ORIGINAL ARTICLE

Mortality in workers in poultry slaughtering/processing plants: the Missouri poultry cohort study

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Background: Subjects who work in poultry slaughtering and processing plants have one of the highest human exposures to viruses that cause cancer in chickens and turkeys. It is not known whether these viruses cause cancer in humans also. Epidemiological studies investigating this issue are scarce.

Aims and Methods: Mortality was studied during the period 1969–90 in a cohort of 7700 subjects who worked in poultry slaughtering and processing plants and were members of a local poultry union in the State of Missouri.

Results and Conclusions: Statistically significant excess risks of non-malignant respiratory diseases, accidents, and symptoms, senility, and ill-defined conditions, and increased but not statistically significant excesses for some cancers were observed in particular race/sex groups. Most of these results were based on small numbers of deaths, and in many cases were evident only in particular subgroups of the cohort. Because of this and the multiple comparisons made, chance could not be ruled out in explaining the findings. Furthermore, the cohort is young, with only 6% deceased at the end of follow up. Further follow up of this cohort is required before a reliable assessment of the potential risk associated with these viruses can be made.

Workers in poultry slaughtering and processing plants have one of the highest human exposures to viruses which naturally infect and cause cancer in chickens and turkeys. These viruses include the avian leukosis/sarcoma viruses (ALSV) and reticuloendotheliosis viruses (REV) that are retroviruses, and Marek's disease virus (MDV), which is a herpes virus. The viruses are widely prevalent in poultry worldwide, with antibody seroprevalence of greater than 80% in some chicken flocks.¹ Humans are commonly exposed to these viruses, and exposure occurs: (1) occupationally among workers engaged in breeding, slaughtering, and processing of chickens and turkeys, and handling of raw poultry products and their eggs; and (2) among the general population through contact with, and ingestion of, poultry and their products including eggs, as well as through contaminated vaccines grown in chicken embryo cells. It was recently reported that all lots of measles and mumps vaccines currently in use in the United States today are contaminated with endogenous ALSV.² Similar evidence of reverse transcriptase activity in measles, mumps, and yellow fever vaccines has been reported elsewhere.³ A survey of commercial eggs in various supermarkets in metropolitan New Orleans indicates that 14% of eggs carry ALSV.⁴ Poultry workers and subjects in the general population have been reported to have antibodies against ALSV, REV, and MDV in their blood.^{5–6} although similar results have not been reported by others.⁷

Because of the widespread human exposure to these viruses, it is important to know whether they cause cancer in humans.

Epidemiological studies specifically evaluating the effect of human exposure to these viruses are rare. Waters *et al* reported no increased risk of cancer in subjects who received yellow fever vaccine,⁸ but the study did not have sufficient latency period. Several studies of farmers and veterinarians and ecological studies in relation to poultry have reported excess of tumours of the haemopoietic and lymphatic systems, as well as cancers of the cervix and ovary, and these studies have been reviewed in detail.¹ We studied

mortality in 2639 workers in poultry slaughtering and processing plants who were members of a meatcutters' union in Baltimore, Maryland. Statistically significant excess of cancers of the oesophagus, pancreas, liver, and rectum, and tumours of the haemopoietic lymphatic systems was observed in the poultry workers.^{9–10}

We report here the findings of a proportional mortality study of 459 deaths among workers in chicken slaughtering plants who were members of another union in Missouri.

METHODS

The study population comprised all 7700 workers who were members of a local poultry union in Missouri (AFL/CIO Local 410) between January 1969 and December 1988, and who worked in five plants where chickens and turkeys were killed, de-boned, or processed. They were followed up from 1 January 1969 to 31 December 1990. Date of birth and social security number which were used for tracing, were missing for 325 subjects. Methods of follow up included: (1) current union records; (2) Social Security Administration Mortality Files; (3) Missouri Motor Vehicle Administration; (4) Missouri State Department of Vital Records; (5) National Death Index (NDI); (6) US Postal Service; and (7) personal contact by letter or telephone call. At the end of follow up, 459 deaths had occurred in the cohort. Because of the extensive methods of follow up that were employed, and the fact that extensive searches for deceased individuals through the NDI and the Missouri State Department of Vital Records were conducted, subjects not successfully traced were virtually limited to the 325 (4.2% of the cohort) without social security number and date of birth.

The primary method of analysis was the estimation of cause specific proportional mortality ratios (PMR), because information on demographic variables, including race, was complete and available for all deceased subjects. We also performed standardised mortality ratio (SMR) analyses, as a check on the PMR results. Since information on race was not available from the union records, in the SMR analyses all subjects were treated as white, because 92% of all deceased

Main messages

- Humans are exposed to retroviruses, which are widespread and naturally infect and cause cancer in chickens and turkeys.
- Human exposure can occur through ingestion of, or contact with, blood and secretions of chickens and turkeys, raw eggs, and raw meat products of poultry animals, and through contaminated vaccines. Virtually all of the measles, mumps, and yellow fever vaccines currently in use in the United States are contaminated with the endogenous forms of these viruses.
- It is not known whether these viruses cause cancer in humans, but the exogenous forms of these viruses have been shown to infect and transform human cells in vitro, and induce cancer in primates.
- Epidemiological studies to investigate the effect of human exposure to these viruses are scarce, and this cohort study of a very highly exposed group of poultry workers is one of the very few to date.
- In spite of the young age of the cohort and the short latency period so far, the cohort is already beginning to show excess of certain cancers, consistent with what little information there is in the literature.

Policy implications

- In spite of widespread human exposure to the oncogenic retroviruses of chickens and turkeys, and the potential they have shown to infect and transform human cells in the laboratory, epidemiological studies investigating their effects in humans are scarce.
- The observation in this study of poultry workers that certain cancers previously observed to be associated with excess occurrence in poultry exposed groups, also appear to be occurring in excess in this study also, in spite of the young age of the cohort and the short latency period, indicates that there is urgent need for future epidemiological studies investigating the health effects of human exposure to these viruses.
- There is also an urgent need to determine whether the endogenous forms of these viruses also transform human cells in vitro, and whether the exogenous forms occur in currently used vaccines. This study attempts to call attention to these issues.

subjects were known to be white. The PMR analyses are presented for each race/sex subgroup, while for the SMR analyses only the results by gender are presented as the estimates are more stable. For the SMR, the study population was stratified by plant and sex and each stratum was subdivided according to age at entry into the cohort (five year intervals) and calendar year (five year intervals). Person-years were accumulated as from the date of union membership or as from 1 January 1969, for those who were already members of the union before that date. Person-years were enumerated up to the date of death, or date of termination of the study on 31 December 1990, whichever was earlier. Expected deaths were derived by multiplying the person-years in each cell by the corresponding gender, calendar year, age specific mortality rate for the United States general population. The PMR was estimated following similar stratification as for the SMR, with deaths in the study population used in the strata instead of person-years, and deaths in the US general population used as reference to calculate expected deaths. For each cell, the proportion of all deaths due to a given cause in the US population was multiplied by the total number of deaths in the corresponding cell of the study population to obtain the expected number of deaths.

RESULTS

The SMR and PMR results for all sites were very similar. For example, in males, the SMR and PMR for all cancers were both 0.7, and in females, 0.9 and 1.0, respectively; for cancer of the lung, the SMR and PMR in males were both 0.9, and in females were both 1.3; for arteriosclerotic heart disease, the SMR and PMR for males were both 1.0, and in females were 0.9 and 1.0, respectively (see table 1).

Statistically significant PMR results were obtained for non-malignant respiratory diseases and symptoms, senility, and ill-defined conditions, in white males; in white females symptoms, senility, and ill-defined conditions was also statistically significant, as well as all accidents. Selected PMRs which appear increased include cancer of the colon, cancer of the pancreas, cancer of the lung, cancer of the

cervix, cancer of the kidney, cancer of the brain and other CNS, and cancer of the lymphatic tissue.

DISCUSSION

The agreement between the PMR and SMR results indicate that the PMR findings provide a valid assessment of risk. This Missouri union cohort is one of only a few studies ever performed on workers in poultry slaughtering/processing plants. In spite of the low statistical power, the results agree closely with what little there is in the published literature, and particularly with those obtained in our earlier study of a similar union in Baltimore, Maryland.^{9 10} Both studies recorded increased risks of cancers of the lung, pancreas, kidney, cervix, and certain tumours of the haemopoietic and lymphatic systems, non-malignant respiratory diseases, and motor vehicle accidents, although some of these were not statistically significant because of small numbers. The Missouri cohort is very young with only 6% deceased, and the maximum period of follow up for any individual in the cohort is 21 years. The Baltimore cohort was also relatively young, with only 14% deceased.

There is growing concern as to whether oncogenic retroviruses such as ALSV and REV, to which the general population is exposed through contaminated vaccines, contact with, and ingestion of, poultry and poultry products, pose a public health threat.^{1 2-6 9 10} These two cohorts include subjects with the highest human exposure to these viruses. Thus they have an important role to play in the future, in the evaluation of the potential carcinogenicity of these viruses in humans. At the moment, although increased risks of certain cancers which were sometimes statistically significant have been recorded in both, neither has sufficient statistical power or latency to provide a reliable assessment of the extent if any, of the potential risks posed by these viruses to humans. Continued observation and further follow up of both cohorts are required before the findings will be informative in this regard, but the results thus far indicate that this and similarly exposed groups warrant future attention. This should be accompanied by laboratory based molecular studies of the oncogenicity in human cells, of the endogenous forms of these viruses which presently contaminate vaccines commonly used in children and adults.

Table 1 Proportional mortality ratios (PMR) and standardised mortality ratios (SMR) by race and sex (Missouri Poultry Union, 1969–90)

Cause of death	Obs	All females	White females	Non-white females	All males	White males	Non-white males
All deaths	Obs	360	330	30	99	94	5
ICD 000–999	SMR	0.9* (0.8 to 0.9)	–	–	1.0 (0.8 to 1.2)	–	–
All cancers	Obs	118	110	8	18	17	1
(ICD 140–209)	PMR	1.0 (0.9 to 1.2)	1.0 (0.9 to 1.3)	1.0 (0.4 to 2.0)	0.7 (0.4 to 1.2)	0.7 (0.4 to 1.2)	–
	SMR	0.9 (0.8 to 1.1)	–	–	0.7 (0.4 to 1.2)	–	–
All infective and parasitic diseases	Obs	7	7	0	2	2	0
(ICD 000–139)	PMR	1.4 (0.6 to 3.0)	2.0 (0.8 to 4.0)				
	SMR	1.5 (0.6 to 3.1)					
Cancer of stomach	Obs	1	1	0	2	2	0
(ICD 151)							
Cancer of colon	Obs	15	15	0	2	2	0
(ICD 153)	PMR	1.4 (0.8 to 2.3)	1.5 (0.8 to 2.4)				
	SMR	1.2 (0.7 to 2.0)					
Cancer of rectum	Obs	2	2	0	0	0	0
(ICD 154)							
Cancer of liver	Obs	1	1	0	0	0	0
(ICD 155–156)							
Cancer of pancreas	Obs	8	8	0	0	0	0
(ICD 157)	PMR	1.5 (0.7 to 3.0)	1.7 (0.7 to 3.3)				
	SMR	1.4 (0.6 to 2.7)					
Cancer of lung	Obs	30	26	4	8	7	1
(ICD 162)	PMR	1.4 (0.9 to 1.9)	1.3 (0.9 to 1.9)	3.1 (0.8 to 7.8)	0.9 (0.4 to 1.8)	0.9 (0.3 to 1.7)	
	SMR	1.2 (0.8 to 1.8)					
Cancer of skin	Obs	1	1	0	0	0	0
(ICD 172–173)							
Cancer of breast	Obs	18	15	3	0	0	0
(ICD 174)	PMR	0.7 (0.4 to 1.2)	0.7 (0.4 to 1.1)	1.8 (0.4 to 5.4)			
	SMR	0.6 (0.4 to 1.0)					
Cancer of cervix uteri	Obs	6	6	1			
(ICD 180)	PMR	2.1 (0.8 to 4.3)	2.1 (0.8 to 4.5)				
	SMR	1.6 (0.6 to 3.6)					
Cancer of corpus uteri	Obs	3	3	0			
(ICD 181–182)	PMR	1.0 (0.2 to 2.9)	1.1 (0.2 to 3.1)				
	SMR	0.9 (0.2 to 2.6)					
Cancer of other genital organs	Obs	5	5	0			
(ICD 183–184)	PMR	0.7 (0.2 to 1.5)	0.7 (0.2 to 1.6)				
	SMR	0.6 (0.2 to 1.3)					
Cancer of prostate	Obs				1	1	0
(ICD 185)							
Cancer of bladder	Obs	2	2	0	1	1	0
(ICD 188)							
Cancer of kidney	Obs	3	3	0	1	1	0
(ICD 189)	PMR	1.6 (0.3 to 4.8)	1.8 (0.4 to 5.2)				
	SMR	1.4 (0.3 to 4.2)					
Cancer of brain and other CNS	Obs	5	5	0	0	0	0
(ICD 191–192)	PMR	1.6 (0.5 to 3.8)	1.7 (0.5 to 3.9)				
	SMR	1.4 (0.5 to 3.2)					
Lymphosarcoma and reticulosarcoma	Obs	2	2	0	0	0	0
(ICD 200)							
Multiple myeloma	Obs	1	1	0	0	0	0
(ICD 203)							

Table 1 Continued

Cause of death	Obs	All females	White females	Non-white females	All males	White males	Non-white males
Leukaemia and aleukaemia (ICD 204–207)		2	2	0	2	2	0
Cancer of other lymphatic tissue (ICD 202–203, 208)	Obs PMR SMR	5 1.2 (0.4 to 2.7) 1.1 (0.3 to 2.5)	5 1.3 (0.4 to 3.1)	0	0	0	0
All haemopoietic and lymphatic cancer (ICD 200–209)	Obs PMR SMR	10 1.0 (0.5 to 1.8) 0.9 (0.4 to 1.6)	10 1.1 (0.5 to 2.0)	0	2	2	0
Benign neoplasms (ICD 210–239)	Obs	1	1	0	0	0	0
Diabetes mellitus (ICD 250)	Obs PMR SMR	9 1.0 (0.5 to 1.9) 0.9 (0.4 to 1.8)	8 1.1 (0.5 to 2.1)	1	0	0	0
All diseases of blood and blood forming organs (ICD 280–289)	Obs	1	1	0	1	1	0
All diseases of nervous system and sense organs (ICD 320–389)	Obs	2	1	1	1	1	0
All diseases of circulatory system (ICD 390–458)	Obs PMR SMR	131 1.0 (0.8 to 1.1) 0.8 (0.7 to 1.0)	118 0.9 (0.8 to 1.1)	13 1.0 (0.5 to 1.7)	32 0.8 (0.6 to 1.1)	30 0.8 (0.5 to 1.1)	2
Arteriosclerotic heart disease and CHD (ICD 410–414)	Obs PMR SMR	82 1.0 (0.8 to 1.3) 0.9 (0.7 to 1.1)	74 1.0 (0.8 to 1.2)	8 1.3 (0.6 to 2.5)	22 0.8 (0.5 to 1.2)	20 0.7 (0.4 to 1.1)	2
All vascular lesions of CNS (ICD 430–438)	Obs PMR SMR	18 0.7 (0.4 to 1.2) 0.7 (0.4 to 1.0)	16 0.7 (0.4 to 1.2)	2	3 0.8 (0.2 to 2.2)	3 0.8 (0.2 to 2.3)	0
All non-malignant respiratory diseases (ICD 460–519)	Obs PMR SMR	17 0.8 (0.5 to 1.2) 0.7 (0.4 to 1.1)	15 0.8 (0.4 to 1.3)	2	11 1.8 (0.9 to 3.2)	11 1.9* (1.0 to 3.5)	0
All pneumonia (ICD 480–486)	Obs PMR SMR	4 0.6 (0.2 to 1.4) 0.5 (0.1 to 1.2)	4 0.6 (0.2 to 1.6)	0	4 2.1 (0.6 to 5.4)	4 2.4 (0.6 to 6.1)	0
Asthma (ICD 493)	Obs	2	2	0	0	0	0
Gastric and duodenal ulcer (ICD 531–533)	Obs	1	0	1	0	0	0
Cirrhosis of liver (ICD 571)	Obs PMR SMR	4 0.6 (0.2 to 1.4) 0.5 (0.1 to 1.2)	4 0.6 (0.2 to 1.6)	0	1	1	0
Nonmalignant diseases of genitourinary system (ICD 580–629)	Obs PMR SMR	6 1.1 (0.4 to 2.5) 1.1 (0.4 to 2.4)	6 1.4 (0.5 to 3.0)	0	2	2	0
Chronic nephritis (ICD 582)	Obs	1	1	0	0	0	0
Symptoms, senility and ill-defined conditions (ICD 780–799)	Obs PMR SMR	14 3.3 (1.8 to 5.5) 3.1* (1.7 to 5.2)	13 3.5* (1.8 to 5.9)	1	8 5.5* (2.4 to 10.9)	8 6.0* (2.6 to 10.8)	0
All external causes of death (ICD 800–998)	Obs PMR SMR	32 1.2 (0.8 to 1.7) 1.1 (0.7 to 1.5)	30 1.2 (0.8 to 1.7)	2	22 1.2 (0.8 to 1.8)	21 1.2 (0.7 to 1.8)	1

Table 1 Continued

Cause of death	Obs	All females	White females	Non-white females	All males	White males	Non-white males
All accidents (ICD 800-949)	Obs	25	23	2	14	14	0
	PMR	1.5*	1.5		1.3	1.3	
	SMR	(1.0-2.2)	(0.9 to 2.2)		(0.7 to 2.2)	(0.7 to 2.2)	
All motor vehicle accidents (ICD 810-827)	Obs	15	15	0	11	11	0
	PMR	1.5	1.6		1.8	1.8	
	SMR	(0.9 to 2.5)	(0.9 to 2.6)		(0.9 to 3.2)	(0.9 to 3.2)	
Suicide (ICD 950-959)	Obs	4	4	0	0	0	0
	PMR	0.6	0.6				
	SMR	(0.2 to 1.6)	(0.2 to 1.6)				
		0.5					
		(0.2 to 1.4)					

SMR, PMR, and confidence intervals reported only for three or more deaths.

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