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A PROSPECTIVE-CONTROLLED STUDY OF PREGNANT VETERINARY STAFF EXPOSED TO INHALED ANESTHETICS AND X-RAYS

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Abstract. Most veterinary staff are women of reproductive age. They are exposed to "waste" anesthetic gas and ionizing radiation in their workplace, which may endanger fetal safety. Presently, exposure of female veterinary staff to these health hazards has not been adequately addressed in the medical literature.
Our primary objective was to investigate the incidence of major malformations associated with occupational exposure to inhaled anesthetics and/or radiation among pregnant veterinary staff. The secondary objective was to determine the rates of other adverse outcomes.
We prospectively collected data on and followed-up women occupationally exposed to inhaled anesthetics and/or radiation in veterinary practices in Ontario, and compared them to controls matched for maternal age and gestational age at the time of call to the Motherisk Program.
A total of 95 women were prospectively enrolled and followed-up. Among the participants there were 87 (93.5%) and 88 (92.8%) livebirths in the study and control groups, respectively. There were 4 (4.8%) major birth defects in the study group and 3 (3.4%) in the control group. The rates of spontaneous abortion were also similar, 6 (6.4%) cases in the study group and 7 (7.4%) cases in the control group.
These results suggest that Ontario female veterinary staff exposed to inhaled anesthetics and/or radiation do not seem to be at an increased risk for major malformations above baseline risk.

Key words:
Occupational exposure, Pregnancy, Birth defects

INTRODUCTION

According to the College of Veterinarians of Ontario [1], there are 2745 veterinarians currently practising in Ontario, 45% of whom are women [2]. Currently, there are 1100 veterinary technicians practising in Ontario with 98% of the women of child-bearing age [3]. Similarly, according to the American Veterinary Medical Association [4], there are 60 929 veterinarians currently practising in the United States, including 36.5% female; of these 13.9% are of child-bearing age. The reproductive effects associated with occupational exposure to inhaled anesthetics and x-rays have not been adequately addressed in the medical literature.

Most of the existing evidence in humans does not associate occupational exposure to inhaled anesthetics with an increased risk of congenital birth defects [5–13]. By con-

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trast, numerous studies [9, 14–19] have documented an increased risk for spontaneous abortions among female personnel, including anesthetists, operating-room nurses, and dental assistants. A recent meta-analysis showed that occupational exposure to inhaled anesthetics is associated with an increased risk for spontaneous abortion (relative risk (RR) =1.48, 95% confidence interval (CI): 1.40 to 1.58) [20]. On the other hand, several researchers have shown that exposure to inhaled anesthetics among veterinary staff is not associated with an increased risk for adverse pregnancy outcome [5,6].

Occupational exposure to ionizing radiation in various fields has been investigated by several groups. A study [21] on female physiotherapists exposed to high-frequency electromagnetic radiation showed no increased risk of major birth defects. These findings were confirmed by Roman et al. [22]. Schenkar et al. [6] reported an increased risk for spontaneous abortion among female veterinarians exposed to five or more x-ray films per week (RR = 1.81, 95% CI: 1.01–3.24) but not among those exposed to 0–4 x-ray films per week (RR = 1.8, 95% CI: 0.7–4.9).

Our primary objective was to compare the rate of major malformations between a group of practising Ontario veterinary staff and a control group of women exposed to non-teratogenic agents, matched for maternal age and gestational age at the time of call to the Motherisk Program. The secondary objective was to compare the rates of other adverse outcomes (i.e. spontaneous abortion, prematurity, and low birth weight) between the groups.

MATERIALS AND METHODS

Advertisements were placed in the *Ontario Veterinary Medical Association* (OVMA) *Magazine* and the *Ontario Association of Veterinary Technicians* (OAVT) *Magazine* inviting veterinary staff who were pregnant or who were planning pregnancy to contact the Motherisk Program to participate in a study on occupational exposures in veterinary medicine. In addition, flyers advertising the study were sent to all veterinary practices in Ontario and to subscribers to the *Ontario Veterinary Medical Association Magazine.* These women who contacted the Motherisk Program were counseled on various occupational exposures, including inhaled anesthetics, x-rays, and toxoplasmosis infection (depending on their concerns). The women were then informed about the study and were invited to participate in it.

Eligible callers were selected for the study based on the following inclusion criteria:

1. Currently pregnant/planning a pregnancy
2. Veterinary staff: veterinarian, registered veterinary technician, animal health technologist/technician, or veterinary assistant
3. Occupational exposure to inhaled anesthetics and/or radiation
4. Verbal informed consent to participate
5. Ability to communicate in English.

There were no exclusion criteria for the study. The study subjects were matched by maternal age (±2 years) and gestational age (±2 weeks) to subjects of the control group consisted of women who contacted the Motherisk Program requesting counseling on exposures known to be safe to the human fetus, such as acetaminophen, erythromycin, penicillins, ibuprofen, naproxen, hair dye, etc. The study was approved by the research Ethics Board at the Hospital for Sick Children.

Data collection and analysis

A standard form was used to collect the following data for each participant: maternal date of birth, obstetrical history, last menstrual period, medical history, cigarette and alcohol use, as well as illicit drug use, and the veterinary staff were further asked about their occupational exposures. Veterinary staff were contacted later during pregnancy and asked details of their occupational exposures. These details included years of practice, type of practice, duration of work-shift, exposure to inhaled anesthetics, x-rays, techniques used, monitoring of “waste” anesthetic gas (WAG), radiation levels, and the use of protective equipment. Veterinary staff were also asked to quantify the use of various techniques and protective equipment. Specifically, they were asked “Of the 10 surgeries/10 animals x-rayed, how frequently do you use the following

techniques/protective equipment: never/rarely: 0–1, sometimes: 2–5 or most of the time/always: 6–10". Participants in both groups were contacted at least four months after their expected date of confinement (EDC), and were asked details about the outcome of the pregnancy, birth weight of the infant, presence or absence of birth defects, and perinatal and postnatal complications. The data from the follow-up of both groups of participants were confirmed by requesting the participants' verbal consent to obtain written documentation from the child's physician. At the time of follow-up calls, study participants were asked further details about their occupational exposure to inhaled anesthetics and x-rays prior and during pregnancy. Major malformations were defined as being either life-threatening, requiring major surgery or having serious cosmetic effects [23]. Fetal distress was defined as decreased heart rate, cord wrapped around baby's neck, or other complications that might lead to intensive care.

Statistical analysis

Continuous data were compared using the Student's t-test when it followed a normal distribution; data not normally distributed were compared using the Mann-Whitney rank sum test. Proportions were compared using the Chi square test or Fisher's exact test, where appropriate.

RESULTS

Enrollment and follow-up

From January 1999 until August 2001, 95 women were enrolled in the study; of these three could not be reached and one was lost to follow-up. All the patients that were followed-up were matched to controls. The majority of the study participants (veterinary subjects) contacted the Motherisk Program in the first trimester (70%), a quarter were in the second trimester (24%), and a few participants contacted the program in the last trimester (6%).

Table 1. Pregnancy outcome and neonatal characteristics of study group and controls

	Study group N = 95	Controls N = 95	P-value
Pregnancy outcome	N = 94 (%)**	N = 95 (%)	0.97
Livebirth	87 (93.5)	88 (92.6)	
Spontaneous abortion	6 (6.4)	7 (7.4)	
Stillbirth	1 (1.1)	0 (0.0)	
Method of delivery	N = 85 (%)***	N = 88 (%)	0.50
Vaginal	65 (76.5)	72 (81.8)	
Cesarian section	20 (23.5)	16 (18.2)	
Gestational age at birth (wks GA)*	N = 8840.0	N = 8839.0	0.02
Birth weight (g)	3597 ± 537	3437 ± 562	0.06
Fetal distress	N = 84 (%)***	N = 88 (%)	0.87
Yes	21 (25.0)	24 (27.3)	
No	63 (75.0)	64 (72.7)	
Delivery	N = 86 (%)	N = 88 (%)	0.80
Term (≥37 wks GA)	80 (93.0)	82 (93.2)	
Pre-term (<37 wks GA)	6 (7.0)	6 (6.8)	

* Mann-Whitney rank sum test was used for these comparisons.
** One study participant was lost to follow-up.
*** Only partial data are available for 3 patients.

Table 2. Major malformations reported among participants

	Study group* N=84 (%)	Controls N=87 (%)	P-value
Birth Defects			0.96
None	80 (95.2)	84 (96.5)	
Major	4 (4.8)	3 (3.4)	
Description of defect	Pyloric stenosis	Trisomy 18	
	Microvillus inclusion disease	Bladder extrophy	
	Diaphragmatic hernia	Congenital hip dysplasia	
	Bilateral hydronephrosis		

* Three study participants could not be reached.

Demographics and obstetrical history

Pre-pregnancy weight was similar between the study and control groups. Parity was the only obstetrical parameter that was significantly different between the two groups. The vast majority (80.0%) of the patients in the study group had no children, compared to approximately half of those in the control group did not have any children. Rates of cigarette smoking and alcohol use in the two groups were similar, with most women consuming less than 5 drinks throughout the pregnancy. There were only 2 smokers in the study and 5 smokers in the control groups.

Pregnancy outcome and neonatal characteristics

Pregnancy outcome and neonatal characteristics are shown in Table 1. The comparison of birth weight between the two groups reached borderline statistical significance ($p = 0.06$), when a baby with trisomy-18 in the control group was excluded. The rates of delivery complications and fetal distress were similar in both groups. Major malformations are summarized in Table 2. The rate of major malformations between the study and control groups was not statistically significantly different ($p = 0.96$). None of the women in either group had any conditions/diseases that would predispose them to giving birth to babies with major malformations.

Occupational characteristics and exposure details

Among veterinary staff enrolled in the study, there were 48 (50.5%) veterinarians, 33 (34.7%) veterinary technicians, 3 (5.3%) animal technicians/technologists, and 11 (11.6%) assisting staff. The majority of the women (78.9%) worked in small-animal practices; the remainder (21.1%) worked in mixed-animal practices. One woman worked in an animal research facility at a pharmaceutical company, where she only performed surgical procedures.

Halothane and isoflurane were the only inhaled anesthetics to which study participants were exposed. Table 3 compares the exposure of veterinary staff to inhaled anesthetics and x-rays before and after diagnosis of pregnancy. The majority (70.4%) of veterinary staff were exposed to either 3–6 h/wk or ≥9h/wk of inhaled anesthetics. The number of participants exposed to ≥9h/wk of inhaled anesthetics decreased substantially after the diagnosis of pregnancy, with most participants reducing their exposure to 3–6 h/wk. Scavenging was the most common precautionary measure used by participants to reduce their exposure to inhaled anesthetics used by participants. The anesthetic techniques used (in decreasing order) were endotracheal tube, mask, and anesthetic chamber.

After the diagnosis of pregnancy, a large number of women completely discontinued taking x-ray films, and the number of women taking ≥10 films/wk drastically decreased (Table 3). Manual restraint was most frequent, usually involving the participant herself and another employee. Veterinary staff also used tranquilizers to facilitate restraining the animal for x-ray procedures. All veterinary staff wore lead aprons when taking x-ray films. However, not all women used lead gloves and thyroid col-

Table 3. Comparison of exposure to inhaled anesthetics and x-rays before and after diagnosis of pregnancy

Occupational characteristics	Exposure before diagnosis of pregnancy	Exposure after diagnosis of pregnancy
Inhaled anesthetics	N = 91 (%)*	N = 92 (%)*
None	0 (0.0)	2 (2.2)
≤2 h/wk	4 (4.4)	23 (25.0)
3–6 h/wk	31 (34.1)	32 (34.8)
7–8 h/wk	23 (25.3)	19 (20.7)
≤9 h/wk	33 (36.3)	16 (17.4)
X-rays	N = 92 (%)*	N = 92 (%)*
None	2 (2.2)	27 (29.3)
≤5 films/wk	43 (46.7)	42 (45.7)
6–9 films/wk	32 (34.8)	19 (19.5)
≥10 films/wk	15 (16.3)	5 (5.4)

* One study participant was lost to follow-up, and only partial data are available for 3 study participants.

Table 4. Details of exposure to inhaled anesthetics by job classification

	Veterinarians N = 48 (%)	Technicians N = 33 (%)	P-value
Use of scavenge system			0.10
Always	48 (100.0)	30 (90.9)	
Sometimes	0 (0.0)	1 (3.0)	
Rarely	0 (0.0)	2 (6.1)	
Use of endotracheal tube*			0.41
Always	48 (100.0)	32 (97.0)	
Sometimes	0 (0.0)	1 (3.0)	
Rarely	0 (0.0)	0 (0.0)	
Use of mask			0.64
Always	1 (2.1)	2 (6.1)	
Sometimes	19 (39.6)	12 (36.4)	
Rarely	28 (58.3)	19 (57.6)	
Use of anesthetic chamber			0.75
Always	0 (0.0)	0 (0.0)	
Sometimes	9 (18.8)	8 (24.2)	
Rarely	39 (81.3)	25 (75.8)	

Scale: always: 6–10, sometimes: 2–5, rarely: 0–1.

lars as precautionary measures. Although most women (92.6%) monitored their radiation exposure using dosimeters (film badges), very few participants were aware of the last reading on their dosimeters.

Analysis of occupational characteristics and exposures by job classification

The study included 48 veterinarians, 33 veterinary technicians, 3 animal health technicians/technologists and 11

assistants. Only the veterinary technicians were included in the analysis since their work duties were well-defined and did vary from one practice to another. Pregnancy outcome did not differ between the veterinarians and the technicians ($p = 1.00$). Maternal age differed between the veterinarians and the technicians ($p < 0.001$) (mean 31.3 and 27.0 years, respectively). The duration of the weekly work-shift and years in practice did not differ between the two groups. Details of occupational exposure to inhaled anesthetics by job classification are shown in Table 4. There were no statistical differences in the frequency of using precautionary measures or anesthesia techniques between the veterinarians and the technicians. Both veterinarians ($p = 0.01$) and technicians ($p = 0.007$) reduced the duration of exposure to inhaled anesthetics after pregnancy was diagnosed. The numbers of women who discontinued exposure to inhaled anesthetics did not differ between the groups ($p = 0.43$). Details of occupational exposure to x-radiation are shown in Table 5. More veterinarians than technicians used tranquilizers to restrain animals for x-ray procedures ($p = 0.01$). There were no statistical differences in the use of precautionary measures such as lead aprons and lead gloves. Both veterinarians ($p < 0.001$) and technicians ($p = 0.05$) reduced exposure to x-rays after pregnancy was diagnosed. The proportion of women who discontinued taking x-ray films after the diagnosis of pregnancy did not differ between the two groups ($p = 0.22$).

Analysis of occupational characteristics and exposures by type of practice

Seventy-five women worked in small-animal practices and 20 in mixed-animal practices. Pregnancy outcome did not differ between these two groups ($p = 1.00$). There were neither statistical differences in maternal age, years in practice or weekly work-shift among the two groups. Details of occupational exposure to inhaled anesthetics by type of practice are shown in Table 6. The frequency of use of scavenging systems differed statistically between the small-animal practice group and the mixed-animal practice group. More mixed-animal workers used anesthetic chambers compared to small-animal workers ($p < 0.001$). Only small-animal workers reduced their duration of exposure to inhaled anesthetics after pregnancy was diagnosed ($p < 0.001$). The number of workers who discontinued use of inhaled anesthetics did not differ between the groups ($p = 0.69$).

Details of occupational exposure to x-radiation by type of practice are shown in Table 7. The method of animal restraint did not differ between the two groups. There were no statistical differences in the use of precautionary measures such as lead aprons, lead gloves or thyroid collars. There was a trend to reduce the amount of exposure to x-rays after pregnancy was diagnosed among small-animal workers ($p < 0.001$) and mixed-animal workers ($p = 0.09$). The number of workers who discontinued taking x-ray films after the diagnosis of pregnancy did not differ between the two groups ($p = 0.75$).

DISCUSSION

This is the first prospective study to examine the reproductive effects associated with occupational exposure to inhaled anesthetics and/or radiation among female veterinary staff. Despite the fact that veterinary staff are exposed to many health hazards in their daily work, the data suggest that they have a similar rate of adverse reproductive effects, including birth defects, spontaneous abortions and pre-term deliveries, compared to women in the general population.

The study group consisted of a sample of veterinary staff, most of whom were practising in Ontario. They voluntarily contacted the Motherisk Program and requested to be enrolled in the study. As initially intended, the sample was heterogeneous, encompassing different types of veterinary staff, including: veterinarians, veterinary technicians, animal health technicians/technologists, veterinary assistants, and animal care aides. The sample also included participants working in small-animal and mixed-animal practices, as well as those practising in rural and urban regions.

Our findings agree with those of Schenkar et al. [6] who demonstrated that the rates of spontaneous abortions were similar among female veterinarians and female

Table 5. Details of exposure to x-radiation by job classification

	Veterinarians* N = 47 (%)	Technicians** N = 32 (%)	P-value
Restraint by participant			0.50
Always	34 (72.3)	24 (75.0)	
Sometimes	11 (23.4)	5 (15.6)	
Rarely	2 (4.3)	3 (9.4)	
Restraint by staff			0.40
Always	39 (83.0)	24 (75.0)	
Sometimes	8 (17.0)	7 (21.9)	
Rarely	0 (0.0)	1 (3.1)	
Restraint using tanquilizers			0.01
Always	1 (2.1)	5 (15.6)	
Sometimes	37 (78.7)	16 (50.0)	
Rarely	9 (19.1)	11 (34.4)	
Restraint by mechanical means			0.69
Always	2 (4.3)	1 (3.1)	
Sometimes	14 (29.8)	7 (21.9)	
Rarely	31 (66.0)	24 (75.0)	
Use of lead apron***			1.00
Always	47 (100.0)	32 (100.0)	
Sometimes	0 (0.0)	0 (0.0)	
Rarely	0 (0.0)	0 (0.0)	
Use of lead gloves			0.22
Always	36 (76.6)	23 (71.9)	
Sometimes	11 (23.4)	7 (21.9)	
Rarely	0 (0.0)	2 (6.3)	
Use of thyroid collar			0.27
Always	41 (87.2)	31 (96.9)	
Sometimes	3 (6.4)	0 (0.0)	
Rarely	3 (6.4)	1 (3.1)	
Use of dosimeter (film-badge)			0.69
Always	37 (80.4)	28 (87.5)	
Sometimes	6 (13.0)	3 (9.4)	
Rarely	3 (6.5)	1 (3.1)	

* One study participant performed surgical procedures in a research facility and thus was not exposed to x-rays.
** One study participant chose to discontinue taking x-rays before pregnancy and after pregnancy was diagnosed.
*** Fisher's exact test was used.

lawyers. Steele and Wilkins III [24] also demonstrated that female veterinary staff were not at an increased risk for spontaneous abortion. Our results do not indicate any statistical differences in the delivery parameters. The suggested difference in gestational age at birth is negated by similar rates of pre-term birth in the study and control groups. The difference in birth weight could be explained by the one week difference in gestational age [25]. A controlled cohort study [6] showed that female veterinarians were not at a greater risk of having low birth-weight infants. Furthermore, the rate of fetal distress was similar between the study and control groups.

The similar rates of major malformations between study and control groups agree with the findings of a previous

Table 6. Details of exposure to inhaled anesthetics by type of practice

	Small-animal practice N = 75 (%)	Mixed-animal practice N = 20 (%)	P-value
Use of scavenge system			0.003
Always	75 (100.0)	17 (85.0)	
Sometimes	0 (0.0)	1 (5.0)	
Rarely	0 (0.0)	2 (10.0)	
Use of endotracheal tube			0.66
Always	72 (96.0)	20 (100.0)	
Sometimes	2 (2.7)	0 (0.0)	
Rarely	1 (1.3)	0 (0.0)	
Use of mask			0.08
Always	2 (2.7)	2 (10.0)	
Sometimes	28 (37.3)	11 (55.0)	
Rarely	45 (60.0)	7 (35.0)	
Use of anesthetic chamber			<0.001
Always	0 (0.0)	14 (70.0)	
Sometimes	15 (20.0)	5 (25.0)	
Rarely	60 (80.0)	1 (5.0)	

study; Johnson et al. [5] have shown that even though the odds ratio for spontaneous abortion with exposure to "waste" anaesthetic gas in female veterinarians and female veterinary assistants was greater than 1.0 when adjusted for use of diagnostic x-rays, it did not reach statistical significance (95% CI: 0.86–9.53 and 0.92–5.52, respectively). The study also found that female veterinarians exposed to WAG were not at an increased risk of giving birth to children with congenital abnormalities (OR = 0.33, 95% CI: 0.12–0.90). Other researchers [6] found an increased risk for major birth defects among female veterinarians, but their study was not designed to detect an increased risk for birth defects. In our study there were four major malformations in the study group and three in the control group; no particular pattern of malformations or syndrome was observed. The substantial difference in the age at follow-up of the off-spring presents a potential problem in that the older the children are, the more opportunities to detect major birth defects. Our study had 80% power to detect a five-fold increase in the rate of major malformations above a 3% baseline risk, with an alpha of 0.05. In order to detect a two-fold increase, 814 subjects are required in each group. Concerns among veterinary staff regarding their exposure to inhaled anesthetics and x-ray are clearly demonstrated by the large number of women who chose to reduce or completely discontinue their exposure upon diagnosis of pregnancy.

Our study attempted to overcome some of the limitations of previous studies by quantifying the duration of exposure to inhaled anesthetics and amount of x-ray-films to which veterinary staff were exposed, and by reporting on the frequency of use of precautionary measures and personal protective equipment by the staff. Since the data were collected prospectively, the likelihood of recall bias is very low.

Despite the availability of means to monitor WAG levels, such as air-sampling, dosimeter badges and portable infra-red analyzers, the majority of the practices did not routinely monitor WAG. This may be due to two major factors: the high cost of monitoring, and the fact that WAG levels at veterinary practices are below the maximum admissible concentration recommended by the United States National Institute for Occupational Safety and Health (NIOSH) [26]. Ward and Byland [27] measured WAG levels of 2 parts per million (ppm) in veterinary facilities compared to 10 ppm in hospitals for

Table 7. Details of exposure to x-rays by type of practice

	Small-animal practice* N = 73 (%)	Mixed-animal practice N = 20 (%)	P-value
Restraint by participant			0.40
Always	52 (71.2)	16 (80.0)	
Sometimes	15 (20.5)	4 (20.0)	
Rarely	6 (8.2)	0 (0.0)	
Restraint by staff			0.68
Always	56 (76.7)	17 (85.0)	
Sometimes	16 (21.9)	3 (15.0)	
Rarely	1 (1.4)	0 (0.0)	
Restraint using tanquilizers			0.63
Always	5 (6.8)	2 (10.0)	
Sometimes	52 (71.2)	12 (60.0)	
Rarely	16 (21.9)	6 (30.0)	
Restraint by mechanical means			0.61
Always	3 (4.1)	0 (0.0)	
Sometimes	18 (24.7)	6 (30.0)	
Rarely	52 (71.2)	14 (70.0)	
Use of lead apron			1.00
Always	73 (100.0)	20 (100.0)	
Sometimes	0 (0.0)	0 (0.0)	
Rarely	0 (0.0)	0 (0.0)	
Use of lead gloves			0.13
Always	62 (84.9)	13 (65.0)	
Sometimes	9 (12.3)	6 (30.0)	
Rarely	2 (2.7)	1 (5.0)	
Use of thyroid collar			0.22
Always	67 (91.8)	18 (90.0)	
Sometimes	4 (5.5)	0 (0.0)	
Rarely	2 (2.7)	2 (10.0)	
Use of dosimeter (film-badge)	N = 72 (%)**	N = 20 (%)	0.60
Always	61 (84.7)	16 (80.0)	
Sometimes	8 (11.1)	2 (10.0)	
Rarely	3 (4.2)	2 (10.0)	

*One study participant performed surgical procedures in a research facility thus was not exposed to x-radiation, and 1 study participant chose to discontinue taking x-rays before pregnancy and after pregnancy was diagnosed.
**Only partial data is available on 1 patient.

humans. They offered several explanations for their findings; operating time is shorter and doors of veterinary surgery rooms are normally left open to allow technicians to concurrently assist in other rooms thus resulting in WAG concentrations being lower than in operating rooms for humans. In addition, veterinary staff spend only a small portion of their working time performing surgery [27]. Despite all these factors, the level of WAG in veterinary facilities primarily depends on the presence of gas scavenging systems, good anesthetic practices, periodic examination, and maintenance of anesthetic machines.

Our data showed some variations in the number of veterinarians who used precautions against exposure to radiation compared to previous studies. In their study of pat-

terns of ionizing radiation exposure among female veterinarians, Morwitz et al. [28] reported that 95.9% of veterinarians wore lead aprons, 87.9% used lead gloves, and 1.2% used thyroid collars. However, that study did not assess the frequency of use of protective equipment. In our study, a large proportion of veterinarians reported using thyroid collars, with more than 75% of those using them always and 6.4% using them sometimes. Langley and coworkers [29] reported that 63% of veterinarians (male and female) always wore film-badges and 10% used them rarely or never.

There are several limitations to this study, one of which is the limited power due to the small sample size. Another limitation is that the frequency of use of various techniques and precautions reported by the participants does not distinguish between whether the frequency is based on subjects' attitudes or the availability of such equipment at the facility. In other words, some of the practices of veterinary staff may be dictated by the availability of the appropriate protective equipment at the facility.

In conclusion, these results suggest that the female veterinary staff exposed to inhaled anesthetics and/or radiation during pregnancy are not at an increased risk for major birth defects above the baseline risk.

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