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Review of hazards to female reproductive health in veterinary practice

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Abstract

OBJECTIVE—To review publications that address female reproductive health hazards in veterinary practice, summarize best practices to mitigate reproductive risks, and identify current knowledge gaps.

DESIGN—Systematized review.

SAMPLE—English-language articles describing chemical, biological, and physical hazards present in the veterinary workplace and associations with adverse reproductive outcomes or recommendations for minimizing risks to female reproductive health.

PROCEDURES—Searches of the CAB abstracts database were performed in July 2012 and in May 2015 with the following search terms: veterinarians AND occupational hazards and vets.id AND occupational hazards.sh. Searches of the PubMed database were conducted in November 2012 and in May 2015 with the following medical subject heading terms: occupational exposure AND veterinarians; anesthetics, inhalation/adverse effects AND veterinarians; risk factors AND pregnancy AND veterinarians; pregnancy outcome AND veterinarians; and animal technicians AND occupational exposure. Two additional PubMed searches were completed in January 2016 with the terms disinfectants/toxicity AND female AND fertility/drug effects and veterinarians/psychology AND stress, psychological. No date limits were applied to searches.

RESULTS—4 sources supporting demographic trends in veterinary medicine and 118 resources reporting potential hazards to female reproductive health were identified. Reported hazards included exposure to anesthetic gases, radiation, antineoplastic drugs, and reproductive hormones; physically demanding work; prolonged standing; and zoonoses.

CONCLUSIONS AND CLINICAL RELEVANCE—Demographic information suggested that an increasing number of women of reproductive age will be exposed to chemical, biological, and physical hazards in veterinary practice. Information on reproductive health hazards and

minimizing risk, with emphasis on developing a safety-focused work culture for all personnel, should be discussed starting in veterinary and veterinary technical schools and integrated into employee training.

Most veterinary personnel engaged in clinical practice are generalists who, during a routine work day, may be exposed to ionizing radiation, anesthetic gases, zoonotic diseases, and trauma from fractious animals—both large and small. No other medical profession is required to assess and manage such a wide range of workplace exposures to chemical, biological, and physical hazards.^{1–8}

Reproductive hazards are those hazards that may negatively impact fertility or pregnancy. The review reported here focused on pregnant women and women of childbearing age working in veterinary practice. Reproductive hazards common in the veterinary workplace can be categorized as chemical, biological, and physical hazards. Chemical hazards include contact with antineoplastic drugs, hormones, pesticides, and anesthetic gases; biological hazards include zoonotic and other infectious agents; and physical hazards include animal-related injuries, radiation exposure, demanding work conditions and physical work load, needle sticks, and psychosocial hazards from workplace stress, long work hours, and other factors that affect mental well-being.

The proportion of women in the veterinary profession in the United States has increased in recent years. More than 90% of veterinary technicians are, and historically have been, female.⁹ Of 105,000 US veterinarians actively practicing in 2015, 58% were women, and more than 80% of new graduates were women.^{10,11} This represents a dramatic shift from the demographic 50 years ago, when almost 90% of US veterinary students were male.¹² As older male veterinarians retire from practice and are replaced by new female graduates, an increasing number of women of reproductive age will encounter workplace hazards that may pose undefined risks to fertility as well as to an embryo or fetus during pregnancy.

Comprehensive guidance to prevent or mitigate exposures to occupational reproductive health hazards for female veterinary personnel is greatly needed.¹³ In recognition of this, the NIOSH, in partnership with the National Occupational Research Agenda and other stakeholders, finalized a series of goals including raising awareness of reproductive hazards, formulating recommendations to mitigate them, and developing fact sheets and other outreach materials for veterinary personnel.¹³

The objectives of the study reported here were to conduct a systematized review of retrievable publications addressing hazards to female reproductive health in the veterinary workplace, to evaluate and summarize recommendations to minimize reproductive risks in veterinary practice, and to identify gaps in current knowledge related to these risks. This report is intended to provide a framework for education, research, and future development of materials in this area.

Materials and Methods

Searches of the CAB abstracts database were conducted in July 2012 and in May 2015. Two sets of search terms, veterinarians AND occupational hazards and vets.id AND occupational

hazards.sh, were used without date limits, and both searches yielded the same results. Searches of PubMed without date limits were conducted in November 2012 and in May 2015, with the following MeSH search terms used: occupational exposure AND veterinarians; anesthetics, inhalation/adverse effects AND veterinarians; risk factors AND pregnancy AND veterinarians; pregnancy outcome AND veterinarians; and animal technicians AND occupational exposure. Two alternate MeSH search terms for the last string, veterinary nurse AND occupational exposure and risk factors AND pregnancy AND animal technicians, produced the same results. Two additional PubMed searches without date limits were completed in January 2016 to discover reproductive hazards related to disinfectants and hazards posed by psychosocial factors. These included MeSH search terms of disinfectants/toxicity AND female AND fertility/drug effects and veterinarians/psychology AND stress, psychological. Additional articles and recommendations were identified on US government and AVMA websites pertaining to reproductive health and by manually searching article reference lists.

The articles were divided among all 4 authors for review, and results were recorded on a shared spreadsheet. We determined relevance to veterinary occupational health and reproductive health and whether the article included best practices for prevention, control, and mitigation of reproductive hazards. References that were not written in English language were excluded. Articles that did not relate to occupational health or reproductive health or were not available were excluded. Excluded articles underwent a second evaluation by 2 reviewers (JMS and BLE).

Information recorded from the literature search included authorship information; title, journal, and year of publication; study type or design; resource type (eg, peer-reviewed journal article, non-peer-reviewed journal article, or meeting proceedings); reproductive hazard; reviewer comments; reviewer; and date. A spreadsheet template was used to organize relevant articles according to hazard (chemical, biological, physical, or general [for resources covering multiple hazards]) and strength of evidence. Strength of evidence was classified as primary, supportive, or anecdotal. Anecdotal publications were those that contained opinions or observations by experts but did not include objective safety data. Publications such as reviews, in which hazards and practices were described but lacked original data to support recommendations, were considered to have supportive evidence. Original studies that included statistically significant associations in reporting risk or contained quantitative or descriptive data to support recommendations were considered primary resources. Except for hazards such as zoonotic diseases with rare outcomes, reproductive risks reported here were supported by primary resources that reported statistically significant associations.

Results

Evaluation of 521 unique articles led to identification of 99 references that described chemical, biological, and physical hazards present in the veterinary workplace and their association with adverse reproductive outcomes, or contained recommendations for minimizing risk from exposure to reproductive hazards (Figure 1). These were categorized as primary (n = 57), supportive (41), or anecdotal (1). Thirty-four of 66 (52%) published

papers pertaining specifically to veterinary occupational health focused predominantly on veterinarians, and 32 (48%) included all veterinary personnel, including veterinarians. In addition, 4 sources identifying demographic trends and 19 US government documents, US government websites, or AVMA websites containing information about reproductive health hazards and their mitigation were identified and included without categorization.

Chemical hazards

Chemical hazards in veterinary medical settings, including those from antineoplastic drugs and other pharmaceuticals, are often similar to those in human health care¹⁴ and have been identified and listed by the NIOSH.¹⁵ Safety data sheets for disinfectants and other chemicals are readily available both from the manufacturer and online. However, these documents do not always provide all necessary information for assessing health risks, and it is often necessary to consult other sources of information to fully assess health hazards from chemicals. The OSHA has published standards and the NIOSH has published guidelines addressing chemical hazards, including how these hazards should be communicated to workers who may be exposed occupationally.^{16–18} Similar to other health-care and industry settings, veterinary practices are subject to the OSHA Hazard Communication Standard¹⁸; information specific to veterinary medicine can be found on the AVMA website.¹⁹ Chemical exposures identified through the literature search that could present a risk to female reproductive health, and best practices to prevent or mitigate such exposures, were summarized (Table 1).^{6,15–17,20–45}

Antineoplastic pharmaceuticals, primarily used to treat cancer in dogs and cats, are important reproductive hazards found in the veterinary setting.⁴⁶ Many antineoplastic drugs have been reported to be carcinogenic, mutagenic, or teratogenic and have been associated with reduced fertility, spontaneous abortion, and fetal loss.^{30–32,46–49} Usage and exposure estimates have been reported for veterinary personnel in Canada⁴⁶ and the Netherlands,⁵⁰ where concerning exposures during preparation and administration of antineoplastic drugs were documented. No such antineoplastic pharmaceutical usage or exposure data for US veterinary personnel were identified in the literature search.

Reproductive hormones used in contemporary veterinary practice are especially hazardous to pregnant women. Prostaglandins, in particular, should be avoided during pregnancy; these and other reproductive hormones warrant meticulous care and training in their use.²³

Beginning in the 1960s and 1970s, there was substantial concern about the effects of inhaled anesthetic gases on reproduction in health-care workers.^{51–56} In response, the NIOSH published recommendations for reducing exposure and risk.⁵⁷ Importantly, most of the early epidemiological reports linking waste anesthetic gas exposure to adverse health events have since been critically reviewed and faulted for inappropriate design or improper statistical analysis.^{58–61} Thus, a direct cause-and-effect relationship between long-term exposure to waste anesthetic gas and adverse reproductive health events has not been firmly established. However, Boivin²⁰ performed a meta-analysis of epidemiological studies and found that data obtained prior to the routine use of scavenging systems (exhaust systems to remove excess anesthetic gases) indicated an increased risk of spontaneous abortion, and Shirangi et al²¹ found an increased risk of preterm delivery in women exposed to unscavenged waste

anesthetic gas for 1 h/wk, compared with that for an unexposed group. At the present time, owing to the almost universal adoption of scavenging systems, reproductive risk from occupational exposure to inhalation anesthetics in veterinary personnel appears to be minimal.^{27,58,59,61–65} Nevertheless, it remains prudent to recommend control measures that reduce occupational exposure.^{51,58–60,24,25,66}

Awareness of potential health hazards from chemicals and pharmaceuticals, along with adoption of measures to reduce potential for exposure, are essential to prevent or reduce adverse health events.⁶⁷ This can be accomplished through elimination or substitution of the chemical, changes to work practices, and use of personal protective equipment.⁴⁶

Biological hazards

Exposure to biological hazards is inevitable when working closely with animals.^{68–72} A subset of these hazards may pose a particular risk for maternal and fetal health, including some zoonotic bacterial and viral pathogens and certain infectious agents that pose an increased risk of illness to immunocompromised individuals (including pregnant women); the most common of these were tabulated with recommendations for prevention (Table 2).^{23,26,68,70,72–84} The many zoonoses (eg, rabies virus, *Salmonella* spp, or herpesvirus B) that can adversely impact human health regardless of pregnancy status were not included in the summary.

Emerging zoonotic diseases pose a risk to people who work at the human-animal interface. It is likely that reproductive health as well as fetal health may be acutely susceptible to adverse outcomes from emerging infectious diseases, particularly before the risk has been identified. Thus, when an emerging zoonotic disease is not yet well characterized, veterinary personnel are advised to strictly adhere to standard precautions.^{72,76}

The proportion and magnitude of biological exposures that result in disease transmission to the veterinary workforce is poorly understood because of a lack of integrated surveillance systems for occupationally related infections. Ultimately, the advent of surveillance systems to consistently and uniformly record injuries and illnesses among veterinary personnel will better characterize the hazards so that attention and resources can be prioritized for most effective risk reduction.^{4,26,74,85} At present, best practices to mitigate these risks include environmental controls, written infection control policies that are consistently applied, staff training in the use of procedures and equipment to reduce risk, and use of appropriate personal protective equipment (eg, gloves, protective outerwear, and facial protection), with emphasis on groups that may be particularly vulnerable, such as pregnant women.^{72,82,86,87}

Physical hazards

Physical hazards that can pose a risk to female reproductive health and recommended measures to prevent or mitigate injury were reviewed (Table 3).^{7,8,21,23,28,29,44,49,72,88–106} Prevention of physical workplace hazards in a veterinary setting is best accomplished through consistent application of safe workplace practices, such as routine use of personal dosimetry and lead apparel when performing radiography.^{28,92–95,97} During much of the first 7 weeks after conception, when the embryo is most susceptible to the effects of radiation, a woman may not be aware that she is pregnant. Therefore, any female veterinary personnel

with the potential to be pregnant should use all available precautions when radiographic equipment is in use.^{23,88,96,107} Needle sticks and other traumatic physical injuries from animal bites, lifts, trips, slips, falls, and automobile accidents can be largely prevented by habitual safety practices.^{7,8,28,37,72,104,106} Most veterinary settings are small, and personnel are often cross-trained to perform multiple tasks, making workplace safety culture especially important in preventing accidents and injury.⁷²

Several studies^{21,98–100,102} identified an association between long work hours, prolonged standing at work, or physically demanding work including manual lifting, and preterm delivery or low birth weight for gestational age. Measures to mitigate certain physical hazards become more important as a pregnancy progresses, including adoption of recommended weight limits for lifting and adjusting work practices to address concerns associated with fatigue, prolonged standing or walking, and working long hours.^{21,23,98–103} The importance of physical work limits during pregnancy should be discussed starting in veterinary and veterinary technical schools and carried through to employee health practices in clinical settings.¹⁰³ Organizational policies regarding reproductive hazards and pregnancy should be documented and clearly communicated to female employees.^{29,44,105}

The association between serious life events and workplace stress on preterm delivery and low birth weight has been established.^{108–111} Specific to veterinary medicine, the literature review identified articles pertaining to stress and work-related exhaustion in the veterinary workplace^{98,103,112,113} and substantial and deeply concerning psychological work stress and suicidal ideation among veterinarians.^{114–116} Given what is known about the detrimental effects of stress on gestation, it is clear that more research in this area, focused on the veterinary community, is needed.

Available guidance resources

Guidance documents regarding veterinary workplace safety and health are available from varied sources, including the NIOSH, OSHA, and AVMA. The NIOSH provides health and safety recommendations to protect workers in workplace settings, including resources specific to workplace hazards and reproductive health^{117,118}; the organization's website also directly addresses veterinary safety and health.¹¹⁹

In the United States, the OSHA is the federal agency charged with enforcing laws regarding workplace safety and health. Exposures that occur in human as well as animal medical facilities are addressed in a variety of OSHA publications.¹²⁰ Although some of the information reflects employer legal obligations, much of the guidance is intended as advisory, so that medical facility managers can optimize prevention practices. The AVMA is a member organization representing > 88,000 veterinarians.¹²¹ The AVMA's website¹²² and the *JAVMA* frequently publish articles addressing veterinary workplace hazards and prevention guidance.

Discussion

Most veterinarians presently in practice are women, and most veterinary technician and veterinary assistant positions are, and historically have been, filled by women. The present

review was performed to summarize the available information on veterinary workplace exposures that can negatively impact a woman's reproductive health, to raise awareness of established risks, and to explore knowledge gaps related to this subject. In addition, the review identified current best practices that veterinary personnel can institute to mitigate risks associated with workplace reproductive hazards.

Exposure to anesthetic gases and ionizing radiation are reproductive hazards that are generally well recognized and addressed in most veterinary workplaces.⁴⁶ Other hazards are perhaps less well understood. For example, our literature review revealed associations between long work hours, physically demanding work, or standing at work for > 4 to 6 hours at a time and preterm delivery.^{21,98–100,102} Historically, the veterinary profession has been a demanding, physically difficult profession often requiring long work hours. Culturally, workplace dispensations for pregnancy (or other conditions requiring special consideration) have not been the norm. Changes in workplace culture regarding perceptions of work ethic could be the most difficult adjustment that must occur to accommodate increasing numbers of women in the veterinary workplace.

We attempted to identify all publications that addressed chemical, biological, and physical hazards in veterinary practice that may impact female reproductive health. This is a broad topic, and it is possible that relevant literature was missed. We also attempted to capture all exposures relevant to veterinary personnel in the literature search; however, it is likely that some exposures that occur in other health-care disciplines and have implications for veterinary personnel were overlooked. Another potential limitation was that the review was focused on general hazard mitigation, as it was performed by public health and occupational health professionals without specialized knowledge in reproductive health.

A number of recent publications on this topic originated from sources in countries other than the United States, reflecting international recognition of the need for occupational health research and guidance for female veterinary personnel. Literature included in the review identified risks to reproductive health and recommendations to mitigate exposures. However, specific information about the extent or scope of risk, such as usage or exposure estimates for a particular hazard, was frequently lacking. Of the 66 published articles pertaining specifically to veterinary occupational health that were identified in the literature search, only 32 (48%) included veterinary technicians and other veterinary staff, a population with arguably as much exposure (or even more exposure) to most hazards as veterinarians. A better understanding of where, how, to whom, and to what extent reproductive health hazards occur in the veterinary workplace would allow for targeted interventions.⁴⁶

Additional research is needed to evaluate associations between psychosocial or workplace stress, physically demanding work, zoonotic diseases, and adverse reproductive outcomes in veterinary clinical practice. In particular, there is an opportunity to apply to veterinary medicine what is known in other fields about mitigating psychosocial and workplace stress and other physical reproductive health hazards such as lifting, working long hours, and prolonged standing. Similarly, best practices for preparation and administration of antineoplastic pharmaceuticals are well established in human health care and can be used in private veterinary practice; however, data are needed on veterinary usage and exposure in the United States, and efforts should be made to increase awareness among veterinary personnel

of the risks and recommendations to mitigate them. In the same way, female veterinarians, technicians, and staff represent a uniquely exposed workforce which, if followed over time, would provide health and safety information applicable to other fields involving animal care.

Although additional research is needed to more clearly define workplace hazards for female veterinary personnel, current knowledge is sufficient to justify instituting interventions to reduce reproductive risks and minimize adverse reproductive outcomes. Best practices for mitigating risk should be introduced and discussed during veterinary and veterinary technician training and integrated into employee training. Early introduction to and familiarity with reproductive health hazards and practical information about mitigating risk, with emphasis on developing a safety-focused work culture for all veterinary personnel, are critical for making the changes necessary to meet current and future veterinary occupational health challenges.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the CDC or the Agency for Toxic Substances and Disease Registry.

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ABBREVIATIONS

NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration

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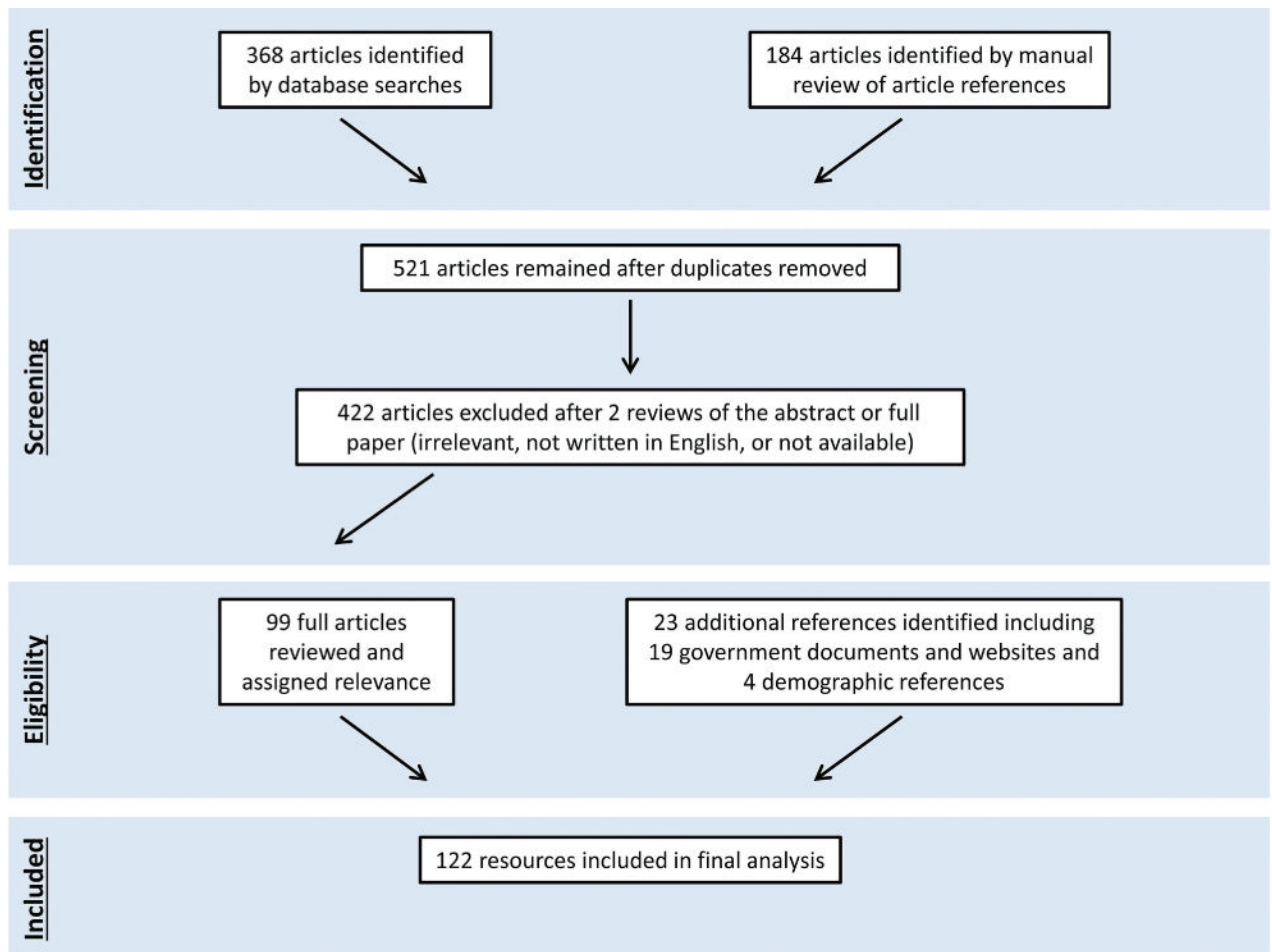


Figure 1. Diagram depicting resource selection process and outcome for a systematized review of hazards to female reproductive health in veterinary practice.

Table 1

Chemical hazards present in veterinary workplaces and recommendations for mitigation of risks to female reproductive health identified in the literature.

Hazard	Reproductive risk	Best practices to mitigate risk
Anesthetic gases	Spontaneous abortions ²⁰ and preterm birth ²¹	<p>Install scavenging and ventilation systems^{6,20–26}</p> <ul style="list-style-type: none"> Operating rooms: 15 air changes/h, with a minimum of 3 air changes of fresh air/h Recovery rooms: 6 air changes/h, with a minimum of 2 air changes of fresh air/h²⁵ <p>Properly inspect and maintain anesthesia machines, breathing circuits, and waste-gas scavenging systems^{6,22,25,26}</p> <ul style="list-style-type: none"> Inspect the anesthetic delivery system before each use for irregularities or breaks Fill vaporizers before or after (not during) the anesthetic procedure Fill vaporizers under a ceiling-mounted hood with an active evacuation system, if available Check the patient's breathing circuit for negative pressure and positive pressure relief Turn on the room or local ventilation system Make sure the scavenging equipment is properly connected Start the gas flow only after anesthesia is induced and the endotracheal tube is placed with the cuff properly inflated Confirm that the endotracheal tube creates a completely sealed airway If a mask is used, make sure it fits the patient well Use an appropriate oxygen flow rate for the animal's size Occlude the Y-piece if the breathing circuit must be disconnected during surgery Turn off the anesthetic gas before turning off the breathing system and flush the patient's airway with oxygen before disconnecting Eliminate residual gases through the scavenging system before disconnecting a patient from the breathing system; empty the breathing bag into the scavenging system <p>Perform a comprehensive maintenance inspection annually Train all workers in hazard awareness, prevention, and control of exposures to waste anesthetic gases²⁵ Inform female veterinary personnel of the risks^{27–29}</p>
Carbon monoxide	Fetal anoxia leading to fetal death ²³	Do not enter a poorly ventilated, artificially heated area where animals may be ill or dying, because of a potential for carbon monoxide exposure ²³
Antineoplastic drugs and other hazardous pharmaceuticals	Reduced fertility, fetal loss, spontaneous abortion, preterm birth, and low birth weight ^{30–32}	<p>Read and follow recommendations in the following publications:</p> <ul style="list-style-type: none"> DHHS (NIOSH) 2010–150¹⁷ and other publications^{33–36} providing guidelines for safe handling of hazardous drugs in veterinary medicine, including receipt and storage, drug preparation, drug administration, waste cleaning and disinfection, drug transportation, spill control, and medical surveillance DHHS (NIOSH) 2004–165,¹⁶ which includes protection recommendations for health-care workers potentially exposed to hazardous drugs including chemotherapeutic drugs used in cancer treatment, antiviral drugs, hormones, and some bioengineered drugs DHHS (NIOSH) 2014–138,¹⁵ which provides a list of antineoplastic and other hazardous drugs <p>Other prevention practices for handling antineoplastic and other hazardous pharmaceuticals include the following:</p>

Hazard	Reproductive risk	Best practices to mitigate risk
		<ul style="list-style-type: none"> Minimum precautions include use of gloves, mask, goggles, and a long-sleeved, water-resistant gown³⁷ Pregnancy intention status is an important determinant regarding prevention behaviors in handling cytotoxic drugs and should be considered in training programs³⁸ <p>Practice institution-wide prevention strategies,³⁷ develop written chemotherapy safety protocols,³³ and communicate risk and prevention strategies to employees^{32,33}</p>
Ethylene oxide (gas sterilization)	Spontaneous abortion ²⁶	<p>Ethylene oxide gas sterilization procedures should be avoided in general veterinary practice because of the challenges involved with safe use²⁶</p> <p>If ethylene oxide is to be used, consult OSHA guidance documents³⁹ and OSHA standards document 29 CFR 1910.1047,⁴⁰ and observe the following:</p> <ul style="list-style-type: none"> Wear proper personal protective equipment when working with ethylene oxide; protective outerwear, chemically resistant gloves, and goggles or face shields should be worn²⁶ Worker exposure to ethylene oxide should be limited to 1 ppm in air measured as an 8-hour time-weighted average. Worker exposure to the agent may not exceed the short-term excursion limit of 5 ppm averaged over any 15-minute sampling period Leave the sterilizer area during the exhaust cycle²⁶ Use engineering controls and good work practices to reduce exposure Implement a written compliance program
Insecticides and other pesticides	Birth defects ⁴¹ and spontaneous abortion ²⁹	<p>Consult safety data sheets for the compounds^{42,43}</p> <p>Use appropriate protective measures to prevent or minimize exposure⁴²</p> <p>Avoid extralabel use⁴²</p> <p>Be aware that pesticide concentrates that require dilution pose a higher risk of exposure</p> <p>Avoid using materials that may absorb the compound and release it later⁴³</p> <p>Inform female veterinary personnel of possible reproductive effects of pesticide exposure^{29,44}</p> <p>Use extreme caution and biological monitoring to regulate occupational exposure to organophosphates^{41,43}</p>
Prostaglandins and other reproductive hormones (eg, GnRH analog, human chorionic gonadotropin, estrogen, progesterone, synthetic progestin, testosterone, and oxytocin)	Spontaneous abortion, fetal death (PGF2 α and its analog), prolongation of pregnancy (synthetic progestin), disruption of menstrual cycle (GnRH analog, synthetic progestin), and increased or decreased uterine bleeding (synthetic progestin) ^{23,45}	<p>Pregnant women should not handle or administer prostaglandin products^{23,45}</p> <p>Avoid direct skin contact by wearing impervious gloves during drug handling; wash hands immediately after removing gloves; adhere to manufacturers' safety warnings⁴⁵</p> <p>When specific warnings and guidelines are not provided, follow NIOSH guidelines¹⁵⁻¹⁷</p> <p>If contact with skin occurs, wash the affected area immediately and seek medical attention⁴⁵</p>

DHHS = US Department of Health and Human Services. GnRH = Gonadotropin-releasing hormone. PG = Prostaglandin.

Table 2

Biological hazards present in veterinary workplaces and recommendations for mitigation of risks to female reproductive health identified in the literature.

Hazard	Reproductive risk	Best practices to mitigate risk
Brucellosis (<i>Brucella spp</i>)	Preterm delivery and low birth weight ⁷⁰	Use standard precautions ⁷² Be aware of risk and attain prompt diagnosis ⁷⁰ Consult an infectious disease specialist if symptoms develop ⁷⁰ Report infection to animal and public health authorities ⁷²
Leptospirosis (<i>Leptospira interrogans</i>)	Infection of the embryo or fetus with outcomes ranging from midgestational fetal death to birth of a healthy infant; maternal death can also occur ^{73,74}	Use standard precautions ⁷² Consult an infectious disease specialist if symptoms develop ⁷³ Contact local or state health departments for guidance following potential exposure ⁷² Wear gloves when handling pet rats ⁷⁵
Listeriosis (<i>Listeria monocytogenes</i>)	Preterm labor, fetal death, stillbirth, and <i>Listeria</i> septicemia and meningitis of the neonate ²⁶	Wear gloves, facial protection, and protective clothing while working with aborted fetuses and tissues or fluids expelled by the dam ^{23,72} Use extra caution when working with sheep, goats, and cattle during pregnancy ²⁶
Lymphocytic choriomeningitis virus infection	Spontaneous abortion and severe birth defects (eg, chorioretinitis, hydrocephalus, and mental retardation) ⁷⁶	Wear gloves and facial protection when handling rodents while pregnant ⁷² Avoid sweeping or vacuuming rodent urine, droppings, and nesting materials ⁷² Report infection to public health authorities ⁷²
Gestational psittacosis (<i>Chlamydophila psittaci</i>)	Adverse pregnancy outcomes are very rare, but stillbirth has been reported ⁷⁷	Wear gloves and N95 respirator when handling ill psittacine birds ⁷² Consider all ill birds to be a potential source of infection ^{68,72} Avoid sweeping or vacuuming bird urine, droppings, and nesting materials; use gloves, N95 respirator, goggles, and surgical cap when cleaning contaminated areas ^{72,77} Report infection to public health authorities ⁷²
Gestational chlamydiosis (<i>Chlamydophila abortus</i>)	Spontaneous abortion, severe chlamydiosis (coagulopathy, intense placentitis), and maternal death ⁷⁸	Wear gloves, N95 respirator, and protective clothing while working with aborted sheep or goat fetuses or tissues and fluids expelled by the dam ^{78,79} Pregnant women should avoid contact with aborting sheep and goats, if possible ⁷⁸ Report infection to public health authorities ⁷²
Q Fever (<i>Coxiella burnetii</i>)	Spontaneous abortion, stillbirth, preterm birth, intrauterine growth retardation, and low birth weight ⁸⁰	Consult an infectious disease specialist if symptoms develop ⁸⁰ Wear gloves, N95 respirator, and protective clothing when working with aborted sheep or goat fetuses or tissues and fluids expelled by the dam ^{23,72} Use extra caution when working with sheep, goats, and cattle during pregnancy ⁸¹ Report infection to public health authorities ⁷²
Toxoplasmosis (<i>Toxoplasma gondii</i>)	Spontaneous abortion, preterm birth, stillbirth, fetal neurological damage, congenital chorioretinitis, hydrocephalus, encephalitis, and mental retardation ^{23,26}	Avoid exposure to cat feces and litter while pregnant ⁸² Consult a health-care provider when considering pregnancy or in early pregnancy about advisability of baseline antibody titer determination (authors' recommendation on the basis of Weese et al ⁸²) Maintain a clinic practice of daily litter pan cleaning by nonpregnant staff members ⁷⁶ Use gloves when conducting feline fecal examinations and wash hands afterward ⁸³
Infections from animal licks, bites, or scratches (eg, <i>Pasturella multocida</i> , <i>Bartonella henselae</i> , <i>Capnocytophaga canimorsus</i>)	Maternal pyrexia, premature labor, chorioamnionitis, and maternal and neonatal death ⁷⁶	Counsel pregnant personnel likely to be exposed to animal flora ⁸⁴ Educate physicians to consider systemic infection with <i>P multocida</i> and other animal flora in symptomatic female veterinary personnel ⁸⁴

Table 3

Physical hazards present in veterinary workplaces and recommendations for mitigation of risks to female reproductive health identified in the literature.

Hazard	Reproductive risk	Best practices to mitigate risk
Radiography	Risks depend on stage of embryonic or fetal development and level of radiation exposure. Outcomes range from death of the embryo to congenital malformations and mental retardation ⁸⁸	Occupational exposure limit for ionizing radiation to the fetus is 5 mSv (0.5 rem) cumulative during pregnancy, with a 0.5 mSv limit for each month of pregnancy ⁸⁹ Keep radiation exposure as low as reasonably achievable or as low as reasonably practicable ⁹⁰⁻⁹³ Avoid radiographic evaluation unless it is justified ⁹⁰ Perform yearly safety verification of gloves and aprons, and check the tube device for leakage ⁹³ Increase distance of the individual performing radiography from the radiation source, reduce the duration and amount of exposure, and use protective barriers between the individual and the source ²³ Perform radiography only in controlled areas ⁹⁰ ; wear radioprotective clothing (eg, lead aprons, thyroid shields, glasses, and gloves) and use personal dosimetry badges worn on the trunk under the lead gown ^{23,28,90,94,95} ; gloves and thyroid shields should have a minimum lead equivalent of 0.5 mm ⁹⁰ Prohibit manual restraint of animals by pregnant women during radiography ⁹⁰ Use tube stands or a pole with a cassette holder, rather than holding with hands, for radiography of large animals ⁹⁰⁻⁹² Emphasize the importance of adequate radiation protection and knowledge in schools of veterinary medicine and professional associations ⁹⁶ Include written policies in a practice infection control plan requiring staff members to notify hospital leadership of pregnancy as soon as the staff member becomes aware of it ⁹⁷ Fully inform female veterinary personnel of the risks from ionizing radiation ^{29,44} Work with employers to reduce exposures during pregnancy and lactation ^{23,49,90}
Standing at work	Preterm delivery ⁹⁸⁻¹⁰⁰ and low birth weight ¹⁰¹	Pregnant personnel should not stand > 6 h/d ⁹⁸ Limit standing and walking at work, especially standing in 1 position, to 4 to 5 hours during the second and third trimesters ^{99,101}
Long working hours	Preterm delivery ^{21,98}	Limit work to < 42-45 h/wk ^{21,98}
Physically demanding work, including lifting	Preterm delivery, maternal hypertension, ¹⁰⁰ and low birth weight ¹⁰²	Reduce or eliminate physically demanding work from job duties of pregnant personnel ^{100,103} Consult MacDonald et al (2013) ¹⁰² for specific guidelines for occupational lifting during pregnancy; guidelines are given for infrequent lifting, repetitive short-duration lifting, and repetitive long-duration lifting in multiple body positions at < 20 wk of gestation and 20 wk of gestation. Reductions in recommended weight limits may need to be made for veterinary personnel, considering the unpredictability of sudden animal movement or pushing and pulling of animals during lifting that may influence recommended weight limits ¹⁰² Minimize or eliminate demanding levels of physical work for women with previous complications of pregnancy that are likely to recur, such as low birth weight of infants and premature labor ²³
Shift and night work	Preterm delivery ¹⁰⁰	Limit shift or night work ¹⁰⁰
Needle sticks	Spontaneous abortion ¹⁰⁴	Establish a needle-stick prevention program ^{7,8} Provide information and training on needle-stick prevention and establish written infection control policies that include needle-stick prevention ^{72,105} Practice standard precautions when using anthelmintic, euthanasia, and anesthetic agents ¹⁰⁴ Avoid recapping needles or use a 1-handed scooping technique to recap ^{37,72,106} Perform worksite analyses for tasks causing needle sticks ¹⁰⁶