2. CANCER IN HUMANS

2.1 General issues regarding the epidemiology of cancer and consumption of red meat and processed meat

The association between consumption of red meat or processed meat and cancer risk has been examined in numerous studies. In this section, the Working Group summarized the results of existing studies. For those studies reporting on the same study population and published at different times, the most recent, complete, or informative publication was included when possible.

In reviewing and interpreting the available literature, the Working Group considered the five following criteria: exposure definition; sample size and number of exposed cases; study design; exposure assessment tools; and adjustment for potential confounding factors described below.

2.1.1 Exposure definition

The Working Group placed the greatest emphasis on the studies that reported data separately for unprocessed red meat (i.e. "red meat") or processed meat, and had a clear definition of what questions or types of meats were included in the meat variables. For definitions, please see Section 1 of this *Monograph* and (a) and (b) below. Studies that defined total red meat as including processed meat and studies that reported on "red meat" (unclear whether unprocessed or total red

meat) were also included in the Working Group discussion, but were given less weight; the latter studies were given the least weight for many cancers (e.g. cancer of the colorectum).

(a)   Red meat

Red meat refers to fresh unprocessed mammalian muscle meat (e.g. beef, veal, pork, lamb, mutton, horse, or goat meat), which may be minced or frozen, and is usually consumed cooked. Studies reporting separate results for individual red meat subtypes (e.g. beef, pork, lamb, etc.) and fresh organ meats (offal) were included as "red meat". Mammalian offal refers to the internal organs and entrails of a butchered animal (scrotum, small intestine, heart, brain, kidney, liver, thymus, pancreas, testicle, tongue, tripe, or stomach) consumed as such. The Working Group considered offal as "red meat".

(b)   Processed meat

Processed meat refers to any meat that has been transformed through one or several of the following processes: salting, curing, fermentation, smoking, or other processes to enhance flavour or improve preservation. Most processed meats are made from pork or beef, but may also include other meats such as poultry and/or offal, or meat by-products such as blood. It is also important to distinguish between industrial processing and household preparations.

This *Monograph* excluded results on poultry, fish, and seafood; studies of dietary patterns (i.e. clusters of food items grouped by investigators or by statistical analysis); and results of reported ratios of red to white meat. Studies with unspecified meat intake, studies that reported only combined results for red and white meat, or studies of white meat were excluded for most cancers, or were given less weight in the evaluation than others. In addition, studies that only reported on estimated carcinogens derived from meat, but not on "red meat" or "processed meat" variables were excluded.

2.1.2 Sample size and the number of exposed cases

The sample size and the number of exposed cases can have an impact on statistical power. As there was a large number of informative studies, those with a sample size of fewer than 100 cases were excluded.

2.1.3 Study design

For cohort studies, prospective cohort studies and case–control or case–cohort analyses of such studies were considered. For cancer sites with a large number of informative studies and with low case fatality, studies based on mortality data were excluded or given less weight. These decisions are noted, where relevant, in the sections for each specific cancer site. For case–control studies, the selection of hospital-based versus population-based cases and controls was considered. Greater emphasis was given during the evaluation to studies that used population-based controls, as they were more representative of the underlying population. For hospital-based controls, studies that clearly listed the diseases of the controls were given greater emphasis, as the inclusion of controls with conditions related to risk factors for the disease under study may lead to bias. In particular, if the people selected

as controls had conditions that could potentially lead to modifications in their diet, they would be less representative of the underlying population, thus leading to biased estimates.

2.1.4 Exposure assessment tools

Greater emphasis was given to studies that used validated dietary instruments and in-person interviews compared with non-validated dietary instruments and mailed, self-administered questionnaires, respectively. The Working Group assessed whether the questionnaires were validated in the population under study, whether the red or processed meat questions captured most subtypes of red or processed meats consumed in that population, and whether there was detailed assessment of portion size (e.g. use of pictures and models, in addition to frequency of consumption).

2.1.5 Adjustment for potential confounding factors

Studies that appropriately adjusted for confounding factors were given greater weight. Studies with insufficient adjustment were either noted and given less weight, or excluded from the review, depending on the number of studies available for a particular cancer site. For each cancer site, potential confounders for associations with meat intake are listed.

In general, total energy/caloric intake, physical activity, and body mass index (BMI) were considered important confounders; however, several other factors were considered for specific cancer sites (e.g. alcohol for cancer of the colorectum and breast, tobacco smoking for cancer of the lung and colorectum, etc.).

Total caloric intake is a putative risk factor for several cancers, and given that red meat and processed meat are significant contributors to total caloric intake, appropriate consideration of this confounder was important. Similarly, given

the established or putative role of other dietary and lifestyle factors that may be correlated with meat intake, the consideration of these factors as possible confounders was important, depending on the cancer site (e.g. dietary fibre, BMI, and physical activity). In particular, it has been shown that individuals who consume high levels of processed meat often tend to eat less fruits and vegetables, to drink more alcoholic beverages, to smoke more tobacco, to consume more calories and more fat, and to be more obese and less active than those who do not consume processed meat (Fung et al., 2003; Dixon et al., 2004; Kesse et al., 2006; Nkondjock & Ghadirian 2005).

References

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