BIJLAGEN

BIJLAGE 1 OVERZICHTSTABEL VAN STUDIES NAAR KANKER IN DE VLEESINDUSTRIE

Study/country/ type of study	**Population** **Exposure**	**Method**	**Outcomes**	**Remarks**
All cancers				
Johnson 2015 USA Cohort study (1)	a cohort of 10,701 workers in the meat and delicatessen departments of supermarkets	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 meat cutters.	The SMR for all malignant diseases was not significantly elevated in the entire cohort or in any race/sex subgroups.
Johnson 2011 USA Cohort studies (2)	Workers in abattoirs (N=4996) and meat processing plants (N=3642) belonging to a meat cutters' union. Study subjects were followed up from January 1950 to December 2006 employed in cattle, pigs, and sheep slaughtering and processing plants	Standardized mortality ratios (SMRs) and proportional mortality ratios (PMRs) were estimated for each cohort as a whole and in subgroups defined by race and sex, using the US general population mortality rates for comparison.	All-cancer mortality was similarly significantly increased in white males only, SMR = 1.1 (95% CI, 1.0–1.1). Oesophagus SMR= 1.4 (95% CI, 1.0–2.1) Lung SMR = 1.3 (95% CI, 1.1–1.4) Skin SMR = 2.1 (95% CI, 0.9–4.4) Bladder SMR = 1.5 (95% CI, 1.0–2.2) Excess of deaths from cancers of the base of the tongue, oesophagus, lung, skin, bone and bladder, lymphoid leukaemia, and benign tumours of the thyroid and other endocrine glands, and possibly Hodgkin's disease.	Table 7 summarizes literature on cancer in meat processing (zie onder)

			Significantly lower SMRs were recorded for cancer of the thymus, mediastinum, pleura, etc., breast cancer, and non-Hodgkin's lymphoma.	
Johnson 2010 USA Cohort study (3)	20,132 workers in poultry slaughtering and processing plants	Mortality in poultry workers was compared with that in the US general population through the estimation of standardized mortality ratios	Significantly increased risks were observed in the cohort as a whole or in subgroups, for several cancer sites: cancers of the buccal cavity and pharynx; pancreas; trachea/bronchus/lung; brain; cervix; lymphoid leukaemia; monocytic leukaemia; and tumours of the haemopoietic and lymphatic systems. Elevated SMRs that were not statistically significant were observed for cancers of the liver, nasopharynx, myelofibrosis, and myeloma. New sites observed to be significantly in excess in this study were cancers of the cervix and penis	
Johnson 2010 (4)	Source population was a total of 28 900 members of a local meat cutters' union in Baltimore. Cancer mortality was updated to the year 2003 for 2,580 of the 2,639 subjects who worked exclusively in poultry plants	Statistical analyses involved estimation of SMR and proportional mortality ratios (PMR), stratifying on age, calendar time, gender, race, and plant, using the US general population as the comparison group.	Compared to the US general population, an excess of cancers of the buccal and nasal cavities and pharynx (base of the tongue, palate and other unspecified mouth, tonsil and oropharynx, nasal cavity/middle ear/accessory sinus), oesophagus, recto-sigmoid/rectum/anus, liver and intrabiliary system, myelofibrosis, lymphoid leukaemia and multiple myeloma was observed in particular subgroups or in the entire poultry cohort. We hypothesize that oncogenic viruses present in poultry, and exposure to fumes, are candidates for an etiologic role to explain the excess occurrence of at least some of these cancers in the poultry workers. Lung cancer SMR = 1.6 (95% CI 0.8-2.8).	
McClean 2004 New Zealand (5)	Workers employed in the New Zealand meat processing industry. A cohort of 6647 individuals assembled from personnel records from three plants was followed from 1988 until 2000.	The observed number of deaths and cancer registrations was compared with expected numbers using five year age and gender specific rates for the New Zealand population.	There was excess mortality from all cancers (SMR 1.12, 95% CI 0.88 to 1.42, 69 deaths) Among the cancers, significant excess mortality was observed for lung cancer (SMR 1.79, 95% CI 1.13 to 2.68, 23 deaths). Overall cancer incidence was close to expected (SIR 0.95, 95% CI 0.80 to 1.12, 143 cases), although there was a significant excess of lung cancer (SIR 1.70, 95% CI 1.11 to 2.49, 26 cases). The	The study has also provided some support for the previous findings of excess risks of leukaemia and non-Hodgkin’s lymphoma

		For each cause of death or cancer type standardised mortality ratios (SMRs) and standardised incidence ratios (SIRs) were calculated as the ratio of observed to expected numbers of deaths and cancer registrations.	incidence of cancers of the lymphatic and haematopoietic system was lower than expected (SIR 0.81, 95% CI 0.41 to 1.45, 11 cases). In conclusion, therefore, this study has shown a significant excess of lung cancer. It is not possible to completely rule out the possibility of confounding by smoking and/or ethnicity, but it is highly unlikely that either is sufficient to account for more than a small part of the excess observed. The strong dose-response relation observed also supports the hypothesis that the effect is related to occupational exposures, and in particular to some component of the biological material contained in animal urine, faeces, and blood.	associated with work in the New Zealand meat industry
McClean 2004 Review of literature (6)	Review of relevant publications were obtained through a computerized literature search with the key words "cancer", "lung cancer", "hematologic neoplasms", "meat products", "abattoirs", and "slaughterhouses", and the evidence available from analyses of routine data, proportionate mortality and incidence studies, and cohort and case-control studies was reviewed. Analyses of routine mortality and incidence record		Several studies have found increased risks of cancer among workers in the meat industry, particularly lung and hematologic cancers. These analyses suggest a significant excess lung cancer risk among meat workers. This risk was associated the most strongly with exposure to animal slaughtering or freshly slaughtered meat or to biological material contained in blood and animal faecal matter, and it was greater than could be attributed to smoking. This finding suggests an etiologic role for biological exposure; however, the specific exposure(s) responsible are unknown, and further research Is clearly required. The results of studies of hematologic cancers have been less consistent, but they suggest a small excess risk for leukaemia in association with similar exposure	
Fritschi 2003 Australia retrospective cohort study (7)	There were 31 124 subjects in the union database. Of these, 19 229 (52.2%) had adequate information and were included in the mortality study, and 17 135 (46.5%) were included in the cancer incidence study	Standardised mortality ratios (SMR) and standardised incidence ratios (SIR) were calculated using Australian population rates	Standardised incidence ratios for cancer were significantly increased for head and neck cancers in male workers but for no other cancer s (table 2). Lung cancer in male meat workers was more common than in the general population with the lower bound of the confidence interval just below 1.	

Lung cancer				
Durusoy, 2005 7 European countries, case-control design (8)	More than 5,900 subjects 15 centers in 6 Central and Eastern European countries, and in Liverpool in the UK. Bucharest, (Romania), Borsod, Heves, Szabolcs, Szolnok and Budapest, (Hungary), Lodz and Warsaw, (Poland), Moscow, (Russia), Banska Bystrica, Bratislava and Nitra, (Slovakia), and Brno, Olomouc and Prague, (Czech Republic).	For each job they employed local experts who assessed the exposure to a number of occupational agents, including (i) meat aerosols and (ii) live animals, on the basis of detailed occupational questionnaires. Information on tobacco consumption and other risk factors was also collected.	A small increased risk of lung cancer was observed with exposure to meat aerosols, after adjusting for smoking, (odds ratio (OR) = 1.27, 95% CI: 0.92, 1.75), which was most apparent for the upper tertile of cumulative exposure (OR = 1.73, 95% CI: 1.03, 2.92). A similar overall effect was observed for exposure to live animals, with an increased risk observed for a high frequency of exposure, (OR = 1.69, 95% CI: 1.21, 2.36) and a high intensity of exposure, (OR = 1.85, 95% CI: 1.16, 2.94), with significant trends for increasing frequency (p = 0.012), intensity (p = 0.015) and cumulative exposure (p = 0.024).	
Johnson 2012 USA Review (9)	We considered studies published up to 2004 on workers in the meat industry that were omitted in the previous reviews (N = 13). Next, we updated the evidence for new meat industry studies published from 2005 to the end of September 2011 (N = 10). Focus on cattle, pigs and sheep as well as poultry	Table S1 shows the 30 studies that were previously reviewed. As can be seen, 83% (25 of 30) of the studies reported a relative risk of at least 1.3 for lung cancer associated with working in the meat industry. Table S2 lists 23 new studies that were not previously reviewed. Of these, 17 (74%) reported an association between lung cancer and the meat industry and the other six did not. Thus, the overwhelming majority of studies in the meat industry conducted to date, that is, 42 of 53 (79%), have reported a minimum relative risk of 1.3 for the disease in meat industry workers or for meat-related occupational exposures such as butchers and meat cutters. Of the 18 studies that controlled for tobacco smoking, 14 (78%) reported this association. All seven (100%) cohort studies of workers in poultry plants reported the association. The evidence thus far indicates that exposure to oncogenic transmissible agents that infect food animals and exposure to fumes from the wrapping machine are almost certainly involved in this occurrence. This is supported by the fact that food animal oncogenic viruses are known to infect and/transform human cells in vitro (Stenkvist and Ponten, 1964; Koo et al., 1991; Johnson and Griswold, 1996), to cause cancer in primates experimentally (McClure et al., 1974), and poultry workers and subjects in the general population have antibodies to these viruses in their blood (Johnson et al., 1995b,c; Choudat et al., 1996; Buehring et al., 2003). The role of exposure to smoke or aerosols during smoking or cooking of meat and poultry that contain		

		carcinogenic PAHs and heterocyclic amines or to nitrosamines during curing of poultry has not been adequately investigated in any study to date		
Lymphomas				
Metayer, 1998 Case-control nested in a cohort study (10)	The present study is a case-control study nested in a cohort of 28,901 local members of a meat cutters' union in Baltimore who were initially followed up between 1949 and 1980	A total of 56 subjects in the cohort had a death certificate diagnosis of tumour of the haemopoietin or lymphatic system *(International Classification of Diseases,* Eighth Revision (ICD-8) (22), codes 200-209) between 1949 and 1980. The next-of-kin of 49 of these persons (88 percent) were identified and successfully interviewed over the telephone,	elevated risks were observed for • butchers who killed animals (OR = 5.3, 95% CI 1.0-27.0); • workers in chicken-slaughtering plants (OR = 3.3, 95% CI 0.8-13.1); and • workers in cattle/sheep/pig abattoirs (OR = 2.8, 95% CI 0.8-9.5). Among supermarket workers, wrapping meat (mainly a female activity) was associated with increased risk of tumours of the haemopoietic and lymphatic systems (OR = 3.8, 95% C11.0-14.3), with the odds of both lymphomas and tumours of the myeloid stem cell being elevated. On the other hand, meat cutting in supermarkets (almost exclusively a male activity) was associated with multiple myeloma; the odds ratio for men was 18.0 (95% C11.6-207.5), with no myeloma cases being recorded in women. These associations persisted after limited control for exposures outside the industry that have also been observed to be associated with excess risk, such as exposure to pesticides, working/living on pig farms, and exposure to X-rays.
Moore, 2007 6 European countries Case-control (11)	a multicentre case-control study during 1998–2004 in the Czech Republic, France, Germany, Ireland, Italy and Spain, including 2,007 cases of non-Hodgkin lymphoma, 339 cases of Hodgkin lymphoma and 2,462 controls.		The odds ratio (OR) non-Hodgkin lymphoma • for ever occupational exposure to meat was 1.18 (95% CI 0.95–1.46), • that for exposure to beef meat was 1.22 (95% CI 0.90–1.67), • that for exposure to chicken meat was 1.19 (95% CI 0.91–1.55). The ORs were higher among workers with longer duration of exposure. An increased risk among workers exposed to beef meat was mainly apparent for • diffuse large B-cell lymphoma (OR 1.49, 95%CI 0.96–2.33), • chronic lymphocytic leukaemia (OR 1.35, 95% CI 0.78–2.34) and • multiple myeloma (OR 1.40, 95%CI 0.67–2.94). The latter 2 types were also associated with exposure to chicken meat (OR 1.55, 95% CI 1.01–2.37, and OR 2.05, 95%CI 1.14–3.69).

			Follicular lymphoma and T-cell lymphoma, as well as Hodgkin lymphoma did not show any increase in risk. Occupational exposure to meat does not appear to represent an important risk factor of lymphoma, although an increased risk of specific types of non-Hodgkin lymphoma cannot be excluded.
Neasham, 2011 European Prospective Investigation into Cancer and Nutrition (EPIC). (12)	Recruitment of subjects took place between 1992 and 2000 in 23 centres located in 10 European countries. The cohort includes participants of both genders, mostly in the age range of 35-70 The current cohort size was 348 555 subjects analysis was based on 866 and 48 newly diagnosed cases of non-Hodgkin's lymphoma (NHL) and Hodgkin's lymphoma (HL).	These were identified in the EPIC sub cohorts with occupational data. Data on 52 occupations were collected through standardised questionnaires. Cox proportional hazard models were used to explore the association between occupation and risk of malignant lymphoma	The following occupations were positively associated with malignant NHL after adjustment for study centre, age, sex, socioeconomic status (SES), smoking and alcohol: **butchers** (HR=1.53, 95% CI 1.05 to 2.48, including multiple myeloma/plasmacytoma; HR =1.30, 95% CI 1.00 to 2.66, excluding multiple myeloma/plasmacytoma) and **car repair workers** (HR =1.50, 95% CI 1.01 to 2.00, including multiple myeloma/plasmacytoma; HR=1.51, 95% CI 1.01 to 2.31, excluding multiple myeloma/plasmacytoma). HL was associated with gasoline station occupation (HR = 4.59, 95% CI 1.08 to 19.6)
Liver and pancreas cancer			
Felini 2011, USA A pilot case-cohort study (13)	30,411 workers from 23 poultry slaughtering and processing plants located in seven states in the United States combined cohort of 30,411 highly exposed	and risk assessed by logistic regression odds ratios (OR) and proportional hazards risk ratios.	respectively for pancreatic/liver cancers • for slaughtering of poultry (OR = 8.9, 95% CI: 2.7–29.3)/OR = 9.1, 95% CI: 1.9–42.9); • catching of live chickens (OR = 3.6, 95% CI: 1.2–10.9)/OR = 1.0, 95% CI: 0.1–8.5); • killing other types of animals for food (OR = 4.8, 95% CI: 1.5–16.6)/OR = 2.0, 95% CI: 0.2–18.2), and • ever worked on a pig raising farm (OR= 3.0, 95% CI: 1.0–8.2) for pancreatic cancer only.

	poultry workers and 16,408 control subjects was conducted,		New non-occupational findings for liver cancer were for receiving immunization with yellow fever vaccine (OR = 8.7, 95% CI: 1.0–76.3); and vaccination with typhoid vaccine (OR = 6.3, 95% CI: 1.1–37.4). This study provides preliminary evidence that exposure to poultry oncogenic viruses may possibly be associated with the occurrence of liver and pancreatic cancers.
Brain cancer			
Gandhi, 2014 USA pilot case-cohort study (14)	A total of 46,819 workers in poultry and non-poultry plants from the same union with cases consisting of 26 (55%) of the 47 brain cancer deaths recorded in the cohort, and controls consisting of a random sample of the cohort (n = 124).	Exposure information was obtained from telephone interviews, and brain cancer mortality risk estimated by odds ratios	Increased risk of brain cancer was associated with killing chickens, odds ratio (OR) = 5.8 (95% confidence interval, 1.2-28.3); working in a shell-fish farm, OR = 13.0 (95% CI, 1.9-84.2); and eating uncooked fish, OR = 8.2 (95% CI, 1.8-37.0). Decreased risks were observed for chicken pox illness, OR = 0.2 (95% CI, 0.1-0.6), and measles vaccination, OR = 0.2 (95% CI, 0.1-0.6). Killing chickens, an activity associated with the highest occupational exposure to poultry oncogenic viruses, was associated with brain cancer mortality, as were occupational and dietary shellfish exposures. These findings are novel.

BIJLAGE 2 OVERZICHTSTABEL VAN OUDERE STUDIES NAAR KANKER IN DE VLEESINDUSTRIE UIT JOHNSON ET AL. 2011

Table 7.	Summary of the findings for cancer in full cohort studies of meat workers in the literature.	
Reference	Description of study	Findings
Johnson and Fischman (1982)	PMR study of 223 death certificates in the Baltimore meat cutters' union	Lung cancer PMR = 1.54
		Bladder cancer PMR = 2.24
		Lymphoma and reticulum cell sarcoma PMR = 2.67
		Multiple myeloma PMR = 2.74
		Myeloid leukaemia PMR = 3.75
Doerken and Rehpenning (1982)	Comparison of lung cancer occurrence in butchers and bakers in Germany	Cancer of the respiratory tract: 36 of 398 *butchers* versus 15 of 399 *bakers*($p < 0.01$)
Fox et al. (1982)	Lung cancer occupational mortality in butchers in England and Wales, Denmark, and Sweden	England and Wales
		1970–1972 (mortality)
		Lung cancer SMR = 1.16
		1966–1967 (cancer incidence)
		Lung cancer SIR = 1.27
		1968–1970 (cancer incidence)
		Lung cancer SIR = 1.20
		Denmark
		1970–1975
		Butchers in slaughterhouses
		Lung cancer SMR = 2.53
		Other butchers
		Lung cancer SMR = 1.65
		Unskilled workers in slaughterhouses

		Lung cancer SMR = 0.85
		Sweden
		1961–1973
		Butchers in slaughterhouses
		Lung cancer SMR = 1.78
		Other butchers
		Lung cancer SMR = 1.30
		Others in slaughterhouses
		Lung cancer SMR = 1.48
Griffith GW (1982)	Lung cancer occupational mortality in butchers in England and Wales (1959–1963)	1951
		Meat and fish curers and smokers
		Lung cancer SMR = 2.00
		Slaughterhouse workers
		Lung cancer SMR = 1.31
		Proprietors etc. of retail stores for grocery, meat, fish, poultry and other foods
		Lung cancer SMR = 1.51
		1959–1963
		Butchers and meat cutters
		Lung cancer SMR = 1.27
Milham (1982)	Death certificate study of lung cancer deaths in Washington State	Lung cancer PMR = 1.07 for butchers and meat cutters in slaughterhouses
		Lung cancer PMR = 0.97 for butchers and meat cutters not in slaughterhouses
Lynge et al. (1983)		1970–1975

	Record linkage study in Denmark of butchers,	*Butcher's shop*
		Self-employed: lung cancer SMR = 1.59
		Skilled: lung cancer SMR = 2.53
		Slaughterhouse
		Skilled butchers: lung cancer SMR = 1.73
		Unskilled: lung cancer SMR = 0.85
		1975–1980
		Butcher's shop
		Self-employed: lung cancer SMR = 1.75
		Skilled: lung cancer SMR = 0.85
		Slaughterhouse
		Skilled butchers: lung cancer SMR = 1.51
		Unskilled: lung cancer SMR = 1.09
Coggon et al. (1989)	Study mortality in *England* in 1) two bacon factories that slaughtered pigs and manufactured pork and beef products. 2) Abattoirs and meat distribution centers that handled beef, pork, lamb	Liver cancer SMR = 5.6 (1.2)
		Lung cancer SMR = 1.3 (1.0)
		Exposure to warm meat, lung cancer SMR = 1.8 (1.2)
Guberan et al. (1993)	Mortality and incidence of cancer among Geneva self-employed butchers and their wives in *Switzerland*	*Mortality*
		All causes mortality SMR = 1.2 (1.1–1.3) in butchers
		All causes mortality SMR = 1.2 (1.1–1.4) in pork butchers

		All cancers SMR = 1.3 (1.1–1.5) in butchers
		All cancers SMR = 1.3 (1.0–1.6) in pork butchers
		Colon/rectum cancer SMR = 2.4 (1.4–3.8) in pork butchers
		Larynx cancer SMR = 3.0 (1.3–5.9) in butchers
		Lung cancer SMR = 1.8 (1.1–2.6) in pork butchers
		Prostate cancer SMR = 2.0 (1.3–3.0) in butchers
		Incidence
		All cancers SIR = 1.9 (1.5–2.4)
		Colon/rectum cancer SIR = 1.9 (1.1–3.0) in butchers
		Colon/rectum cancer SIR = 3.9 (2.3–6.1) in pork butchers
		Lung cancer SIR = 2.3 (1.4–3.7) in pork butchers
		Prostate cancer SIR = 1.7 (1.1–2.7) in butchers
		Prostate cancer SIR = 1.9 (1.0–3.4) in pork butchers
		Liver cancer SIR = 4.1 (1.4–9.4)
Coggon and Wield (1995)	Mortality of butchers identified from census in England and Wales	No significantly increased SMR was observed
Johnson et al. (1995a)	Mortality in union workers in abattoirs and processing plants handling cattle, pigs, sheep in Baltimore, United States.	*Abattoir*
		Lung cancer SMR = 1.4 (1.2–1.6)
		Oesophageal cancer SMR = 1.7 (1.0–2.6)
		Kidney cancer SMR = 2.0 (1.2–3.2)
		Processing plants
		Lung cancer SMR = 1.5 (1.3–1.8)
		Oesophageal cancer SMR = 1.7 (1.0–2.8)
		Buccal cavity and pharynx SMR = 2.0 (1.2–3.2)

		Bone cancer SMR = 4.2 (1.1–11)
		Pig processing plants
		Lung cancer SMR = 2.3 (1.1–4.0)
		Cattle processing plants
		Lung cancer SMR = 1.5 (1.2–1.7)
		Buccal cavity cancer SMR = 2.2 (1.3–3.4)
		Oesophagus cancer SMR = 2.6 (1.4–4.6) for non-white males only
		Bone cancer SMR = 4.4 (1.2–11.3)
Boffetta et al. (2000)	Record linkage cancer incidence study of butchers and meat workers identified from census in *Sweden*	Stomach cancer SIR = 1.1 (1.0)
		Rectum cancer SIR = 1.2(1.0)
		Larynx cancer SIR = 1.7 (1.2)
		Lung cancer SIR = 1.3 (1.2)
		Prostate cancer SIR = 1.1 (1.0)
		Bladder cancer SIR = 1.2(1.0)
		Oral cavity, pharynx SIR = 1.6 (1.0**)**
Fritschi et al. (2003)	Mortality and cancer incidence in members of a meat workers union in *Australia* employed in poultry processing, abattoirs, supermarket meat rooms etc.	All cause SMR = 1.2 (1.1–1.3)
		Lung cancer SIR = 1.6 (1.0–2.6)
		Head and neck SIR = 1.9 (1.0–3.2)*
McLean et al. (2004)	Mortality and cancer incidence in meat workers in one mutton and	*Mortality overall*
		Lung cancer SMR = 1.8 (1.1–2.7)
		Thyroid cancer SMR = 15.6 (1.9–56.2)

	beef plant and two sheep plants in New Zealand.	*Incidence overall*
		Lung cancer SIR = 1.7 (1.1–2.5)
		Incidence by job
		Slaughter board department
		Lung cancer SIR = 1.87 (1.05–3.10)
		Processing department
		Lung cancer SIR = 2.91 (1.10–6.37)
		Exposure to raw meat
		Lung cancer SIR = 1.77 (1.05–2.81)
		Exposure to urine
		Lung cancer SIR = 1.72 (1.09–2.61)
		Exposure to faeces
		Lung cancer SIR = 1.97 (1.26–2.95)
		Exposure to blood
		Lung cancer SIR = 1.91 (1.21–2.90)
		Processing department
		Lymphohaematopoietic cancer SIR = 6.25 (1.25–20.03) for 15+ duration of employment
Besson et al. (2006)	Death certificate study among butchers or meat cutters in 24 states in the US.	Oral cavity cancer OR = 1.5 (1.1)
		Pharynx cancer OR = 1.6 (1.0)
		Oesophagus cancer OR = 1.2 (1.0)
		Bladder cancer OR = 1.2 (1.0**)**

BIJLAGE 3 ONCOGENE MICRO-ORGANISMEN (15)(16)

Micro-organismen als virussen, bacteriën en parasite zijn etiologische factoren bij specifieke kankers bij mensen en verantwoordelijk voor naar schatting 20% van alle kankers bij mensen. Met uitzondering van straling, zonlicht en tabaksrook zijn infecties daarmee de belangrijkste oorzaak van kanker bij mensen. De prevalentie van tumorvirussen varieert in verschillende delen van de wereld: in tropische gebieden zijn deze virussen betrokken bij 30% van de kankers, in ontwikkelde landen in ongeveer 10%. Daarbij komen steeds meer aanwijzingen dat hoe jonger men aan deze micro-organismen is blootgesteld, hoe groter de kans op de ontwikkeling van kanker. Mogelijk heeft dit te maken met de ontwikkeling van het immuunsysteem dat in de jeugd mogelijk onvoldoende is ontwikkeld om bescherming te bieden tegen infectieuze agentia die later wellicht kanker kunnen veroorzaken.

Humane DNA-tumor virussen zijn EBV, HBV, Kaposi's sarcoma herpesvirus (KSHV), human papilloma virus (HPV) en Merkel cell polyomavirus (MCV), Humane RNA tumor virussen zijn retrovirussen zoals human T-cell leukaemia virus-1 (HTLV-1) en human immunodeficiencyvirus-1 (HIV-1), en flavivirussen zoals hepatitis C virus(HCV). De lijst van kanker gerelateerd aan micro-organismen omvat kanker van het urogenitaal systeem (HPV), maag (H.Pylori), lever (HBV, HBC, liver flukes), blaas (schistosoma haematobium), prostaat (XMRV) en andere specifieke kankers zoals T-cel leukemie bij volwassenen (HTLV-1), Kaposi sarcoom (HHV-8), Merkel Cell Carcinoom (MCPyV) en Burkitt's lymfoom (EBV).

Studies met tumor virussen hebben het inzicht in het ontstaan van kanker op moleculair niveau sterk beinvloed. Door de analyse van experimentele cel transformative door virussen is het bestaan van oncogenen en tumor suppressor genen ontdekt. Vervolgstudies met virale oncogenen leerden dat het bestaan van oncogenen en tumor suppressor genen niet uniek was voor virussen, en dat vergelijkbare genen als proto-oncogenen in alle cellen aanwezig zijn. Deze proto-oncogenen komen normaliter niet tot ontwikkeling in een cel, maar na bijvoorbeeld een infectie met tumor virussen. Het begrijpen hoe virale oncogenen de expressie van groei promotoren in cellen kan beïnvloeden heeft nieuwe inzichten opgeleverd in de basis mechanismen van de ontwikkeling van kanker. Het lijkt er zelfs op dan dierlijke virussen oncogenen in menselijke cellen tot expressie kunnen laten komen zonder zich in het DNA te nestelen. Ze laten dan ook geen sporen na in het DNA. Het lijkt erop dat ze alleen interfereren met het immuunsysteem en zo kanker kunnen bevorderen. Dit wordt wel beschreven als de "hit and run" hypothese. Wellicht hebben de antilichamen die worden aangemaakt tegen de dierlijke virussen zelf oncogene of mitogene effecten op de cellen, maar men weet niet hoe dit in zijn werk gaat.

In hoeverre potentieel oncogene micro-organismen die voorkomen bij dieren van invloed zijn op het ontstaan van kanker bij mensen is niet goed bekend. Het ontbreek vooral aan goede epidemiologische studies. Uit verschillende onderzoeken komen wel aanwijzingen naar voren. Zo is bij verwerkers van pluimvee (met name in de vleesverwerking; die vaak blootstaan aan pluimvee virussen als avian leucosis/sarcoma, reticuloendothesliosis, and Marek's disease virussen) een overmaat aan verschillende kankers gevonden, zoals longkanker (SMR = 1.6, 95% CI = 1.3–1.7), cervixkanker (SMR = 2.2, 95% CI = 1.3–3.5), peniskanker (SMR = 8.6,95% CI = 1.0–31.1), hersentumoren (SMR = 1.7, 95%CI = 1.1–2.4), lymphoide leukemie (SMR = 2.2, 95% CI = 1.1–4.1), en monocyten leukemie (SMR = 9.2, 95% CI = 1.1–33.4)

LITERATURE REFERENCES

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