Occupational Exposures to Antineoplastic Drugs and Ionizing Radiation in Canadian Veterinary Settings: Findings From a National Surveillance Project

Amy L. Hall, MSc,[1] Hugh W. Davies, PhD,[2] Paul A. Demers, PhD,[3] Anne-Marie Nicol, PhD,[4] Cheryl E. Peters, MSc[1]

ABSTRACT

OBJECTIVES: Although veterinary workers may encounter various occupational health hazards, a national characterization of exposures is lacking in Canada. This study used secondary data sources to identify veterinary exposure prevalence for ionizing radiation and antineoplastic agents, as part of a national surveillance project.

METHODS: For ionizing radiation, data from the Radiation Protection Bureau of Health Canada were used to identify veterinarians and veterinary technicians monitored in 2006. This was combined with Census statistics to estimate a prevalence range and dose levels. For antineoplastic agents, exposure prevalence was estimated using statistics on employment by practice type and antineoplastic agent usage rates, obtained from veterinary licensing bodies and peer-reviewed literature.

RESULTS: In 2006, 7,013 (37% of all) Canadian veterinary workers were monitored for ionizing radiation exposure. An estimated 3.3% to 8.2% of all veterinarians and 2.4% to 7.2% of veterinary technicians were exposed to an annual ionizing radiation dose above 0.1 mSv, representing a total of between 536 and 1,450 workers. All monitored doses were below regulatory limits. For antineoplastic agents, exposure was predicted in up to 5,300 (23%) of all veterinary workers, with an estimated prevalence range of 22% to 24% of veterinarians and 20% to 21% of veterinary technicians.

CONCLUSION: This is the first national-level assessment of exposure to ionizing radiation and antineoplastic agents in Canadian veterinary settings. These hazards may pose considerable health risks. Exposures appeared to be low, however our estimates should be validated with comprehensive exposure monitoring and examination of determinants across practice areas, occupations, and tasks.

KEY WORDS: Veterinarians; occupational exposure; radiation; antineoplastic agents; Canada

La traduction du résumé se trouve à la fin de l'article.

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Canadian veterinary work occurs in a variety of environments with diverse animal patient populations. Occupational hazards encountered in veterinary settings include acute injury, zoonoses, ionizing radiation, pharmaceuticals, pesticides, anesthetic gases, and disinfectants.[1,2] To date, much information about hazardous exposures has been obtained from regional self-report surveys.[1-3] While this has provided useful information on the nature of hazards and regional prevalence, we lack an understanding of where, and to what extent, exposures are occurring nationally.

CAREX Canada is a national surveillance project that uses secondary data sources to estimate exposure prevalence to known and suspected carcinogens in Canadian workplaces, identify how and where people are exposed, and when possible, determine levels of exposure. It has developed estimates of exposure for ionizing radiation and antineoplastic agents, both of which are encountered in veterinary settings.

The use of ionizing radiation (a known human carcinogen) in radiographic procedures is common in veterinary practice.[1,2] While average annual doses in these settings are low relative to other exposed occupations,[4] accumulation of low levels of ionizing radiation might represent a health hazard.[5] Doses can be affected by veterinary-specific workplace determinants, including the common practice of manually restraining animals during radiography.[1,2] An Australian veterinarian study noted "radiographs are taken sometimes showing fingers…the entire hand and…other portions of the person restraining an animal…".[6] Furthermore, because most veterinarians are generalists, radiographic equipment may be older and lack exposure-reducing features found in more specialized human medical settings.[6]

Antineoplastic agents are used primarily in companion animal practice to treat cancers in dogs and cats.[3,7] They have been recognized as an occupational hazard since the late 1970s,[8] with possible mutagenic, teratogenic, and carcinogenic health effects.

Veterinary oncology practice is expanding, due partly to improved comparative cancer research capabilities following the canine genome sequence's release in 2005.[9] Increases in use of antineoplastic agents and potential for exposure in veterinary practice

Author Affiliations

1. School of Population and Public Health, University of British Columbia, Vancouver, BC
2. Associate Professor, School of Population and Public Health, University of British Columbia, Vancouver, BC
3. Director, Occupational Cancer Research Centre, Cancer Care Ontario, Toronto, ON
4. Assistant Professor, Faculty of Health Sciences, Simon Fraser University, Vancouver, BC

Correspondence: Amy Hall, University of British Columbia, 2206 East Mall (3rd Floor), Vancouver, BC V6T 1Z3, E-mail: amyhall@mail.ubc.ca

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Conflict of Interest: None to declare.

Table 1. Registered Private Veterinary Practices in Canada, February 2013[12]

Animal Practice Type	Number of Registered Practices (% of Total)	Primary Patient Population
Companion	2059 (64)	Dogs, cats, and exotic species
Mixed	927 (29)	Combination of Large and Companion animals
Large	238 (7)	Livestock (sheep, cattle, goats, swine, poultry) and horses
All	3224 (100)	

Table 2. National Dose Registry (NDR) Monitoring of Radiation Doses for Veterinary Workers in Canada, 2006*

Job Title	Total Number in Canada's 2006 Census (% Female)	Total Number Monitored in NDR (% Female)	Lower Estimate: Number Monitored in NDR With Exposure >0.1 mSv	Upper Estimate: Extrapolated Number Exposed
Veterinarian	7895 (50)	3229 (59)	264	650
Veterinary technician	11,135 (91)	3784 (95)	272	800
TOTAL	19,030	7013	536	1450

* Upper estimates rounded to the nearest 10.

Table 3. Number of Veterinary Workers Exposed (Lower and Upper Estimate) by Dose Level*

	Dose Level (Lower Estimate)			Dose Level (Upper Estimate)		
Job Title	Low	Moderate	High	Low	Moderate	High
Veterinarian	256	8	0	630	20	0
Veterinary technician	251	21	0	740	60	0
Total	507	29	0	1370	80	0

* Low (>0.1 to 1 mSv), Moderate (>1 to 20 mSv), High (>20 mSv).

will likely continue, since cancer is one of the leading causes of pet death and over half of Canadian households have at least one dog or cat.[10]

While the potential for exposure to antineoplastic agents and ionizing radiation may be greater in veterinary versus human settings,[6,11] we lack information on how many Canadian workers may encounter them. Such information could help identify individuals at risk for exposure and disease, direct prevention efforts, and inform future research. Here we present a first step to characterizing veterinary exposures to these substances on a national level.

METHODS

There are approximately 12,600 registered veterinarians in Canada, employed primarily in private practice, government, education, research, and industry.[12] An additional 11,100 Canadians are trained as "veterinary technicians", to assist veterinarians.[13]

In Canada, 75% of veterinarians work in private practice, generally divided into the categories of "companion", "mixed", and "large" animal practice (Table 1). Practice type can be predictive of occupational exposures, since treatment options vary by the species of animal being treated.[14] Regional variations in the proportions and numbers of practice types are also expected, due to the effects of population size (on companion animal practices) and agriculture (on large animal practices).

Due to variations in the availability and quality of secondary data, each substance was assessed independently. For antineoplastic agents, we assessed the numbers of veterinarians and veterinary technicians exposed in private practice only. For ionizing radiation, we assessed those exposed in all industry sectors (including government, education, research, and industry).

All study procedures were approved by the Institutional Review Board of the University of British Columbia. Written informed consent by participants was unnecessary, due to the secondary and anonymous nature of the data used.

Ionizing radiation

Numbers of workers exposed to ionizing radiation were estimated from data in the Radiation Protection Bureau of Health Canada's National Dose Registry (NDR), which contains radiation dose information for over 100,000 currently monitored workers. We extracted data for the years 2005, 2006 and 2007.[4,15] Estimates were based on 2006 data (chosen for comparability with the 2006 Census of Population),[13] while 2005 and 2007 were used to examine consistency across years.

Data for whole-body doses of ionizing radiation for the occupational codes "veterinarians" and "veterinary technicians" were extracted, including number of workers monitored, job title, industry sector, sex, average radiation dose, and the average dose of individuals with positive measurements (>0.1 mSv, the NDR's reported limit of detection). Due to variations in regulatory limits across agencies and worker type, dose categories were created based on definitions provided by the NDR: low (>0.1 to 1 mSv), moderate (>1 to 20 mSv), and high (>20 mSv).[15]

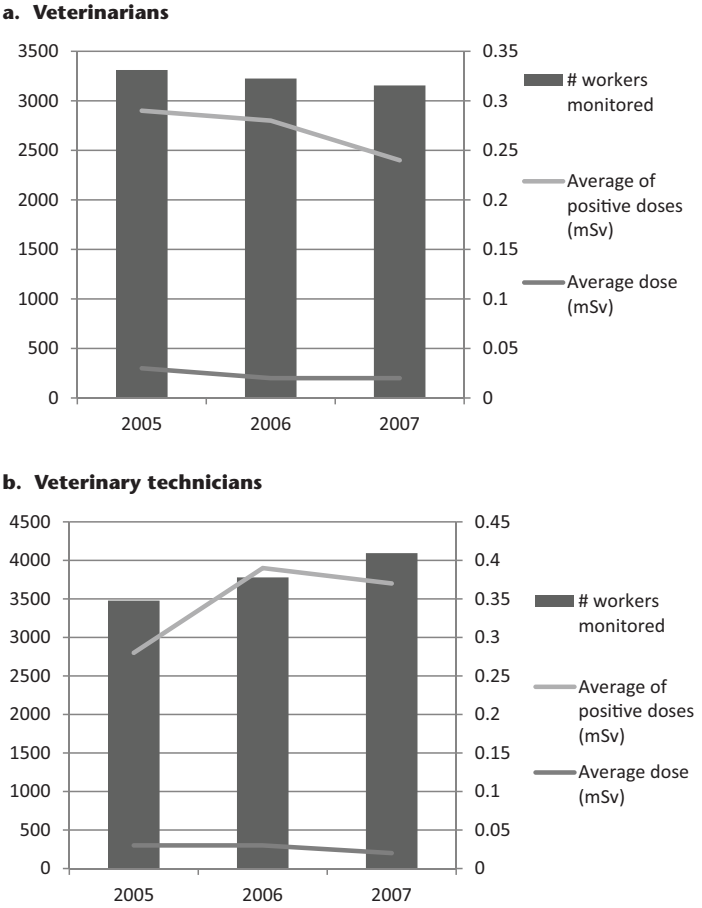
Because regulation of radiation exposure monitoring among veterinary workers is conducted on a provincial basis, the degree to which the NDR captures radiation-exposed workers is unknown. To account for this uncertainty, we calculated a range of potentially exposed workers. The low end was represented by the number of individuals with measured radiation doses in the NDR. To extrapolate an upper estimate of exposure prevalence, we applied the proportion of NDR-monitored workers in each dose level group to the total number of veterinarians and veterinary technicians tabulated in the 2006 Census.

We also examined the proportions of workers monitored by province/territory and by sex, to examine regional trends in the NDR's radiation monitoring program.

Antineoplastic agents

For veterinarians in Canada, licensing and membership in professional bodies is mandatory. The total number of registered veterinarians by province/territory was obtained from the Canadian

Figure 1. Time trends in radiation monitoring by the National Dose Registry (numbers of workers monitored, average of positive doses [>0.1 mSv], and average doses)



Veterinary Medical Association.[12] Current statistics on practice area were requested from each of the 12 provincial and territorial veterinary medical associations. Since the majority of treatment with antineoplastic agents occurs in companion animals, veterinarians working in large animal practices were excluded from our analysis.

The total number of veterinary technicians by province/territory was obtained from the 2006 Census. Because the Census does not contain detailed information on practice area and professional association membership is not mandatory for veterinary technicians in most jurisdictions, we used North American human resource compositions in veterinary practice[16,17] to estimate a ratio of 0.8 veterinary technicians to veterinarians in companion and mixed animal practice.

Prevalence of antineoplastic agent use was estimated from the literature. A recent survey reported cytotoxic drug use in 46% of companion and mixed animal practices in western Canada,[1] while in other countries, similar[18] and higher[19] rates have been reported. Based on these findings, we assumed that on average, antineoplastic agents are used at least once annually in 40% of companion and mixed animal practices in Canada.

To estimate numbers of veterinarians and veterinary technicians exposed, the information on prevalence of antineoplastic agent use was combined with worker numbers in companion and mixed practices in each province/territory. A range of potentially exposed workers was calculated, with the low end including only companion animal practices, and the high end including both companion and mixed animal practices.

In companion animal practices, we applied the assumption that all staff may be exposed. This was based on reports of persistent surface contamination with antineoplastic agents in human medical and pharmacy[20,21] and recently veterinary[11,22] settings.

While mixed animal practice is composed of both companion and large animal practitioners, information on the proportions of staff handling particular animal species was not available. To address this uncertainty, we assumed that 50% of veterinarians and veterinary technicians in mixed animal practice work primarily with companion animals and may be exposed.

RESULTS

Ionizing radiation

The National Dose Registry monitored radiation doses for 7,013 veterinarians and veterinary technicians in 2006, of whom 536 had a dose >0.1 mSv (Table 2). The Census tabulated over 19,000 workers in these job categories, indicating that 37% of all veterinary workers were monitored in 2006. No reported doses exceeded the federal occupational exposure limit of 20 mSv per year. Nationally, females were monitored for radiation dose in higher proportions than males for both occupations.

Using annual report data from the NDR, we estimated that a minimum of 264 (3.3% of all) veterinarians and 272 (2.4% of all) veterinary technicians in Canada had annual doses >0.1 mSv in 2006. By assuming a similar rate of exposure in the monitored and unmonitored workers and extrapolating to the Census, we estimated an upper range of 650 (8.2% of all) veterinarians and 800 (7.2% of all) veterinary technicians with annual doses >0.1 mSv.

The percentage of all veterinary workers monitored by province/territory in 2006 ranged from 12% to 94% for veterinarians and 9% to over 80% for veterinary technicians. Most measured veterinary workers fell into the low dose category (Table 3); no measured doses were noted in the high dose category. This was also the case in the other two years for which dose information was available (2005 and 2007, data not shown).

Figure 1 shows time trends for the number of workers monitored, average dose, and average detectable dose (>0.1 mSv), for veterinarians and veterinary technicians respectively.

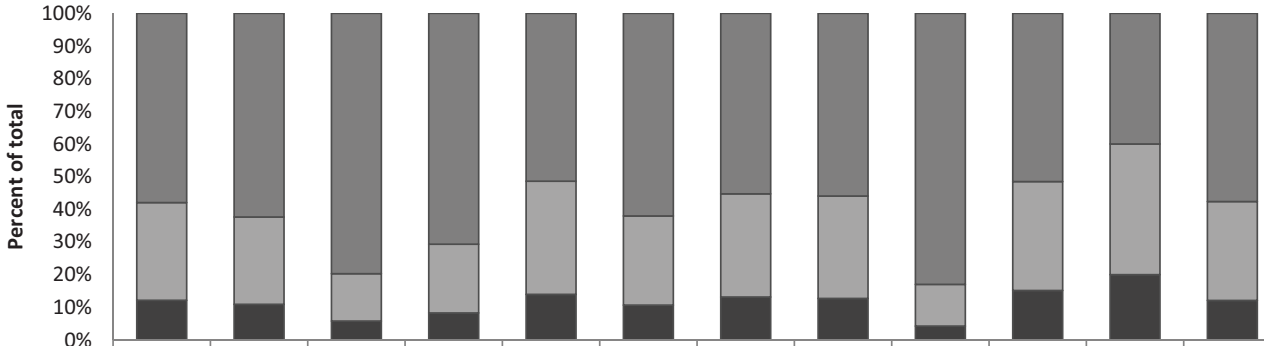
Slightly fewer veterinarians were being monitored over time from 2005 to 2007. Average dose was consistently low over the entire group, and exposures appeared to decline for veterinarians with measured doses >0.1 mSv. Data for the 10 years up to and including 2007 (not shown) show this to be a persistent trend between 1997 and 2007. The numbers of veterinarians monitored slowly decreased over time, with over 4,200 monitored in 1997 versus 3,155 monitored in 2007.

For veterinary technicians, average dose was low, although doses >0.1 mSv increased between 2005 and 2007 and were higher overall than for veterinarians. Also in contrast to veterinarians, more veterinary technicians were being monitored over time; in 1997, fewer than 200 were monitored, increasing to 4,100 in 2007.

Antineoplastic agents

We estimated that exposure to antineoplastic agents occurred in 21% (n = 5,000; Figure 2) to 23% (n = 5,300; data not shown) of all

Figure 2. Veterinary workers (veterinarians and veterinary technicians) by Canadian jurisdiction, practice area, and exposure to antineoplastic agents*



	BC	AB	SK	MB	ON	QC	NB	NS	PE	NL/LD	YT/NT	Canada
Total (n)	3100	2800	1100	940	9200	5000	420	660	390	170	20	23,800
Total in Companion Animal practice (n)	1600	1200	200	280	6200	2200	240	370	60	110	20	12,500
Exposed in Companion Animal practice (n)	650	490	80	110	2500	860	100	150	20	50	10	5000

* Provincial estimates rounded to two significant digits; national estimates to the nearest hundred.

veterinarians and veterinary technicians in Canada. For veterinarians, between 2,800 and 3,000 may be occupationally exposed to antineoplastic agents, representing 22% to 24% of these workers. For veterinary technicians, we estimated that between 2,200 and 2,400 were exposed, representing 20% to 21% of these workers.

Exposure prevalence differed by province and territory, driven by population size and proportions of companion animal clinics in each region. The greatest numbers exposed were located in the province of Ontario, which had the largest population and number of companion animal clinics in Canada.[12]

CONCLUSIONS

Ionizing radiation

Our estimates showed that 3.3% to 8.2% of veterinarians and 2.4% to 7.2% of veterinary technicians were exposed to an annual ionizing radiation dose above 0.1 mSv in Canada in 2006. Monitored dose levels were low in both groups compared to typical Canadian occupational exposure limits for radiation workers in veterinary settings.[23]

Although the use of radiography is prevalent in Canadian veterinary practice,[1,2] we observed a wide range in the proportions of workers monitored by province/territory, from 12% to 94% of veterinarians and 9% to 80% of veterinary technicians. This may be due to variations in monitoring requirements across jurisdictions. Most veterinary workers are employed in private practice, which falls under provincial and territorial jurisdiction for regulation and monitoring of occupational exposure. While occupational dose limits vary somewhat across jurisdictions, greater variation has been noted in monitoring requirements. For example, in British Columbia, WorkSafeBC requires that a personal dosimeter be provided to and used by a worker if exposure may exceed the provincial workplace action level for ionizing radiation (equal to 10 mSv under normal conditions),[24] whereas in Saskatchewan, regulations state that a dosimeter must be issued "If an occupational worker may receive an effective dose greater than 1 millisievert in a one year period…".[25]

Our finding that monitoring of veterinary technicians increased between 1997 and 2007 could be explained by a growing workforce, which according to the Census grew from 4,545 workers in 1996 to 11,135 in 2006. An increase in the numbers of veterinary technicians taking on responsibility for radiographic tasks might also explain the decreasing prevalence of monitoring in veterinarians noted in this time period.

Previous self-report surveys have noted prevalent use of X-rays by veterinarians and veterinary technicians in Canada.[1,2] Interestingly, one study found that 90% of veterinarians (495/549) who reported X-ray use also reported possession of a dosimeter, and 15 of these individuals (14 in private practice and 1 in academia) reported dosimeter readings of >20 mSv/year in the previous five years.[1] Although response bias may have played a role in reported prevalence rates, and the doses exceeding 20 mSv/year may reflect a recent increase in exposures, these results suggest that the NDR program may not be capturing all exposed workers.

A strength of our estimates is that they were based on dosimetry data at the individual level, obtained from a large centralized database on occupational exposures to ionizing radiation in Canada. However the NDR's limited descriptive data does not allow for meaningful examination of exposure determinants. For example, while our results show that average doses >0.1 mSv increased in veterinary technicians between 2005 and 2007 and were higher overall than for veterinarians, we cannot determine which job tasks or other workplace factors may account for these differences.

While the NDR data show interesting trends in monitoring for radiation exposures in Canada, it is unclear where gaps exist – we cannot distinguish why major differences occur in proportions of workers monitored across provinces, whether the measurements in the NDR represent a disproportionate number of workers in particular practice areas, or if we are missing individuals with high doses. Since fewer than 40% of veterinary workers are being captured in the NDR, outreach to employers and workers regarding the potential health hazards of ionizing radiation exposure and workplace monitoring requirements may be warranted.

Antineoplastic agents

Our findings show that 21% to 23% of veterinarians and veterinary technicians in Canada are potentially exposed to antineoplastic agents through their work with companion animals. These estimates incorporated several assumptions and may underestimate the numbers of workers exposed. Although most veterinary antineoplastic agents are used in private practice with companion animals, applications in other species (e.g., horses) and work environments (e.g., academia and research) occur to a lesser extent[1] and were not assessed in our study.

Our assumption that antineoplastic agents were used in 40% of companion and mixed animal practices may be conservative. In addition to the recent finding of 46% usage prevalence in one Canadian region,[1] a UK study reported 71% of companion animal practices using cytotoxic drugs to treat dogs or cats within the past year,[19] while in an Australian survey, 46% of veterinary nurses reported working with chemotherapeutic agents.[18]

One prior study reported a lower prevalence, with only 1% to 3% of veterinary workers in the Netherlands exposed to antineoplastics.[11] However this study appeared to examine all workers in veterinary workplaces while ours focused on workers likely to be handling the drugs. Also, our study's definition of exposure was broad: in addition to those directly contacting antineoplastics during their preparation, administration, and cleanup, we counted workers with potential for contact with contaminated work surfaces.

Other information on determinants of exposure should be collected to expand upon our findings. Practice size and specialty is one factor likely to affect exposures through various means (e.g., frequency of use, engineering controls, and safety policies in place). Taking usage frequency as an example, a study of Australian veterinary nurses found that use of cytotoxics was more frequently reported in workers employed by animal hospitals (60%) than clinics (35%).[18]

Our findings underline how little is known about antineoplastic agent use and exposure in Canadian veterinary settings. This may be due in part to their emerging use in veterinary medicine, which is likely to increase as the fields of comparative and clinical veterinary oncology expand. To effectively target interventions and mitigate exposures, surveillance should be performed in these environments to measure contamination levels and determine which factors put workers at greatest risk of exposure.

Implications

To address the challenges of Canada's large geography and regional variability in assessing national-level exposures in veterinary settings, we developed ranges of exposure prevalence for antineoplastic agents and ionizing radiation. To our knowledge, this is the first national exposure assessment of veterinary workers. It also adds to a small number of existing veterinary technician studies.[2,11,18]

Although the Canadian veterinary workforce is relatively small, their exposures merit attention. A review of carcinogenic risks in veterinarians conducted in 2000[26] found possible increased mortality from lymphohaematopoeitic cancers, melanoma, and colon cancer in this occupational group. Studies of disease burden have found increased risks of adverse reproductive outcomes in veterinarians exposed to high doses of radiation,[27,28] with differing degrees of risk across practice type.[29] Similar reproductive outcomes have also been observed in health care workers exposed to antineoplastic agents.[8,30]

Exposures linked to adverse reproductive outcomes are of particular significance in veterinary settings given that the majority of veterinary technicians in Canada are females of reproductive age.[16] A demographic shift is also being observed in veterinarians (a historically male-dominated profession), with females now representing approximately 50% of the workforce.[12]

Occupational hazards encountered in veterinary settings extend beyond the substances discussed here. As the CAREX Canada project evolves, exposure estimates for other known and potentially carcinogenic substances – including ethylene oxide, formalin and pesticides – will be assessed. Other potentially exposed occupations within veterinary and animal care settings – including animal groomers, handlers and other assisting workers – also require assessment.

Summary

Understanding where exposures occur and to what extent allows for targeted interventions to reduce exposures and mitigate the potential for negative health outcomes. Our estimates provide an initial step to characterizing exposure prevalence for antineoplastic agents and ionizing radiation in Canadian veterinary settings. They could be significantly strengthened by the collection and incorporation of further information on determinants and levels of exposure across practice areas, occupations and tasks.

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RÉSUMÉ

OBJECTIFS : Bien que les agents vétérinaires puissent être exposés à divers dangers pour la santé au travail, il manque au Canada une caractérisation nationale de ce type d'exposition. Dans le cadre d'un projet de surveillance national, nous avons utilisé des sources de données secondaires pour cerner la prévalence des expositions aux rayonnements ionisants et aux antinéoplasiques en milieu vétérinaire.

MÉTHODE : Pour les rayonnements ionisants, les données du Bureau de la radioprotection de Santé Canada ont servi à identifier les vétérinaires et les techniciens vétérinaires surveillés en 2006. Nous avons combiné ces données aux chiffres du Recensement pour estimer un intervalle de prévalence et des niveaux de dose. Pour les antinéoplasiques, la prévalence de l'exposition a été estimée à l'aide des statistiques sur l'emploi par type de pratique et des taux d'utilisation des antinéoplasiques, lesquels ont été obtenus dans les revues évaluées par les pairs et auprès des organismes de réglementation de la profession vétérinaire.

RÉSULTATS : En 2006, 7 013 (37 %) des agents vétérinaires canadiens ont été surveillés pour leur exposition aux rayonnements ionisants. On estime qu'entre 3,3 % et 8,2 % des médecins vétérinaires et entre 2,4 % et 7,2 % des techniciens vétérinaires ont été exposés à une dose annuelle de rayonnements ionisants supérieure à 0,1 mSv, soit entre 536 et 1 450 personnes en tout. Toutes les doses surveillées étaient en deçà des limites réglementaires. Pour les antinéoplasiques, une exposition était prévisible chez jusqu'à 5 300 agents vétérinaires (soit 23 %), avec un intervalle de prévalence estimatif de 22 % à 24 % des médecins vétérinaires et de 20 % à 21 % des techniciens vétérinaires.

CONCLUSION : Il s'agit de la première évaluation nationale de l'exposition aux rayonnements ionisants et aux antinéoplasiques en milieu vétérinaire au Canada. Ces dangers peuvent poser des risques considérables pour la santé. Les niveaux d'exposition semblent être faibles, mais nos estimations devraient être validées par une surveillance complète de l'exposition et par un examen des déterminants selon la sphère de pratique, la profession et la tâche.

MOTS CLÉS : vétérinaire; exposition professionnelle; rayonnement; antinéoplasiques; Canada