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Burden of diseases estimates associated to different red meat cooking practices

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ABSTRACT

The burden of disease estimate has been performed for diseases attributable to nutritional deficiency, foodborne pathogens, the environment, infection and other factors. However, the burden of disease estimate attributable to different food processing practices has not been investigated before. The aim of this study is to compare the burden of disease estimate attributed to red meat consumption processed using different cooking practices.

The red meat cooking practices were categorized into three: (A) barbecuing/grilling; (B) frying/broiling and (C) roasting/baking. The associated endpoints, affected population, intake and dose–response data are obtained by literature survey. The selected endpoints are four types of cancer: colorectal, prostate, breast and pancreatic. The burden of disease per cooking practice, endpoint, sex and age is estimated in the Danish population, using disability adjusted life years (DALY) as a common health metric.

The results reveal that the consumption of barbecued red meat is associated with the highest disease burden, followed by fried red meat and roasted red meat.

The method used to quantify the difference in disease burden of different cooking practices can help to inform the consumer to make a choice on whether the benefit of a preferred cooking style is worth the associated health loss.

1. Introduction

Food processing adds values to products; processed food products display specific flavor, taste, color or texture, which can be seen as a benefit from a food quality perspective (Heinz and Hautzinger, 2007). In addition, processing, especially cooking at high temperature, may inactivate pathogens in the food (WHO/FAO, 2004) but may also cause formation of hazardous chemical compounds (Badry, 2010). Thus, cooking at high temperature can be both beneficial and detrimental for health, which may leave the consumer with a dilemma when cooking.

Meat and meat products are ubiquitous and consumed cooked worldwide. Meat is cooked in various ways, and the cooking practices often used are braising, stewing, broiling/frying, grilling/barbecuing and roasting/baking. When meat is cooked at high temperatures, several hazardous chemical contaminants such as polycyclic aromatic hydrocarbons (PAHs) and heterocyclic amines (HCAs) may be formed (Jägerstad and Skog, 2005; Aaslyng et al., 2013). The concentration of these contaminants varies with meat type, temperature and time of cooking, and method of cooking (Knutsen et al., 2007; Badry, 2010; Aaslyng et al., 2013). Some of these chemical contaminants are known to be carcinogenic and may cause substantial health losses (EFSA, 2008; SCF, 2002). To inform consumers on the potential health impact of cooking red meat, it is relevant to quantify these health losses.

Burden of diseases is a quantitative measure of population health outcome using the information on mortality and morbidity (Murray and Lopez, 1996) and in addition recovery in the population (Hoekstra et al., 2012). Knowledge of burden of disease estimates may help to prioritize the major causes of health loss and to evaluate the potential impact of taking action to improve health. Burden of disease estimate has been performed for diseases attributed to nutritional deficiency, foodborne pathogens, environment, infections and other factors (Murray and Lopez, 1996; Murray et al., 2013; Gkogka et al., 2011; Havelaar et al., 2012). However, to our knowledge, the burden of disease estimate attributed to meat cooking practices has not been studied before.

The aim of this study is to compare the burden of disease estimates (expressed in disability adjusted life years, DALY) attributed to different cooking practices used to process red meat. The

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available data from epidemiological studies where cancer risks (consequential to exposure to PHAs and HCAs) are associated with cooking practices are applied, together with Danish consumption data. A method is developed that allows the estimation of the burden of disease for different cooking practices for different sexes and different age classes, based on these data. The outcome of this study will enable us to inform consumers on the difference between the expected health impacts of different cooking practices and may allow individuals to weigh that against the perceived quality associated to these cooking practices. The following section details how the burden of disease can be estimated for the different red meat cooking practices.

2. Material and methods

For the purpose of this study, we have considered three categories of red meat preparation by the consumer: (A) barbecuing (BBQ)/grilling; (B) frying/broiling; (C) roasting/baking. Red meat is defined as meat from pork, beef, goat and lamb (Pedersen et al., 2010; Aaslyng et al., 2013). More detailed definitions of the meat and the preparation styles are not applicable in this study: when applying data from other studies (as in Table 3) the terminology used in these other studies was adopted.

The health hazards, endpoints and affected populations related to the consumption of cooked red meat are obtained from the literature. In order to estimate the probability of onset of each disease that can arise from the different cooking practices, the relative risks (RR) associated to intake of red meat per cooking practice were identified from literature, stratified and modeled using a linear or a log-linear function. Model validation is performed to select the best fit, using residual analysis and QQ-plot (Ekstrøm and Sørensen, 2011). Next, the RR based on the Danish red meat intake distribution is estimated. Then, the probability of onset of the disease per cooking practice is estimated as a function of the incidence of disease, the frequency of the application of the cooking practices, the probability of intake and the RR for different age classes and sexes.

The burden of disease of each cooking practice per selected endpoints is estimated using the DALY model developed in Hoekstra et al. (2012). For the sake of relative comparison, the burden of disease for no intake of cooked red meat is also estimated. The analysis is performed in R-statistical software, version 2.15.2 and MS Excel 2010. A detailed description of the method is presented in the following sections.

2.1. Major health hazards associated with cooked meat consumption

When meat is heat treated, deleterious compounds including various mutagens and carcinogens may be formed. The two widely known group of hazardous chemical compounds formed during meat cooking are HCAs and PAHs (Jägerstad and Skog, 2005; Badry, 2010; Aaslyng et al., 2013). The formation of these toxicants is primarily linked to the cooking temperature–time relationship and the final concentration in the meat varies with different cooking practices (Badry, 2010). Other disease causing chemical contaminants can be present in the meat, such as dioxins and furans; however, these contaminants are environmental pollutant and are not typically linked to the cooking practices of meat. Therefore, the burden of disease linked to the environmental contaminants of meat is not considered in this study.

Even though both HCAs and PAHs are associated with serious health risks, there are only few reports concerning the intake of these components (Aaslyng et al., 2013). The lack of data about the intake of these compounds makes it difficult to make a direct link of these compounds with the cancer risks. However, several epidemiological studies correlate red meat intake cooked in different ways with cancer risks. Hence, in this study we use the epidemiological studies to estimate the burden of disease of eating red meat cooked in various ways.

2.2. Health effect related to cooked red meat consumption

The most common health effect associated with the consumption of cooked red meat is cancer. There are different types of cancer caused by the chemical contaminants formed during red meat cooking at high temperature. Cancer accounts for the highest mortality and morbidity worldwide, which is the major burden of disease (Ma and Yu, 2006). Colorectal cancer is the cancer type most often associated with meat consumption (Probst-Hensch et al., 1997; Sinha et al., 1999, 2001, 2005; Ishibe et al., 2002; Wu et al., 2006; Butler et al., 2003; Gunter et al., 2005; Cross et al., 2007) followed by breast cancer (Zheng et al., 1998; Steck et al., 2007), prostate cancer (Cross et al., 2005; Koutros et al., 2008; John et al., 2011) and pancreatic cancer (Anderson et al., 2002; Li et al., 2007; Stolzenberg-Solomon et al., 2007). In this study we have therefore selected these endpoints. The population is based on studies referred to in Table 1.

2.3. Intake of red meat

To assess the burden of diseases of the different meat cooking practices we have to know the intake of meat. For that purpose we have adopted the red meat consumption distributions by age classes and sexes from Pedersen et al. (2010) and presented in Table 2.

The age classes for intake (Table 2) were adapted to fit with the selected populations for the endpoints (Table 1). When the age class in the intake distribution is 35–44, 45–54, 55–64 and 65–75 years, the age in the selected population (for instance, age 40–79 years, prostate cancer) is then accordingly categorized as 40–44, 45–54, 55–64 and 65–79 respectively. Furthermore, since the last age class in Table 2 is 65–75, we have assumed that persons older than 75 years have the same intake distribution as persons aged 65–75 year.

2.4. Estimating the probability of onset of the diseases

To estimate the probability of onset of the diseases, we did a literature search that particularly focussed on red meat intake by cooking practice in relation with the endpoints we have considered. The relative risk data for different intake levels, endpoints and cooking practices are presented in Table 3.

The dose–response modeling requires point estimates of mean intake in g/day for the intake categories as applied in the different studies. Generally, these mean intakes are not provided in the selected studies. Therefore, different assumptions have been made when the intakes were not sufficiently quantified to be used for the dose–response modelling in this assessment:

1. For the intakes that are given in interval, for example Butler et al. (2003), we have taken the mean.
2. For the intakes that are described in qualitative terms such as low, medium and high intake (Punnen et al., 2011), we have assumed the 10 percentile, median and 90 percentile of Danish meat consumption (Pedersen et al., 2010; Table 2).
3. For the intake given as below median and above median (John et al., 2011), we have assumed 60 and 120 g/day respectively, which is roughly below and above median of Danish red meat intake (Pedersen et al., 2010).
4. For the intakes that are given by quartiles (Fu et al., 2011); Q1, Q2, Q3, Q4, we have assumed no intake, 25%, median and 75% of the Danish intake respectively. The no intake is assumed for Q1 because the relative risk for Q1 is 1.

All the data used for the dose–response modeling are presented in Table 3. Since the prevalence of the selected endpoints at population level in Denmark is less than 10%, we have assumed that the odds ratio (OR) and the hazard ratio (HR) in the Anderson et al. (2012) study are similar to the relative risk (RR) (Cummings, 2009; McNutt et al., 2003).

Table 1
Selected endpoints and population.

Selected endpoints	Population	Reference
Colorectal cancer	Both sexes, age 50–71 years	Cross et al. (2007)
Prostate cancer	Men, age 40–79 years	John et al. (2011)
Pancreatic cancer	Both sexes, age 50–71 years	Stolzenberg-Solomon et al. (2007)
Breast cancer	Women, age >49 years	Steck et al. (2007)

Table 2
The red meat intake (g/day) distribution in Denmark by age classes and sexes (Pedersen et al., 2010).

Percentile		1	5	10	25	50	75	90	95	99
Sex	Age									
Men	35–44	38	55	69	100	139	188	261	292	364
	45–54	24	57	67	96	134	177	223	256	282
	55–64	28	60	70	91	124	164	223	259	348
	65–75	16	41	58	81	112	145	178	193	239
Women	35–44	13	27	39	59	83	111	136	158	198
	45–54	7	25	36	53	79	106	140	156	197
	55–64	6	24	37	54	76	103	125	144	183
	65–75	11	18	29	48	70	92	123	147	243
$p(i)$ (%)[a]		2	6	4	26	24	26	4	6	2

[a] The probability of intake $p(i)$ gives the fraction of the population that is assumed to have the indicated intake i in each age/sex class. It is assumed to be an interval around the percentiles reported by Pedersen et al. (2010), where the reported percentile is the median value of each interval. This $p(i)$ is required for the model calculations (Section 2.4).