World Cancer Research Fund International

CUP GLOBAL
Cancer Update Programme

Unifying research on nutrition, physical activity and cancer

# Dietary and lifestyle patterns for cancer prevention:

## evidence and recommendations from CUP Global


American Institute for Cancer Research

World Cancer Research Fund

Wereld Kanker Onderzoek Fonds

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# Abbreviation list

**AICR** – American Institute for Cancer Research
**CUP Global** – Global Cancer Update Programme
**DLP** – Dietary and Lifestyle Pattern
**The Panel** – CUP Global Expert Panel

# Foreword

This report is the latest contribution of World Cancer Research Fund (WCRF) International's Global Cancer Update Programme (CUP Global). CUP Global analyses scientific research on the links between modifiable risk factors related to diet, nutrition, physical activity and body weight and cancer. This report provides a comprehensive evaluation of the available global evidence on the link between dietary and lifestyle patterns and cancer risk. From that evaluation, it brings forward recommendations for the public and the scientific community, and outlines considerations for policy.

For effective non-communicable disease prevention, such as cancer, modifiable risk factors should be viewed holistically. Interactions take place at different levels: nutrients within a food, and foods with each other. To add to this complexity, dietary patterns are themselves correlated with other health-related behaviours. Singling out the effects of individual nutrients or foods does not fully account for the integrated effects of diet and other modifiable behaviours on cancer risk – these are best captured through studying dietary and lifestyle patterns.

Approaching risk factors for cancer holistically also has benefits when communicating recommendations to the public. Dietary and lifestyle patterns have greater 'real life' meaning, as individuals do not eat foods or nutrients in isolation but follow a pattern of behaviours. Promoting the combinations of foods and other behaviour-related factors that best protect health allows for more complete public health messaging and supports more comprehensive policy strategies. As the research field increasingly embraced this more holistic approach, WCRF International has seized the opportunity to use these findings with the view to improve our understanding of how modifiable risk factors impact cancer risk. This approach does not come at the expense of granularity, and specific elements of diet are still described.

Following the 2018 Third Expert Report, WCRF International looked to deepen our existing knowledge of global dietary and lifestyle patterns. This new work area for WCRF International signifies a move to more nuanced reviews, with a specific focus and investigating the impact on specific cancers. The reviews were commissioned with a focus on breast and colorectal cancer; the second and third most common cancers globally. As they are also the two most common cancers influenced by dietary and lifestyle patterns, they provide us with the greatest information on the effects of patterns on cancer risk.

The CUP Global process is robust, rigorously reviewing the evidence and incorporating expert opinion. The diligent work of multiple research teams from across the world, along with meticulous application of the CUP Global process by the Secretariat, provided the CUP Global Expert Panel with a thorough review of the available evidence. This included evidence from epidemiological studies and for potential biological mechanisms which underpin these associations. The Expert Panel judged the strength of this evidence and made recommendations for cancer preventive dietary and lifestyle pattern for breast and colorectal cancer. The totality of the evidence was brought together in a recommendation for overall cancer prevention, which allows for a more holistic view of cancer prevention that is more practical and translatable at a population level.

Since the publication of the Second Expert Report in 2007, WCRF International has been calling for global, national and local actors to take action to improve global health so that more are able to live healthier lives. This report reinforces this and presents considerations for policymakers so their citizens are supported in following a cancer preventative dietary and lifestyle pattern. The Cancer Prevention Blueprint, recently published by the WCRF International Policy and Public Affairs team, outlines policy recommendations to support the WCRF/AICR cancer prevention recommendations. The blueprint therefore provides a means to support the development of healthy environments. The current report provides further rationale for environments which support adherence to healthy dietary and lifestyle patterns. Such supportive environments, where healthy dietary and lifestyle patterns that are sustainable environmentally, economically and socially can be practiced by all people, cannot be established without major changes to current food systems. This requires bold global action, as food systems are built across national borders. Policymakers need to work together to ensure the needs of all individuals are addressed.

The efforts of the research teams undertaking the CUP Global reviews, combined with discussions held at CUP Global Expert Panel meetings, highlighted limitations in current dietary and lifestyle patterns research. In some cases, this limited the Panel's ability to form strong conclusions on the strength of the evidence. The dietary and lifestyle patterns research community has grown considerably, and we hope that the quality of studies will continue to improve. In this report, WCRF International also includes recommendations for future research to strengthen this crucial growing research area.

It is WCRF International's view that the analysis and recommendations presented here are an important summation of the associations between the available evidence on dietary and lifestyle patterns and breast and colorectal cancer risk. Moreover, they present a unique opportunity to reframe our thinking of how modifiable behavioural risk factors interact with each other and how comprehensive policies are needed to shape the environment and make it supportive of healthy behaviours. Implementing the recommendations within this report would be a game changer for global public health.

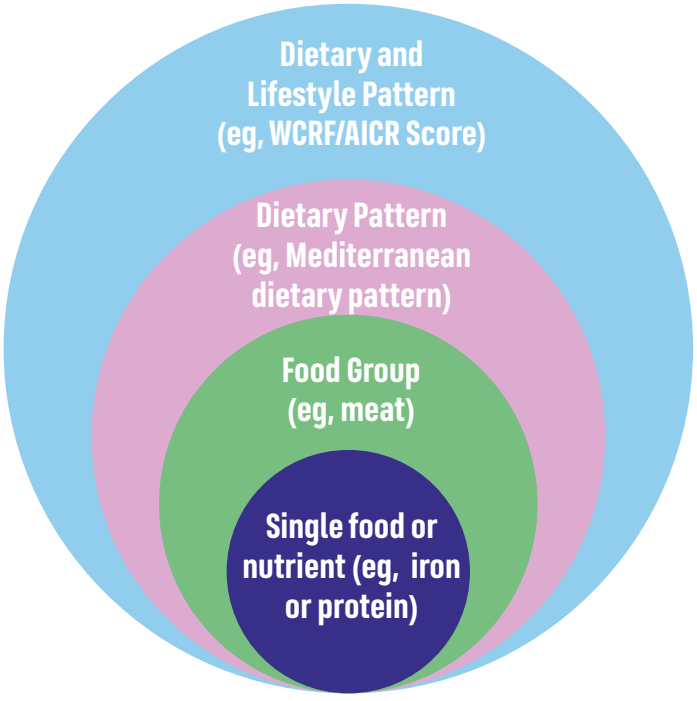
**Francesco Branca**
*Invited Professor, Institute of Global Health, University of Geneva*

# Executive summary

## Background

Breast and colorectal cancer are the second and third most common cancers worldwide, making up 12% and 10% of all new cancers in 2022, respectively. Research demonstrates that risk factors relating to aspects of an unhealthy diet, low physical activity levels and increased body-mass index increase incidence of both cancers. While the majority of cancer cases are diagnosed in the over 50s, rates of early-onset breast and colorectal cancers are rising.

Individuals have a pattern of living and, as part of this, consume foods made of nutrients. Therefore, the study of individual nutrients, as well as patterns, is important. Focusing solely on the relationships between single nutrients or food groups and cancer risk brings several limitations when trying to understand the impact of modifiable risk factors on cancer risk. Using approaches which consider diet, and other various lifestyle factors as an integrated pattern, can show how these components of lifestyle act synergistically. Researchers have categorised these into 1) dietary patterns and 2) dietary and lifestyle patterns – the former including only elements related to the diets we eat, while the latter includes additional lifestyle-related modifiable factors such as physical activity, bodyweight and breastfeeding. See the below figure for more information.




There is increasing demand for reliable, evidence-based recommendations on dietary and dietary and lifestyle patterns for cancer prevention. This is a key reason why World Cancer Research Fund (WCRF) International has sought to summarise and interpret the available evidence.

This report is from WCRF International's Global Cancer Update Programme (CUP Global): the world's largest source of scientific research on cancer prevention and survivorship through diet, nutrition, physical activity and body weight. While the 2018 WCRF/AICR Third Expert Report on Diet, Nutrition, Physical Activity and Cancer: A Global Perspective reviewed the strength of the evidence between dietary and dietary and lifestyle patterns and cancer, only limited evidence was found for cancers of the mouth, pharynx and larynx. Since 2018, approaches for studying dietary and lifestyle patterns and non-communicable diseases has continued advancing, and WCRF International has refined its methodology for systematically reviewing the relationships between dietary and dietary and lifestyle patterns and cancer risk. Additionally, there is a growing body of evidence which suggests that the more of the 2018 WCRF/AICR Cancer Prevention Recommendations are followed, the lower the cancer risk.

## Aims of this report

Our current report focuses on providing clarity on the evidence on how dietary and dietary and lifestyle patterns affect cancer risk.

The report also outlines barriers that may prevent populations adhering to a healthy dietary and lifestyle pattern. We hope that the recommendations presented in this report are not only adapted for specific cultures, but that policymakers understand that meaningful changes to dietary and lifestyle are unlikely to occur without supportive societal policies. Additionally, we hope that the research recommendations presented in the report can be used by epidemiologists and the wider research community to allow for deeper understanding of dietary and lifestyle patterns evidence in the future.

## Evidence underpinning this report

This report summarises the latest research on dietary and lifestyle patterns and breast and colorectal cancers. CUP Global collaborators at the Health Research Institute of the Balearic Islands and the Harvard T.H. Chan School of Public Health carried out comprehensive reviews on dietary and lifestyle patterns and breast and colorectal incidence and mortality.

Data from 84 publications were analysed on breast cancer incidence and mortality, and 86 studies were analysed for colorectal cancer, with a wide variety of different patterns looked at for each cancer type. An independent panel of experts graded the strength of this evidence using WCRF International's pre-determined criteria to give a final evidence judgement for each pattern.

The patterns which were found to have associations between breast and colorectal cancers overlapped in their components. This led the Panel to, instead of providing guidance or recommendations on the individual patterns, develop an overall recommendation for each cancer. The Panel then looked at the evidence as a whole and developed an overarching recommendation for cancer prevention more generally.

## Recommendation for a DLP for cancer prevention, with specific considerations for breast and colorectal cancer

**For cancer prevention, follow a healthy dietary pattern, aim to be physically active, maintain a healthy body weight and avoid smoking.**

**In such a dietary pattern, fruit, vegetables and fibre containing foods are prioritised.**

**For colorectal cancer prevention,** there is a specific recommendation to include calcium-containing foods (such as dairy products) and coffee in this dietary pattern, with strong wording on avoiding processed meats.

**For breast cancer prevention,** there is stronger wording on avoiding alcohol, due to consistent evidence showing that any amount of alcohol increases breast cancer risk.

This is not intended to supersede the 2018 WCRF/AICR Cancer Prevention Recommendations, but to support them. The evidence presented in the current report further demonstrates that these recommendations work as an integrated pattern.

## *Considerations for policymakers to promote a cancer preventative DLP*

To enable individuals to follow our recommendation for a cancer preventative dietary and lifestyle pattern, policymakers need to ensure that their citizens not only understand the importance of adhering to our recommendations for cancer prevention, but that they live in an environment which is conducive to this. There are a number of key points that should be considered by policymakers at all levels to support adherence to a healthy dietary and lifestyle pattern for cancer prevention:

- *It is important that our recommendation for a cancer preventative dietary and lifestyle pattern is tailored to the region. This will only be adopted by individuals and communities, and be sustainable if it is seen as culturally acceptable. Because of this, we made every effort to ensure that the constituents are not prescriptive but can be adapted to include foods available globally.*
- *When developing or updating food-based dietary guidelines, awareness of how the diet impacts, and is impacted by, our changing climate should be communicated.*
- *For further policy tools to promote our recommendations and our dietary and lifestyle pattern, please refer to WCRF International's Policy Blueprint. This includes principles for design and implementation of policies, and how policies can be developed to address health inequalities.*

WCRF International acknowledges that, as a result of the current food system, a sustainable healthy dietary and lifestyle pattern is not currently achievable in all areas of the world. This will only be possible with substantial changes to both diets and food systems, especially in high income countries where agriculture and food production and distribution, specifically that which is animal-based, are particularly resource intensive.

## *Recommendations for future research on DLPs*

At WCRF International, our panel of experts and the Cancer Incidence Expert Committee are continually discussing how the evidence base within incidence research can be strengthened. We have agreed upon several key areas:

- *Studies should aim to ensure that all relevant confounders, especially those specific to the cancer of interest, are adjusted for.*
- *Data on confounders, as well as the relevant exposures, should be assessed using the most accurate methods possible. The ability to collect repeat measures on both exposures and any relevant confounders throughout a study's follow-up period is considered a particular strength.*
- *For all commonly studied patterns, standardised scoring systems to measure adherence need to be developed. Where these standardised scoring systems already exist, these should be used.*
- *All studies looking at the alignment of populations to dietary and lifestyle patterns should consider, and report on, the demographic diversity of the study population. Few studies on dietary patterns or dietary and lifestyle patterns are currently conducted in Africa or South America, and we encourage research in these areas.*

Highlighting limitations in the current research evidence base enables us to look to the future with insights on where further, high-quality, research is needed.

# Summary of the evidence on DLPs and breast and colorectal cancer risk and CUP Global Panel recommendations

| PATTERN TYPES AND COMPONENTS | | | | EVIDENCE | RECOMMENDATIONS |
|---|---|---|---|---|---|
| | Pattern name & type | Main foods & behaviours included in this pattern | | Evidence conclusion | |
| | | More of these: | Less of these: | | |
| **Patterns strongly associated with a decreased risk of cancer** | WCRF/ AICR Cancer Prevention score* | • Keeping weight within a healthy BMI range<br>• Physical activity<br>• Wholegrains & fibre containing foods<br>• Vegetables<br>• Fruits | • "Fast foods" and other foods high in fat, starches and salt<br>• Red and processed meat<br>• Sugar sweetened beverages<br>• Alcohol consumption | Strong evidence that following the WCRF/AICR score is associated with a reduced risk of breast and colorectal cancer<br>Evidence grading: strong probable | *For cancer prevention, follow a healthy dietary pattern, aim to be physically active, maintain a healthy body weight and avoid smoking.*<br><br>We recommend that people follow a dietary pattern which prioritises fibre-containing foods, fruits and vegetables, they maintain a healthy body weight and are physically active. They should also restrict their alcohol and red and processed meat consumption.<br><br>*Specific recommendations for breast cancer:*<br>• **we recommend avoiding alcohol consumption**<br><br>*Specific recommendations for colorectal cancer:*<br>• **we recommend avoiding processed meat**<br>• **we recommend including calcium containing foods and coffee as part of your dietary pattern** |
| **Patterns strongly associated with an increased risk of cancer** | Empirical Lifestyle Index for Hyper-insulinemia* | • Higher BMI<br>• Liquor/alcoholic drinks<br>• Butter<br>• Red meat<br>• Fruit juice | • Physical activity<br>• Coffee<br>• Fruits (whole)<br>• Wine<br>• High fat dairy | Strong evidence that following this pattern is associated with an increased risk of colorectal cancer<br>Evidence grading: strong probable | |
| | Empirical Dietary Index for Hyperin-sulinemia* | • Red and processed meat<br>• Poultry<br>• Butter<br>• French fries<br>• Tomatoes<br>• Low fat dairy | • Coffee<br>• Whole fruits<br>• Wine<br>• High fat dairy<br>• Green leafy vegetables | Strong evidence that following this pattern is associated with an increased risk of colorectal cancer<br>Evidence grading: strong probable | |
| | Empirical Dietary Inflammatory Pattern* | • Red and processed meat<br>• Refined grains<br>• Sugar sweetened beverages<br>• Tomatoes<br>• Fish (excluding dark meat fish) and seafood | • Beer<br>• Wine<br>• Tea & coffee<br>• Dark yellow, and leafy green vegetables<br>• Fruit juice | Strong evidence that following this pattern is associated with an increased risk of colorectal cancer<br>Evidence grading: strong probable | |
| **Patterns with limited evidence of an association with decreased risk of cancer** | American Cancer Society Guidelines* | • Physical activity<br>• Keeping weight within a healthy BMI range<br>• Fruits and vegetables<br>• Wholegrains & fibre containing cereals | • Red and processed meat<br>• Sugar sweetened beverages<br>• Highly processed foods and refined grain products | Limited evidence that suggests following this pattern is associated with a reduced risk of colorectal cancer<br>Evidence grading: limited suggestive | |

*For more information about the development and scoring of these patterns, and how they relate to our recommendations, please see the full report.

## Summary of the evidence on DLPs and breast and colorectal cancer risk and CUP Global Panel recommendations (continued)

| PATTERN TYPES AND COMPONENTS | | | | EVIDENCE | RECOMMENDATIONS |
|---|---|---|---|---|---|
| | Pattern name & type | Main foods & behaviours included in this pattern | | Evidence conclusion | |
| | | More of these: | Less of these: | | |
| **Patterns with limited evidence of an association with decreased risk of cancer** | Mediterra-nean type dietary pattern* | • Fruits and vegetables<br>• Nuts & seeds<br>• Legumes and fibre-containing grains and cereals<br>• Fish and seafood<br>• Olive oil<br>*Some variants of this pattern also include red wine* | • Red and processed meat<br>• Dairy products (in most patterns) | Limited evidence that suggests following this pattern is associated with a reduced risk of colorectal cancer<br>Evidence grading: limited suggestive | *For cancer prevention, follow a healthy dietary pattern, aim to be physically active, maintain a healthy body weight and avoid smoking.*<br><br>We recommend that people follow a dietary pattern which prioritises fibre-containing foods, fruits and vegetables, they maintain a healthy body weight and are physically active. They should also restrict their alcohol and red and processed meat consumption.<br><br>*Specific recommendations for breast cancer:*<br>• **we recommend avoiding alcohol consumption**<br>*Specific recommendations for colorectal cancer:*<br>• **we recommend avoiding processed meat**<br>• **we recommend including calcium containing foods and coffee as part of your dietary pattern** |
| | Health Eating Index (HEI & the Alternative Healthy Eating Index (AHEI)* | Both the HEI and AHEI include fruits, vegetables and wholegrains<br>*HEI includes dairy, and the AHEI also includes legumes, nuts and moderate alcohol intake as beneficial* | Both HEI and AHEI: salt, added sugars and saturated fats.<br>AHEI also limits dairy | Limited evidence that suggests following this pattern is associated with a reduced risk of colorectal cancer<br>Evidence grading: limited suggestive | |
| | The Dietary Approaches to Stop Hypertension Diet* | • Fruits and vegetables<br>• Nuts & seeds<br>• Legumes and fibre containing cereals<br>• Dairy | • Sugar sweetened beverages<br>• Salt<br>• Red and processed meat | Limited evidence that suggests following this pattern is associated with a reduced risk of colorectal cancer<br>Evidence grading: limited suggestive | |
| | Prudent/ vegetarian/ Mediterra-nean-type* | • Fruits and vegetables<br>• Legumes<br>• Fish and seafood<br>*Some studies also included cereals, poultry, dairy and olive oil/ unsaturated fatty acids in these patterns* | | Limited evidence that suggests following this pattern is associated with a reduced risk of breast cancer<br>Evidence grading: limited suggestive | |
| **Patterns with limited evidence of an association with increased risk of cancer** | Western/ Meat/ Alcohol* | • Potatoes<br>• Grains and cereals<br>• Red and processed meats<br>• Eggs<br>• Snacks, sweets and ultra processed foods<br>*Some studies also included alcohol, poultry, dairy products and sugar sweetened beverages in these patterns* | | Limited evidence that suggests following this pattern is associated with an increased risk of breast cancer<br>Evidence grading: limited suggestive | |

# Purpose of this overview

There exists globally a multitude of dietary and dietary and lifestyle patterns (DLPs). Our aim for this document is to provide clarity on the evidence for the association between the most widely published DLPs and cancer incidence and mortality, to support DLP-related recommendations for cancer prevention. Here, we aim to achieve this by:

- Providing an overview of the work conducted as part of the Global Cancer Update Programme (CUP Global) regarding DLPs and cancer incidence to date. It does this by:
    - summarising the history of DLPs research within CUP Global,
    - drawing overarching conclusions from the most recent set of CUP Global reviews; these looked specifically at DLPs and breast and colorectal cancer incidence and mortality.
- Outlining recommendations on DLP for the prevention of these cancers, based on the evidence conclusions drawn from these reviews.
- Bringing together the recommendations for the individual cancer types by proposing a recommendation for overall cancer prevention and outline the rationale for this.
- Placing the recommendation for overall cancer prevention in its wider environmental and policy context. In doing so, we hope this document can serve as a valuable resource for other organisations to gain an understanding of the barriers present for some populations in adopting or maintaining a healthy DLP, as well as how adhering to such a DLP has implications beyond cancer prevention.

Studies on DLPs were included in the Second and Third Expert Reports.[1, 2] However, this is the first time that evidence on adherence to DLPs for cancer prevention has been systematically reviewed and judged using the CUP Global grading criteria. This is also the first-time the evidence has been judged to be sufficiently strong for the independent CUP Global Expert Panel (herein referred to as the Panel) to make specific recommendations on DLPs. The robust process of synthesis and analysis, and the Panel's evidence-based recommendations ensure that World Cancer Research Fund International provides an authoritative voice as our recommendations are based on only the evidence the Panel has judged to be high quality and with strong evidence of causality.

## Who this report is for

The information included in this report has been developed for those with an interest in, and desire to communicate about, the current state of the evidence regarding the associations between DLPs and cancer risk, and their wider role in cancer prevention. This includes, but is not limited to:

- Civil society, patient, and charitable organisations (e.g. cancer charities),
- Researchers working in the areas of diet, nutrition, physical activity, body weight, and cancer,
- Policymakers in public health settings,
- Health professionals looking to provide evidence-based recommendations on preventing cancer,
- Individuals with an interest in diet, nutrition and physical activity, especially with the view to reducing cancer risk.

This overview can be accessed by anyone seeking a deeper understanding of the science underpinning the recommendations, and their wider potential implications.

# Introduction to CUP Global

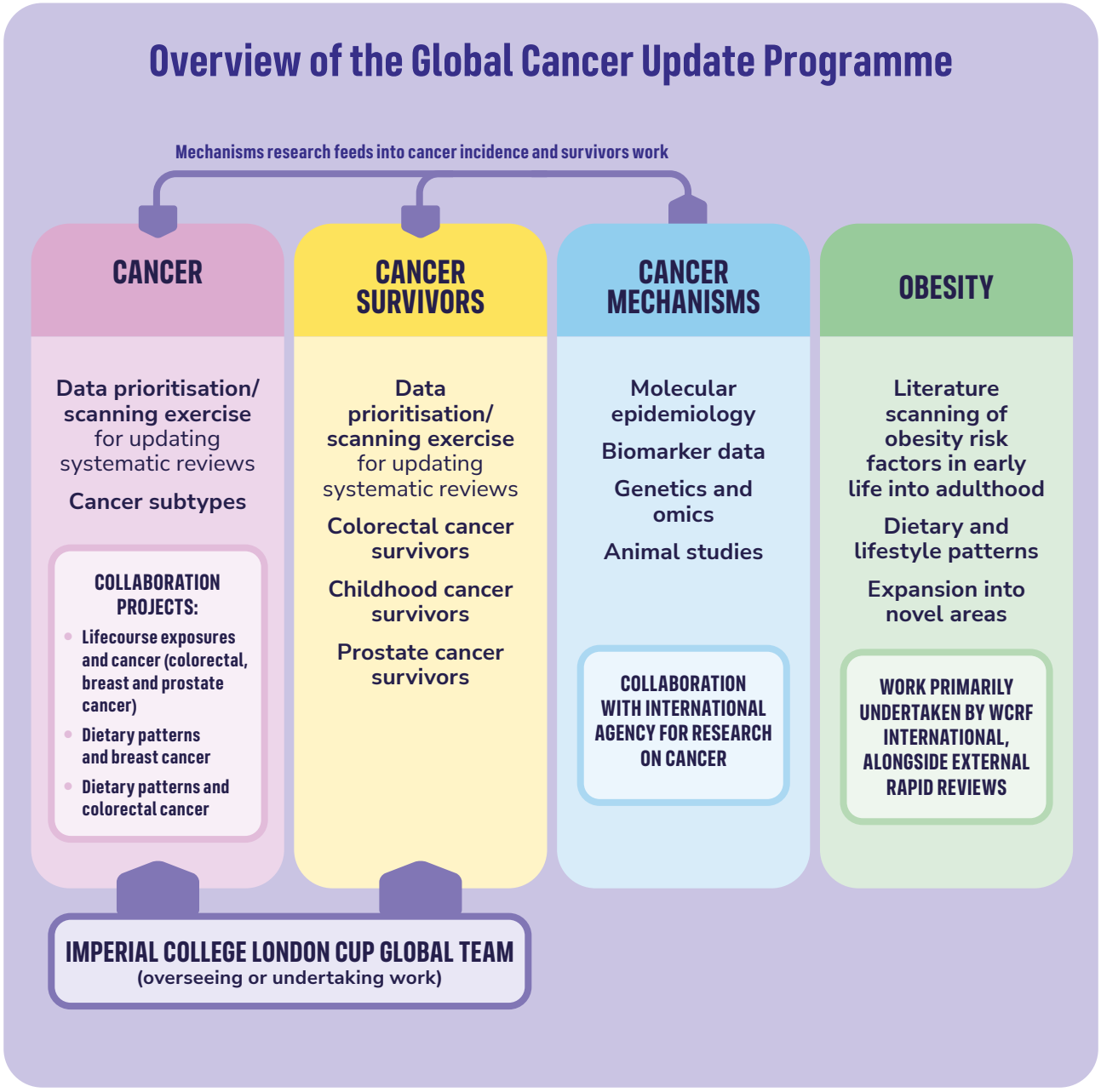
CUP Global analyses the global research on how diet, nutrition, physical activity, and body weight affect cancer risk and survival. It is led by WCRF International in partnership with American Institute for Cancer Research (AICR), World Cancer Research Fund in the UK, and Wereld Kanker Onderzoek Fonds in the Netherlands.

Many world-renowned experts contribute to the CUP Global process. The Panel evaluates the strength of the evidence from systematic reviews conducted by well-established research teams, develops guidance and recommendations, makes recommendations for future research and provides input on the direction of the work. Topic-specific expertise for key areas of work is provided via Expert Committees; of relevance to the current report is the Cancer Incidence Expert Committee. Additional expertise is provided via formal observers to the Panel, representing key organisations in the field (including the World Health Organization, International Agency for Research on Cancer, UICC and the National Cancer Institute).

*Areas of research focus within CUP Global*

The current work is organised into four areas:

- cancer incidence
- cancer survivors
- cancer mechanisms
- obesity

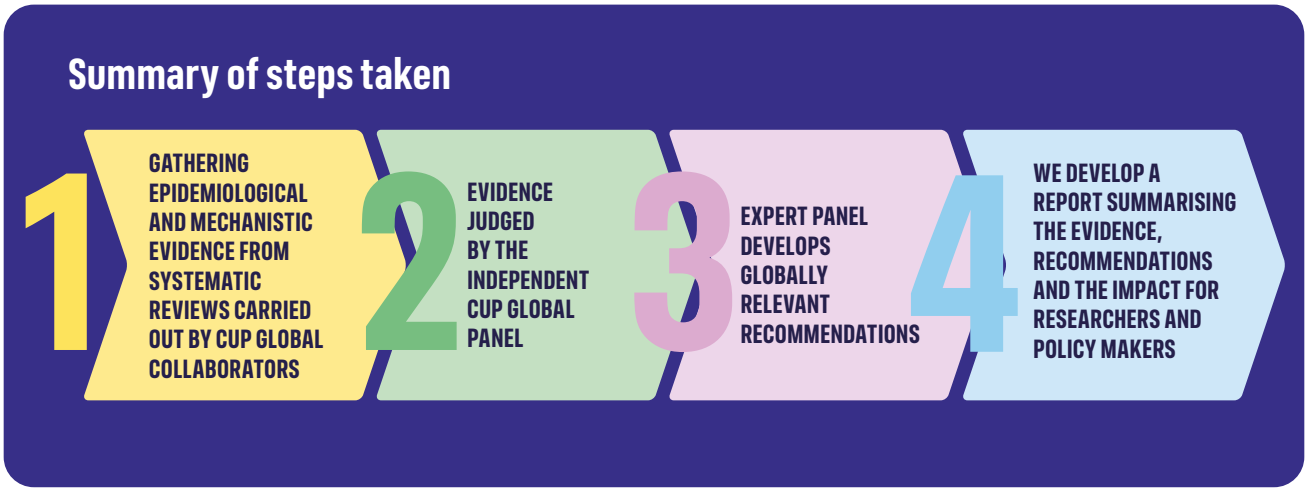


The mechanisms work supports the cancer incidence and survivors work through developing a clearer understanding of the biological processes that underpin associations between diet, nutrition, physical activity, body weight and cancer. The DLPs work is part of the cancer incidence work area.

### *CUP Global process of developing evidence-based recommendations*

Built into CUP Global is a comprehensive process for assessing the available evidence and developing recommendations. We are one of the few organisations which develops recommendations specifically for cancer prevention.

A four-step process takes us from the systematic gathering of evidence by the CUP Global collaborators to audience specific outputs on globally relevant recommendations.




As part of Step 2, the Expert Committee on Cancer Incidence and the Panel independently evaluate and judge the likelihood of causality between exposures and cancer incidence and mortality, using pre-defined grading criteria *(See appendix 1)*. Mechanistic evidence is considered a potential upgrading factor when judging evidence of an association. Evidence is graded as 'strong' (with subgrades of 'convincing', 'probable' or 'substantial effect on risk unlikely') when strong evidence is found between an exposure (diet or lifestyle factor) and the risk of the outcome or 'limited' (with subgrades 'limited-suggestive' or 'limited-no conclusion'). 'Limited suggestive' evidence may be limited in amount or methodological limitations but shows a generally consistent direction of effect. Associations judged 'limited no conclusion' have sufficient evidence to be considered by the Panel, but due to limited or inconsistent evidence and methodological limitations no conclusions regarding the magnitude or direction of effect could be drawn. For further information on the grading criteria and process, see here.

Evidence graded as ‘strong’ justifies its consideration to be used as the basis for forming the recommendations in step three of our process. Limited gradings are not typically used to support the development of recommendations. If the available evidence does not warrant strong confidence in achieving an outcome, but there is a low likelihood of harm, it is possible for pragmatic guidance to be issued. This is explored in more detail in our guidance for those living with and beyond a breast or colorectal cancer diagnosis.

When developing recommendations or guidance, the Panel considers several factors including:

- Potential implications for other cancers or other diseases
- Likely utility of a recommendation in practice
- Application in specific population groups
- Relevant contextual factors. Examples include socio-economic factors and environmental effects

# Background

## Background to DLPs within CUP Global

***Dietary Patterns in Previous WCRF International Expert Reports***

A look at the chronology of WCRF International's work clearly shows a longstanding interest in the study of dietary patterns in cancer epidemiology. The work overviewed in this report, therefore, builds on evidence presented in previous WCRF/AICR Expert Reports.


The 1997 WCRF/AICR First Expert Report included Cancer Prevention Recommendations highlighting the benefits to populations of consuming a nutritionally adequate and varied diet,[3] based primarily on foods of plant origin. Dietary patterns were not formally reviewed, so no formal judgements were made regarding them.

The 2007 Second Expert Report examined a wider range of patterns.[1] Again, no judgements on their relationship with cancer risk were made, and the Panel highlighted four limitations affecting evidence interpretation:

1. Lack of agreement on what constitutes a dietary pattern, leading to large variations between studies investigating the same pattern
2. Confounding not being adequately accounted for in the primary literature (variables which influence the relationship being studied)
3. The literature's focus on specific foods and not patterns of diet
4. Reporting bias, especially when measures of self-reported intake are used

The 2018 Third Expert Report assessed the relationship between foods, beverages and lifestyle factors and cancer risk.[2] The WCRF/AICR Cancer Prevention Recommendations it presented were based on risk factors found to be causally associated with cancer development.

While the recommendations have now been standardised to a more formalised DLP score,[4] the evidence underpinning them came from studying individual foods and food groups. The Third Expert Report also reviewed the evidence for several 'healthy' dietary patterns, including the American Cancer Society guidelines score, the Healthy Eating Index, the alternate Mediterranean score and the 2007 WCRF/AICR score (for the constituents of these patterns, *see appendix 3*). The 2007 WCRF/AICR score is based on the Cancer Prevention Recommendations outlined in the Second Expert Report.[1] For several cancers, including breast and colorectal cancers, the association with healthy dietary patterns (taken together) was graded as 'limited-no conclusion'. The exception to this was cancers of the mouth, pharynx and larynx which were graded as 'limited-suggestive' for a decreased risk. The 2018 WCRF/AICR Cancer Prevention Recommendations were subsequently developed into a score, which researchers have used to define a DLP.[4]

### *Rationale for studying DLPs*

Despite limitations in the evidence, dietary patterns remained an area of interest for WCRF International. The growth of the field, the evidence related to their impact on non-communicable diseases (including cancer) and improvements in our understanding and interpretation of dietary patterns prompted us to continue to study DLPs.

They provide great potential and a unique approach to understanding the impact of a whole lifestyle approach to understanding cancer risk. It is difficult to make inferences about the relative contribution of individual foods or food groups to cancer risk for multiple reasons. High consumption of particular foods is typically associated with higher or lower consumption of another. Furthermore, interactions of foods with each other may impact the bioavailability of their nutrients, further reducing the ability to understand the effects of individual foods. However, dietary patterns can potentially reflect how various individual dietary components contribute synergistically to impact cancer risk. As consumption of foods cluster, it can be difficult to disentangle the effects of individual items on risk, since foods may be confounded with other dietary components. Additionally, substitution effects may make it difficult to identify which food is impacting risk (food being reduced vs food being increased). Utilising approaches to characterise whole dietary patterns removes the need to adjust for the effects of any given component.[5,6] Single nutrient analysis is most informative when focusing on diseases of under and overnutrition and nutrient deficiencies. For non-communicable diseases involving complex interactions of multiple exposures across many decades, it is important to supplement the information gained from studies of single nutrients or individual foods, with research that assesses patterns of overall diet and lifestyle.

Noting the limitations of the Third Expert Report in synthesising evidence on dietary patterns, WCRF International worked with experts to develop a protocol which would provide a framework for systematic literature reviews on the relationship between whole DLPs and cancer risk.[7] The study of dietary and dietary and lifestyle patterns over long time periods minimises the impact of any substitution effects. These can occur when studying the effects of single foods, as the effect of decreasing or increasing the consumption of foods may be hidden by the foods they are substituted with or may be substituting. DLPs also account for the additive effects of the exposure to multiple foods and other modifiable risk factors.

For the definitions of dietary patterns and dietary and lifestyle patterns as they are used within CUP Global, *see Box 1*.

**Box 1:** *Definitions of dietary patterns and DLPs within CUP Global.*

**Dietary patterns:** Quantities, proportions, variety or combinations of different foods, drinks and nutrients, and the frequency with which they are habitually consumed.

**Dietary and lifestyle patterns:** Combination of a certain dietary pattern *with* measures of body fatness, other risk factors and/or behaviour factors such as physical activity, alcohol and smoking.

## Overview of CUP Global reviews into DLPs in breast and colorectal cancers

***Rationale for focusing on breast and colorectal cancers***

WCRF International has established collaborations and commissioned the Health Research Institute of the Balearic Islands and the Harvard T.H. Chan school of Public Health to undertake reviews using the DLP protocol (described above) on DLPs and risk of breast and colorectal cancers, respectively. Breast and colorectal cancers are the 2nd and 3rd most common cancers globally,[8] and are among the most studied. They are also among the cancers which are most influenced by dietary and lifestyle exposures.[2]

The main contributors to cancer risk vary by geographical region. Analysis from the Global Burden of Diseases Study showed alcohol use is the most pronounced attributable risk factor for breast cancer disability adjusted life years, with its contribution increasing in countries low and middle on the Social Development Index.[9] Contributions of modifiable risk factors for colorectal cancer showed similar variations by regional developmental status.[10] Low calcium diets were the biggest contributor to disability adjusted life years in sub-Saharan Africa, whereas alcohol and greater adiposity were the main colorectal cancer risk factors in higher income regions. Additionally, the incidence rates of both breast and colorectal cancers in those under 50 years of age are rising in several high-income countries.[11] Evidence suggests that greater body size, metabolic factors and dietary habits are causally associated with these increases.[12]

Globally, incidence rates for both cancers are highest in the countries placed very high on the Human Development Index. However, for many countries in this category, rates of colorectal cancer incidence and mortality overall are decreasing. The latter is likely predominantly due to more comprehensive screening programmes. Conversely, as countries go through developmental transition, they are faced with increasing incidence and mortality rates.[12] The disparity in colorectal cancer incidence rate trends is mirrored for breast cancer.[13] This demonstrates the complexity in understanding cancer development and the need for evidence based and globally relevant recommendations for these highly prevalent cancers.

***Methods used for the CUP Global reviews and recommendations***

For the CUP Global breast cancer and colorectal cancer reviews, PubMed and Embase databases were searched for relevant publications from inception to 31 March 2022 and 31 March 2023.[14-16] Randomised controlled trials, longitudinal observational studies and pooled analyses in adults looking at alignment with DLPs, and patterns not including lifestyle components for breast and colorectal cancer incidence or mortality, were reviewed for inclusion. Included studies needed a comparison group, and to report the components and cut-off points of the indices or scores used to measure pattern adherence.

In parallel with the epidemiological reviews, mechanistic reviews (which delved into the evidence underpinning the observed epidemiological associations) were conducted. These reviews focused on patterns which were likely to have the greatest mechanistic evidence base and, in discussion with the relevant collaborators, were highlighted as having the strongest associations with cancer incidence. *Appendix 1* outlines the grading criteria used to judge the strength of the evidence for cancer incidence. Some evidence of plausible mechanisms is required for a 'limited-suggestive' grading. Strong evidence of plausible mechanisms can be used to upgrade evidence judgements.

When considering which dietary patterns and DLPs have potential to form the basis of recommendations or guidance, the Panel noted many commonalities in the components of the patterns. As a result, it was felt developing statements on individual patterns may generate unnecessary confusion when communicating with the public. Instead the approach was taken to develop one recommendation of a DLP which would be relevant for breast and colorectal cancer prevention. To develop these recommendations, focus was placed on patterns whose association with cancer risk was judged to have a strong likelihood of causality. When components were present in multiple patterns which were judged 'limited-suggestive', these were also considered. As noted in the section on research recommendations, there was a paucity of evidence on dietary patterns and breast or colorectal cancer mortality. Resultingly, the evidence and subsequent recommendations presented here focus on cancer incidence. The following recommendations have been developed for colorectal, breast, and overall cancer prevention at a global population level. WCRF International strongly recommends being mindful of cultural dietary and lifestyle practises when providing examples of pattern components for specific populations.

# DLPs and colorectal cancer incidence and mortality

## Strength of DLP and colorectal cancer evidence

Overall, the CUP Global colorectal cancer reviews provide strong evidence that following a healthy DLP lowers risk of developing colorectal cancer.[15-16] Two dietary patterns and two DLPs were graded as having a 'strong-probable' likelihood of causality for their associations with colorectal cancer incidence and mortality. For a full breakdown on the pattern gradings by the Panel for colorectal cancer, see appendix 2a.

### *WCRF/AICR Score grading and rationale*

- The WCRF/AICR Score was graded as having a 'strong-probable' likelihood of causality for a decreased risk of colorectal cancer.

The WCRF/AICR Score is an integrated package of 10 modifiable behaviours concerning diet, physical activity, and body weight, operationalised from the 2018 WCRF/AICR Cancer Prevention Recommendations. Adherence to seven-eight of the Recommendations (depending on the inclusion of the Recommendation regarding breastfeeding) was measured in 13 independent cohorts and a protective association was consistently seen. Biological mechanisms supporting the observed epidemiological associations were not reviewed in detail for DLPs in this review, as per the prioritisation process described above. However, biological plausibility for the DLP was assumed from reviewing the strong evidence found as part of the Third Expert Report for the specific components of the WCRF/AICR Cancer Prevention recommendations.

### *Hybrid patterns score grading and rationale*

The hybrid patterns were graded as 'strong-probable' for their likelihood of causality for an increased colorectal cancer risk. These patterns are:

- Empirical Dietary Index for Hyperinsulinaemia (Dietary pattern)
- Empirical Dietary Inflammatory Pattern (Dietary pattern)
- Empirical Lifestyle Index for Hyperinsulinaemia (DLP)

The hybrid patterns were constructed from components found to predict biomarkers associated with increased insulin (The Empirical Dietary Index for Hyperinsulinemia and the Empirical Lifestyle Index for Hyperinsulinemia) or inflammation levels (Empirical Dietary Inflammatory Pattern). These patterns inversely (negatively) scored foods associated with lowering levels of insulin or inflammation. Higher scores (containing greater proportions of foods known to raise insulin secretion or inflammation levels) reflect a more hyperinsulinemic or hyperinflammatory dietary pattern.

When reviewing the mechanisms supporting the epidemiological data in this review, consistent evidence was found for associations between inflammation, insulin (as intermediate phenotypes between the dietary patterns and colorectal cancer) and higher risk of colorectal cancer. High concentrations of chronic insulin secretion have an important role in the development of colorectal cancer, and there is also evidence for the role of inflammation in its development.[17]

Insulinaemia and systemic inflammation are biologically interrelated pathways, and accordingly there is some overlap between the hybrid patterns. Mechanisms underpinning hybrid patterns and intermediate phenotypes were not examined as part of the review but, as noted, these patterns were derived by their ability to increase biomarkers associated with insulin and inflammation, both of which are strongly associated with colorectal cancer incidence.

***Hybrid patterns and their scoring***

The Empirical Dietary Index for Hyperinsulinaemia and the Empirical Dietary Inflammatory Pattern both positively score (i.e. contribute to a more hyperinsulinemic or pro-inflammatory dietary pattern) red and processed meat, as well as refined grains and sugar/artificially sweetened beverages. Additionally, these patterns negatively score components associated with lowering insulin and inflammation such as wholegrains, fruits, vegetables, alcohol and coffee. The hybrid lifestyle score additionally positively scores adiposity and negatively scores physical activity as well as the dietary components.

As part of the index for hyperinsulinaemia, butter/margarine and high fat dairy are associated with increased insulinemic dietary potential but low fat dairy and total calcium are not.[18] While these patterns largely complement known risk factors for colorectal cancer, some components which were negatively scored in the hybrid patterns (suggesting they lowered the inflammatory and/or insulinemic potential of the diet) do not include prior understanding of foods which lower colorectal cancer risk. For example, alcohol consumption is negatively scored in these patterns but has strong evidence of an increased risk for colorectal cancer. In non-drinkers, associations between the Empirical Dietary Inflammatory Pattern and colorectal cancer risk were stronger than in those who consumed alcohol. Tabung et al. (2018) suggests that pathways other than inflammation may be more central to explaining alcohol's effects on colorectal cancer risk.[19] In addition, (moderate) alcohol, especially wine, may interact differently with foods when consumed with meals, as in the Mediterranean-type dietary pattern, compared with non-intake or excessive intake. However, an effective dietary pattern for disease (cancer) prevention should not be heavily reliant on any single food item. This allows for those who may not tolerate certain foods or beverages to still achieve the benefits of lowering the insulinemic or inflammatory potential of their diets without consuming all the components. More research is being conducted on hybrid dietary patterns, including translation into the clinic, other 'real-world' settings and global translation in diverse populations with cultural differences and multiple other factors shaping the prevailing dietary patterns.

Overall, these diets are important contributors to our understanding of how patterns derived from biomarkers, nutrients and contaminants can predict cancer risk. Knowing that pro-insulinemic diets are predictive of C-peptide (a marker of plasma insulin) concentrations in overweight and sedentary individuals,[18] these findings also suggest a need for prevention education to be targeted at those who are at increased risk. The strong associations between adherence to these patterns and increased colorectal cancer risk indicates avoiding foods with insulin and inflammation raising potential is a possible effective strategy for lowering risk of colorectal and colon cancer, specifically. Where there is agreement between negatively scored components in the hybrid patterns and positively scored components in patterns where evidence was found for reduced risk, there is increased confidence that they should be part of a DLP for colorectal cancer prevention. Similarly, those scored positively can inform us of components to potentially avoid in such a DLP.

## A recommended DLP for colorectal cancer prevention

Based on the associations from the DLPs that were graded as 'strong' or 'limited-suggestive', the Panel developed a recommendation for a healthy DLP for colorectal cancer prevention.

> *For the prevention of colorectal cancer, follow a healthy dietary pattern, aim to be physically active, maintain a healthy body weight and avoid smoking.*

Many of the dietary patterns and DLPs reviewed had substantial overlap in their score components; this was especially the case for the Mediterranean dietary pattern, Healthy Eating Index, Alternative Healthy Eating Index, and the Dietary Approaches to Stop Hypertension diet. There are some differences, which are explored further in *appendix 3*. The Panel emphasised, when developing this recommendation, that it should be considered as a composite pattern of behaviours and not viewed as individual recommendations on specific foods.

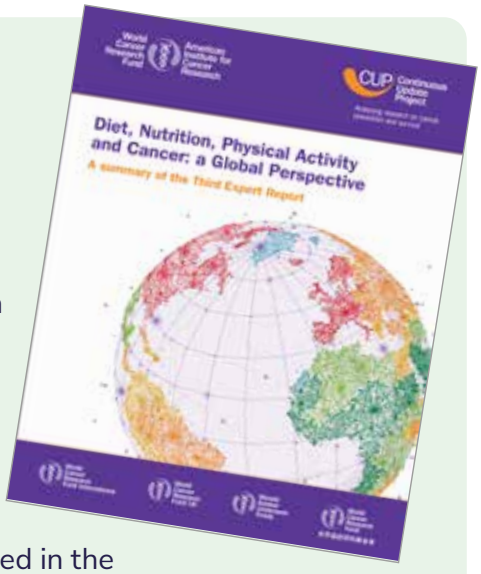
The Panel recommended for colorectal cancer prevention a healthy DLP which broadly involves the following:

- Maintaining a healthy weight and habitually taking part in physical activity.
- Prioritising consumption of fruit and vegetables, as well as fibre-containing foods.
- Including the consumption of coffee and calcium containing foods, such as dairy products.
- Limiting consumption of sugar sweetened beverages and alcohol.
- Avoiding processed meat.
- Not smoking.

Plausible mechanistic evidence has been reported for the association of dairy and colorectal cancer risk.[20-21] Most dietary patterns in the CUP Global reviews did not differentiate between high and low-fat dairy, however dairy's protective effect does not appear to substantially differ between products with different fat contents.[21] It should be acknowledged that the colorectal cancer protective properties of dairy largely stem from its high calcium content. For those who are not able to digest dairy, alternate food sources with a high bioavailability of calcium should be prioritised.

This demonstrates the necessity of shifting focus from the actions of single DLP components to prioritising the overall inclusion of foods associated with colorectal cancer prevention. In alignment with our Cancer Prevention Recommendations, intake of calcium from food/beverages should be prioritised, as WCRF International recommends against the use of supplements for overall cancer prevention.

### *How Third Expert Report Evidence supports this DLP*




When investigating individual exposures, the Third Expert Report found strong evidence for a causal relationship between physical activity, wholegrains, dietary fibre, dairy products and calcium supplements with a reduced risk of colorectal cancer.[2] Strong evidence was also found between red and processed meat, alcohol and a greater body weight and an increased risk. These exposures were incorporated in the WCRF/AICR Cancer Prevention Recommendations, largely under "be physically active" and "eat a diet rich in wholegrains, vegetables, fruits and beans". The exception to this was dairy and calcium which are not included in the recommendations as limited evidence was found for dairy and increased risk of prostate cancer. For prevention of colorectal cancer specifically, evidence for dairy and calcium is deemed strong enough to recommend its inclusion in a DLP with this aim.

# DLPs and breast cancer incidence and mortality

## Strength of DLP and breast cancer evidence

Overall, the CUP Global review showed that there is strong evidence that following a healthy DLP lowers risk of developing breast cancer.[14] From the patterns reviewed, one 'strong-probable' grading was given. For a full breakdown on the pattern gradings by the Panel for breast cancer, *see Appendix 2b*.

***WCRF/AICR score & American Cancer Society grading and rationale***

- WCRF/AICR score and the American Cancer Society score were graded as having a 'strong-probable' likelihood of being causally associated with a decreased risk of breast cancer.

Adherence to these scores was assessed in 19 publications (15 assessing the WCRF/AICR score, four the American Cancer Society score, one looking at both scores). A 'strong-probable' grading was given for associations with breast cancer overall and post-menopausal breast cancer, with a 'limited-suggestive' grading for pre-menopausal breast cancer. This suggests that, while following the WCRF/AICR Cancer Prevention Recommendations may lower the risk of developing pre-menopausal breast cancer, the evidence for this subtype is currently limited. The WCRF/AICR Cancer Prevention Recommendations provide a blueprint of health behaviour targets for overall cancer prevention, and this review provides further evidence for their importance for breast cancer prevention.

As was the case for colorectal cancer, patterns incorporating modifiable risk factors (namely markers of adiposity, smoking and physical activity) showed stronger associations with breast cancer incidence than patterns scoring dietary factors alone. This emphasises the need to consider all aspects of modifiable behaviour when forming Cancer Prevention Recommendations.

In general, the evidence for associations between modifiable risk factors and post-menopausal breast cancer was stronger than for pre-menopausal breast cancer. The difference in the strength of the evidence partially reflects the smaller number of studies and smaller sample sizes in studies specifically looking at pre-menopausal breast in this review. It could also reflect the differing risk factors for these diseases. The Third Expert Report found strong evidence of greater body weight being a risk factor for post-menopausal breast cancer.[2] At the same time, the opposite was found for pre-menopausal breast cancer. This has been postulated to be related to changes in oestrogen levels and their tissue of origin and the effect of obesity on mammographic breast density.[22] The findings here suggest that risk factors related to modifiable behaviours are more closely associated with post-menopausal than pre-menopausal breast cancer, consistent with previously published literature.[23-24] As the burden of post-menopausal breast cancer is significantly increasing in countries undergoing socio-economic transition,[25] prevention efforts emphasising healthy DLPs are of heightened importance in these settings.

## A recommended DLP for breast cancer prevention

In both CUP Global breast and colorectal cancer reviews there was clear overlap in the patterns showing associations with cancer incidence. Based on patterns graded 'strong' or 'limited-suggestive', the Panel developed a recommendation for a DLP for breast cancer prevention.

*For the prevention of breast cancer, follow a healthy dietary pattern, aim to be physically active, maintain a healthy body weight and avoid smoking.*

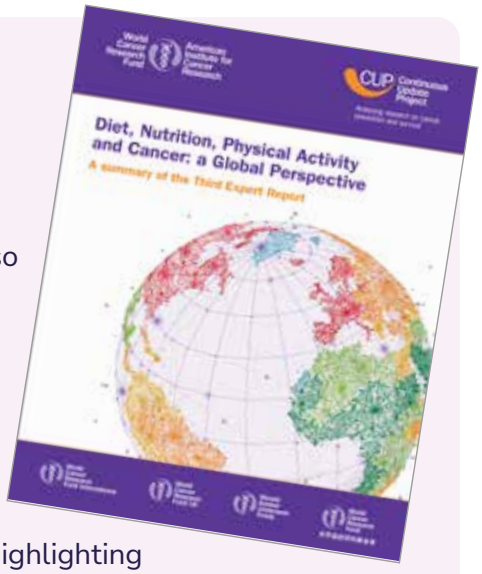
While there are similarities in the healthy DLPs for breast and colorectal cancer prevention, there are also distinct features for particular components. For example, the evidence for calcium-containing foods is particularly strong for colorectal cancer and so features in a colorectal cancer-specific DLP. Similarly, the weight of the evidence related to alcohol and breast cancer generated stronger wording around avoiding alcohol for breast cancer prevention.

For breast cancer prevention, the Panel recommended a healthy DLP which includes:

- Maintaining a healthy weight, habitually taking part in physical activity
- Prioritising fruit and vegetables and fibre containing foods
- Lower consumption of red and process foods and sugar sweetened beverages
- Avoiding alcohol and smoking

Such a DLP would likely be beneficial for the prevention of both pre- and post-menopausal breast cancer but especially for post-menopausal breast cancer. This is partly due to evidence of greater body weight having beneficial effects for pre-menopausal breast cancer. Overall, the weight of evidence for maintaining a healthy weight and a reduced risk of post-menopausal breast cancer, among other health benefits, warrants its inclusion in this DLP.

***How The Third Expert Report Evidence supports this DLP***




The evidence for which pattern components to prioritise is supported by findings from the Third Expert Report. Here, a consistent association between physical activity and a lower risk of both pre- and post-menopausal breast cancer was also noted.[2] Similarly, there was some evidence of a protective effect from the consumption of non-starchy vegetables and oestrogen receptor negative breast cancer. Alcohol was strongly associated with an increased risk for both pre- and post-menopausal breast cancer in the Third Expert Report.[2] Almost four-fifths of European women are unaware of the risks surrounding alcohol consumption and breast cancer,[26] highlighting an important area to target policy efforts. Additionally, evidence for dairy products and foods containing calcium was judged as 'limited- suggestive' for a reduced risk of breast cancer. However, this was not reflected in the patterns reviewed here, and hence calcium is not included above DLP.

# A healthy DLP for overall cancer prevention

When developing the 2018 WCRF/AICR Cancer Prevention Recommendations, the need to approach the recommendations as a package of behaviours was emphasised. The CUP Global Panel sought to emphasise this further with developing this DLP and highlighted that the more components of our DLP adhered to, the better for cancer risk reduction.

The CUP Global grading criteria acknowledge that there may be occasions when the Panel may wish to make an overarching conclusion and propose a Recommendation based on all the available evidence on a topic, alongside expert opinion: this is one such occasion. As noted above, breast and colorectal cancers are two of the cancer types with the largest evidence base behind them, and so it was likely studying DLPs in relation to other cancers would not provide the depth of information seen in these reviews. While dietary patterns analysis does not elucidate the specific beneficial food(s) of a pattern, the various patterns investigated in CUP Global converged on a number of factors which were protective, and others which appeared to increase cancer risk. The Panel felt that by considering the findings of both the reviews, they were able to make an overarching conclusion and recommendation.

***There is strong evidence that following a healthy dietary and lifestyle pattern lowers cancer risk.***

***For cancer prevention, follow a healthy dietary pattern, aim to be physically active, maintain a healthy body weight and avoid smoking.***

A pattern which provides the best chances of reducing cancer risk is one which habitually includes as many health promoting behaviours as possible while minimising health harming behaviours. In both the breast and colorectal cancer reviews,[14-16] the evidence for patterns including broader components of lifestyle was stronger than just for those encompassing diet only. Modifiable behaviours, including being physically active and maintaining a healthy body weight, are important aspects of the DLP for cancer prevention. Our findings highlight the need to view healthy living holistically, adhering to as many aspects of our recommended DLP as possible. It is likely that more benefit is gained by attempting to adhere to as much of the DLP as possible on an everyday basis throughout life.

The below table, details a recommended DLP for overall cancer prevention, and brings together the specific considerations for breast and colorectal cancers.

<table>
<tr><th colspan="2">For overall cancer prevention</th></tr>
<tr><th>Restrict these behaviours</th><th>Prioritise these behaviours</th></tr>
<tr><td>Alcohol consumption</td><td>Fruit and vegetable consumption</td></tr>
<tr><td rowspan="3">Red/processed meats consumption</td><td>Fibre containing foods, e.g. legumes, wholegrains consumption</td></tr>
<tr><td>Maintaining a healthy body weight</td></tr>
<tr><td>Being physically active</td></tr>
<tr><th colspan="2">Additional specific consideration for breast cancer prevention</th></tr>
<tr><td colspan="2">Avoiding alcohol consumption<br>For breast cancer incidence, the evidence suggests that any amount of alcohol increases risk</td></tr>
<tr><th colspan="2">Additional specific consideration for colorectal cancer prevention</th></tr>
<tr><td rowspan="2">Avoiding processed meats</td><td>Including calcium-containing products, such as dairy in your dietary pattern</td></tr>
<tr><td>Including coffee in your dietary pattern</td></tr>
</table>

## Additional considerations & rationale for a DLP for overall cancer prevention

- **Eat a diet rich in a variety of fruits, vegetables and wholegrains**

The greatest benefit of consuming these foods comes when an individual includes a diverse range of different colours, from a variety of sources, in most meals. This will ensure such a dietary pattern provides a range of nutrients, antioxidants and fibre types, increasing the overall nutritional benefit of the diet. There is some evidence suggesting that specific 'high-metabolic' vegetables (such as spinach and aubergine) provide greater benefits for chronic disease risk.[27] Clearer evidence accumulation for the role of these vegetables on cancer risk would allow refinement of the recommendations, including which to prioritise and specific portion sizes.

- **Consideration should be given regarding food preparation methods**

How food is cooked and prepared can have a significant impact on its health benefit. For example, potatoes were often included in patterns which were associated with reduced risk of cancer. When fried in the form of chips (French fries) potatoes formed part of western-type dietary patterns which were found to be associated with increased risk. Home-made and minimally processed foods should be preferred over fast foods, ready-to-eat foods and ultra-processed foods.

- **Healthier lean protein sources, such as legumes, fish and poultry should be prioritised over red and processed meats, which should be limited.**

This is especially the case for colorectal cancer, where the evidence for processed meats and an increased colorectal cancer risk is particularly strong

- **For breast and colorectal cancer, and for the prevention of cancer overall, smoking should be avoided.**

## Additional health benefits of a healthy DLP for overall cancer prevention

Evidence from the Third Expert Report found that fruits, vegetables, wholegrains, foods containing dietary fibre and aerobic physical activity reduce the risk of weight gain and overweight and obesity. Additionally, sedentary behaviour, sugar sweetened drinks, and 'fast food' were found to increase risk of weight gain and overweight and obesity. In the Third Expert Report, risk of weight gain, and overweight and obesity were the only outcomes where strong evidence was found for dietary patterns. Here, a 'Mediterranean type' dietary pattern was associated with a decreased risk of obesity, and a 'Western type' diet (characterised by high intakes of free/added sugars, meat and dietary fat) was associated with an increased risk of obesity.

Living with obesity is associated with an increased risk of at least 13 different cancers.[28] Additionally, maintaining a healthy weight is an important contributor to the DLPs judged as having a strong association with reduced risk of breast and colorectal cancer in the current CUP Global reviews. Excess sugar intake, in the form of sweets and sugar sweetened beverages, is strongly linked to increased risk of weight gain and overweight and obesity so should constitute a small proportion of a person's diet.[2] A dietary pattern which limits sweets and emphasises wholegrains and high-fibre foods is likely to have lower quantities of ultra-processed foods compared to a standard westernised diet.

Adherence to the WCRF/AICR score (both 2007 and 2018 scores) was identified as having a strong likelihood of causality for a reduced risk of both breast and colorectal cancers. Consequently, the overall recommendation is not dissimilar to our current Cancer Prevention Recommendations. The DLP presented here supports and adds confidence to our Cancer Prevention Recommendations, as we now have strong evidence that they are associated with a reduced risk of breast and colorectal cancers. Following this DLP should ensure an adequate supply of a range of dietary nutrients through diet. WCRF International recommends against the use of dietary supplements for the prevention of cancer.

The recommendation for a DLP presented here would likely have beneficial impacts upon wider health and reduce the risk of specific diseases. For example, avoiding alcohol consumption would have further health benefits for liver disease and dementia, while limiting sugar sweetened drinks also benefits oral health. This new WCRF International recommendation for a healthy DLP is in harmony with other global guidelines for prevention of cancer and other non-communicable diseases, as well as national food-based dietary guidelines. This provides further evidence that following such a pattern also has additional benefits for the prevention of other non-communicable diseases. For example, the American Cancer Society guidelines also recommend maintaining a healthy body weight throughout life, being physically active and following a healthy eating pattern.[29] Additionally, adhering to several patterns included in our reviews is demonstrated to be beneficial for a number of non-communicable diseases. Research has shown that following our Cancer Prevention Recommendations can lower diabetes risk, cardiovascular-specific and all-cause mortality.[30-31]

# Recommendations for future DLPs research

## Recurring issues in DLP studies

### *Risk of bias*

Both reviews highlighted the need for better designed prospective studies assessing alignment to the DLPs. In the observational studies, the potential for bias in the included studies was measured using a modified version of the Risk of Bias for Nutritional Observational Studies (RoB-NOBs) tool.[14-16] Bias was found most prominently in domains one (confounding) and four (departure from intended exposures). For example, in the 86 papers included in the colorectal cancer review, 31 studies were considered to have critical risk of bias for confounding. To improve study quality, researchers should ensure all relevant confounders are adjusted for, especially total energy intake. Cancer-specific confounders, such as endoscopic screening in colorectal cancer incidence studies and reproductive factors for breast cancer need to be considered and were not always adjusted for. Additionally, 68 studies in the colorectal cancer review were found to have critical risk of bias for domain four. This was largely due to adherence only being measured at baseline, showing most studies lacked long term dietary assessment. Use of repeated measures of both exposures and confounders, using validated tools, will reduce exposure misclassification and risk of bias in these domains.

### *Within pattern variation*

The reviews found substantial heterogeneity in how adherence to scores was operationalised. This was present even for studies looking at the same pattern. For example, the included components, measurements, and cut-offs used for scoring often differed. This limited the ability to meta-analyse the results of the studies. As a result, meta-analyses were not conducted for either breast or colorectal cancer. Standardisation of DLP scoring and food groupings would allow for greater comparability of the findings, further strengthening the evidence in this field. This is something WCRF International addressed in the2019 paper which provided a standardised scoring system for the 2018 WCRF/AICR Cancer Prevention Recommendations.[4] Similar standardisation of other dietary patterns and DLPs is needed.

### *Cancer mortality*

In contrast to the research on cancer incidence, there are comparatively few studies reporting data on the effect of dietary patterns and DLPs and mortality from breast or colorectal cancer. Seven studies looked at the effect on breast cancer mortality, and eight on colorectal cancer mortality. Collecting these data may require studies to have longer follow-ups than when solely looking at cancer incidence, but this would allow more detailed and impactful conclusions on adherence to DLPs to be drawn.

## Considerations for future DLP research

Building on the above limitations, there are several considerations for future study design which, if implemented, would help deepen our understanding of DLPs and cancer risk. Based on the limitations evident from conducting the current reviews, the Panel and Cancer Incidence Expert Committee have made recommendations for future research.

Researchers need to consider both cancer subtypes and sex differences when designing future studies. This was highlighted in the colorectal cancer CUP Global review, where distinct differences in the strength of associations were seen when stratifying results. When stratified by sex, results for men consistently showed stronger inverse associations with healthy DLPs, pointing to biological, hormonal or behaviour differences between the sexes. When it was possible to explore associations by anatomical location, significant differences emerged. For example, the Mediterranean dietary pattern was graded as having a greater likelihood of causality with rectal than colon cancer but this association was more consistently seen in study samples of men. Further work to fully understand these anatomical subsite differences, and the impact of sex on them, should be carefully considered within study design. There was insufficient evidence to form conclusions on the effect on breast or colorectal cancer tumour subtypes and so research including this detail would strengthen our understanding in this area.

***Study design***

Including a temporal dimension to research of DLPs would provide additional information on how the spacing of energy intake across the day impacts cancer risk. A few studies have reported on how timing and spacing of meals impacts diet quality and measures of adiposity.[32, 33] Additional knowledge could be gained from assessing adherence to temporal dietary patterns, however studies including data on eating occurrence are currently limited.[34] This particularly applies when looking at associations with cancer, although the evidence is very limited. One study suggested that greater time between final meal and sleep modified the effect of the WCRF/AICR score on breast cancer risk.[35] Assessment methods considering time of feeding should be developed and validated to explore this further.

Regarding other study types, the reviews highlight the scarcity of randomised controlled trials for dietary patterns and DLPs, with one intervention trial found for both breast and colorectal cancer outcomes. For certain dietary pattern exposures, trials may offer a useful evaluation method. Employing this study design to assess adherence to DLPs poses more challenges compared with intervention trials on single foods or nutrients. Utilising a choice of endpoints could potentially improve their feasibility. Such endpoints could be levels of biomarkers on a mechanistic pathway or polyp development for colorectal cancer. Such biomarkers may not be available for breast cancer[36] so intervention trials to support breast cancer specific recommendations on patterns of diet may be less feasible.

A benefit of studying DLPs is understanding how components may act synergistically on health. Greater awareness of how dietary pattern components may act synergistically at a biological level to prevent an internal environment which is conducive to cancer development would assist in cancer prevention and would aid our understanding of the underlying mechanisms. Further knowledge around the extent of potential cumulative effects of pattern components would strengthen this field.

***Geographical and demographic diversity***

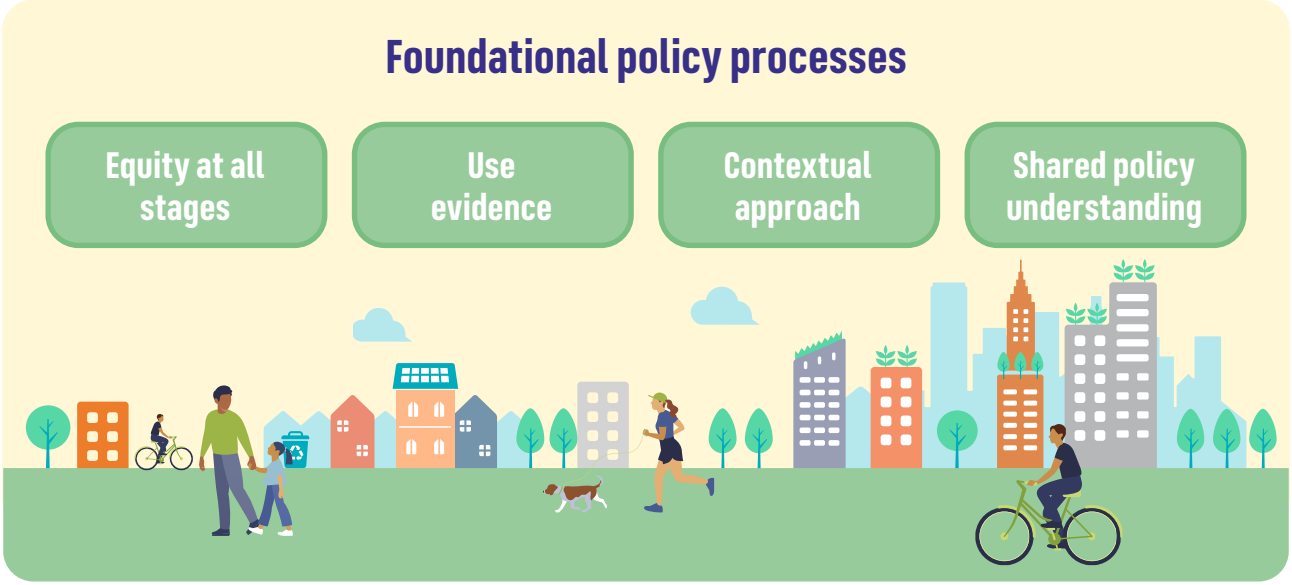
Greater considerations of demographic diversity within studies will strengthen the findings from this work by ensuring greater generalisability, reach and therefore impact of future recommendations. While this can be challenging, researchers need to explore methods which ensure diverse recruitment by sex, racial and ethnic group and socio-economic status. To maintain the global relevance of this work, more prospective studies are warranted across different geographical regions, noting variations in cultural habits and food availability. Attention should be given to studying DLPs for cancer prevention in Africa and South America, as no studies were available to be included from these regions in the current reviews. Greater consideration to demography and regional diets can also inform us of how relationships between DLPs and cancer risk may (or may not) differ globally. As different global regions vary in their consumption of the pattern components, such studies will allow researchers and policymakers to better adapt our DLP recommendations to reflect aspects of diet more relevant to their population. Dietary patterns are subject to temporal changes as countries develop and as research on healthy diets and lifestyles evolves. It is imperative that recommendations, and the analysis that they are based on, are updated as new information comes to light.

# Wider considerations surrounding a healthy DLP for cancer prevention for policymakers

When communicating our recommendation for a DLP for overall cancer prevention, it is important to consider cancer prevention more broadly. We hope when developing food-based guidelines, policymakers will not only focus on specific foods and nutrients but also highlight other aspects of modifiable behaviour which impact cancer prevention, including how patterns of behaviour interact to form a pattern of living. There is also a growing body of evidence demonstrating that recommendations for cancer prevention can also reduce the risk of other diseases and conditions.[30-31]

Having formed a globally applicable recommendation on DLPs for overall cancer prevention, it is necessary to acknowledge the importance of barriers and facilitators to following a healthy DLP. These barriers and facilitators vary widely and include resource availability, cultural norms, social networks and the overall circumstances that individuals and communities live in. If healthy options are not readily accessible to individuals, they will find it difficult to maintain such a DLP.

The United Nations/World Health Organization's definition of sustainable healthy diets is multi-dimensional,[37] encompassing an individual's economic, environmental, socio-cultural and health needs. This aligns with the United Nation's interconnected environmental, social and economic pillars of sustainability. To ensure our cancer-preventative DLP meets the needs of future generations we consider our DLP through this framework, and from the perspective of how our DLP could inform public health communications and policy development. These include marketing restrictions, fiscal policies, active transport promotion and effective education.




## A healthy DLP and environmental sustainability

The United Nation's Intergovernmental Panel on Climate Change found that a sustainable diet could simultaneously improve health outcomes while also providing major opportunities for reducing greenhouse gas emissions.[38] Food production has major impacts on multiple environmental markers, including making up around one-third of total greenhouse gas emissions, with the majority of emissions coming from developed countries.[39] It is vital we understand how dietary patterns impact all environmental markers in order to explore how to adapt food systems to provide healthy diets in an environmentally sustainable manner. From analysis of 'sustainable healthy dietary patterns' adherence to these will likely have beneficial impacts on greenhouse gas emissions including nitrous oxide.[40] Half of all greenhouse gas emissions are thought to come from food production and agriculture. Therefore, a major driver of a sustainable DLP is through reduced red meat production, and associated animal feed production (for example soy), compared with current diets. However, for other markers including water utilisation, it is unclear how transitioning to a more sustainable DLP will impact them.[40-41] Despite this, the current evidence suggests that changing to a cancer preventative DLP has the potential to reduce resource use overall and enable more sustainable food systems.

There is not currently adequate utilisation of policy tools to improve the environmental sustainability of our diets. An assessment of national food-based dietary guidelines reported that less than half mentioned environmental sustainability,[42] with an even smaller percentage providing guidance on how to adapt diets for sustainability. National food-based dietary guidelines have the potential to be both healthier and more environmentally sustainable.

Currently, adherence to the guidelines of numerous nations, including those contributing significantly to greenhouse gas emissions, would mean not meeting international targets on land, freshwater and nitrogen use.[43] Environmental sustainability and practical advice for implementing sustainable healthy diets needs to be given greater importance in updated dietary guidelines, in both background and consumer facing documents.

## A healthy DLP and economic sustainability

Cost is often a barrier to a healthy DLP for individuals with healthy eating unaffordable for almost three billion people globally.[44] The majority of countries for whom the cost of a heathy diet is the same or greater than the median income are low-middle income countries. However, even in high income countries almost half of a households disposable income is needed to meet national dietary guidelines. In the UK, households with children, those living with a disability or from a Black and Minority Ethnic background are more likely to experience food insecurity.[45]

The EAT-Lancet Commission developed a healthy dietary pattern which minimises impact on environmental systems.[46] Transitioning to such a sustainable dietary pattern is predicted to increase the affordability of the diet for high- and middle-income countries. For lower middle and low-income countries, sustainable diet scenarios were found to be less affordable than current diets.[47] With the costs greater than household income for one-fifth of the world, the EAT-Lancet diet is unaffordable without changes to local and global food systems.[48] Fruit and vegetables account for the majority of costs associated with the Eat-Lancet diet, and in lower income countries they account for a greater percentage of household expenditure. As a possible consequence, average fruit and vegetable consumption is reportedly lowest in these countries.[49] Additionally, the proportion of individuals meeting World Health Organization recommendations for fruit and vegetable intake is lower in low and lower-middle income countries with unstable food prices.[49] Therefore, to improve affordability of healthy and sustainable diets in lower income countries, changes to food systems need to occur alongside socio-economic development. Such changes can use the sustainable, resilient and inclusive goals of Food 2030 as a blueprint.[50] For food systems built on staple crops, any changes in dietary patterns will likely confer increased costs to households.[51] As outlined by the Global Food Policy Report, agricultural policies and investment needs to include nutritious foods to improve the diversification of diets and reduce the affordability gap in healthy diets, especially in low income countries.[52] Accounting for changes to food waste, socio-economic development and diet-related climate change and health care costs, increases the projected affordability of sustainable healthy diets, so that they are cheaper or equivalent to the benchmark dietary pattern.[47] Socio-economic development and an understanding of food system changes, especially in regard to food waste, is required to ensure the affordability of healthy sustainability dietary patterns. Additionally, inclusion of all the potential economic costs and savings need to be included in analysis for a full understanding of the co-benefits of sustainable DLPs.

For healthcare systems, a 2016 analysis of transitioning to the 2007 WCRF/AICR Cancer Prevention Recommendations projected global health related cost savings of $735bn per year.[51] These costs are not uniformly shared globally, with developed nations seeing the greatest reductions in both greenhouse gas emissions and health related costs. An understanding of the trade-offs required for a diet which is both healthy, affordable and reduces greenhouse gas emissions is required.

A detailed understanding of how these differ between individual countries is also required. This will aide in identifying necessary policies to create environments where increasing incomes do not automatically lead to western-type dietary patterns, and resultant poorer health outcomes and accompanying costs to households, healthcare systems and the planet.

Monetary tools are a means to encourage health promoting behaviours. Price reductions or subsidies for healthy food are effective ways of modifying purchasing decisions,[53] especially when paired with taxes on unhealthier foods.[54] These demand-side tools may have the greatest health benefits for those on lower incomes and may help reduce health inequalities when accompanied by wider policy shifts that include providing easier access to healthy food and educational programmes (for example, increasing awareness of the links between DLPs and health and how to store and cook healthy food).[55] WCRF International's assessments have shown economic leverage is currently an underused policy tool.[56]

## A healthy DLP and social sustainability

Almost a third of the world's population has an insufficient level of physical activity, and this figure is increasing.[57] Intrinsic barriers to increasing physical activity, such as time and motivation, are prevalent, but there are also wider systemic structures that influence behaviour related to physical activity. Safety and accessibility concerns are highlighted as obstacles to physical activity more often by those from Black and Minority Ethnic backgrounds, lower socio-economic groups and those living with disabilities.[58] These have also been highlighted as barriers to participation for young women.[59] For a number of high income countries, this means that over half the population faces these obstacles to achieving physical activity recommendations. More needs to be done to address them to enable people to successfully follow healthy DLPs.

Aligning with the principle of proportional universality, women and girls, as well as those over 60 years of age, in regions where rates of physical activity are the lowest should be especially targeted by measures to increase it. As highlighted by the World Health Organization's Global Action Plan for Physical Activity,[60] investing in physical activity will contribute to a vast number of the 2030 Sustainable Development Goals being met.[61] These are not solely around health and well-being, but also around reducing inequalities more broadly (for example in income disparities between global populations and increasing social, economic and political inclusion). There is currently insufficient policy action to support active environments.[62] Awareness of the specific barriers (and facilitators) to increasing and maintaining physical activity should be considered when designing health promotion interventions, including potential socio-cultural barriers which are especially prevalent for women but are caused by wider societal issues and attitudes.[59] Encouragingly, public health is increasingly featuring in local planning policy.[63] This demonstrates that the need for an interdisciplinary approach to shaping whole environments is being acknowledged by policymakers. Effort should be made to ensure that public spaces are accessible and safe for all and are built in a way that minimises impact on the environment.

How healthy DLPs are translated globally is an increasing area of research focus. Within the CUP Global reviews, a Mediterranean-type dietary pattern was graded 'limited-suggestive' for its association with colorectal cancer. There is also an increasing body of research reporting that it may be associated with a reduced risk of other site-specific cancers and improved cancer survival. Diets and dietary patterns from other countries and regions, particularly those from low-income countries, are less well explored for their cancer-prevention properties. This should be considered an area of importance for future research. For example, given what we know about the links between consumption of red and processed meat, and increased risk of several site-specific cancers, vegetarian and plant-based diets should be further explored for their potential to prevent cancer. If these links are established this could be especially significant for countries, such as India, that have high rates of vegetarianism. This evidence could also be the basis for increasing rates of these diets globally.

Less than half of the world's population is meeting national food-based dietary guidelines and international physical activity guidelines.[64, 60] There are significant differences between regions and countries. For example, the deficit between wholegrain and vegetable consumption and national guidance is greatest in high income countries where people tend to eat more meat.[64] As developmental transition occurs, efforts to ensure this does not become more widespread are required. Supported by findings that in developed countries awareness of the health risks of red and processed meat is low,[65] low adherence appears due to current education strategies not being sufficiently effective, as well as other factors beyond education. These could include cost, but also culture, with meat consumption preferences varying by region. Increasing age, education level and being a girl/woman are associated with increased vegetable intake in high income countries.[66-67] In general, boys/men are less aware of the links between fruit and vegetable consumption and disease prevention and nutritional recommendations overall.[68] While meat consumption is still rising globally, it is encouraging that in higher income countries, growth in red meat consumption is projected to slow.[69]

Our recommendation of a DLP for cancer prevention has the aim of being globally relevant and applicable, but its effectiveness relies on local interpretation and implementation. The most appropriate policy tools will likely differ according to the community they are targetting, and awarness of this is required for effectiveness. WCRF International works with several global partner organisations and policy makers to help governments and policymakers design and implement policies to reduce preventable cases of diet-related cancer and other non-communicable diseases. *Box 2* outlines some of our tools to promote, monitor and evaluate global policy on cancer prevention.

**Box 2:** *WCRF International's Policy Blueprint for Cancer Prevention and associated policy work*

The NOURISHING database is structured around a policy framework of 10 action areas where implementation would promote healthy diets, including action on food labelling and advertising and purchase incentives. It houses information on government policies from around the world on diet and nutrition. Similarly, the MOVING database is structured around a framework of six action areas to promote physical activity. The database contains policies implemented by nation states, from promoting active transport to encouraging accessible green spaces.

A new policy blueprint integrates the NOURISHING and MOVING frameworks and maps the WCRF/AICR Cancer Prevention Recommendations against eight policy areas that should be prioritised by policymakers. It puts these policies in context of their potential co-benefits for environmental sustainability, prevention of other non-communicable diseases, and reducing health inequality. Using the WCRF International Policy Blueprint for Cancer Prevention alongside our recommendation for dietary and lifestyle patterns for cancer prevention provides policymakers with the evidence and rationale behind policy areas to effectively respond to the growing challenge of preventable cancers.

## Conclusion

Part of the rationale for studying DLPs is that they lend themselves to health communications for the public and guidance for policymakers. To ensure this is done effectively, this report outlines the evidence for the most widely published DLPs and breast and colorectal cancer risk. Based on this evidence, WCRF International developed a recommendation for cancer prevention.

Only when the facilitators and barriers to adhering to such a DLP are understood can this knowledge be used to develop policy that can most effectively benefit population health. Ensuring that the food systems that individuals interact with, and the wider society that they are part of, enables them to follow a sustainable, cancer preventative DLP is paramount to sustaining healthy nations and the health of our planet.

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# Appendix 1 – WCRF International CUP Global Cancer Incidence Grading Criteria

| EVIDENCE GRADES | | GRADING CRITERIA FOR EVIDENCE ON DIET, NUTRITION, PHYSICAL ACTIVITY AND CANCER INCIDENCE | Het | PB | Mec |
|---|---|---|---|---|---|
| STRONG EVIDENCE | CONVINCING | Evidence from more than one good quality study type, including at least two independent cohort studies (acceptable study designs listed below)* | NO | NO | REQUIRED |
| | PROBABLE | Evidence from at least two good quality independent cohort studies | NO | NO | REQUIRED |
| LIMITED EVIDENCE | LIMITED–SUGGESTIVE | Evidence from at least two independent cohort studies | YES | YES | REQUIRED |
| | LIMITED–NO CONCLUSION | Any of the following reasons:<br>- Too few studies available<br>- Inconsistency of direction of effect<br>- Magnitude of effect unlikely to affect cancer risk<br>- Poor quality of studies (for example, lack of adjustment for known confounders) | – | – | – |
| STRONG EVIDENCE | SUBSTANTIAL EFFECT ON RISK UNLIKELY | Evidence of the absence of an effect. All of the following generally required:<br>- Evidence from more than one good quality study type (acceptable study designs listed below)*<br>- Evidence from at least two independent cohort studies<br>- Summary estimate of effect close to 1.0 for comparison of high-versus low-exposure categories | NO | NO | ABSENCE |

**Het:** Subststantial unexplained heterogeneity or some unexplained heterogeneity

**PB:** Publication bias

**Mec**: Strong and plausible mechanistic evidence is required, desirable but not required, not required or absent

*RCTs, longitudinal, observational or pooled analyses of individual data of these studies. Good quality studies exclude with confidence the possibility that the observed association results from random or systematic error, including confounding, measurement error and selection bias.

**Special upgrading factors:**

- Presence of a plausible biological gradient ('dose response') in the association. Such a gradient need not be linear or even in the same direction across the different levels of exposure, so long as this can be explained plausibly. There is also a requirement for the convincing (strong evidence) grade.
- A particularly large summary effect size (an odds ratio or relative risk of 2.0 or more, depending on the unit of exposure), after appropriate control for confounders.
- Consideration of precision.
- Evidence from randomised trials in humans.
- Evidence from appropriately controlled experiments demonstrating one or more plausible and specifuc mechanisms operating in humans.
- Robust and reproducible evidence from experimental studies in appropriate animal models showing that typical human exposure can lead to relevant cancer outcomes.

# Appendix 2 – Summary Evidence matrix of the CUP Global Panel

## a. Colorectal cancer

### DIETARY PATTERNS AND DIETARY AND LIFESTYLE PATTERNS AND COLORECTAL CANCER

| 2024 | | DECREASES RISK | | INCREASES RISK | |
|---|---|---|---|---|---|
| | | EXPOSURE | OUTCOME | EXPOSURE | OUTCOME |
| | | **DIETARY AND LIFESTYLE PATTERNS** | | | |
| STRONG EVIDENCE | CONVINCING | | | | |
| | PROBABLE | WCRF/AICR Score | Colorectal cancer<br>Colon cancer | ELIH | Colorectal cancer |
| | | **DIETARY PATTERNS** | | | |
| | | | | EDIH | Colorectal cancer<br>Colon cancer |
| | | | | EDIP | Colorectal cancer<br>Colon cancer |
| LIMITED EVIDENCE | LIMITED-SUGGESTIVE | **DIETARY AND LIFESTYLE PATTERNS** | | | |
| | | American Cancer Society | Colorectal cancer | | |
| | | Healthy Living Index (and modifications)[2] | Colorectal cancer | | |
| | | **DIETARY PATTERNS** | | | |
| | | Mediterranean dietary pattern | Colorectal cancer<br>Rectal cancer | | |
| | | Healthful plant based diet[1] | Colorectal cancer | | |
| | | HEI, AHEI | Colorectal cancer<br>Colon cancer<br>Rectal cancer | | |
| | | The DASH diet | Colorectal cancer<br>Colon cancer<br>Rectal cancer | | |
| | LIMITED-NO CONCLUSION | Dietary patterns:<br>Mediterranean dietary patterns (for colon cancer), pro/overall plant-based diets[1], unhealthful plant-based dietary patterns[1], healthful plant-based dietary patterns[1] (for rectal cancer), Healthy Nordic Food Index, Prime Dietary Quality Score, evolutionary concordance diet score, WCRF/AICR dietary score[3], American Cancer Society Guidelines, Chinese Food Pagoda Score, Dutch dietary guidelines index, healthy dietary quality index/healthy diet, 2013 Danish dietary guidelines Index Score, PNNS-GS2 score, Colorectal Dietary Quality Index, Colorectal cancer score, Global Diet Quality Sore, Healthful Global diet Quality Score, Unhealthful Global Dietary Quality Score, Dietary recommendations for cardiometabolic health, Low-fat RCT, Healthy/ Prudent/ Vegetable-rich a *posteriori* dietary patterns, Western/ Meat/ Alcohol a *posteriori* dietary patterns, Traditional/Mixed/Ethnic[4] a *posteriori* dietary patterns<br>Dietary and lifestyle patterns:<br>WCRF/AICR Cancer Prevention Score (for rectal cancer), Healthy Living Index (and modifications)[2] (for colon and rectal cancer), Evolutionary-concordant diet score + evolutionary concordant lifestyle score, Ideal cardiovascular health metrics score | | | |
| STRONG EVIDENCE | EFFECT ON RISK UNLIKELY | | | | |

**Abbreviations:**

EDIH: Empirical Dietary Index for Hyperinsulinemia, EDIP: Empirical Dietary Inflammatory Pattern, ELIH: Empirical lifestyle Index for hyperinsulinemia, WCRF/AICR: World Cancer Research Fund/American Institute for Cancer Research Cancer Prevention Score, HEI: Health Eating Index, AHEI: Alternative Healthy Eating Index, DASH diet: Dietary Approaches to Stop Hypertension, PNNS-GS2 score: French National Nutrition Health Program Guideline Score 2.

**Footnotes:**

[1] Plant-based dietary patterns: All of plant based dietary patterns studied still contained some level of meat consumption.

[2] Healthy living Index (and modifications): Group included patterns termed by the researchers as Healthy Living Index, Healthy Lifestyle score, Healthy Lifestyle, Healthy Index. These indices measured adherence to health behaviours including being physically active, maintaining a healthy body weight and adhering to a specific healthy eating guidelines such as a combination of the PNNS (the French national program for health and nutrition), the ANSES (the French food safety agency), and the World Health Organization, the Chinese food pagoda score, Healthy Eating Index, or by the levels of their consumption of 'ideal food groups' (fruits, vegetables, fish, and consumption of processed and unprocessed meat)

[3] WCRF/AICR as a dietary pattern does not include the WCRF/AICR recommendations on maintaining a healthy body weight, being physically active or breast feeding.

[4] Traditional/Ethnic/Mixed- *a posteriori* dietary pattern which did not fit into the healthy or unhealthy *a posteriori* pattern groupings

## b. Breast cancer

### DIETARY PATTERNS AND DIETARY AND LIFESTYLE PATTERNS AND BREAST CANCER

| 2022 | | DECREASES RISK | | INCREASES RISK | |
|---|---|---|---|---|---|
| | | EXPOSURE | OUTCOME | EXPOSURE | OUTCOME |
| | | **DIETARY AND LIFESTYLE PATTERNS** | | | |
| STRONG EVIDENCE | CONVINCING | | | | |
| | PROBABLE | WCRF/AICR & American Cancer Society score | Breast cancer[1]<br>Post-menopausal breast cancer | | |
| | | **DIETARY AND LIFESTYLE PATTERNS** | | | |
| | | WCRF/AICR score<br>*a priori* DLPs based on general recommendations for a healthy lifestyle (HLI, HI, DGA score | Pre-menopausal breast cancer<br>Post-menopausal breast cancer | | |
| LIMITED EVIDENCE | LIMITED-SUGGESTIVE | **DIETARY PATTERNS** | | | |
| | | Prudent/Vegetarian/ Mediterranean[2] | Breast cancer[1] | Western/ Meat/ Alcohol | Post-menopausal breast cancer |
| | LIMITED-NO CONCLUSION | Dietary patterns:<br>Mediterranean dietary pattern, pro-vegetarian/plant-based dietary pattern, healthful pro-vegetarian/plant-based diet score, unhealthful pro-vegetarian/plant based score, palaeolithic diet, traditional Mexican diet, The DASH score, HEI, AHEI, healthy Nordic Food Index, Recommended food score, WCRF/AICR dietary score[3], WHO Healthy diet Indicator, Dutch dietary guidelines, Diabetes Risk Reduction Diet score, PNNS-GS, UK and European dietary guidelines, Diet Quality Index-revised, Low fat dietary interventions, Western/Meat/alcohol (for pre-menopausal and overall breast cancer), Prudent/Vegetarian/ Mediterranean (in pre & post-menopausal breast cancer), Traditional/ Ethnic/ Mixed[4], pro-oestrogen dietary patterns, pro-inflammatory dietary patterns, hybrid dietary patterns derived from nutrients,<br>Dietary and lifestyle patterns:<br>HLI/PNNS-GS, Healthy Index, HLI, HI & DGA in all women | | | |
| STRONG EVIDENCE | SUBSTANTIAL EFFECT ON RISK UNLIKELY | | | | |

**Abbreviations:**

WCRF/AICR: World Cancer Research Fund/American Institute for Cancer Research, The DASH diet: The Dietary Approaches to Stop Hypertension diet, HEI,AHEI: Healthy Eating Index, Alternative Healthy Eating Index, PNNS-GS: French National Nutrition Health Program Guideline Score, HLI: Healthy Living Index, HI: Healthy Index, DGA: Dietary Guidelines for Americans

**Footnotes:**

[1] Breast cancer – the Panel's conclusion relates to overall breast cancer (menopausal status unspecified)

[2] Prudent/Vegetarian/Mediterranean- Classed as healthier *a posteriori* dietary pattern

[3] WCRF/AICR Dietary score – The WCRF/AICR score as a dietary pattern does not include the WCRF/AICR recommendations on maintaining a healthy body weight, being physically active of breast feeding.

[4] Traditional/Ethnic/Mixed- *a posteriori* dietary pattern which did not fit into the healthy or unhealthy *a posteriori* pattern groupings.

# Appendix 3 – Summary of pattern components

## Dietary and lifestyle patterns in breast cancer

| Pattern sub-group | Pattern name | No. publications | Score versions | Foods and lifestyle factors |
|---|---|---|---|---|
| **"a priori" dietary and lifestyle patterns** | | | | |
| | | | | ADIPOSITY; PHYSICAL ACTIVITY; SMOKING; ALCOHOL; FRUITS; VEGETABLES; NUTS/SEEDS; POTATOES; LEGUMES; GRAINS AND CEREALS/FIBRE; POULTRY; RED MEAT/PROCESSED MEAT; EGGS; CREAMBUTTER/MARGARINE/LARD; DAIRY PRODUCTS; FISH AND SEAFOOD; SNACKS/SWEETS/ULTRA-PROCESSED FOODS; SUGAR-SWEETENED BEVERAGES; OLIVE/VEG OIL OR HIGH UNSAT/LOW SAT FATTY ACIDS; SODIUM; COFFEE/TEA; ADDED SUGAR |
| Based on specific recommendations for cancer prevention | World Cancer Research Fund/ American Institute for Cancer Research (WCRF/ AICR) score | 15 | 15 | |
| | American Cancer Society (ACS) guidelines | 4 | 4 | |
| Based on general recommendations for a healthy lifestyle | Healthy Lifestyle Index (HLI) (and modifications) | 5 | 5 | |
| | Dietary Guidelines for Americans (DGAs) | 1 | 1 | |
| | Health Index (HI) (French recommendations and World Health Organization (WHO)) | 1 | 1 | |
| | French National Nutrition Health Program-Guideline Score (PNNS-GS) | 1 | 1 | |
| Hybrid* | Estrogen-related lifestyle pattern* | 1 | 1 | |
| **"a priori" dietary pattern** | | | | |
| Based on culturally defined dietary habits<br>Based on dietary guidelines | Mediterranean diet score (MDS and modifications) | 15 | 23 | |
| | Pro-vegetarian/ plant-based diets | 3 | 3 | |
| | Healthful pro-vegetarian/plant-based diets | 2 | 2 | |
| | Unhealthful pro-vegetarian/plant-based diets | 2 | 2 | |
| | Palaeolithic diet | 1 | 1 | |
| | Mexican diet | 1 | 1 | |

# Dietary and lifestyle patterns in breast cancer (continued)

| Pattern sub-group | Pattern name | No. publications | Score versions | Foods and lifestyle factors |
|---|---|---|---|---|
| **"a priori" dietary pattern** | | | | |
| Based on dietary guidelines | Healthy Eating Index (HEI) and alternate HEI (AHEI) | 7 | 12 | |
| | Dietary Approaches to Stop Hypertension (DASH) | 5 | 5 | |
| | Recommended Food Score (RFS) | 2 | 2 | |
| | Diet Quality Index (DQI) | 1 | 1 | |
| | Diabetes Risk Reduction Diet (DRRD) | 1 | 1 | |
| | Healthy Diet Index (HDI) (WHO guidelines) | 1 | 1 | |
| | Nordic diet | 2 | 2 | |
| | Cumulative risk factors (UK and European guidelines | 1 | 1 | |
| | French National Nutrition Health Program (PNNS) | 1 | 1 | |
| | The 2015 Dutch dietary guidelines | 1 | 1 | |
| | World Cancer Research Fund (WCRF) diet | 1 | 1 | |
| **"a posteriori" dietary patterns** | | | | |
| Prudent/Vegetarian/ Mediterranean | | 18 | 24 | |
| Western/Meat/Alcohol | | 17 | 24 | |
| Traditional/Ethnic/Mixed | | 12 | 18 | |

ADIPOSITY · PHYSICAL ACTIVITY · SMOKING · ALCOHOL · FRUITS · VEGETABLES · NUTS/SEEDS · POTATOES · LEGUMES · GRAINS AND CEREALS/FIBRE · POULTRY · RED MEAT/PROCESSED MEAT · EGGS · CREAMBUTTER/MARGARINE/LARD · DAIRY PRODUCTS · FISH AND SEAFOOD · SNACKS/SWEETS/ULTRA-PROCESSED FOODS · SUGAR-SWEETENED BEVERAGES · OLIVE/VEG OIL OR HIGH UNSAT/ LOW SAT FATTY ACIDS · SODIUM · COFFEE/TEA · ADDED SUGAR

*The dietary component of this lifestyle pattern is obtained using reduced rank regression (hybrid).

**Summary of components of "a priori" dietary interventions (randomized controlled trials).**

| Dietary intervention | No. of papers | Intervention arms | Foods | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ALCOHOL | FRUITS | VEGETABLES | NUTS/SEEDS | LEGUMES | GRAINS AND CEREALS | CARBOHYDRATES | FISH AND SEAFOOD | WHITE MEAT | RED MEAT/PROCESSED MEAT | CREAM/BUTTER/MARGARINE | SWEETS | SUGAR-SWEETENED BEVERAGES | SOFRITO | OLIVE OIL (EXTRA VIRGIN) | TOTAL FAT |
| Mediterranean Diet (PREDIMED) | 1 | Mediterranean diet supplemented with extra virgin olive oil (EVOO) | | | | | | | | | | | | | | | | |
| | | Mediterranean diet supplemented with nuts | | | | | | | | | | | | | | | | |
| | | Control diet (low-fat diet: low-fat meat, fish and dairy, limit butter, margarine, lard, olive oil, nuts, commercial sweets and snacks | | | | | | | | | | | | | | | | |
| Low-fat diet (WHI-DM) | 5 | Low-fat diet (reduction to 20% from ≥ 32% of total energy) | | | | | | | | | | | | | | | | |
| | | Control diet (usual diet) | | | | | | | | | | | | | | | | |
| Low-fat diet (CDBCP) | 1 | Low-fat diet (reduction to 15% of calories and increase carbohydrates to 65%) | | | | | | | | | | | | | | | | |
| | | Control diet (general dietary advice based on Canada's Food Guide) | | | | | | | | | | | | | | | | |

Dark green colour is used to indicate a higher intake/positively loaded food groups in most of the patterns; light green colour is used to indicate a higher intake/positively loaded specific food groups in some of the patterns; dark red is used to indicate a lower intake of food groups in most of the patterns; light red is used to indicate a lower intake of specific food groups and yellow is used to indicate moderate intake.

# Dietary and lifestyle patterns in colorectal cancer

| Pattern group | | Pattern name | No. of papers | Score versions | Characteristic | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dietary and lifestyle patterns** | | | | | | | | | | | | | | | | |
| | | | | | ADIPOSITY | PHYSICAL ACTIVITY | SMOKING | ALCOHOL | FRUITS | VEGETABLES | LEGUMES | (WHOLE) GRAINS AND CEREALS/FIBER | DAIRY PRODUCTS | RED MEAT/PROCESSED MEAT | SUGAR-SWEETENED BEVERAGES | SODIUM |
| "A priori" dietary-lifestyle patterns | Based on specific recommendations for cancer prevention | WCRF/AICR recommendations score | 16 | 16 | | | 2 | | | | 4 | 11 | | 14 | 9 | 6 |
| | | American Cancer Society (ACS) guidelines | 5 | 5 | 5 | 5 | 2 | 3 | 5 | 5 | | 4 | | 5 | | |
| | | Healthy Lifestyle Index (HLI) and Protective Lifestyle Factor Index Score (PLFIS) for cancer prevention | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 2 | 3 | 1 | |
| | Based on general recommendations for a healthy lifestyle | Healthy Lifestyle Index (HLI) (and modifications) for a healthy lifestyle | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 1 | 2 | 2 | 3 | 1 | 2 |
| | | Evolutionary-concordant diet + lifestyle score | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 |
| | | Programme National Nutrition Santé Guideline Score (PNNS-GS) | 1 | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 |
| | | Ideal Cardiovascular Health Metrics (ICVHMs) | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | | 1 | | 1 | | |
| "A posteriori" | Based on cluster analysis | High risk classes* | 1 | 17 | 7 | 4 | 7 | 5 | 1 | 1 | | | | 5 | | |
| Hybrid | Derived from biological markers | Empirical Lifestyle Index for Hyperinsulinemia (ELIH) (& modifications) * | 2 | 2 | 1 | 1 | | 2 | 2 | 1 | | | 2 | 2 | 1 | |
| | | Lifestyle inflammation scores (LIS) + Dietary inflammation scores (DIS)* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

Dark green indicates higher exposure values in most patterns (≥50% of score versions); light green indicates higher intake in some patterns (between 2 – 50% for patterns with ≥4 score versions, or 1 if 3 score versions for that pattern). Dark red signifies lower intake in most patterns, while light red denotes lower intake in some patterns. Yellow signifies moderate intake in most patterns. *For comparability, food group intakes were reversed to indicate a healthy diet direction in this table.

| Pattern group | Pattern name | No. of papers | Score versions | Foods |
|---|---|---|---|---|
| "a priori" dietary patterns | | | | |
| | | | | ALCOHOL; FRUITS; VEGETABLES; NUTS/SEEDS; LEGUMES; (WHOLE) GRAINS AND CEREALS/FIBRE; POULTRY; RED MEAT/PROCESSED MEAT; EGGS; CREAM/BUTTER/MARGARINE/LARD/SAT FAT; DAIRY PRODUCTS; FISH AND SEAFOOD; SNACKS/SWEETS/ULTRA-PROCESSED FOODS; SUGAR-SWEETENED BEVERAGES; OLIVE/VEG OIL OR HIGH UNSAT/LOW SAT FATTY ACIDS; SODIUM; COFFEE/TEA; ADDED SUGAR |
| Based on culturally defined dietary habits | Mediterranean Diet Score (MDS and modifications) | 10 | 10 | |
| | Pro-/overall plant-based diets | 4 | 4 | |
| | Healthful plant-based diet index (hPDI) | 2 | 2 | |
| | Unhealthful plant-based diet index (uPDI) | 3 | 2 | |
| | Healthy Nordic Food Index (HNFI) | 3 | 2 | |
| | The prime diet quality score (PDQS) | 1 | 1 | |
| | Evolutionary-concordance diet score | 1 | 1 | |
| Based on dietary guide-lines | Healthy Eating Index (HEI)/ alternate HEI (AHEI) | 10 | 12 | |
| | Dietary Approaches to Stop Hypertension (DASH) | 5 | 5 | |
| | WCRF/AICR diet | 6 | 6 | |
| | American Cancer Society (ACS) diet | 2 | 2 | |
| | Recommended Food Score (RFS) | 2 | 2 | |
| | The Chinese Food Pagoda (CHFP) score | 2 | 2 | |
| | Dutch Dietary Guidelines (DDG) Index | 2 | 2 | |
| | Healthy dietary quality index | 2 | 2 | |
| | 2013 Danish Dietary Guidelines Index score | 1 | 1 | |
| | Programme National Nutrition Santé-Guidelines Score 2 (PNNS-GS2) | 1 | 1 | |

| Pattern group | Pattern name | No. of papers | Score versions | Foods |
|---|---|---|---|---|
| **"a priori" dietary patterns** | | | | |
| | | | | ALCOHOL · FRUITS · VEGETABLES · NUTS/SEEDS · LEGUMES · (WHOLE) GRAINS AND CEREALS/FIBRE · POULTRY · RED MEAT/PROCESSED MEAT · EGGS · CREAM/BUTTER/MARGARINE/LARD/SAT FAT · DAIRY PRODUCTS · FISH AND SEAFOOD · SNACKS/SWEETS/ULTRA-PROCESSED FOODS · SUGAR-SWEETENED BEVERAGES · OLIVE/VEG OIL OR HIGH UNSAT/LOW SAT FATTY ACIDS · SODIUM · COFFEE/TEA · ADDED SUGAR |
| Based on dietary guide-lines | Colorectal cancer diet quality index (CDQI) | 1 | 1 | |
| | Colorectal cancer dietary score (CRC score) | 1 | 1 | |
| | The Lifelines Diet Score (LLDS) | 1 | 1 | |
| | Global diet quality score (GDQS) | 1 | 1 | |
| | healthful Global diet quality score (hGDQS) | 1 | 1 | |
| | unhealthful Global diet quality score (uGDQS) | 1 | 1 | |
| | Dietary recommendations for cardio-metabolic health | 1 | 1 | |

WCRF/AICR; World Cancer Research Fund/ American Institute for Cancer Research

| Pattern group | No. of papers | Score versions | Foods |
|---|---|---|---|
| **"a posteriori" dietary patterns** | | | |
| | | | ALCOHOL · FRUITS · VEGETABLES · POTATOES · LEGUMES · GRAINS AND CEREALS · POULTRY · RED MEAT/PROCESSED MEAT · EGGS · CREAM/BUTTER/MARGARINE/LARD · DAIRY PRODUCTS · FISH AND SEAFOOD · SNACKS/SWEETS/ULTRA-PROCESSED FOODS · SUGAR-SWEETENED BEVERAGES · OLIVE/VEGETABLE OIL · COFFEE/TEA · RICE/NOODLE/PASTA/PIZZA |
| Prudent/ Healthy/ Vegetable-rich | 12 | 13 | |
| Western/ Meat/ Alcohol | 10 | 16 | |
| Traditional/ Ethnic/ Mixed | 5 | 6 | |

| Pattern group | Pattern name | No. of papers | Score versions | Foods | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| "a priori" dietary patterns | | | | | | | | | | | | | | | | | | | |
| | | | | ALCOHOL | FRUITS | VEGETABLES | LEGUMES | GRAINS AND CEREALS | POULTRY | RED MEAT/PROCESSED MEAT | EGGS | CREAM/BUTTER/ MARGARINE/ LARD | LOW-FAT DAIRY PRODUCTS | HIGH FAT DAIRY PRODUCTS | FISH AND SEAFOOD | SNACKS/SWEETS/ ULTRA-PROCESSED FOODS | SUGAR-SWEETENED BEVERAGES | COFFEE/TEA | FRENCH FRIES |
| Derived from biological markers | Empirical Dietary Index for Hyperinsulinemia (EDIH) | 4 | 3 | | | | | | | | | | | | | | | | |
| | Empirical Dietary Inflammatory Pattern (EDIP) | 4 | 3 | | | | | | | | | | | | | | | | |
| | Dietary inflammation scores (DIS) | 1 | 1 | | | | | | | | | | | | | | | | |
| Derived from bacteria | Sulfur Microbial Diet Score | 1 | 1 | | | | | | | | | | | | | | | | |

Dark green colour is used to indicate a higher intake of food groups in most of the patterns (≥50% of score versions; light green colour is used to indicate a higher intake of specific food groups in some of the patterns (<50% for patterns score versions); dark red is used to indicate a lower intake of food groups in most of the patterns; light red is used to indicate a lower intake of specific food groups in some of the patterns; and yellow is used to indicate moderate intake in most of the patterns.

World Cancer Research Fund International

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American Institute for Cancer Research

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