation, including soaking and heating, and more advanced methods, including germination and fermentation, appear to reduce the inhibitory potential. Therefore, most people can generally consume whole grains, vegetables, fruits and pulses with little to no risk. Those with nutritional deficiencies or at high risk for nutritional deficiencies – particularly undernourished children and those who rely heavily on foods containing these compounds as staple foods without much additional diversity in the diet – may need to adopt behaviours that minimize the ability of these compounds to inhibit absorption of other nutrients.
- ▶ These recommendations do not cover children under 2 years of age. However, whole grains, vegetables, fruits and pulses can be healthy sources of carbohydrates in complementary foods consumed by children from 6 months to 2 years of age, and are strongly preferred to foods containing free sugars.¹

¹ WHO recommends that infants should be exclusively breastfed for the first 6 months of life to achieve optimal growth, development and health. Thereafter, to meet their evolving nutritional requirements, infants should receive nutritionally adequate and safe complementary foods, while continuing to breastfeed for up to 2 years or beyond (61, 62).

Translation and implementation

The recommendation in this guideline should be considered in conjunction with other WHO guidance on healthy diets to guide effective policy actions and intervention programmes to promote healthy diets and nutrition, and prevent diet-related NCDs.

A detailed discussion of how the recommendations on carbohydrate intake might be implemented is beyond the scope of this guideline, however they can be considered by policymakers and programme managers when discussing possible measures, including:

- ▶ assessing current intakes of dietary fibre, vegetables and fruits in their populations relative to benchmarks;
- ▶ developing policy measures to increase intake of dietary fibre, whole grains, vegetables, fruits and pulses, where necessary, through a range of public health interventions, many of which are already being implemented by countries, including
 - nutrition labelling (i.e. mandatory nutrient declaration) and front-of-pack labelling systems
 - fiscal policies (i.e. subsidies) targeting foods containing dietary fibre, whole grains, vegetables, fruits and pulses
 - consumer education; and
- ▶ translating the recommendations into culturally and contextually specific food-based dietary guidelines that take into account locally available foods and dietary customs.

Providing overall dietary guidance is beyond the scope of this guideline because such guidance should be based on overall dietary goals that consider all required nutrients. However, it is feasible to achieve the recommendations in this guideline while respecting national dietary customs, because a wide variety of dietary fibre-containing wholegrains, fruits, vegetables and pulses are available in many countries.

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Annex

Calculation of values for children

Recommended levels of intake of dietary fibre, and vegetables and fruits for children were extrapolated from adult values by scaling down (or up, in the case of 10-year-olds) daily total energy expenditure (dTEE) estimates for children that considered a range of different body sizes and physical activity levels for both girls and boys. Calculations were made using information from the 2001 Joint FAO/WHO/United Nations University Expert Consultation on Human Energy Requirements (1). Separate dTEE values for boys and girls were averaged, yielding a single value for each age. Using an average adult intake of 2000 kcal/day, and 25 g of dietary fibre and 400 g of vegetables and fruits per day yields 0.0125 g of fibre and 0.2 g of vegetables and fruits per 1 kcal. Values are averaged across the age brackets used in the recommendations (i.e. 2–5 years, 6–9 years) and rounded to whole numbers. Because average energy expenditure in children and adolescents becomes greater than the value used for adults beginning at 10 years of age, values were not extrapolated beyond 10 years of age. Recommended intakes for children 10 years and older are therefore the same as for adults.

Age (years)	dTEE (kcal)	Fibre intake (g/day)	Average (g/day)	Vegetable + fruit intake (g/day)	Average (g/day)
2	1076	13.5	2–5 years: 15	215	2–5 years: 250
3	1193	14.9		239	
4	1290	16.1		258	
5	1388	17.4		278	
6	1488	18.6	6–9 years: 21	298	6–9 years: 350
7	1608	20.1		322	
8	1746	21.8		349	
9	1895	23.7		379	
10	2055	25.7	25	411	400

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