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Protocol for a Scoping/Systematic Review: Measuring occupational exposure for veterinary personnel involved with 18F-FDG PET/CT

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Author Contributions: MS is the guarantor (responsible for quality and typically associated with correspondence), LC contributed to selection criteria, LC/EF developed the search strategy, LC provided content expertise.

Abstract:

Background: As Positron Emission Tomography use is increasing in veterinary medicine, personnel are potentially exposed to increasing levels of occupational radiation.

Objectives: To estimate the average exposure received by veterinary personnel during an F18-FDG PET procedure by reviewing the existing literature in both veterinary and human medicine.

Design: Primary and secondary literature, including grey literature (conference proceedings), was collected in English from 1978 from citation databases: CAB Abstracts (CABDirect), Scopus, CINAHL(Ebsco), and Biosis(Web of Science) on 12 January 2024 utilizing Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Data will be characterized from the study using tables and figures to describe protocol information, form of dosimetry, comparison/control populations, personnel role, animal species, average exposures, number of scans, duration of exposure, comparisons with other dosimetry or measures and reporting guidelines used in each study.

Registration: This has been submitted to SYREAF on this date, and eScholarship, University of California (<https://escholarship.org/>) on this date.

Amendments from Original Protocol:

Not applicable.

Funding and Support:

Not applicable

Role of Sponsor or Funder:

Not applicable

Introduction

Rationale

Positron Emission Tomography (PET) is a growing imaging modality within the field of veterinary medicine. PET scans are a valuable tool in various fields including oncology, neurology and orthopedics [1–3]. Because veterinary medicine often follows in the footsteps of the human medical field, there is significantly more research and knowledge relating to occupational exposures during human PET scans [4]. As more veterinary hospitals are using PET scanning as a diagnostic tool, veterinary staff are becoming increasingly involved with these nuclear medicine procedures. Occupational exposure to ionizing radiation can be a concern to veterinary nuclear medicine technologists, anesthetists, radiologists, or other personnel involved during a PET scan. There can be a lack of awareness about how much exposure should be expected during a veterinary PET scan and whether these doses received are cause for concern.

This scoping review aims to synthesize the literature on occupational exposures during 18F-FDG PET scans in both veterinary and human medicine. The goal is to provide a clearer picture of the amount of ionizing radiation received by veterinary personnel, and to contribute information to protocols, dose reduction, and safety considerations.

Objectives

Population: Veterinary and human medical personnel that are involved with PET scans in the clinical environment.

Exposure: Any PET scans utilizing an 18F-FDG radiotracer.

Outcome: Identifying exposure by dosimetry. Secondary outcomes of interest include identifying variation of protocols utilized in animals, comparison populations, measurement strategies.

Methods

Information Sources:

Database	Interface	Date Coverage	Date Searched
CAB Abstracts (included products: CAB ABSTRACTS, VetMed Resource, CABI Full Text, Global Health, Animal Health and Production Compendium (AHPC))	CABDirect	1972 to Present	12 January 2024
Medline (Included products: Medline, in process citations, "ahead of print" citations, out-of-scope citations, journals indexing prior to medline inclusion, pre-1966 citations, PubMed Central, author manuscripts NIH funding, NCBI Bookshelf)	PubMed	1902 to Present	12 January 2024
Scopus	Scopus	1996 to Present	12 January 2024
Biosis	Web of Science	1926 to Present	12 January 2024
Cinahl	Ebsco	1937 - Present	12 January 2024

Search Strategy:

PRISMA-S Template (based on v1.0 retrieved from <https://osf.io/2ybwn/>)

Databases and Interfaces Searched:

Simultaneous Searches:

None performed

Item 2: Other Online Resources (As Needed):

Conference Proceeding/Registry/ Web Sites or Engine	Coverage Dates	Membership Required?	URL	Date Searched:
Not Performed				

Manual Searching (searching relevant journals Table of Contents):

Not Performed

Citation Searching And Text Analysis:

Article Citation:
Martinez, N. E., Kraft, S. L., & Johnson, T. E. (2014). A proposed simple model for estimating occupational radiation dose to staff from veterinary 18F-FDG pet procedures. <i>Health physics</i> , 106(5), 583–591. https://doi.org/10.1097/HP.0000000000000037
Martinez, N. E., Kraft, S. L., Gibbons, D. S., Arceneaux, B. K., Stewart, J. A., Mama, K. R., & Johnson, T. E. (2012). Occupational per-patient radiation dose from a conservative protocol for veterinary (18) F-fluorodeoxyglucose positron emission tomography. <i>Veterinary radiology & ultrasound : the official journal of the American College of Veterinary Radiology and the International Veterinary Radiology Association</i> , 53(5), 591–597. https://doi.org/10.1111/j.1740-8261.2012.01958.x
Suwannasaeng, Nattawipa & Kakizaki, Takehiko & Wada, Seiichi & Natsuhori, Masahiro. (2022). External Exposure to Veterinary Staff and Pet Owners from 18F-fluorodeoxyglucose (18F-FDG) Positron Emission Tomography 獣医診療における18F標識フルオロデオキシグルコース (18F-FDG) 陽電子断層撮影へ関わる獣医療スタッフと飼い主の外部被ばく線量評価. <i>RADIOISOTOPES</i> . 71. 115-126. 10.3769/radioisotopes.71.115.
Guiu-Souto, J., Sánchez-García, M., Vázquez-Vázquez, R., Otero, C., Luna, V., Mosquera, J., Busto, R. L., Aguiar, P., Ruibal, Á., Pardo-Montero, J., & Pombar-Cameán, M. (2016). Evaluation and optimization of occupational eye lens dosimetry during positron emission tomography (PET) procedures. <i>Journal of radiological protection : official journal of the Society for Radiological Protection</i> , 36(2), 299–308. https://doi.org/10.1088/0952-4746/36/2/299
Skovorodko, K., Bareikė, M., Gudelis, A., & Gricienė, B. (2020). Occupational exposure in a PET/CT facility using two different automatic infusion systems. <i>Physica medica : PM : an international journal devoted to the applications of physics to medicine and biology : official journal of the Italian Association of Biomedical Physics (AIFB)</i> , 77, 169–175. https://doi.org/10.1016/j.ejmp.2020.08.014
Benatar NA, Cronin BF, O'Doherty MJ. Radiation dose rates from patients undergoing PET: implications for technologists and waiting areas. <i>Eur J Nucl Med</i> . 2000 May;27(5):583-9. doi: 10.1007/s002590050546. PMID: 10853815.
Jha AK, Zade A, Rangarajan V. Estimation of radiation dose received by the radiation worker during F-18 FDG injection process. <i>Indian J Nucl Med</i> . 2011 Jan;26(1):11-3. doi: 10.4103/0972-3919.84591. PMID: 21969773; PMCID: PMC3180714.

Kumar S, Pandey AK, Sharma P, Shamim SA, Malhotra A, Kumar R. Instantaneous exposure to nuclear medicine staff involved in PET-CT imaging in developing countries: experience from a tertiary care centre in India. *Jpn J Radiol*. 2012 May;30(4):291-5. doi: 10.1007/s11604-011-0045-4. Epub 2012 Jan 14. PMID: 22246804.

Verma S, Kheruka SC, Maurya AK, Kumar N, Gambhir S, Kumari S. Benefits of adopting good radiation practices in reducing the whole body radiation dose to the nuclear medicine personnel during (18)F-fluorodeoxyglucose positron emission tomography/computed tomography imaging. *Indian J Nucl Med*. 2016 Jan-Mar;31(1):27-30. doi: 10.4103/0972-3919.172348. PMID: 26917890; PMCID: PMC4746836.

Demir M, Demir B, Sayman H, Sager S, Sabbir Ahmed A, Uslu I. Radiation protection for accompanying person and radiation workers in PET/CT. *Radiat Prot Dosimetry*. 2011 Nov;147(4):528-32. doi: 10.1093/rpd/ncq497. Epub 2010 Dec 23. PMID: 21183551.

Biran T, Weininger J, Malchi S, Marciano R, Chisin R. Measurements of occupational exposure for a technologist performing 18F FDG PET scans. *Health Phys*. 2004 Nov;87(5):539-44. doi: 10.1097/01.hp.0000137180.85643.9d. PMID: 15551792.

Chiesa C, De Sanctis V, Crippa F, Schiavini M, Fraigola CE, Bogni A, Pascali C, Decise D, Marchesini R, Bombardieri E. Radiation dose to technicians per nuclear medicine procedure: comparison between technetium-99m, gallium-67, and iodine-131 radiotracers and fluorine-18 fluorodeoxyglucose. *Eur J Nucl Med*. 1997 Nov;24(11):1380-9. doi: 10.1007/s002590050164. PMID: 9371871.

Guillet B, Quentin P, Waultier S, Bourrelly M, Pisano P, Mundler O. Technologist radiation exposure in routine clinical practice with 18F-FDG PET. *J Nucl Med Technol*. 2005 Sep;33(3):175-9. PMID: 16145226.

Leide-Svegborn S. Radiation exposure of patients and personnel from a PET/CT procedure with 18F-FDG. *Radiat Prot Dosimetry*. 2010 Apr-May;139(1-3):208-13. doi: 10.1093/rpd/ncq026. Epub 2010 Feb 18. PMID: 20167792.

Roberts FO, Gunawardana DH, Pathmaraj K, Wallace A, U PL, Mi T, Berlangieri SU, O'Keefe GJ, Rowe CC, Scott AM. Radiation dose to PET technologists and strategies to lower occupational exposure. *J Nucl Med Technol*. 2005 Mar;33(1):44-7. PMID: 15731021.

Seierstad T, Strandén E, Bjering K, Evensen M, Holt A, Michalsen HM, Wetteland O. Doses to nuclear technicians in a dedicated PET/CT centre utilising 18F fluorodeoxyglucose (FDG). *Radiat Prot Dosimetry*. 2007;123(2):246-9. doi: 10.1093/rpd/ncl141. Epub 2006 Sep 20. PMID: 16987913.

Soret M, Maisonobe JA, Payen S, Gaubert A, Brunel S, Bergeret S, Berenbaum A, Hubert E, Kas A. Radiation dose to nuclear medicine technologists when operating PET/MR compared with PET/CT. *J Radiol Prot*. 2022 Apr 27;42(2). doi: 10.1088/1361-6498/ac5e50. PMID: 35296565.

Pavičar B, Davidović J, Petrović B, Vuleta G, Trivić S, Šajinović V, Egeljić-Mihailović N, Todorović N, Predojević B. Nuclear medicine staff exposure to ionising radiation in ¹⁸F-FDG PET/CT practice: a preliminary retrospective

study. Arh Hig Rada Toksikol. 2021 Sep 28;72(3):216-224. doi: 10.2478/aiht-2021-72-3517. PMID: 34587667; PMCID: PMC8576747.

Costa PF, Reinhardt M, Poppe B. OCCUPATIONAL EXPOSURE FROM F-18-FDG PET/CT: IMPLEMENTATION TO ROUTINE CLINICAL PRACTICE. Radiat Prot Dosimetry. 2018 May 1;179(3):291-298. doi: 10.1093/rpd/ncx276. PMID: 29253239.

Ahmed IES, Zamzam AMM, Yassin HM. Statistical analysis of the occupational radiation doses in three different positron emission tomography-computed tomography centers in Egypt. World J Nucl Med. 2019 Jul-Sep;18(3):287-292. doi: 10.4103/wjnm.WJNM_42_18. PMID: 31516373; PMCID: PMC6714156.

Antic V, Ciraj-Bjelac O, Stankovic J, Arandjic D, Todorovic N, Lucic S. Radiation exposure to nuclear medicine staff involved in PET/CT practice in Serbia. Radiat Prot Dosimetry. 2014 Dec;162(4):577-85. doi: 10.1093/rpd/ncu001. Epub 2014 Jan 23. PMID: 24464817.

Process: Key articles were discovered by content expert (LC) in Google Scholar and PubMed. Records were located in PubMed and CAB Abstracts where indexing terms and record numbers were captured. Terms were built based on word frequency in SR Accelerator and indexing terms from Yale MeSH Analyser (Yale University, United States) including content expert feedback (LC).

Contacts (Researchers contacted for additional information):

Not applicable

Process: Not applicable.

Additional Methodologies Not Listed Above:

Process: Citation tracking (Snowball Method) was employed, where included studies' citations and cited by data were extracted from Scopus (Elsevier, Netherlands) and put back into Title/Abstract Screening to make sure no articles were missed with database searching.

Limits and Restrictions

Date and Time Period: 1978 - present [5]

Language: English

Publication status: grey(conference proceedings) and published literature will be included in this study.

Species Included: Humans, dogs, cats, rabbits, rats and mice.

Study Design: Any descriptive, experimental or observational design.

Database Subset: Not Applied

Pre-specified cut-off or saturation point for results: Not Applied

Other Restrictions:

Search Filters:

Database	Interface	Search Filters Applied
CAB Abstracts	CAB Direct	Language
Medline	PubMed	Language
Scopus	Scopus	Language
Biosis	Web of Science	Language
CINAHL	Ebsco	Language

Full Search Strategy:

Search Database:CABDirect

Search ID	Terms (copy and paste)	Results
#1 F18	title:(¹⁸ F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR ¹⁸ F-fluorodeoxyglucose OR [¹⁸ F]FDG* OR (18)F-fluorodeoxyglucose OR [¹⁸ F]-fluorodeoxyglucose OR (18) F-fluorodeoxyglucose) OR ab:(¹⁸ F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR ¹⁸ F-fluorodeoxyglucose OR [¹⁸ F]FDG* OR (18)F-fluorodeoxyglucose OR [¹⁸ F]-fluorodeoxyglucose OR F-fluorodeoxyglucose)	422
#2 exposure	title:(¹⁸ F-FDG* OR "radiation dose*" OR "radiation dosage" OR "radiometry" OR "dosimetry" OR "body burden" OR "radiation monitoring" OR "radiation protection" OR "whole-body" OR "Radiometry" OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR	462,282

	"Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting") OR ab:(“exposure*” OR "radiation dose*” OR "radiation dosage" OR “radiometry” OR “dosimetry” OR "body burden" OR "radiation monitoring" OR "radiation protection" OR “whole-body” OR “Radiometry” OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting") OR de:(“radiation”)	
#3 occupational	title:(technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel") OR ab:(technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel") OR id:(“staff” or “employees”) OR de:(“personnel”)	151,355
#4	#1 AND #2 AND #3	4
#5	#4 AND English	3
Copy and paste	(title:(technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel") OR ab:(technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel") OR id:(“staff” or “employees”) OR de:(“personnel”)) AND (title:(“exposure*” OR "radiation dose*” OR "radiation dosage" OR "radiometry" OR "dosimetry" OR "body burden" OR "radiation monitoring" OR "radiation protection" OR "whole-body" OR "Radiometry" OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting") OR ab:(“exposure*” OR "radiation dose*” OR "radiation dosage" OR "radiometry" OR "dosimetry" OR "body burden" OR "radiation monitoring" OR "radiation protection" OR "whole-body" OR	

	"Radiometry" OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting") OR de:("radiation")) AND (title:("18F-FDG*" OR "F18-FDG*" OR "Fluorodeoxyglucose F18" OR "18F-fluorodeoxyglucose" OR "[18F]FDG*" OR "(18)F-fluorodeoxyglucose" OR "[18]F-fluorodeoxyglucose" OR "(18) F-fluorodeoxyglucose") OR ab:("18F-FDG*" OR "F18-FDG*" OR "Fluorodeoxyglucose F18" OR "18F-fluorodeoxyglucose" OR "[18F]FDG*" OR "(18)F-fluorodeoxyglucose" OR "[18]F-fluorodeoxyglucose" OR "F-fluorodeoxyglucose"))	
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Search Database: PubMed

Search ID	Terms (copy and paste)	Results
#1 F18	"18F-FDG*" [tiab] OR "F18-FDG*" [tiab] OR "Fluorodeoxyglucose F18" [Mesh] OR "18F-fluorodeoxyglucose" [tiab] OR "[18F]FDG*" [tiab] OR "(18)F-fluorodeoxyglucose" [tiab] OR "[18]F-fluorodeoxyglucose" [tiab] OR "F-fluorodeoxyglucose" [tiab] OR "*F-fluorodeoxyglucose" [tiab]	41,471
#2 exposure	"exposure*" [tiab] OR "radiation dose*" [tiab] OR "radiation dosage" [tiab] OR "radiometry" [tiab] OR "dosimetry" [tiab] OR "body burden" [tiab] OR "radiation monitoring" [tiab] OR "radiation protection" [tiab] OR "whole-body" [tiab] OR "Radiometry" [Mesh] OR "Thermoluminescent Dosimetry" [Mesh] OR "Film Dosimetry" [Mesh] OR "Body Burden" [Mesh] OR "Radiation Monitoring" [Mesh] OR "Radiation Protection" [Mesh] OR "Whole-body Counting" [Mesh] OR "Radiation Exposure" [Mesh] OR "Radiation Dosage" [Mesh] OR "Whole-Body Counting" [Mesh]	1,324,193
#3 occupational	"technician*" OR "technologist*" OR "nurse*" [tiab] OR "radiographer" [tiab] OR "personnel" [tiab] OR "Allied Health Personnel" [Mesh] OR "Occupational Exposure" [Mesh] OR "Animal Technicians" [Mesh] OR "Animal Technicians" [Mesh] OR "Health Personnel" [Mesh] OR "staff" [tiab] OR "employees" [tiab]	1,022,739
#4	#1 AND #2 AND #3	132
#5	#4 AND English	132
Copy and paste	((("18f fdg*" [Title/Abstract] OR "f18 fdg*" [Title/Abstract] OR "Fluorodeoxyglucose F18" [MeSH Terms] OR "18F-fluorodeoxyglucose" [Title/Abstract] OR "18f	

	<p>fdg*[Title/Abstract] OR "18 f fluorodeoxyglucose"[Title/Abstract] OR "18 f fluorodeoxyglucose"[Title/Abstract] OR "F-fluorodeoxyglucose"[Title/Abstract] OR "F-fluorodeoxyglucose"[Title/Abstract]) AND "english"[Language] AND (("exposure*[Title/Abstract] OR "radiation dose*[Title/Abstract] OR "Radiation Dosage"[Title/Abstract] OR "Radiometry"[Title/Abstract] OR "dosimetry"[Title/Abstract] OR "Body Burden"[Title/Abstract] OR "Radiation Monitoring"[Title/Abstract] OR "Radiation Protection"[Title/Abstract] OR "whole-body"[Title/Abstract] OR "Radiometry"[MeSH Terms] OR "Thermoluminescent Dosimetry"[MeSH Terms] OR "Film Dosimetry"[MeSH Terms] OR "Body Burden"[MeSH Terms] OR "Radiation Monitoring"[MeSH Terms] OR "Radiation Protection"[MeSH Terms] OR "whole body counting"[MeSH Terms] OR "Radiation Exposure"[MeSH Terms] OR "Radiation Dosage"[MeSH Terms] OR "whole body counting"[MeSH Terms]) AND "english"[Language]) AND (("technician*[All Fields] OR "technologist*[All Fields] OR "nurse*[Title/Abstract] OR "radiographer"[Title/Abstract] OR "personnel"[Title/Abstract] OR "Allied Health Personnel"[MeSH Terms] OR "Occupational Exposure"[MeSH Terms] OR "Animal Technicians"[MeSH Terms] OR "Animal Technicians"[MeSH Terms] OR "Health Personnel"[MeSH Terms] OR "staff"[Title/Abstract] OR "employees"[Title/Abstract]) AND "english"[Language])) AND (english[Filter])</p>	
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Search Database: Scopus

Search ID	Terms (copy and paste)	Results
#1 F18	<p>TITLE-ABS-KEY (18F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR 18F-fluorodeoxyglucose OR [18F]FDG* OR (18)F-fluorodeoxyglucose OR [18]F-fluorodeoxyglucose OR "F-fluorodeoxyglucose" OR "*F-Fluorodeoxyglucose")</p>	10,717
#2 Exposure	<p>TITLE-ABS-KEY (exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR Radiometry OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting")</p>	2,294,630
#3 occupational	<p>TITLE-ABS-KEY (technician* OR technologist*)</p>	1,981,538

	OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR staff OR employees)	
#4	#1 AND #2 AND #3	35
#5	#4 AND English	33
Copy and paste	(TITLE-ABS-KEY ((technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR staff OR employees)) AND TITLE-ABS-KEY ((exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR radiometry OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting")) AND TITLE-ABS-KEY ((18f-fdg* OR f18-fdg* OR "Fluorodeoxyglucose F18" OR 18f-fluorodeoxyglucose OR [18f]fdg* OR (18) f-fluorodeoxyglucose OR [18]f-fluorodeoxyglucose OR "F-fluorodeoxyglucose" OR "*F-Fluorodeoxyglucose"))) AND (LIMIT-TO (LANGUAGE , "English")))	

Search Database:BIOSIS

Search ID	Terms (copy and paste)	Results
#1 F18	TS=(18F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR 18F-fluorodeoxyglucose OR [18F]FDG* OR (18)F-fluorodeoxyglucose OR [18]F-fluorodeoxyglucose OR "F-Fluorodeoxyglucose" OR "*F-Fluordeoxyglucose")	9,528
#2 Exposure	TS=(exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR Radiometry	1,048,916

	OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting")	
#3 occupational	TS=(technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR "staff" OR "employees")	144,471
#4	#1 AND #2 AND #3	21
#5	#4 AND English	21
Copy and paste	TS=(18F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR 18F-fluorodeoxyglucose OR [18F]FDG* OR (18)F-fluorodeoxyglucose OR [18]F-fluorodeoxyglucose OR "F-Fluorodeoxyglucose" OR "*F-Fluorodeoxyglucose") AND TS=(exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR Radiometry OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting") AND TS=(technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR "staff" OR "employees")	

Database: CINAHL

Search ID	Terms (copy and paste)	Results
#1 F18	(MM "Fludeoxyglucose F 18") OR TI (18F-FDG* OR	7,938

	F18-FDG* OR "Fluorodeoxyglucose F18" OR 18F-fluorodeoxyglucose OR [18F]FDG* OR (18)F-fluorodeoxyglucose OR [18]F-fluorodeoxyglucose OR "F-Fluorodeoxyglucose" OR "*F-Fluorodeoxyglucose") OR AB (18F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR 18F-fluorodeoxyglucose OR [18F]FDG* OR (18)F-fluorodeoxyglucose OR [18]F-fluorodeoxyglucose OR "F-Fluorodeoxyglucose" OR "*F-Fluorodeoxyglucose"))	
#2 Exposure	(MM "Radiation Monitoring") OR (MM "Radiometry") OR (MM "Radiation Dosage") OR (MM "Spectrometry, X-Ray Emission") OR (MM "Radiation Monitoring") OR (MM "Body Burden") OR (MM "Dosimetry") OR TI (exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR Radiometry OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting") OR AB (exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR Radiometry OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting")	193,692
#3 occupational	(MM "Radiologic Technologists") OR TI (technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR "staff" OR "employees") OR AB (technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR "staff" OR "employees")	552,987
#4	#1 AND #2 AND #3	23
#5	#4 AND English	22
Copy and Paste		

	<p>((MM "Fludeoxyglucose F 18") OR TI (18F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR 18F-fluorodeoxyglucose OR [18F]FDG* OR (18)F-fluorodeoxyglucose OR [18]F-fluorodeoxyglucose OR "F-Fluorodeoxyglucose" OR "*F-Fluorodeoxyglucose") OR AB (18F-FDG* OR F18-FDG* OR "Fluorodeoxyglucose F18" OR 18F-fluorodeoxyglucose OR [18F]FDG* OR (18)F-fluorodeoxyglucose OR [18]F-fluorodeoxyglucose OR "F-Fluorodeoxyglucose" OR "*F-Fluorodeoxyglucose")) AND ((MM "Radiation Monitoring") OR (MM "Radiometry") OR (MM "Radiation Dosage") OR (MM "Spectrometry, X-Ray Emission") OR (MM "Radiation Monitoring") OR (MM "Body Burden") OR (MM "Dosimetry") OR TI (exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR Radiometry OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting") OR AB (exposure* OR "radiation dose*" OR "radiation dosage" OR radiometry OR dosimetry OR "body burden" OR "radiation monitoring" OR "radiation protection" OR whole-body OR Radiometry OR "Thermoluminescent Dosimetry" OR "Film Dosimetry" OR "Body Burden" OR "Radiation Monitoring" OR "Radiation Protection" OR "Whole-body) Counting" OR "Radiation Exposure" OR "Radiation Dosage" OR "Whole-Body Counting")) AND ((MM "Radiologic Technologists") OR TI (technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR "staff" OR "employees") OR AB (technician* OR technologist* OR nurse* OR radiographer OR personnel OR "Allied Health Personnel" OR "Occupational Exposure" OR "Animal Technicians" OR "Animal Technicians" OR "Health Personnel" OR "staff" OR "employees"))</p>	
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Updates: Not Applicable

Search Designers:

Information Specialist (EF) and content expert (LC) worked together to identify relevant terms and indexing in specialized databases.

Peer Review:

Search was not peer reviewed but checked against known articles of interest (21 PMIDs) and search was run to see if all 21 articles were located.

Total Records	Total Records after deduplication	Deduplication software/methodology
211	157	Zotero
157	153	Covidence

Records Screened: 153

Study Records:

SR-Accelerator (Bond University, Australia) was used to identify search terms and Zotero (Corporation for Digital Scholarship, USA) to deduplicate studies. Covidence (Australia) was used to deduplicate and screen studies for title/abstract and full-text screening. Microsoft Excel (Microsoft, USA) was used to characterize/extract relevant information for the study.

Selection Process:

Two screeners (LC/EF) will go through Title/Abstract and full text articles while MS will arbitrate disagreement between screeners.

Inclusion/exclusion criteria as follows:

Include	Exclude
Any study with F18 radioisotope	Any studies that use other radioisotopes
Include companion animals, lab animals and humans	Large animal
Has to include dosimetry of personnel	Dosimetry of patients
PET/CTs or PET/MRI or other diagnostic imaging coupled with PET	PET/linear accelerator or therapies coupled with PET PET isotope production centers
Primary studies	Narrative reviews or book chapters or editorials

Data Collection Process:

Information will be extracted on a spreadsheet in Excel by two participants (LC/EF) and arbitration will be done by (MS).

Protocol information from each study
Form of dosimetry used in study
Comparison/control population
Personnel role(s)
Animal species including human
Average exposures
of scans
Duration of exposure
Comparison with other dosimetry?
Reporting guideline used?

Outcomes and Prioritization:

Risk of bias in Individual Studies:

No risk of bias was performed for this scoping review.

Data Synthesis:

Data characterization will be performed with included studies.

Confidence in Cumulative Evidence:

Not applicable for the Scoping Review

Discussion:

Positron Emission Tomography (PET) is a valuable diagnostic tool in veterinary medicine. PET scans involve the intravenous administration of radiopharmaceuticals, which are circulated throughout the patient and emit positrons. The gamma-rays originating from the positrons are detected by PET scanners to create detailed 3-D images. While PET scans provide invaluable information for accurate diagnosis and treatment planning, it also raises concerns regarding the occupational radiation exposure of veterinary staff involved in the process.

Radiation exposure is an inherent risk associated with the handling and administration of radiopharmaceuticals in PET imaging. The primary sources of occupational exposure include the preparation and administration of radiopharmaceuticals followed by the handling, positioning and monitoring of radioactive patients [6]. When compared to human imaging, veterinary PET scans present unique challenges due to the variety of patient sizes, differences in staff training, and the handling or restraint that may be required [7]. Understanding and mitigating these risks are critical to ensuring the safety of veterinary professionals and the patients under their care.

Unlike in human medicine, veterinary PET scans are performed while the patient is under general anesthesia or monitored heavy sedation and this requires multiple staff members to be involved with the procedure [8]. There are also differences in equipment and imaging protocols that affect the level of exposure that the veterinary staff receive [7,8]. Decisions about whether to inject the radioisotope before or after the induction of general anesthesia can have a large impact on the staff exposure due to the need for close restraint of a radioactive animal [7]. When the isotope is injected after anesthesia induction, there is more anesthesia time for the patient, but a large reduction in exposure for all staff involved [8]. The lack of standardized guidelines specifically tailored to veterinary PET imaging poses challenges in establishing consistent safety practices.

The literature on occupational radiation exposure in veterinary PET remains limited, but a large number of studies focusing on human PET imaging are available [4,9–12]. There is a need for more research specific to veterinary settings to evaluate the unique challenges associated with the scanning of animals. This research aims to bridge the gap in knowledge by reviewing the current literature on occupational radiation exposure in veterinary PET and including human PET research as a comparison. By analyzing available data, identifying best practices, and evaluating potential risks, this study aims to provide insights into strategies for minimizing radiation exposure in veterinary settings and to contribute to the development of standardized guidelines for occupational safety.

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