



## Cancer mortality in the meat and delicatessen departments of supermarkets (1950–2006)



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### ABSTRACT

Meat cutters and meat wrappers in the meat department of supermarkets are exposed to oncogenic viruses present in raw meat from cattle, pigs, sheep, and poultry, and their products (unpasteurized milk and raw eggs). Up to the mid 1970s, meat wrappers were also exposed to carcinogens present in fumes emitted from the machine used to wrap meat. Because of this we studied cancer mortality in a cohort of 10,701 workers in the meat and delicatessen departments of supermarkets, and we report here the findings after the third follow-up. Standardized mortality ratios (SMR) were estimated in the cohort as a whole and in race/sex subgroups, using the US population for comparison. Study subjects were followed up from January 1950 to December 2006.

Significantly increased SMRs of 1.3 (95% CI, 1.2–1.5), and 2.7 (95% CI, 1.2–5.3) were recorded for cancers of the lung, and tonsils/oropharynx, respectively, in the entire cohort, affecting nearly all race/sex subgroups. SMRs of 4.6 (95% CI, 1.0–13.6) for cancer of the floor of the mouth, and 2.8 (95% CI, 1.3–5.3) for cancer of the gall bladder and biliary tract were recorded only in White male meatcutters. Significantly decreased SMRs were observed for a few cancers.

It is not known if the observed excess of cancers is a result of occupational exposures. However, substantial evidence points to fumes from the wrapping machine as a possible candidate for explaining the excess in female meat wrappers. Nested case–control studies that can examine risks from occupational exposures in greater detail, and adequately control for confounding factors are now needed, to permit specifically investigate the role of the oncogenic viruses, fumes and non-occupational risk factors in the occurrence of these cancers. The findings are important, not only occupationally but also because the general population may also experience these exposures, albeit to a lesser degree.

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### 1. Introduction

Animals used for food such as cattle, pigs, sheep, goats, chickens and turkeys are naturally infected with viruses that cause cancer in them. These viruses include bovine papilloma viruses that cause tumors in the skin and alimentary tract of cattle; bovine leukemia virus that causes lymphosarcoma in cattle; Jaagsiekte sheep retrovirus that causes lung cancer in sheep; enzootic nasal tumor viruses that cause nasal cancer in goats; avian leukosis/sarcoma viruses that cause a wide variety of tumors in chickens including lymphoid leukemia, fibrosarcomas, tumors of the brain, ovary, bladder, etc.; reticuloendotheliosis viruses that cause

lymphoid leukemia in poultry; and Marek's disease virus that causes neoplastic diseases in lymphoid and neural tissues in chickens (Burny and Mammerickx, 1987; Campo, 1987; Cousens et al., 1999, 2008; Gissmann, 1984; Lancaster and Olson, 1982; Ortin et al., 2003; Palmarini and Fan, 2001; Saif et al., 2003). Human exposure to these oncogenic agents is widespread, and occurs both occupationally and non-occupationally through contact with live animals, their contaminated secretions, blood, and raw products, through ingestion of raw or inadequately cooked meat and other products such as unpasteurized milk or raw eggs, through vaccination with vaccines grown in eggs during manufacture, and through transplants (Buehring et al., 2003; Choudat et al., 1996; Hussain et al., 2003; Johnson et al., 1995a,b; Patience et al., 1998; Pham et al., 1999; Tsang et al., 1999). It has been recognized for decades that the viruses show potential for causing cancer in humans, since they infect and transform human cells in vitro (Diglio and Ferrer, 1976; Graves and Ferrer, 1976; Johnson and Griswold, 1996; Stenkvis and Ponten, 1964); experimentally they

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cause cancer in primates (McClure et al., 1974; Munroe and Windle, 1963); and it has been reported in some but not all studies that exposed subjects in occupational and general populations have antibodies in their blood to some of these viruses (Buehring et al., 2003; Choudat et al., 1996; Hussain et al., 2003; Johnson et al., 1995a,b). However until recently, the dearth of suitable epidemiologic studies, and molecular studies demonstrating the presence of the viruses in human tumor tissues, have limited the ability to incriminate these viruses in the etiology of human cancers. Because of the widespread exposure to these agents in the general population, a well-defined group with greater than background exposure is needed to facilitate observing the health effects of these viruses. Occupational cohorts are ideal for this purpose because meat and poultry workers in cattle, pigs, sheep, and poultry slaughterhouses and processing plants who handle these animals have the highest human exposures to these viruses. Important epidemiologic evidence accumulating from occupational cohort studies with these types of workers from all over the world have consistently reported an excess occurrence of certain cancers in these workers (Boffetta et al., 2000; Coggon et al., 1989; Guberan et al., 1993; Johnson, 2011; Johnson et al., 1986a,b, 2010a,b; McLean et al., 2004; McLean and Pearce, 2004).

We report here on cancer mortality in a cohort of meat cutters and meat wrappers in the meat and delicatessen departments of supermarkets that has been previously followed-up on two occasions. A study of these workers is important for the following reasons, 1) the workers are concomitantly exposed to oncogenic viruses of all animals commonly used for human food, hence providing an opportunity to observe the cumulative effects if any, of these agents; 2) because of their much lower exposure to the oncogenic viruses than those encountered in slaughtering and processing plants, supermarket workers also provide a suitable group to investigate the effect of exposure to the oncogenic viruses at a level lower than that experienced by slaughterhouse and processing plants workers but higher than that seen in the general population; 3) confounding carcinogenic exposures that occur in slaughterhouses and processing plants such as exposure to polycyclic aromatic hydrocarbons, nitrosamines, and heterocyclic amines, during the smoking, curing and cooking of meat and poultry (Jakszyn et al., 2004; Nordholm et al., 1986) are absent in supermarkets; 4) the clean environment in the supermarket provides a natural experiment to investigate the only two major occupational carcinogenic exposures that occur there, viz i) exposure to food animal oncogenic viruses, and ii) exposure to fumes from the wrapping machine. Men and women in the meat and deli departments of supermarkets belonging to this cohort performed distinct tasks at the time the cohort was originally assembled in 1979. In the meat department both worked in the same room; the men primarily were engaged in cutting raw meat (meat cutters), while women were primarily engaged in wrapping raw meat (meat wrappers). Only occasionally did men assist the women in wrapping meat. Due to their primary job duties, men are assumed to be at higher risk of exposure to the oncogenic viruses because of frequent cuts from sharp knives and sharp bone splinters during cutting meat that permit easier entry of viruses into the body through the skin (Cai et al., 2005). Aerosol exposure to these agents produced from powered sawing machines during cutting is also assumed to be higher for men than for women who did not cut meat. Women on the other hand were much more highly exposed than men to fumes from the wrapping machine that contained carcinogenic polycyclic aromatic hydrocarbons (PAH), benzene, and phthalates (Smith et al., 1983), as this typically was their primary job, especially in the earlier decades of follow-up. They did not cut meat in those early days. In the deli department, typically cooked meat was handled, and wrapping of meat was performed. This study of meat department supermarket workers therefore offers a unique opportunity to investigate the independent effects of exposure to fumes from the wrapping machine in women, and oncogenic viruses during cutting meat. To our knowledge no one else has specifically studied this important group for cancer occurrence.

Accordingly, we report here on cancer mortality in a cohort of 10,701 subjects who worked in the meat and deli departments of supermarkets anytime between 1950 and 1979. They were identified from the roster of the United Food & Commercial Workers (UFCW) union in Baltimore, Maryland. The cohort was previously followed up for mortality on two occasions, from 1949 to 1980 and from 1949 to 1989 (Johnson, 1994; Johnson et al., 1986a,b). At the first follow-up, an excess occurrence of cancer of the buccal cavity and pharynx was observed in men, and an excess of lung cancer and tumors of the hemopoietic lymphatic systems (myeloid leukemia and non-Hodgkin's lymphoma) was observed in women (Johnson et al., 1986a,b). At the second follow-up, the significant excess of cancers of the buccal cavity and pharynx which was initially observed in men at the first follow-up persisted, and in addition, a significant deficit of deaths from tumors of the hemopoietic and lymphatic (H & L) systems was recorded also in men. In women, a significant excess risk of lung cancer continued to be observed, while the excess risk from tumors of the H & L systems (myeloma, leukemia, other lymphatic tumors) also continued to be observed, but this excess was no longer significant (Johnson, 1994).

Here we report on the third follow-up of cancer mortality in this cohort up to the end of 2006 for an additional 17 years since the second follow-up. By 2006, 40% of the cohort was now deceased, as compared with only 15% during the previous follow-up.

## 2. Methods

As mentioned above, the 10,701 subjects that comprise the study population consisted of male meat cutters and female meat wrappers who worked in the meat and deli departments of supermarkets anytime between 1950 and 1979, and they were identified from union rosters in 1979. Information on duration of employment was available during the first follow-up but was not updated beyond 1979, hence analysis by duration of employment was not possible in this update. In the study reported here, subjects were followed up from January 1, 1950 until December 31, 2006. Since the National Death Index (NDI) contained records of deaths in the United States only from 1979 onward, it was not employed in identifying deaths that occurred between 1950 and 1978 in the first follow-up. Therefore, a wide variety of methods had to be used to assess whether the study subjects were alive or dead between 1950 and 1978 in the first follow-up. These methods included, the Social Security Administration (SSA), the Maryland State Department of Vital Records, the Maryland State Department of Motor Vehicles, the Health Care Financing Administration, the Veterans Administration, and personal contact by telephone, US Postal Services, obituaries, and union records. The NDI was used in the first follow-up for the two years 1979–1980 only. The vital status of 92% of the study subjects was confirmed using these methods. For the second and the current follow-ups, the tracing methods were limited to the NDI, the Pension Benefit Information (a private company that identifies deaths in this study from 1950 onwards using various federal record systems), and internet tracing methods such as Private Eye and Ancestry.com.

A total of 4270 deaths (40%) were recorded among the 10,701 supermarket workers. The underlying cause of death, as listed in the death certificates was used in the statistical analysis and deaths were coded according to the 9th ICD Revision. Standardized mortality ratios (SMR) were estimated using the OCMAP Plus software for analyzing cohort mortality studies from the University of Pittsburgh, using the United States general population rates for comparison. The study population was stratified by calendar time, race, sex, age (5-year intervals) and company. Person-years accumulation started from the date the company was unionized for those subjects who were already employed prior to the company being unionized, or from the date they joined the union (which was virtually the same as the date of employment) if the company had already been unionized by the time they were employed (membership in the union was compulsory within 30 days of employment). Person-years accumulation was terminated on the

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