

Chapter 10

Recommendations

Research recommendations

Research conducted to date suggests that many aspects of nutrition, including fruit and vegetable intake, are important factors in cancer prevention, but there remain many areas of uncertainty. Governments, voluntary organizations and the private sector should continue to invest in research on nutrition and cancer to better understand these relationships. Specific research needs and opportunities are listed below (not in any order of priority).

1. Improve understanding of biological mechanisms linking fruit and vegetable intake to cancer risk

- Develop and validate intermediate biomarkers of cancer risk against subsequent cancer outcomes in long-term animal and human studies to enable the assessment of effects of fruit and vegetables on intermediate steps in the cancer process.
- Conduct animal experiments to elucidate biological mechanisms, particularly experiments that test the effects of nutritional-level doses of whole foods in model systems with direct relevance to human cancers.
- Conduct research on the mechanisms of alteration of cancers by fruit and vegetable constituents across the entire lifespan, from intra-uterine life to the stages of cancer survivorship.

- Better define the biological interactions between genetic polymorphisms, cancer risk and variations in intake of fruit and vegetables. This can be done by stratified analyses and/or by analyses of genetic associations alone for genes known to affect important metabolic pathways of relevance to fruit and vegetables.

2. Improve dietary assessment

The interpretation of the weak associations often observed between fruit and vegetable intake and cancer risk is currently complicated by uncertainty as to whether they reflect stronger associations that have been diluted by measurement error. Considerable misclassification may result from the use of dietary assessment questionnaires derived from food frequency methods, which may be inadequate for measuring the small to modest levels of increased risk associated with common dietary exposures, that could have large public health importance. There is a need to:

- Develop and validate biomarkers of fruit and vegetable intake and include assessment of those biomarkers in future studies. Biological sample banks in cohort studies are a useful resource for this purpose.
- Develop standardized and validated methods that can be used in different populations to estimate the usual intake of fruit and vegetables by individuals. To estimate food intake in cohort studies with

more accuracy, there may be a need for alternatives to current food frequency questionnaires, such as multiple dietary recalls or food records, which have traditionally been used only for food frequency validation or calibration purposes.

- Develop better ways to classify fruits and vegetables as to their cancer risk. Both empirical and theoretical approaches are needed to explore the relative advantages and limitations of alternative food classification methods, such as considering fruit and vegetables as a single class of foods, as two distinct classes and/or as various subclasses defined by their food chemistry.
 - Better assess the effects on cancer risk related to food-processing and cooking.
- #### 3. Extend epidemiological research to explore new aspects
- Conduct human intervention studies of the effects of fruit and vegetables on intermediate markers of cancer risk, such as cell-cycle control, early genetic changes, genetic factors, enzyme levels, immune function and infections of relevance to cancer, such as *Helicobacter pylori*.
 - Conduct more epidemiological studies in developing countries. Such studies offer advantages of assessing associations between diet and cancer across a wider range of diets and cancers and with a different profile of confounding

factors. They would best be conducted in a coordinated way to allow cross-national comparisons and pooled analyses. Opportunities to add nutritional assessments into other large-scale studies in developing countries should be sought as a time-efficient and cost-efficient strategy.

- Conduct more research on the relationship between nutrition after the diagnosis of cancer and cancer outcomes and survival.
- Conduct more research on the behavioural and policy factors such as access to fruit and vegetables, and barriers to adequate consumption, that will be needed to increase consumption of fruit and vegetables in the populations of the world.
- Continue to conduct selected ecological studies to document any changes in cancer incidence that accompany dietary changes coincident with migration or special circumstances that arise in specific populations. Studies of special populations and unusual circumstances can help in assessing the effects on cancer of sudden or extreme diet changes.

4. Improve study designs

Improvements are needed in the design of future studies, both those conducted in experimental animals and in humans. In particular, there is a need to:

- Design studies to enable their pooling into joint analyses, so that a wider range of fruit and vegetable intakes as well as larger sample sizes will be available to allow assessment of associations with uncommon cancers as well as the investigation of interactions between fruit and vegetables and other factors.
- Develop methods to assess the impact of diet over longer periods of life, to capture potentially impor-

tant relationships between cancer risk and diet *in utero*, in childhood or in early adulthood.

- More consistently employ animal cancer model systems to enable their findings to be better compared both with each other and with human cancer studies. When possible, excessive carcinogen loads should be avoided, and the nutritional exposures that are studied should emulate human diets.
 - Develop methods to better assess the impact of selection bias and recall bias in case-control studies. Uncertainties about such biases greatly weakens confidence in the results of reported case-control studies.
- 5. Improve the reporting and analysis of data in nutritional epidemiological studies**
- Better describe the foods included in categories of "fruit and vegetables" in study reports. A full description would list all foods included in groupings, describing how mixed dishes were analysed, and how food frequency measures were translated into amounts.
 - Incorporate adjustments for measurement error in epidemiological studies. Such adjustments can be accurately made only when well conducted validation studies are incorporated into studies.
 - Conduct more analyses of interactions between fruit and vegetable intake and other cancer risk factors, especially tobacco use, alcohol drinking, genetic predisposition, body weight, and physical activity.
 - Conduct analyses to explore the complexity of the relationships between fruit and vegetables and many other aspects of diet. Methods of diet pattern recognition should be explored to determine whether they might add understanding of the relationship

between fruit and vegetables within the diet and cancer risk reduction.

- Examine the reasons for inconsistencies in findings across different types of study, different time periods and different countries, with the aim of explaining the considerable heterogeneity of findings across studies rather than simply ignoring it or reducing it by exclusion or adjustment. Those reasons might themselves clarify the relationships being studied, as well as the public health implications of the body of evidence.

Public health recommendations

Governments, non-governmental organizations and other organizations (e.g., worksites, schools and health-care systems) should include the promotion of fruit and vegetables in the diet as an important aspect of their food policy and nutrition education. In addition to the universal importance of tobacco regulations in cancer control, governments have a special responsibility to assure the availability of fruit and vegetables as objectives of policies in agriculture, economics and trade. As research continues to better define the relationships between fruit and vegetable intake and cancer risk, it is important to remember that a diet high in fruit and vegetables also offers many health advantages in addition to cancer prevention, including lowering the risk of other chronic diseases (WHO, 2003). Therefore all organizations as well as governments should continue efforts to increase or maintain fruit and vegetable intake as an important objective of programmes to improve nutrition in order to reduce the burden of cancer and other chronic diseases.