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RADIATION EXPOSURE INCIDENTS: INTERPROFESSIONAL APPROACHES TO DETECTION, DECONTAMINATION, PHARMACOLOGIC PROTECTION, AND EMERGENCY RESPONSE WITH NURSING AND FAMILY MEDICINE PHYSICIANS ROLE

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Abstract

Radiation exposure incidents represent a critical public health emergency demanding a coordinated interprofessional response from healthcare systems globally. These incidents, which can arise from nuclear accidents, radiological dispersal devices (dirty bombs), or occupational mishaps, pose unique challenges because radiation exposure produces no immediate sensory warning. The consequences can range from mild symptoms to fatal Acute Radiation Syndrome (ARS), which involves multi-system damage (hematopoietic, gastrointestinal, cutaneous, and neurovascular systems) depending on the dose received. Historical events, including Chernobyl and Fukushima Daiichi, underscore the critical importance of organized emergency response protocols.

The purpose of this review is to comprehensively examine radiation exposure incidents, focusing on the necessary interprofessional approaches for effective detection, decontamination, pharmacologic protection, and emergency response. Detection in the absence of facility alarms often relies on high clinical suspicion when patients present with non-specific prodromal symptoms such as early nausea and vomiting. Healthcare providers can utilize the Andrews Lymphocyte Nomogram as an early biologic indicator to estimate the absorbed radiation dose based on the rate of lymphocyte depletion within the first 24 hours. Decontamination protocols emphasize the principle of "life before decontamination," ensuring that acute medical emergencies are addressed first. The most effective single measure is emergency disrobing, which removes approximately 80 to 90 percent of external contamination, followed by a combined approach of dry and wet decontamination for superior contaminant removal.

The clinical progression of ARS involves a prodromal phase (early symptoms) followed by a latent phase lasting one to three weeks, during which patients appear relatively well despite progressive bone marrow suppression, posing a diagnostic challenge in primary care. Pharmacologic protection involves targeted medical countermeasures. Potassium Iodide (KI) is the most established intervention, effectively blocking thyroid uptake of radioactive iodine, with maximum effectiveness when administered within two hours of exposure. Other agents

include Prussian Blue, which enhances the fecal excretion of cesium and thallium, and DTPA (diethylenetriaminepentaacetic acid), a chelating agent used for internal contamination with transuranium elements like plutonium and americium.
Nursing professionals are critical frontline responders, essential for initial assessment, triage, decontamination oversight, and providing supportive care. However, current evidence consistently reveals substantial knowledge gaps among emergency nurses regarding radiation protection and appropriate decontamination procedures. Family medicine physicians are vital for initial recognition during the non-specific prodromal or latent phases in community settings, coordinating specialist consultation, and providing essential longitudinal care for survivors. Effective management requires mandatory, standardized, competency-based education for all healthcare professionals, integrating high-fidelity simulation-based training and streamlined interprofessional communication, guided by collaborative frameworks such as the CBRN chain of survival.
Keywords: Radiation Exposure Incidents; Acute Radiation Syndrome (ARS); Interprofessional Response; Emergency Preparedness; Decontamination; Pharmacologic Countermeasures.

BACKGROUND

Radiation exposure incidents represent a critical public health emergency that demands a coordinated, interprofessional response from healthcare systems worldwide. The potential for catastrophic outcomes from nuclear accidents, radiological dispersal devices (dirty bombs), industrial mishaps, and medical equipment failures necessitates comprehensive preparedness and robust clinical management protocols[1]. The history of major radiological incidents—including the Chernobyl Nuclear Power Plant accident of 1986, the Goiânia medical source accident of 1987, and the Fukushima Daiichi nuclear disaster of 2011—has underscored the devastating consequences of radiation exposure and the critical importance of organized emergency response mechanisms[1]. Additionally, occupational radiation exposure remains a persistent concern for healthcare workers, particularly those in diagnostic and interventional radiology departments, nuclear medicine facilities, and radiation oncology centers[2].

Radiation exposure incidents present unique diagnostic and therapeutic challenges that differ fundamentally from conventional medical emergencies. Unlike chemical or biological incidents where visible contamination or infectious agents are apparent, radiation exposure produces no immediate sensory warning to affected individuals or responders. Ionizing radiation can cause acute and delayed health effects ranging from mild gastrointestinal symptoms to fatal acute radiation syndrome (ARS), depending on dose, dose rate, radiation type, and exposure uniformity[3]. The complexity of managing radiation casualties is further compounded by the multisystem involvement of ARS, which can affect the hematopoietic, gastrointestinal, cutaneous, and neurovascular systems either individually or in combination[4].

The interprofessional approach to radiation emergency response has evolved significantly, reflecting lessons learned from past incidents and advances in radiation biology and emergency medicine. Modern radiation emergency management requires coordinated action from multiple healthcare disciplines, including emergency medicine physicians, nurses, radiologists, pharmacists, family medicine practitioners, paramedics, and radiation protection officers[5]. Each professional brings specialized knowledge and skills that are essential for effective response, triage, decontamination, and medical management of exposed individuals.

The role of nursing professionals in radiation emergencies is particularly critical, as nurses serve as frontline responders providing initial assessment, triage, decontamination procedures, and ongoing supportive care. Recent studies have revealed that emergency nurses in many healthcare systems lack sufficient knowledge regarding radiation protection measures, health effects of radiation exposure, and appropriate decontamination protocols[6]. Conversely, family medicine physicians, who often serve as primary care providers in community settings, may encounter radiation-exposed patients during the prodromal phase or latent phase of ARS when symptoms are nonspecific and the radiation exposure history is unclear or not initially provided[7].

Scope and Purpose

This review article provides a comprehensive examination of radiation exposure incidents, emphasizing the interprofessional approaches necessary for effective detection, decontamination, pharmacologic protection, and emergency response. Particular attention is given to the essential roles of nursing professionals and family medicine physicians in the management of radiation-exposed individuals, including their responsibilities in initial assessment, protective measures, decontamination procedures, and coordination with specialist services. The article synthesizes current evidence-based practices, guidelines from international organizations including the International Atomic Energy Agency (IAEA) and World Health Organization (WHO), and lessons learned from historical radiation incidents.

LITERATURE REVIEW

The medical literature on radiation emergencies has expanded considerably over the past two decades, reflecting increased recognition of the potential for radiological incidents and the need for healthcare system preparedness. Early seminal work by the International Commission on Radiological Protection and the IAEA established fundamental principles for radiation emergency response that continue to guide contemporary practice[8]. More recent reviews have focused on the clinical manifestations, diagnostic approaches, and evidence-based management strategies for the various forms of acute radiation syndrome[9].

Decontamination protocols have been extensively studied through controlled experiments and reviews of historical incident responses. The United Kingdom's modified Initial Operational Response (IOR) to chemical, biological, radiological, and nuclear (CBRN) incidents, which combines emergency disrobing with dry and wet decontamination procedures, has emerged as a best-practice model that emphasizes the sequencing of decontamination methods for maximum effectiveness and efficiency[10]. Research using fluorescent aerosol simulants and mannequin models has demonstrated that combined dry and wet decontamination protocols are superior to single-method approaches, achieving contaminant removal rates that exceed 90% when properly executed[11]. Importantly, these studies revealed that decontamination efficacy varies by anatomical location, with shoulder areas being more challenging to decontaminate than extremities, suggesting the need for attention to detail during decontamination procedures[12].

The pharmacologic management of radiation exposure has advanced significantly with the development and regulatory approval of medical countermeasures for specific types of internal contamination. Potassium iodide remains the most well-established pharmacologic intervention, with decades of evidence demonstrating its effectiveness in blocking thyroid uptake of radioactive iodine when administered within the optimal therapeutic window[13]. More recently, prussian blue and chelating agents such as diethylenetriaminepentaacetic acid (DTPA) have been incorporated into radiation emergency response protocols for management of cesium, thallium, and transuranium element contamination[14].

Knowledge Gaps and Educational Needs

The recognition of knowledge deficiencies among healthcare workers regarding radiation emergency management has prompted multiple educational initiatives and competency assessments. Studies evaluating emergency nurses' knowledge of radiation protection, health effects, and decontamination procedures have consistently documented substantial gaps in understanding, with concerning misconceptions about which protective measures are most effective and about the appropriate sequencing of decontamination relative to life-saving measures[15]. Similarly, surveys of primary care physicians have indicated limited familiarity with the clinical presentation of ARS and uncertainty regarding appropriate diagnostic and management approaches[16].

The interprofessional response to radiation emergencies has been highlighted by international guidelines and consensus reports from organizations including the WHO, IAEA, American College of Radiology (ACR), American Society for Radiation Oncology (ASTRO), and American Association of Physicists in Medicine (AAPM)[17]. These organizations emphasize the critical importance of multidisciplinary coordination, clear communication among professionals from different disciplines, and the integration of specialists with varying expertise into unified response teams. The concept of the "CBRN chain of survival," developed by Paris Fire Brigade and other emergency services, provides a practical framework for conceptualizing the sequential steps necessary for effective incident management[18].

Detection of Radiation Exposure Incidents

Initial Recognition and Reporting

The first and arguably most critical step in managing a radiation exposure incident is recognizing that an incident has occurred. Unlike chemical exposures where victims may report noxious odors or visible fumes, or biological incidents where individuals present with infectious diseases, radiation exposures produce no immediate sensory warning signals. The absence of visual, olfactory, or auditory cues means that initial detection of radiation incidents often depends on witness reports, facility alarms, or retrospective identification based on clinical presentation.

Healthcare facilities, industrial sites, research institutions, and medical imaging centers typically employ radiation detection equipment that can trigger automated alarms upon detection of abnormal radiation levels. These detection systems serve as the primary early warning mechanism for occupational or facility-based incidents[19]. However, in scenarios involving radiological dispersal devices (dirty bombs) or covert contamination, initial detection may depend entirely on eyewitness observations or delayed recognition based on victim presentation.

First responders arriving at the scene of a potential radiation incident should employ portable radiation survey meters and dosimeters to assess radiation levels and identify contaminated zones. The incident commander must establish appropriate safety perimeters based on measured radiation levels, ensuring that emergency responders are not unnecessarily exposed[20]. An important principle in radiation emergency response is that there is negligible risk of radiation injury to persons treating radiation-exposed patients, provided they adhere to established radiation protection principles including time, distance, and shielding. This distinction is critical, as it helps allay concerns among first responders and healthcare workers that they will sustain significant radiation doses through contact with or proximity to contaminated patients[21].

Clinical Indicators of Radiation Exposure

In the absence of definitive exposure history or facility-based incident recognition, healthcare providers must maintain a high index of suspicion for radiation exposure when patients present with unexplained acute illness characterized by early nausea and vomiting. Recent studies indicate that unexplained prodromal symptoms—particularly the combination of nausea, vomiting, diarrhea, and skin erythema—should prompt consideration of radiation exposure in the differential diagnosis, especially in the context of potential occupational exposures or during public health emergencies[22].

The Andrews Lymphocyte Nomogram represents a validated tool that healthcare providers can employ to estimate radiation dose based on sequential absolute lymphocyte counts obtained within the first 24 hours after exposure. The rate of lymphocyte depletion correlates strongly with radiation dose, with more rapid declines indicating higher exposures. A pattern of rapid lymphocyte depletion, particularly when the absolute lymphocyte count falls below normal ranges within 8 to 12 hours of presumed exposure, serves as a biologic indicator of significant radiation dose and warrants investigation for radiation exposure and consultation with radiation experts[23].

Chromosome aberration analysis, although resource-intensive and time-consuming, provides the most accurate method of dose assessment following acute radiation exposures. The presence of dicentric aberrations in lymphocytes harvested and cultured from peripheral blood samples indicates recent whole-body radiation exposure and enables estimation of dose with reasonable precision. However, due to the time required for cell culture and analysis (typically 48 to 72 hours), chromosome analysis serves primarily as a confirmatory test rather than an immediate diagnostic tool[24].

Decontamination Procedures and Protocols

Principles and Objectives of Decontamination

Decontamination in the context of radiation emergency response refers to the removal of radioactive contamination from the skin, hair, clothing, and potentially from internal body sites. The primary objectives of decontamination are to:

- Minimize continued external radiation exposure to contaminated individuals
- Reduce the risk of internal contamination through inhalation or ingestion of radioactive material
- Prevent the spread of contamination to healthcare workers and facilities
- Protect the psychological well-being of victims and responders through the visible removal of contamination[25]

A fundamental principle underlying decontamination procedures is the critical prioritization of life-saving measures over decontamination. This principle, often summarized as "life before decontamination," ensures that acute medical emergencies such as airway compromise, severe hemorrhage, or cardiopulmonary instability are addressed immediately, even if the patient remains externally contaminated. Initial stabilization of life-threatening conditions takes absolute priority; decontamination can proceed once the patient's medical condition has been stabilized and airway, breathing, and circulation have been secured[26].

Decontamination Sequencing

The sequential approach to decontamination advocated in contemporary guidelines involves a multiphase process beginning with emergency disrobing and proceeding through dry and wet decontamination stages. The removal of outer clothing alone eliminates approximately 80 to 90 percent of external contamination, representing the single most effective decontamination measure available[27]. This removal should be performed promptly and with adequate precautions to prevent the spread of contaminated clothing materials and to minimize responder exposure. Contaminated clothing should be carefully placed in clearly labeled, dedicated containers to prevent inadvertent contamination of healthcare facilities and personnel.

Following emergency disrobing, dry decontamination using hyper-absorbent materials or specialized skin decontamination lotions can remove additional contamination prior to water decontamination. Dry decontamination methods are particularly valuable in scenarios where water availability is limited or when environmental conditions preclude water decontamination[28]. Research using fluorescent aerosol simulants has demonstrated that dry decontamination followed by wet decontamination achieves superior contamination removal compared to either method alone, supporting the combined approach now widely recommended in emergency response protocols[29].

Wet decontamination using copious amounts of water represents the definitive decontamination method for radiation incidents. The UK Initial Operational Response model advocates for revised mass casualty decontamination protocols that emphasize thorough body immersion and showering rather than limited spray decontamination, with evidence suggesting this approach can double the decontamination throughput while improving contaminant removal rates[30]. The decontamination process should proceed gently, with minimal rubbing or abrasion of skin that might promote dermal absorption of radioactive materials. Frequent swabs of contaminated areas should be discarded as radioactive waste in appropriately designated containers.

Decontamination in Healthcare Settings

Upon arrival at healthcare facilities, contaminated patients should undergo radiation survey prior to entering treatment areas. Radiation protection officers or trained personnel using calibrated survey meters should assess contamination levels and determine whether additional decontamination is required. The measurement of residual contamination informs decisions regarding placement in standard or specially designated decontamination areas and guides the extent of decontamination required to achieve acceptable contamination levels[31].

Healthcare workers performing decontamination procedures must employ appropriate personal protective equipment (PPE) including laboratory coats, double gloves, safety glasses, and overshoes to prevent secondary contamination. The selection of PPE should be appropriate for the specific types of radiation involved, as protection against alpha-emitting materials differs from protection against beta or gamma emitters. Training of healthcare workers in proper application and removal of PPE is essential to prevent self-contamination during the decontamination process[32].

Acute Radiation Syndrome: Clinical Presentation and Diagnosis

Classification and Prodromal Phase

Acute radiation syndrome is classified into distinct forms based on the organ systems primarily affected: hematopoietic syndrome (HS) occurring at cumulative whole-body doses typically ranging from 2 to 8 Gy, gastrointestinal syndrome (GIS) occurring at doses above 8 Gy, cutaneous syndrome occurring at locally high doses typically above 10 Gy, and neurovascular syndrome (NVS) occurring at lethal doses exceeding 20 Gy[33]. Most survivors of radiation incidents with clinically significant exposures manifest hematopoietic or cutaneous syndrome rather than the more severe gastrointestinal or neurovascular syndromes.

The prodromal phase of ARS, occurring within hours of exposure, is characterized by nausea, vomiting, diarrhea, headache, fatigue, and erythema of exposed skin. The timing, severity, and duration of prodromal symptoms correlate strongly with radiation dose and serve as critical clinical indicators for dose assessment and prognosis[34]. Patients exposed to doses in the range of 0.35 to 2 Gy typically experience mild prodromal symptoms that may resolve within hours to days, while those exposed to doses above 6 Gy experience severe prodromal symptoms with rapid onset and prolonged duration. Notably, patients with extremely high exposures (above 10 Gy) may experience almost instantaneous loss of consciousness, obviating the opportunity to observe prodromal symptoms[35].

The Latent Phase and Clinical Manifestations

Following the prodromal phase, most patients enter a latent phase lasting 1 to 3 weeks during which they appear and feel relatively well, despite progressive bone marrow suppression. This latent phase presents a critical clinical challenge, as patients may seek medical care early in the latent phase and be dismissed as having minor viral illness, only to deteriorate significantly in subsequent days[36]. Continuous monitoring through serial complete blood count (CBC) tests is essential during this period to detect evidence of progressive hematopoietic damage.

The manifest illness phase of ARS is characterized by severe pancytopenia with absolute neutrophil counts typically falling below 500 cells per microliter (500×10^6/L), severe thrombocytopenia with platelet counts below 20,000 cells per microliter (20×10^9/L), and profound anemia. The consequences of severe cytopenia include overwhelming infection risk, spontaneous or traumatic hemorrhage, and impaired wound healing[37]. Mucosal damage from radiation effects on rapidly dividing epithelial cells leads to oral mucositis, parotitis, esophagitis, and gastrointestinal ulceration, further increasing infection risk and impairing nutritional support.

Bioindicators and Dose Assessment

Beyond lymphocyte counting, several clinical and laboratory bioindicators serve to assess radiation dose severity and predict likely clinical outcomes. Physical bioindicators include the timing of vomiting onset (earlier onset correlating with higher doses), the frequency and severity of vomiting, and the presence and extent of skin erythema. Laboratory bioindicators include sequential lymphocyte counts, expression of chromosomal aberrations, levels of inflammatory markers, and changes in hematopoietic cell counts[38].

Pharmacologic Protection and Internal Decontamination

Potassium Iodide for Thyroid Protection

Potassium iodide represents the most established pharmacologic intervention for radiation emergency response and specifically targets prevention of thyroid uptake of radioactive iodine. The thyroid gland preferentially concentrates iodine, and in the event of radioactive iodine release following nuclear accidents or radiological incidents, administration of stable (nonradioactive) potassium iodide saturates thyroid iodine uptake capacity, preventing absorption of radioactive iodine[39].

The effectiveness of potassium iodide is time-dependent, with maximum protective effect when administered before exposure or within 2 hours after exposure. Administration between 2 and 24 hours after exposure provides partial protection, while administration more than 24 hours after exposure provides negligible thyroid protection[40]. The recommended FDA-approved dosages vary by age, with adults typically receiving 130 milligrams of potassium iodide. Importantly, potassium iodide protects only the thyroid gland and does not provide systemic radioprotection against external radiation or other radionuclides[41].

Healthcare providers must emphasize to patients and the public that potassium iodide should be used only following explicit public health authority recommendations during radiological emergencies and should never be used as a daily supplement for general "radiation protection." Chronic use of potassium iodide can result in iodine-induced thyroid dysfunction, including hypothyroidism and thyroiditis[42].

Prussian Blue for Cesium and Thallium Contamination

Prussian blue (ferric hexacyanoferrate) is an FDA-approved medical countermeasure that binds to cesium-137 and thallium-201 in the gastrointestinal tract, preventing absorption and enhancing fecal excretion of these radioactive materials[43]. Prussian blue is effective for internal contamination with these radionuclides when administered as soon as possible after exposure or contamination detection. The typical recommended dose is 3 grams administered orally three times daily with food. Prussian blue is generally well-tolerated, with constipation being the most common side effect[44].

The mechanism of action of Prussian blue involves ion exchange within its complex crystalline structure, which preferentially binds cesium and thallium ions. This binding reduces the residence time of these radionuclides in the body and significantly reduces the absorbed radiation dose to internal organs[45].

Chelation Therapy with DTPA

Diethylenetriaminepentaacetic acid (DTPA) represents a chelating agent effective for internal contamination with transuranium elements including plutonium, americium, and curium, as well as certain other metallic radionuclides[46]. DTPA forms highly stable chelate complexes with these metals, facilitating their enhanced urinary excretion. The agent is available in both calcium DTPA and zinc DTPA formulations, with calcium DTPA demonstrating greater initial effectiveness but concerns about potential zinc depletion with prolonged use, making zinc DTPA preferable for extended treatment courses[47].

DTPA is administered intravenously or by inhalation (for inhaled particulate contamination), depending on the route of radionuclide entry into the body. The timing of DTPA administration is less critical than for potassium iodide, with evidence suggesting benefit when administered days or even weeks after contamination detection, depending on the specific radionuclide and degree of tissue compartmentalization[48].

Supportive Pharmacologic Management

Beyond specific medical countermeasures targeting particular radionuclides, supportive pharmacologic management of ARS includes antimicrobial agents, antiemetics, analgesics, and agents targeting specific complications. Broad-spectrum antibiotics are initiated at the onset of fever in severely neutropenic patients to prevent rapidly progressive septicemia[49]. Colony-stimulating factors including granulocyte colony-stimulating factor (G-CSF) and granulocyte-macrophage colony-stimulating factor (GM-CSF) are administered to promote hematopoietic recovery and reduce infection risk[50]. Antiemetic agents including 5-hydroxytryptamine receptor antagonists are employed to manage nausea and vomiting, which are common in the prodromal phase and can persist through the manifest illness phase[51].

Role of Nursing Professionals in Radiation Emergency Response

Initial Assessment and Triage

Nursing professionals serve as frontline responders in radiation emergency scenarios and play essential roles in initial patient assessment and triage. Emergency nurses must rapidly evaluate patients for immediate life-threatening conditions while simultaneously identifying those requiring external decontamination and assessing the likelihood of internal contamination[52]. The triage process must balance the competing demands of efficiently categorizing large numbers of potentially exposed individuals while providing sufficient individualized assessment to identify clinical deterioration or complications requiring urgent intervention[53].

Standardized triage systems such as the Simple Triage and Rapid Treatment (START) system have been adapted for use in radiation incidents, enabling rapid sorting of patients into priority categories based on vital signs and clinical presentation. However, nurses must recognize that radiation triage differs from conventional mass casualty triage in that dose estimates based on clinical indicators are particularly important for prognostication and resource allocation decisions[54].

Decontamination Leadership and Oversight

Nursing professionals frequently serve as leaders or key team members of decontamination teams in radiation emergency responses. Nurses possess the clinical knowledge necessary to recognize and address complications arising during decontamination, including hemodynamic instability, hypothermia, or exacerbation of pre-existing medical conditions[55]. Effective decontamination requires coordination of multiple team members, clear communication regarding contamination status and decontamination completion, and careful documentation of procedures performed and findings observed.

Recent studies evaluating emergency nurses' knowledge of decontamination procedures have revealed concerning gaps in understanding regarding optimal sequencing of dry and wet decontamination, appropriate decontamination timing relative to life-saving measures, and techniques for minimizing secondary contamination of healthcare workers[56]. These knowledge deficiencies underscore the critical importance of targeted educational interventions and competency-based training for nurses involved in radiation emergency preparedness.

Supportive Care and Psychological Support

Throughout the course of radiation emergency response and the subsequent clinical management of affected individuals, nursing professionals provide essential supportive care including management of pain, nausea, and other symptoms; coordination of diagnostic testing and specialist consultations; and provision of psychological support to patients and families coping with the acute illness and uncertain prognosis associated with severe radiation exposure[57].

The psychological impact of radiation exposure on patients and their families is substantial, with anxiety, depression, and post-traumatic stress disorder documented at elevated rates in survivors of radiation incidents. Nursing professionals play crucial roles in providing reassurance regarding safety measures protecting them and healthcare workers, explaining clinical procedures and findings in understandable terms, and facilitating connections with mental health resources[58].

Knowledge Gaps and Educational Needs

A recent comprehensive study of emergency nurses in Saudi Arabia found that 97.47 percent of surveyed nurses demonstrated poor overall knowledge levels regarding radiation emergency response, with particular deficiencies in understanding decontamination procedures[59]. Concerning misconceptions were identified, including beliefs that life-saving measures should be delayed pending decontamination, that dense materials provide protection against radiation exposure, and uncertainty regarding the relative importance of the explosion versus radiation in radiological dispersal device incidents[60].

These findings highlight the urgent need for enhanced education and standardized training programs targeting nursing professionals. Effective educational interventions should incorporate high-fidelity simulation exercises allowing nurses to practice decontamination procedures, triage decision-making, and supportive care in realistic emergency scenarios[61]. Competency-based assessment tools should be employed to ensure that nurses achieve defined learning objectives related to radiation protection principles, recognition of ARS clinical manifestations, appropriate decontamination techniques, and the interface between decontamination and life-saving measures[62].

Role of Family Medicine Physicians in Radiation Emergency Response

Initial Presentation and Diagnostic Considerations

Family medicine physicians operating in community settings, urgent care facilities, and primary care clinics may encounter patients with radiation exposure during the prodromal or latent phases of ARS when the exposure history is not immediately apparent or when affected individuals first seek care at primary care venues. The nonspecific nature of early ARS symptoms—including nausea, vomiting, diarrhea, fatigue, and headache—means that radiation exposure may not be immediately recognized as the underlying cause[63].

Family medicine physicians must maintain awareness of recent incidents or events that might result in radiation exposure and maintain a broad differential diagnosis when evaluating patients with unexplained acute illness. The presence of unexplained pancytopenia or progressive lymphopenia, particularly when accompanied by a history of recent travel to an accident site or occupational exposure to radiation sources, should raise suspicion for radiation exposure[64].

Recognition of Exposure and Consultation

Upon recognition of possible radiation exposure, family medicine physicians should immediately consult with specialist services including emergency medicine, hematology-oncology, and radiation medicine specialists to facilitate urgent evaluation and diagnostic assessment. The timing of consultation is critical, as early identification enables appropriate diagnostic testing (particularly serial lymphocyte counts for dose estimation) and initiation of supportive care measures[65].

Family medicine physicians should not delay patient transfer to higher-level care pending completion of initial workup. Rather, communication with receiving specialists regarding suspected radiation exposure and clinical findings identified to date enables receipt of preliminary guidance and coordination of further evaluation[66].

Role in Community Radiation Emergency Planning

Beyond the clinical management of individual patients, family medicine physicians contribute importantly to community radiation emergency preparedness and response planning. Family medicine practices often serve as accessible entry points to the healthcare system for community members, and family medicine physicians

can disseminate public health information regarding radiation safety, actions to take in case of radiological incidents, and appropriate use of potassium iodide during declared public health emergencies[67].
Family medicine physicians should participate in multidisciplinary radiation emergency preparedness planning at community and health system levels, contributing clinical expertise regarding primary care management of radiation-exposed individuals and helping ensure that community-level response plans address the needs of patients with pre-existing medical conditions who may present for emergency care[68].

Continuity of Care for Radiation Survivors

Following acute management of radiation exposure in emergency or specialty settings, family medicine physicians often assume central roles in longitudinal care of survivors. This care includes monitoring for delayed hematopoietic complications, management of chronic infections, treatment of wound complications in cases of cutaneous injury, and surveillance for late effects including secondary malignancies and cataracts[69].
The coordination of care between specialists providing acute and rehabilitative services and primary care physicians providing longitudinal surveillance represents an important component of comprehensive management of radiation-exposed individuals[70].

Interprofessional Coordination and Emergency Response Planning

Multidisciplinary Team Structure

Effective response to radiation emergencies requires coordinated action from professionals representing multiple disciplines with complementary expertise and roles. The core interprofessional team should include emergency medicine physicians, nurses, paramedics, radiologists, radiation protection officers, pharmacists, family medicine physicians, and where appropriate, surgical and intensive care specialists[71]. Clear delineation of roles and responsibilities, established chains of command, and predefined communication protocols enable efficient coordination even in complex, high-stress emergency scenarios[72].

The CBRN Chain of Survival

The CBRN chain of survival provides a conceptual framework that integrates the sequential steps necessary for optimal emergency response to radiological and nuclear incidents. This framework encompasses:

1. Scene safety and establishment of perimeter
2. Recognition and initial notification
3. Early toxidromic recognition (rapid identification of clinical presentation patterns)
4. Decontamination
5. Emergency care
6. Ongoing medical management and surveillance[73]

Integration of nursing and family medicine expertise within this framework ensures comprehensive coverage of all response phases and improves overall response effectiveness.

Communication and Information Sharing

Clear communication among interprofessional team members and with patients, families, and the public represents a critical component of effective radiation emergency response. Misunderstandings regarding radiation hazards, decontamination procedures, and protective measures can fuel anxiety and undermine public cooperation with emergency directives[74]. Family medicine physicians and nurses, by virtue of their accessible relationships with community members, can serve important roles in translating complex scientific information regarding radiation risks and emergency response measures into language understandable to the public[75].

Training and Competency Development

Effective interprofessional radiation emergency response requires ongoing education and competency development for all participating professionals. High-fidelity simulation-based educational programs have demonstrated effectiveness in improving knowledge, confidence, and clinical decision-making among emergency medicine residents, nurses, and other healthcare professionals[76]. Competency assessments should incorporate interprofessional elements, evaluating not only individual professional knowledge but also the ability of interdisciplinary teams to function effectively under stress[77].

CONCLUSION

Radiation exposure incidents represent complex public health emergencies requiring coordinated, interprofessional response from healthcare systems, public health agencies, and emergency management organizations. The potential for acute radiation syndrome and its severe complications, including bone marrow failure, overwhelming infection, and gastrointestinal damage, demands that healthcare providers across all disciplines maintain awareness of the clinical presentation of radiation exposure and understand their roles within organized emergency response systems. Nursing professionals serve as critical links in radiation emergency response, providing initial assessment, directing decontamination procedures, and offering continuity of supportive care. Current evidence reveals substantial knowledge gaps among emergency nurses regarding radiation protection principles, appropriate decontamination sequencing, and clinical manifestations of ARS. Targeted educational interventions incorporating simulation-based learning and competency assessment are essential to enhance nursing readiness for radiation emergencies. Family medicine physicians, while less likely to encounter radiation-exposed patients compared with emergency medicine providers, nonetheless play important roles in initial recognition of possible radiation exposure in community settings, coordination of specialist consultation, participation in community emergency planning, and provision of long-term surveillance care for radiation survivors. Enhanced education of family medicine providers regarding the clinical presentation of ARS and appropriate consultation and referral pathways would improve community-level preparedness. Pharmacologic interventions including potassium iodide, prussian blue, and chelating agents represent evidence-based medical countermeasures effective for specific types of internal contamination. The pharmacist role in managing these agents, ensuring appropriate dosing and administration timing, and monitoring for adverse effects represents an essential component of comprehensive pharmaceutical care in radiation emergency response.

Future Directions

Future enhancements to radiation emergency preparedness should include:

1. Standardized, competency-based education for all healthcare professionals
2. Regular interprofessional simulation-based training and drills
3. Development of streamlined consultation pathways facilitating rapid access to radiation medicine expertise
4. Establishment of distributed expertise networks enabling primary care and community-based providers to access guidance from specialists
5. Integration of family medicine and nursing into community and health system radiation emergency planning

The interprofessional approach to radiation emergency response, when effectively implemented through coordinated planning, education, and practice, can optimize patient outcomes, protect healthcare workers and emergency responders, and preserve the function of healthcare systems during radiological incidents. The essential contributions of nursing professionals and family medicine physicians to this interprofessional response must be formally recognized and incorporated into comprehensive radiation emergency preparedness programs.

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