Special Article

Lifestyle and Cancer Risk

Elisabete Weiderpass

Department of Medical Epidemiology and Biostatistics, Karolinska Institutet, Stockholm, Sweden; Departmant of Etiological Research,
Cancer Registry of Norway, Oslo, Norway; Department of Genetic Epidemiology, Folkhalsan Research Center, Helsinki, Finland;
Department of Community Medicine, University of Troms∅, Troms∅, Norway

The main behavioural and environmental risk factors for cancer mortality in the world are related to diet and physical inactivity, use of addictive substances, sexual and reproductive health, exposure to air pollution and use of contaminated needles. The population attributable fraction for all cancer sites worldwide considering the joint effect of these factors is about 35% (34 % for low- and middle-income countries and 37% for high-income countries). Seventy-one percent of lung cancer deaths are caused by tobacco use (lung cancer is the leading cause of cancer death globally). The combined effects of tobacco use, low fruit and vegetable intake, urban air pollution, and indoor smoke from household use of solid fuels cause 76% of lung cancer deaths. Exposure to these behavioural and environmental factors is preventable; modifications in lifestyle could have a large impact in reducing the cancer burden worldwide. The evidence of association between lifestyle factors and cancer, as well as the main international recommendations for prevention are briefly reviewed and commented upon here.

Key words: Environment, Lifestyle, Primary prevention, Risk factors
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INTRODUCTION

Trends in cancer mortality are driven by changes in exposure to risk factors (passive to primary prevention), appropriate screening (secondary prevention) and adequate treatment (tertiary prevention). Therapeutic interventions have so far not reduced substantially overall cancer mortality, although some advances have been made for specific cancer sites (example Hodgkin's diseases and testicular cancer). Behavioural changes and screening practices, on the other hand, have had an impact in overall cancer mortality in selected countries in the last decades. Examples of this are decreasing lung cancer rates in males living in developed countries due to decreasing prevalence of smoking over time, and decreasing mortality for breast cancer in regions where organised mammography screening programmes covering large parts of the population are available [1,2].

Primary prevention though behavioural and environmental interventions - referred to below as 'lifestyle' - is beyond a doubt the most cost-effective alternative for preventing a large burden of chronic and degenerative diseases worldwide, including cancer.

In order to set priorities for the cancer prevention agendas in each country, it is necessary to understand which are the main preventable causes of cancer, and direct prevention efforts towards them, whenever possible.

MATERIALS

The World Health Organisation (WHO) performed a large project aiming to assess major health risk factors for mortality that could be prevented, the 'Comparative Risk Assessment Project' [3-5]. Within the framework of this project, the impact of lifestyle on cancer mortality was calculated using lifestyle exposure estimates and cancer mortality data available in 2001. The results of this study were published in 2005 [2] and updated in 2009 [5], and are still the most updated overall estimates of avoidable cancer deaths worldwide.

Another international charity, the World Cancer Research Fund, performed an in-depth analysis of the association between food, nutrition, physical activity and cancer globally: they reviewed all the relevant literature on the topic, and performed meta-analysis, and summarised their findings, with recommendations based on solid evidence, in a report published in 2007 [6]. This report is being constantly updated and is available at www.wcrf.org

Given the very high importance of these extensive research works for orienting public health policies in cancer prevention, their findings will be briefly summarised in the paragraphs below, and subsequently commented on in regard to prevention strategies.

Corresponding author : Elisabete Weiderpass, PO Box 281, 171 77 Stockholm, Sweden, Tel : +358408453406, E-mail : eliwei@ki.se

Table 1. Cancer risk factors, exposure variables, theoretical-minimum-risk exposure distributions, disease outcomes* [2].

Exposure variable		Theoretical-minimum-risk exposure distribution	Cancer site affected (age groups assessed)
Diet and physical inactivity			
Overweight and obesity	BMI (kg/m²)	21 SD 1 kg/m²	Corpus uteri, colorectal ($\geq$ 30 years) post-menopausal breast ($\geq$ 45 years), gallbladder[+], kidney[+]
Low fruit and vegetable intake	Fruit and vegetable intake per day	600 SD 50 g / day per adult	Colorectal, stomach, lung, oesophagus ($\geq$ 15 years)
Physical inactivity	Three categories: inactive, insufficiently active (< 2.5 h/week of moderate-intensity activity, or < 4000 KJ/week) and sufficiently active. Activity in work, spare time and transport considered	$\geq$ 2.5 hours/week of moderate-intensity activity or equivalent (400 KJ/week)	Breast, colorectal ($\geq$ 15 years), prostate[+]
Addictive substances			
Smoking*	Current levels of smoking impact ratio (indirect indicator of accumulated smoking risk based on excess lung-cancer mortality)	No smoking	Lung, mouth, oropharynx, oesophagus, stomach, liver, pancreas, cervix uteri, bladder, leukaemia ($\geq$ 30 years).
Alcohol use	Current alcohol consumption volumes and patterns	No alcohol use[+]	Liver, mouth, oropharynx, breast, oesophagus, selected other cancers ($\geq$ 15 years)
Sexual and reproductive health			
Unsafe sex	Sex with an infected partner without any measure to prevent infection	No unsafe sex	Cervix uteri (all ages) [§]
Environmental risks			
Urban air pollution	Estimated yearly average particulate matter concentration for particles with aerodynamic diameters < 2.5 microns or 10 microns (PM2.5 or PM10)	7.5 μg/m³ for PM2.5 15 μg/m³ for PM10	Lung ($\geq$ 30 years)
Indoor smoke from household use of solid fuels	Household use of solid fuels	No household solid fuel use with limited ventilation	Lung ($\geq$ 30 years)
Other selected risks			
Contaminated injections in health-care settings	Exposure to $\geq$ 1 contaminated injection (potential transmission of hepatitis B or C viruses)	No contaminated injections	Liver (all ages)

*New exposure data and epidemiological evidence on disease outcomes and relative risk used when new epidemiological analyses allowed improvments compared with original analyses of Comparative Risk Assesment project-eg, relative risks for site-specific cancers as a result of smoking with better adjustment for potentioal confounders and new exposure data sources for overweight and obesity.

[+]Outcomes likely to be causal but not quantified because of insufficient evidence on prevalence or hazard size.

Corresponding ICD 9 3-digit codes: bladder cancer 188; breast cancer 174; cervix uteri cancer 180; colorectal cancers 153-154; corpus uteri cancer 179, 182; leukaemia 204-208; liver cancer 155; mouth and oropharynx cancer 140-149; oesophageal cancer 150; pancreatic cancer 157; stomach cancer 151; trachea, bronchus, and lung cancers 162; selected other cancers 210-239.

Total deaths from cancer are from WHO (World Health Organization). Methods used by WHO are based on a combination of vital statistics for countries with complete vital registration and medical certification of deaths, and on a combination of demographic techniques and information from cancer registries for countries with incomplete vital statistics, with sample registration or surveillance systems, or without vital registration.

[+]Alcohol has benefits as well as harms for different diseases, also depending on patterns of alcohol consumption. A theoretical minimum of zero was chosen for alcohol use because, despite benefits for specific diseases (cardiovascular) in some populations, global and regional burden of disease due to alcohol use was dominated by its effects on neuropsychological diseases and injuries, which are considerably larger than benefits to vascular diseases. Furthermore, no benefits for neoplastic disease have been noted from alcohol.

[§]A proportion of HPV (Human papillomavirus) infections that lead to cervix uteri cancer are transmitted through routes other than sexual contact. PAF (population attributable fraction) for unsafe sex, as defined in the Comparative Risk Assessment Project, measures current population-level cervix cancer mortality that would be reduced, had there never been any sexual transmission of infection--i.e., the consequences of past and current exposure, as for accumulated hazards of smoking. By considering health consequences of past and current exposure, nearly all sexually transmitted diseases are attributable to unsafe sex because, in the absence of sexual transmission in the past, current infections transmitted through other forms of contact would not occur if infected hosts acquired their infection sexually (and so on in the sequence of past infected hosts).

RESULTS AND DISCUSSION

I. Brief summary of the WHO burden of disease study-causes of cancer worldwide: comparative assessment of nine behavioural and environmental risk factors [2]

The lifestyle exposures used in this WHO evaluation were selected based on the probability of being a leading cause of cancer worldwide, high likelihood of causality, availability of exposure data for most populations, and the potential for prevention through lifestyle modification.

These are:
- Use of addictive substances: cigarette smoking and alcohol consumption;
- Diet: overweight and obesity (i.e. high body mass index) and low fruit and vegetable intake;
- Physical inactivity;
- Sexual and reproductive health: exposure to unsafe sex;
- Environmental risks: urban air pollution, and indoor smoke from household solid fuels; and
- Exposure to contaminated needles/injections in health care settings.

Their theoretical-minimum-risk exposure distribution and the cancer sites affected by them are summarised in Table 1 (modified from Danaei et al., 2005 [2]). They represent the alternative scenario defined as the exposure distribution that would result in the lowest population risk, for example if all the population were lifelong non-smokers; or had the ideal body mass index, or were consuming sufficient fruits and vegetables).

The population attributable fraction (PAF) for these individual risk factors has been calculated. In summary the PAF estimates the proportion reduction in site-specific cancer mortality that would happen given that the exposure to the risk factor was reduced to the theoretically-minimum-exposure distribution. The PAF estimates were calculated taking into account age, sex, geographical region, prevalence of the risk factors, cancer mortality rates, and multiple risk factors (i.e. the fact that part of the population may be exposed to more than one risk factor, for example being a smoker and obese).

Of the 7 million cancer deaths worldwide in the year 2001, the joint effect of these preventable risk factors is about 35%, or 2.43 million deaths.

The largest PAF, over 60%, was observed for cervical cancer (caused by unsafe sex and consequently infection with human papillomaviruses (HPV), a necessary cause of cervical cancer), lung cancer (caused in at least 70% of the cases by smoking; the combined effects of tobacco use, low fruit and vegetable intake, urban air pollution, and indoor smoke from household use of solid fuels cause 76% of lung cancer deaths), and oesophageal cancer (caused by smoking in 42% of the cases, 26% by alcohol use, and 18% by low fruit and vegetable consumption).

The individual and joint contribution of risk factors in Table 1 to mortality from site-specific cancers are shown in Table 2 (modified from Danaei et al., 2005 [2]). Cancers with very low 5 year survival rates were represented over 1/3 of all risk-factor attributable deaths: 37% to lung cancer (908 000 deaths), 12% to liver cancer (283000 deaths), and 11% to oesophageal cancer (271000 deaths).

Most of the cancer deaths, 70%, attributed to the lifestyle factors in Table 1 happened in low- and middle-income countries, and 30%, in high-income countries. Lung (512000), liver (229000) and oesophagus (222 000) had the largest number of cancer-attributable deaths in low- and middle-income countries, while lung cancer accounted for 52%, or risk-factor attributable deaths in high-income countries.

Overall, smoking is estimated to have caused 21% of cancer deaths worldwide: 29% in high-income countries and 18% in low- and middle-income countries. However, the number of smoking attributable deaths was larger in low- and middle-income countries (896 000) than in high-income countries (596000).

Low fruit and vegetable consumption caused 5% of all cancer deaths worldwide: 6% in low- and middle-income countries and 3% in high-income countries (Table 2).

Alcohol use is estimated to have caused 5% of all cancer deaths worldwide, the proportion being similar in low- and middle-income countries.

Cancer potentially caused by agents transmitted by contaminated injections in health-care settings occurred mainly in the East Asia Pacific region (91000 of 108 000).

Cancers caused by indoor smoke from solid fuels - mainly due to combustion of coal - were restricted to the East Asia and Pacific and Sub-Saharan African regions.

Overweight and obesity and physical inactivity affected mostly cancer mortality in Europe and Central Asia.

Twice as many men (1.6 million) as women (0.83 million) died due to the lifestyle factors studied: 41% of deaths from cancer attributable to these risk factors in

Table 2. Individual and joint contributions of risk factors in Table 1 (see above) to mortality from site-specific cancers [2].

	Total deaths	PAF (%) and number of attributable cancer deaths (thousands) for individual risk factors	PAF (%) due to joint hazards of risk factors
Worldwide			
Mouth and oropharynx cancers	311 633	Alcohol use (16%, 51), smoking (42%, 131)	52
Oesophageal cancer	437 511	Alcohol use (26%, 116), smoking (42%, 184), low fruit and vegetable intake (18%, 80)	62
Stomach cancer	841 693	Smoking (13%, 111), low fruit and vegetable intake (18%, 147)	28
Colon and rectum cancers	613 740	Overweight and obesity (11%, 69), physical inactivity (15%, 90), low fruit and vegetable intake (2%, 12)	13
Liver cancer	606 441	Smoking (14%, 85), alcohol use (25%, 150), contaminated injections in health-care settings (18%, 111)	47
Pancreatic cancer	226 981	Smoking (22%, 50)	22
Trachea, bronchus, and lung cancers	1 226 574	Smoking (70%, 856), low fruit and vegetable intake (11%, 135), indoor smoke from household use of solid fuels (1%, 16), urban air pollution (5%, 64)	74
Breast cancer	472 424	Alcohol use (5%, 26), overweight and obesity (9%, 43), physical inactivity (10%, 45)	21
Cervix uteri cancer	234 728	Smoking (2%, 6), unsafe sex (100%, 235)	100
Corpus uteri cancer	70 881	Overweight and obesity (40%, 28)	40
Bladder cancer	175 318	Smoking (28%, 48)	28
Leukaemia	263 169	Smoking (9%, 23)	9
Selected other cancers	145 802	Alcohol use (6%, 8)	6
All other cancers	1 391 507	None of selected risk factors	-
All cancers	7 018 402	Alcohol use (3%, 351), smoking (21%, 1493), low fruit and vegetable intake (5%, 374), indoor smoke from household use of solid fuels (< 0.5%, 16), urban air pollution (1%, 64), Overweight and obesity (2%, 139), physical inactivity (2%, 135), contaminated injections in health-care settings (2%, 111), unsafe sex (3%, 235)	35
Low- and middle-income countries			
Mouth and oropharynx cancers	271 074	Alcohol use (14%, 38), smoking (37%, 100)	48
Oesophageal cancer	379 760	Alcohol use (24%, 92), smoking (37%, 141), low fruit and vegetable intake (19%, 73)	58
Stomach cancer	695 426	Smoking (11%, 74), low fruit and vegetable intake (19%, 130)	27
Colon and rectum cancers	356 949	Overweight and obesity (9%, 32), physical inactivity (15%, 54), low fruit and vegetable intake (2%, 9)	11
Liver cancer	504 407	Smoking (11%, 56), alcohol use (23%, 117), contaminated injections in health care settings (21%, 108)	45
Pancreatic cancer	116 827	Smoking (15%, 18)	15
Trachea, bronchus, and lung cancers	770 938	Smoking (60%, 466), low fruit and vegetable intake (13%, 98), indoor smoke from household use of solid fuels (2%, 16), urban air pollution (7%, 52)	66
Breast cancer	317 195	Alcohol use (4%, 12), overweight and obesity (7%, 23), physical inactivity (10%, 30)	18
Cervix uteri cancer	218 064	Smoking (2%, 4), unsafe sex (100%, 218)	100
Corpus uteri cancer	43 926	Overweight and obesity (37%, 16)	37
Bladder cancer	116 682	Smoking (21%, 24)	21
Leukaemia	190 059	Smoking (6%, 11)	6
Selected other cancers	88 709	Alcohol use (4%, 3)	4
All other cancers	882 001	None of selected risk factors	-
All cancers	4 952 014	Alcohol use (5%, 262), smoking (18%, 896), low fruit and vegetable intake (6%, 311), indoor smoke from household use of solid fuels (< 0.5%, 16), urban air pollution (1%, 52), Overweight and obesity (1%, 71), physical inactivity (2%, 84), contaminated injections in health-care settings (2%, 108), unsafe sex (4%, 218)	34

men compared to 27% in women. Lung cancer was the most important preventable cancer in men (45% of all lifestyle attributable cancer deaths) and cervix uteri cancer in women (28% of all lifestyle attributable cancer deaths). Smoking and alcohol use accounted for the main differences in cancer mortality patterns attributable to lifestyle between men and women. The largest differences in male-female patterns for PAF for cancer

Table 2. Continued

	Total deaths	PAF (%) and number of attributable cancer deaths (thousands) for individual risk factors	PAF (%) due to joint hazards of risk factors
High-income countries			
Mouth and oropharynx cancers	40559	Alcohol use (33%, 14), smoking (71%, 29)	80
Oesophageal cancer	57752	Alcohol use (41%, 24), smoking (71%, 41), low fruit and vegetable intake (12%, 7)	85
Stomach cancer	146267	Smoking (25%, 36), low fruit and vegetable intake (12%, 17)	34
Colon and rectum cancers	256791	Overweight and obesity (14%, 37), physical inactivity (14%, 36), low fruit and vegetable intake (1%, 3)	15
Liver cancer	102033	Smoking (29%, 29), alcohol use (32%, 33), contaminated injections in health-care settings (3%, 3)	52
Pancreatic cancer	110154	Smoking (30%, 33)	30
Trachea, bronchus, and lung cancers	455636	Smoking (86%, 391), low fruit and vegetable intake (8%, 36), indoor smoke from household use of solid fuels (0%), urban air pollution (3%, 12)	87
Breast cancer	155230	Alcohol use (9%, 14), overweight and obesity (13%, 20), physical inactivity (9%, 15)	27
Cervix uteri cancer	16663	Smoking (11%, 2), unsafe sex (100%, 17)	100
Corpus uteri cancer	26955	Overweight and obesity (43%, 12)	43
Bladder cancer	58636	Smoking (41%, 24)	41
Leukaemia	73110	Smoking (17%, 12)	17
Selected other cancers	57095	Alcohol use (8%, 5)	8
All other cancers	509507	None of selected risk factors	-
All cancers	2066388	Alcohol use (4%, 88), smoking (29%, 596), low fruit and vegetable intake (3%, 64), indoor smoke from household use of solid fuels (0%), urban air pollution (1%, 12), Overweight and obesity (3%, 69), physical inactivity (2%, 51), contaminated injections in health-care settings (< 0.5%, 3), unsafe sex (1%, 17)	37

PAF: population attributable fraction.

mortality were for mouth and oropharynx (66% in men, 23% in women).

Besides cancer mortality, the risk factors described above cause an enormous burden to individuals and the society globally in terms of DALY's (disability adjusted life year's): alcohol causes 4% of all DALY's, being the 3rd most frequent cause of DALY's after childhood overweight and unsafe sex). Smoking causes 3,7% of all DALY's being the 6th most frequent cause of DALY's after the reasons above, lack of sanitation and high blood pressure).

II. Comments and Considerations about the WHO Study [5]

In summary, according to the WHO study, at least 35% of deaths from cancer worldwide were caused by nine potentially modifiable lifestyle factors, in particular smoking and alcohol use both in high-income and low- and middle-income countries.

Human papillomavirus (HPV) infection is a major factor for cancer mortality in women in particularly in Sub-Saharan Africa and South Asia, i.e. regions where population-based programmes for cervical cancer screening are not yet properly implemented. In recent years vaccines against the HPV genotypes that cause most cervical cancer cases around the world, namely types 16 and 18, have been approved for use in adolescent and young women. Vaccination is being implemented in several high-income countries, but the costs of vaccination are still prohibitive for implementation worldwide. Nevertheless, there is hope that cervical cancer incidence - and mortality - may dramatically change in the next decades [7-9].

Several other important lifestyle factors that do cause a substantial proportion of cancer morbidity and mortality in the world were not accessed in the WHO project, mainly because of lack of comparable statistics about their prevalence worldwide by gender in different age groups. Among these are the most carcinogenic substances occurring in occupational settings [10-13], exposure to ultraviolet light and use of ultraviolet-emitting tanning devices [14], environmental tobacco smoking [15-17], several dietary factors commented on below [6,17], use of medicines such as hormone replacement therapy [18-20], exposure to ionizing radiation [14], aflatoxins [21-23], and other infections, such as *Helicobacter pylori* [24,25], human immunodeficiency virus type 1 and type

2 [25,26], and parasites [24].

Also the links between the lifestyle factors and cancer sites affected included in the WHO study were very conservative–only associations which were widely accepted at the time of the study were included. During the past few years other associations have been established and were not included in the WHO report, such as the association between colon cancer and alcohol [6,16,17], and several other dietary factors. Thus, dietary factors, obesity, and physical (in)activity, in particular, may have been somewhat under-represented in the estimates of the GBD (Global Burden of Disease) WHO report; thus, probably a larger proportion of cancers are actually attributable to lifestyle factors and can therefore be prevented.

III. The World Cancer Research Fund Report 2007 [6]

The WCRF 2007 report estimates that 35% of the cancer incidence worldwide could be attributable to food, nutrition, and physical (in)activity: the report did not consider smoking and other environmental or lifestyle factors. The main conclusions of the report are summarised in Figure 1.

As body fatness does increase risk of several cancers (colorectal, breast (post-menopausal), kidney, oesophageal, gastric cardia, endometrial, gallbladder) keeping a healthy weight throughout life may be one of the most important ways to protect against cancer. The definition of healthy weight does vary in different populations: for example in Korea the recommended BMI to prevent cancer is lower than the recommended BMI in Caucasian populations in West Europe/USA.

All forms of physical activity do protect against some cancers (colon/colorectal cancer (convincing evidence) and post-menopausal breast and endometrial (probable evidence)), as well as other diseases, and against weight gain, overweight and obesity, while sedentary attitude causes the opposite; weight gain, overweight and obesity are causes of some cancers independently of the level of physical activity.

Most diets that are protective against cancer include fruits, cereals (grains), pulses (legumes), and non-starchy plants, including green, leafy vegetables, broccoli, okra, aubergine (eggplant) and bok choi, as well as non-
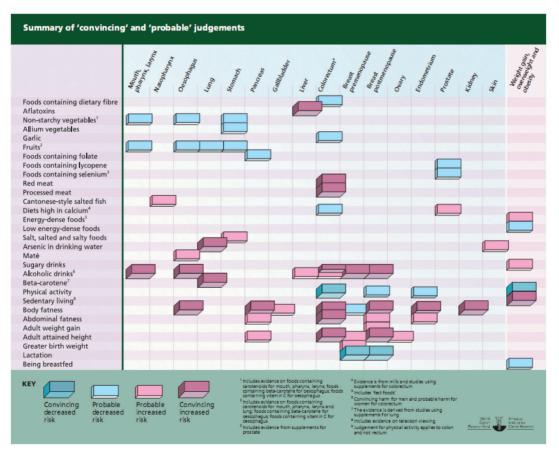

Figure 1. Food, nutrition, physical activity, and the prevention of cancer: overview of the Panels key judgement [6].

Table 3. Summary of the World Cancer Research Fund recommendations for food, nutrition, physical activity and prevention of cancer [6].

Potentially modifiable risk factors	Recommendations	Public health goal	Personal recommendation
Body fatness	Be as lean as possible within the normal range* of body weight	Median adult body mass index (BMI 9 to be between 21 and 23, depending on the normal range for different populations[†] The proportion of the population that is overweight or obese to be no more than the current level, or preferably lower, in 10 years	Ensure that body weight though childhood and adolescent growth projects[†] towards the lower end of the normal BMI range at age 21 Maintain body weight within the normal range from age 21 Avoid weight gain and increases in waist circumference throughout adulthood
Physical activity	Be physically active as part of everyday life	The proportion of the population that is sedentary[†] to be halved every 10 years. Average physical activity levels to be above 1.6	Be moderately physically active, equivalent to brisk walking±, for at least 30 minutes a day As fitness improves, aim for 60 minutes or more of moderate, or for 30 minutes or more of vigorous, physical activity every day±,¶
Foods and drinks that promote weight gain	Limit consumption of energy-dense foods[§] Avoid sugary drinks[ᵝ]	Average energy density of diets[λ] to be lowered towards 125 kcal per 100 g Population average consumption of sugary drinks[ᵝ] to be halved every 10 years	Consume energy-dense foods[§,£] sparingly Avoid sugary drinks[ᵝ] Consume 'fast foods'[ϵ] sparingly, if at all
Plant foods	Eat mostly foods of plant origin	Population average consumption of non-starchy[#] vegetables and of fruits to be at least 600 g (21 oz) daily** Relatively unprocessed cereals (grains) an/or pulses (legumes), and other foods that are a natural source of dietary fibre, to contribute to a population average of at least 25 g non-starchy polysaccharide daily	Eat at least five portions/servings (at least 400 g or 14 oz) of a variety** of non-starchy vegetables and of fruits every day Eat relatively unprocessed cereals (grains) and/or pulses (legumes) with every meal[††] Limit refined starchy foods People who consume starchy roots or tubers[††] as staples also to ensure intake of sufficient non-starchy vegetables, fruits, and pulses (legumes)

* 'Normal range' refers to appropriate ranges issued by national governments or the World Health Organisation (WHO).

[†] To minimise the proportion of the population outside the normal range.

[†] 'Projects' in this context means following a pattern of growth (weight and height) throughout childhood that leads to adult BMI at the lower end of the normal range. Such patterns of growth are specified in the International Obesity task Force and WHO growth reference charts.

[∥] The term 'sedentary' refers to a PAL of 1.4 or less. PAL is a way of representing the average intensity of daily physical activity. PAL is calculated as total energy expenditure as a multiple of basal metabolic rate.

± Can be incorporated in occupational, transport, household, or leisure activities.

¶ This is because physical activity of longer duration or greater intensity is more beneficial.

[§] Energy-dense foods are defined as those with an energy content of more than about 225-275 kcal per 100 g.

[ᵝ] This principally refers to drinks with added sugars. Fruit juices should also be limited.

[λ] This does not include drinks.

£ Limit processed energy-dense foods. Relatively unprocessed energy-dense foods, such as nuts and seeds, have not been shown to contribute to weight gain when consumed as parts of typical diets, and these and many vegetable oils are valuable sources of nutrients.

ϵ 'Fast foods' refers to readily available convenience foods that tend to be energy-dense and consumed frequently and in large quantities.

This is best made up from a range of various amounts of non-starchy vegetables and fruits of different colours including red, green, yellow, white, purple, and orange, including tomato-based products and allium vegetables such as garlic.

**Relatively unprocessed cereals (grains) and/or pulses (legumes) to contribute to an average of at least 25 g non-starch polysaccharide daily.

[††] These foods are low in energy density and promote healthy weight.

[††] Mainly populations in Africa, Latin America, and Asia Pacific region.

[∥∥] 'Red meat' refers to beef, pork, lamb, and goat from domesticated animals including that contained in processed foods.

±± 'Processed meat' refers to meat preserved by smoking, curing or salting, or addition of chemical preservatives, including that contained in processed foods.

¶¶ This recommendation takes into account that there is a likely protective effect for coronary heart disease.

§§ Children and pregnant women should not consume alcoholic beverages.

ᵝᵝ One 'drink' contains about 10-15 grams of ethanol.

λλ Methods of preservation that do not or need not to use salt include refrigeration, freezing, drying, bottling, canning and fermentation.

££ This may not always be feasible. In some situations of illness or dietary inadequacy, supplements may be valuable.

ϵϵ Breastfeeding protects both mother and child.

'Exclusively' means human milk only, with no other food or drink, including water.

*** In accordance with the UN Global strategy on Infant and Young Child Feeding.

[†††] Cancer survivors are people who are living with a diagnosis of cancer, including those who have recovered from the disease.

[†††] This recommendation does not apply to those who are undergoing active treatment.

[∥∥∥] This includes all cancer survivors, before, during, and after active treatment.

Table 3. Continued

Potentially modifiable risk factors	Recommedations	Public Health Goal	Personal recommendation
Animal foods	Limit intale of red meat[||] and avoid processed meat[±±]	Population average consumption of red meat to be no more than 300 g (11 oz 9 a week, very little if any of which to be processed	People who eat red meat[||] to consume less than 500 g (18 oz) a week, very little if any to be processed[±±]
Alcohol drinks	Limit alcoholic drinks[¶¶]	Proportion of the population drinking more than the recommended limits to be reduced by one-third every 10 years[¶¶,§§]	If alcoholic drinks are consumed, limit consumption to no more than two drinks a day for men and one drink a day for women [¶¶,§§,ĥ]
Preservation, processing, preparation	Limit consumption of salt[ᴬᴬ]. Avoid mouldy cereals (grains) or pulses (legumes)	Population average consumption of salt from all sources to be less than 5 g (2 g or sodium) a day. Proportion of the population consuming more than 6 g of salt (2.4 of sodium) a day to be halved every 10 years. Minimum exposure to aflatoxins from mouldy cereals (grains) or pulses (legumes)	Avoid salt-preserved, salted, or salty foods; preserve foods without using salt[ᴬᴬ]. Limit consumption of processed foods with added salt to ensure an intake of less than 6 g (2.4 g sodium) a day. Do not eat mouldy cereals (grains) or pulses (legumes)
Dietary supplements	Aim to meet nutritional needs through diet alone[εε]	Maximise the proportion of the population achieving nutritional adequacy without dietary supplements	Dietary supplements are not recommended for cancer prevention
Breastfeeding	Mothers to breastfeed; children to be breastfed[≠∈]	The majority of mothers to breastfeed exclusively, for six months[##,""]	Aim to brestfeed infants exclusively up to six months and continue with complementary feeding thereafter[##,""]
Cancer survivors[†††]	Follow recommendations for cancer prevention above[†††]	All cancer survivors[|||] to receive nutritional care from an appropriately trained professional. If able to do so, and unless otherwise advised, aim to follow the recommendations for diet, healthy weight, and physical activity[†††]	

starchy roots and tubers such as carrots, artichokes, celery root, and turnips. Most probably these diets protect against cancer due to the high nutrient, high fibre content and low in energy density, although the exact mechanisms of carcinogenicity are not yet completely understood.

The WCRF 2007 report points out in particular the confirmed association between consumption of red meat (i.e. beef, pork, lamb, and goat) and processed meat (i.e. meats preserved by smoking, curing or salting, or addition of chemical preservatives, including that contained in processed foods) and the risk of colorectal cancer, in addition to confirming the associations between overweight and obesity, physical inactivity, alcohol use and risk of several cancer sites [6]. However, studies on entirely vegetarian populations have not been consistent, showing an overall decrease in cancer incidence. This suggests that the consumption of red meat should be limited.

The WCRF report also stresses the clear evidence of associations between alcohol consumption and several cancer sites (mouth, pharynx, larynx, oesophagus, colorectum in men, breast (pre-and post-menopausal)). In particular there is new evidence of the association with colorectal cancer risk and breast cancer risk among females: the increase in breast cancer risk is about 10% per 10 grams of alcohol consumed per day (i.e. per 1

drink per day), and the association seems to be linear without a threshold of risk, i.e. the higher the amount of alcohol consumed per day the higher the risk of breast cancer. Thus, based solely on the evidence on cancer, even small amounts of alcoholic drinks should be avoided, i.e. there is no 'safe drinking' in regard to cancer risk. All alcoholic drinks (beer, wine, rice wine, sake, spirits or licquors) have similar effects on cancer risk, the total amount of ethanol consumed is the factor determining risk. Given that modest amounts of alcohol consumption are likely protective for cardiovascular diseases, the recommendations from WCRF are to limit alcohol consumption to no more than 2 drinks a day for men and one drink per day for woman. Current Korean recommendations are 2 drinks a day for both men and women for the sake of simplicity of the risk communication with the general public.

Consumption of salt-preserved, salted, or salty foods are possibly linked to stomach cancer risk, and therefore should be avoided. The overall consumption of salt itself should be limited to no less than 6 grams (2.4 grams of sodium) per day. Similarly, mouldy cereals (grains) or pulses (legumes) may be contaminated with aflatoxins, which causes liver cancer, and therefore should be completely avoided.

There is no sufficient evidence so far that dietary supplements have any impact on preventing cancer risk;

therefore, for cancer prevention purposes, dietary supplements are not recommended.

Trends in the prevalence of lifestyle factors are changing constantly, in particular for overweight and obesity (increasing dramatically worldwide in all age groups and in both genders), physical activity levels (decreasing worldwide as urbanisation increases), smoking (decreasing in most high-income countries among males, still increasing in selected high-income countries among females, still increasing in most low- and middle-income countries), and alcohol consumption (mixed pattern of changes in consumption among males and females in different regions of the world). Therefore, we will probably observe substantial changes in the PAF attributable to these factors in the next years. Moreover, our knowledge about the associations between lifestyle risk factors and cancer incidence - and consequently mortality - is improving constantly, as newer and larger population-based studies are becoming available.

Despite all the available information reported above, our current knowledge on the association between lifestyle and cancer is still limited.

IV. Cancer Prevention

By far the most important preventable determinant of cancer mortality is cigarette smoking. While some high-income countries have successfully managed to decrease overall smoking prevalence in adults (USA, Nordic countries). This was achieved with public health campaigns carried on for decades, large-scale education (including as formal subjects on health education at school), and public health policy prohibiting smoking in public places (schools, hospitals, work places, public transport), as well as progressive increase in taxation on smoking products. Although smoking rates in Korea have declined among men during the last years, about 40% of the adult male population still smokes [27]. Therefore all efforts should be combined from the public health community, civil society and government to encourage smokers to stop smoking, and to avoid that children, teenagers and young adults start smoking at all [28]. A complete ban of smoking in public places, including restaurants and bars has been shown to be effective in decreasing overall smoking rates as well as improving lung function in bar and restaurant workers [28].

Given our high level of confidence in the evidence between lifestyle factors and cancer risk, several several national and international organisations have issued guidelines for cancer prevention. In relation to food,

including alcoholic beverage drinking, nutrition, and physical activity, the WCRF issued recommendations for populations (i.e. for public health authorities, based on public health goals) and individuals [6]. These recommendations are summarised in Table 3. Regarding the body fatness recommendation it is important to notice that what is considered normal range varies in different populations: for example in Korea the recommended BMI to prevent cancer is lower than the recommended BMI in Caucasian populations in West Europe/USA.

The recommendations for physical activity may be more easily accommodated in routine activities of daily life, such as climbing stairs (instead of using elevators), using a bicycle to travel to/from work/school in places where this is possible, getting off the subway one station before the destination and walk the last part of the journey, parking the car relatively far away from the destination place to allow at least some walking, and so on. In addition to these specific recommendations the WCRF stresses the importance of not smoking and avoiding exposure to tobacco smoke (i.e. passive smoking or second-hand smoking) entirely.

CONCLUSION

Large-scale, evidence-based preventive efforts, including policies and programmes for lifestyle modification, have the potential to avoid at least 40% of the millions of cancer deaths yearly.

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FURTHER READING

For those interested in further reading the following documents and websites may be valuable:

1. International Agency for Research on Cancer website (http://www.iarc.fr/); Documents on the Monographs unit:http://www.iarc.fr/en/publications

/pdfs-online/monographs/index.php. A list of the substances evaluated for carcinogenicity can be downloaded at the following link: http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf.

2. World Cancer Research Fund website: http://www.wcrf-uk.org for downloading the WCRF 2007 report on food, nutrition, physical activity and prevention of cancer: a global perspective, as well as watching the excellent lectures on nutrition and cancer from the WCRF International Conference 2010.

3. Global Burden of Disease project: (GBD) is a comprehensive regional and global assessment of mortality and disability from 107 diseases and injuries and ten risk factors. The GBD is assessed using the GBD study by the World Health Organization (WHO), and is an example of an evidence-based input to public health policy debate. The aim of the study was to provide information and projections about disease burden on a global scale. The GBD project was initiated in 1992 and is currently a collaborative effort between more than 800 experts worldwide, including researchers at the Harvard School of Public Health, the Institute for Health Metrics and Evaluation (IHME), WHO and the World Bank. The original project estimated health gaps using disability-adjusted life years (DALYs) for eight regions of the world in 1990. It provides a standardised approach to epidemiological assessment and uses a standard unit, the DALY, to aid comparisons. Website: http://www.who.int/topics/global_ burden_of_disease/en/.

Appendix 1. World Cancer Research Fund Policy report 2007 [29]

1. MULTINATIONAL BODIES

Includes policy-makers and decision-takers in international political, economic, and trade bodies such as the International Monetary Fund, the World Bank, the World Trade Organization, the European Union, the North American Free Trade Association, the southern Latin American trade association (Mercosul) and others, as well as the United Nations (UN) and its constituent bodies. Key UN organisations include the Food and Agriculture Organization, the World Health Organization, the Pan American Health Organization, the International Agency for Research on Cancer, the United Nations Children's Fund, the United Nations Development Programme, the UN Educational, Scientific and Cultural Organization, the World Food Programme, the International Labour Office, and many others. Also includes inter-UN bodies concerned with food and nutrition, notably the UN System Standing Committee on Nutrition and the Codex Alimentarius Commission. (For international civil society organisations and transnational industries, see Civil society organisations and Industry.)

A. AIM: Originate and promote coordinated strategies that protect public health through food, nutrition, and physical activity (Includes the prevention of cancer and other chronic diseases. Thus, the European Union, the World Bank, the International Monetary Fund, the World Trade Organization, the Codex Alimentarius Commission, and other multinational bodies, especially those whose decisions have the force of law or that are otherwise binding, need to incorporate protection and maintenance of public health as an invariable part of their work)

B. RECOMMENDATIONS

All multinational bodies: Build the protection and maintenance of public health into all relevant agriculture, food, health, economic, trade, environmental, and other agreements

United Nations bodies: Work together to ensure integrated policies among all relevant agencies

2. CIVIL SOCIETY ORGANISATIONS

International, national, and local civil society organisations. Includes public interest and consumer organisations, professional and scientific bodies, political parties, trades unions, religious groups, women's groups, and small farming and fishing cooperatives. Excludes industry and business interest organisations, and the media. (See Industry and Media below)

A. AIM: Create, advocate, and develop sustainable policies and actions that ensure healthy food, nutrition, and physical activity for all

B. RECOMMENDATIONS

All civil society organisations: Create, develop, and press governments and other actors (i.e. multinational bodies, industry, media, schools, workplaces and other institutions, health and other professionals, and people, and also other civil society organisations) to implement effective policies and programmes for nutrition and physical activity

Civil society organisations concerned with public health:

Hold other actors to account regarding their policies and actions on food, nutrition, and physical activity, including the prevention of cancer

Mobilise the media and public opinion in support of improved public health, including healthy nutrition, sustained physical activity, and the prevention of cancer

Form alliances with associated civil society organisations including those concerned with public policy, justice, equity, and environmental protection

Advocate traditional cultures and ways of life when these generate healthy, diverse, and sustainable dietary patterns and regular physical activity

3. GOVERNMENTS

Policy-makers and decision-takers in national and also sub-national (state, provincial, municipal, local) government and its agencies. Relevant government departments include office of the head of state or prime minister, finance, trade, employment, social security, justice, home affairs, and foreign affairs as well as food, agriculture, and health. Also includes publicly funded agencies and institutions whose work affects public health. National government international trade and aid agencies are also included here.

A. AIM: Use legislation, pricing, and other policies at all levels of government to promote healthy patterns of diet and physical activity

B. RECOMMENDATIONS

Examine, audit, and revise legislation and regulations so that they protect public health and prevent disease, including cancer

Ensure that built and external environments are designed and maintained in ways that facilitate physical activity and other healthy behaviour

Encourage safe, nutrient-dense, and relatively unprocessed foods and drinks and discourage sugary and alcoholic drinks, 'fast food' , and other processed foods (those relatively high in sugars, refined starches, fat, or salt)

Require schools to provide meals to high nutritional standards and facilities for recreation and sport, and to include nutrition and physical activity in core curricula

Require all government and publicly funded facilities that provide catering to ensure that their meals, foods, and drinks are of high nutritional quality

Require widespread dedicated walking and cycling facilities throughout built and external environments

Restrict advertising and marketing of 'fast food' and other processed foods and sugary drinks to children, on television, in other media, and in supermarkets

Incorporate UN recommendations on breastfeeding into law or appropriate public health and consumer protection rules Give greater priority to research on, and programmes to improve, public health including the prevention of cancer and other diseases

Establish and maintain publicly funded information and education on, and surveillance of, food, nutrition, and physical activity status

Ensure that international food trade and aid sustains future health as well as providing immediate relief for populations in recipient countries

Most of the above recommendations can be achieved by means of legislation, pricing, or other regulation unless there is good independent evidence that existing voluntary codes have been proved to be effective.

4. INDUSTRY

Owners, directors, executives, and other decision-takers in all transnational, international, and national industries whose policies and practices have an impact on health. These include food producers, manufacturers, distributors, retailers, and caterers. They also include all industries responsible for shaping built environments and the entertainment, leisure, and sports industries.

A. AIM: Emphasise the priority given to public health including cancer prevention in strategic planning and action

B. RECOMMENDATIONS

Built environment industries: Plan, commission, construct, and operate all built environments so as to protect public health and facilitate physical activity

Food and drink industries:

Make public health an explicit priority in all stages of food systems including product research, development, formulation and reformulation, and promotion

Ensure that healthy meals, snacks, foods, and drinks are competitively priced compared with other products

Collaborate in order to stop advertising, promotion, and easy availability of sugary drinks and unhealthy foods to children

Ensure that marketing and promotion of breast milk substitutes and complementary foods follow the terms of UN codes and strategies on infant and young child

Appendix 1. Continued

feeding

Ensure accuracy, uniformity, and availability of product information in all advertising and promotion and on food labels (Relatively healthy processed foods and drinks are packaged or presented in appropriate portion sizes as recommended by national governments or UN agencies, are explicitly labelled, are relatively low in added saturated fats, fats and oils, and sugars and syrups and are therefore relatively nutrient-dense and low in energy density, low in salt, and contain minimal or no trans-fatty acids. Fresh or minimally processed energy-dense foods that are also nutrient-dense, such as nuts, seeds, and some oils, are healthy.)

Physical activity industry (Such as sporting goods manufacturers and providers of health centres and sports facilities): Promote goods and services that encourage participation in physical activity by people of all ages, rather than in competitive or elite sporting performance

Entertainment and leisure industry: Give higher priority to entertainment products and services that enable everybody, especially children and young people, to be physically active

5. MEDIA

Owners, directors, editors, journalists, and other opinion-formers from the lay, technical, and specialist broadcast, print, and electronic media and entertainment communication industries, and the advertising, publicity and public relations industries

A. AIM: Sustain increased coverage of public health and well-being and prevention of obesity and chronic diseases including cancer

B. RECOMMENDATIONS

All media:

Emphasise news, features, and campaigns designed to promote public health and to prevent cancer, and put health coverage in context

Give executives resources and authority to ensure that their writers and editors have, or know how to access, expertise in public health

Distinguish between news and editorial coverage, and advertisements and other commercially sponsored material

Advertising and publicity media: Advise clients against campaigns that make misleading or unsubstantiated claims, or that promote unhealthy diets, physical inactivity, or overweight and obesity

6. SCHOOLS

Includes directors and managers of nurseries, pre-schools, and primary and secondary schools. (For universities and other higher education institutions, see Workplaces and institutions.)

A. AIM: Make food systems, food, nutrition, and regular physical activity essential parts of school life and learning

B. RECOMMENDATIONS

Provide healthy daily meals for all staff and pupils, together with facilities for active recreation, activity, and sports

Incorporate food and nutrition (including food preparation and cooking skills) and physical education into the mandatory core curriculum

Ensure that teaching materials are independently originated and free from commercial bias

Do not allow vending machines that offer snacks high in sugar, fat or salt, or sugary drinks, and withdraw such 'fast foods' and drinks from school canteens

7. WORKPLACES AND INSTITUTIONS

Includes all managers and directors in all workplaces, public and private. Also universities and other higher education institutions, hospitals, hostels, care homes (for people without and with cancer), armed forces facilities, prisons, and other institutional settings

A. AIM: Institute and implement policies that promote physical activity, and healthy meals and bodyweight

B. RECOMMENDATIONS

Workplaces and institutions:

Use price and other incentives to encourage healthy eating and active commuting, and to discourage motorised transport

Ensure that physical environments are designed or adapted and maintained to facilitate physical activity and weight control

Encourage sustained breastfeeding with supportive environments and employment contracts, and access to childcare

Do not allow vending machines that offer snacks high in sugar, fat, or salt, or sugary drinks, and withdraw such 'fast foods' and drinks from canteens

Institutions: Provide healthy meals, facilities for physical activity, and access to advice on nutrition, fitness, weight control, and disease prevention

8. HEALTH AND OTHER PROFESSIONALS

A. AIM: Conduct professional practice to realise the potential for promoting health including cancer prevention

B. RECOMMENDATIONS

All professionals:

Include food, nutrition, physical activity, and cancer prevention in core professional training and continuing development

Work with other disciplines to help understand how to improve public health, including cancer prevention, through food, nutrition, and physical activity

Health professionals

(include relevant academics and researchers, and physicians, nutritionists, dietitians, nurses, and other health workers in medicine, public health, environmental health, and associated fields. Other professionals include architects and engineers, relevant civil servants, trades unionists, social scientists, economists, environmentalists, agronomists, food scientists and technologists, journalists, and teachers)

Prioritise public health including cancer prevention, and food, nutrition, and physical activity, in core training, practice, and professional development

Take a lead in educating and working with colleagues, other professionals, and other actors to improve public health including cancer prevention

Involve people as family and community members, and take account of their personal characteristics in all types of professional practice

9. PEOPLE

As members of networks, communities, clubs, families, and households, not just as individuals.

A. AIM: Act as members of households and communities and as citizens, not just as customers and consumers, in achieving healthy ways of life

B. RECOMMENDATIONS

Support organisations and initiatives whose purpose is to improve public and personal health and to prevent chronic diseases including cancer

Develop policies and set examples within the household and community to enable healthy eating, sustained physical activity, and weight control

Ensure that personal, household, family, and community good health and protection against disease are priorities when making major decisions

Use independent nutrition guides, food labels, and other reliable information when planning household supplies and purchasing foods and drinks