



National nurse readiness for radiation emergencies and nuclear events: A systematic review of the literature

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ABSTRACT

Background: Little is known regarding the capacity of U.S. nurses to respond following a large-scale radiation release, despite its relevance to our National Security Strategy.

Purpose: To conduct a systematic review of the literature to assess nurse readiness for radiation emergencies and nuclear events.

Methods: A systematic review of publications identified through a comprehensive search of four relevant databases (Embase, PubMed/Medline, Scopus, and Web of Science) was conducted ($n = 62$).

Findings: Limited evidence exists to support that nurses are prepared or willing to respond to a large-scale emergency resulting from a radiation release or nuclear-level event.

Discussion: History suggests nurses will be expected to perform triage, minimize radiation exposure, decontaminate, manage trauma, treat burns, and coordinate care for patients. Research is needed to identify the specific roles and responsibilities of nurses in radiation emergencies and nuclear response and to ascertain quantitative measurement of the level of national nurse readiness for these large-scale radiation emergency and nuclear events.

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Introduction

Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.

Marie Curie

Current instability in the global geopolitical climate has made the exchange of nuclear weapons or a terrorist attack upon a nuclear power plant a potential reality. Should either of these events occur a public health emergency of international concern would result. Apprehension regarding the capacity of our national health care system to respond to a major radiation event involving either the accidental or deliberate release of ionizing radiation is of paramount importance to the Office of the Assistant Secretary for Preparedness and Response, the Centers for Disease Control and Prevention, the U.S. Department of Homeland Security, and the U.S. Department of Defense. The government's heightened attention revolves around the ubiquitous risk of several potential disaster scenarios including radioactive dispersal devices, subversive assault on national energy sources such as nuclear power plants, large-scale industrial releases, and surreptitious placement of radioactive materials. Escalating these concerns is the growing tension between the U.S. government and other countries (Russia, China, and North Korea in particular) in possession of nuclear weaponry. Nuclear proliferation has persisted since the end of the cold war and nine countries are known to stockpile nuclear weapons (Burkle & Dallas, 2016). A nuclear detonation would have devastating results and there would be limited time to take critical protection steps. Despite the fear and chaos surrounding such an event, planning and preparation can lessen deaths and illness and research supports that lives can be saved if a rapidly deployed and robust multidisciplinary health response exists.

As the largest component of the health care sector, nurses and advanced practice nurses will be critical to an effective public health response to any event involving a major radiation release. In fact, nurse readiness is critical to supporting the National Health Security Strategy. Despite this certainty, little is known regarding the capacity of U.S. nurses to respond following a radiation dispersal device (RDD) event. Federal officials, public health, and policymakers require a substantive body of evidence on which to base clinical response initiatives if they wish to effectively plan, prepare for, and mitigate the impact of a large-scale radiation release or detonation of a nuclear weapon (RDDs) on the U.S. and global population. The purpose of this study is to conduct a systematic review of the literature to assess nurse readiness for radiation emergencies and nuclear events. Ultimately, this evidence could be used by federal officials and public health leaders to advocate for greater preparedness initiatives and inform national and international radiation/nuclear disaster workforce policy.

Methods

Search Strategy

In order to capture the broad scope of variables impacting nurse readiness for radiation emergencies and nuclear events, a systematic review of the literature was conducted using a modified Preferred Reporting Items for Systematic Reviews and Meta-Analyses approach (<http://www.prisma-statement.org/>, 2018). This framework provides for a guided search and review method with prespecified inclusion and exclusion criteria, definition of terms, and documentation of selection decisions, as recommended by Moher, Liberati, Tetzlaff, Altman, and Group (2009). A systematic review is a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, as well as to collect and analyze data from the studies that are included in the review. A detailed search strategy was developed in collaboration with an expert medical librarian at the National Academy of Medicine Center for Research in Washington, DC. In total, a series of four progressive literature searches with specific search terms were executed in order to ensure broad coverage of the topic (Table 1).

The initial search strategy identified 1,795 published works (Figure 1). Two additional studies were located by reviewing the references of these published works. Duplicates were removed (1,638), and the titles and abstracts of the remaining 159 published works were reviewed by the research team (T.G.V., R.L., A.B., C.P.T., S.S.F.) for relevance to the question at hand. Of these, 86 papers were removed, as they did not meet the inclusion criteria. A second review of the published works excluded an additional 11 articles that did not fully meet the inclusion criteria. In total, 62 articles met inclusion criteria and were retained for analysis. Thematic analysis was conducted by the study team (T.G.V., R.L., A.B., C.P.T.) to identify the key concepts or major themes, and a second round of analysis was conducted to identify sub-themes and factors associated with nurse readiness that may be amenable to mitigation. The two-tiered review of the articles supported many of the previously identified trends in the literature review and surfaced no new ideas, indicating that thematic saturation had been achieved.

Inclusion Criteria

A summary of inclusion criteria, exclusion criteria, and selection process is depicted in Figure 2. To ensure timeliness and relevance studies were extended back to 1979 (1979–2018) in order to capture three sentinel global radiation disaster events: Three Mile Island in 1979, Chernobyl in 1986, and Fukushima-Dai-ichi in 2011. International literature published in English was included and definitions of key terms are listed in Figure 3.

Table 1 – Search Strategies and Terms

Search Strategies	
Literature searches	<ol style="list-style-type: none"> 1. Nursing Terms AND Nuclear/Radiological Terms AND Emergency Preparedness Terms 2. Nursing Terms AND Nuclear/Radiological Terms AND Workforce Terms 3. Nursing Terms AND Willingness Terms 4. Nursing Terms AND Nuclear/Radiological Terms AND Willingness Terms
Search terminology	
Nursing terms	Emergency nursing (MeSH), Hospital nursing staff, Nurse participation, Nurse Practitioners (MeSH), Nurse's role (MeSH), Nurses (MeSH), Nurses, Community Health (MeSH), Nurses, Public Health (MeSH), Nursing (MeSH), Nursing staff (MeSH), Nursing staff, hospital (MeSH), Nursing workforce
Nuclear/radiological terms, nuclear accidents	Accident, nuclear (MeSH), Chernobyl nuclear disaster (MeSH), Fukushima nuclear disaster (MeSH), Nuclear accidents, Nuclear detonation, Nuclear power accident, Nuclear power plant accident, Radiation emergency, Radiation hazard, Radiation injuries (MeSH), Radioactive contamination, Radioactive fallout (MeSH), Radioactive Hazard Release (MeSH), Radioactive release, Radiological dispersal, Three mile island disaster
Nuclear/radiological terms, nuclear attack/nuclear war	Atomic warfare, Dirty bomb, Nuclear attack, Nuclear detonation, Nuclear disaster, Nuclear missiles, Nuclear strike, Nuclear terrorism, Nuclear war, Nuclear warfare (MeSH), Nuclear weapons (MeSH), Radioactive dispersal devices, Radiological terrorism
Emergency preparedness terms	Civil defense (MeSH term for emergency preparedness), Clinical decision making (MeSH), Decision making (MeSH), Decontamination (MeSH), Delivery of health care (MeSH), Emergency care (MeSH), Emergency health service (MeSH), Emergency hospital planning, Emergency medical services, Emergency planning Emergency Preparedness, Emergency response, Emergency response system, Medical surge, Public health preparedness, Radiation response, Skin decontamination, Surge capacity (MeSH), Surge response, Transport
Willingness terms	Attitude of health personnel (MeSH), Belief in duty to care, Health personnel attitude, Willing, Willing to do, Willingness, Willingness in disaster, Willingness to care for patients, Willingness to provide care, Willingness to report to duty, Willingness to report to work, Willingness to work in disaster, Work in disaster

Data Evaluation and Study Quality

The authors independently assigned an evidence level and corresponding quality grade as outlined by [Dearholt and Dang \(2017\)](#). Inter-rater reliability was calculated to be 0.90. Evidence levels were defined as level I: experimental study, randomized controlled trial, level II: quasi-experimental study, level III: non-experimental study or systematic review, level IV: opinion of respected authorities and/or nationally recognized expert committees/consensus panels, and level V: case reports or expert commentary based on experiential and nonresearch evidence. In order to assess the quality of these studies, the authors used the critical appraisal tool as outlined by [Crowe and Sheppard \(2011\)](#), and [Crowe \(2013\)](#) which yields a score between 0 and 40. This tool is best utilized for studies with evidence levels I to III and, as such, was not used to review works graded as level IV or V. The scores were translated to percentages and recorded in [Table 2](#).

Findings

Review and categorization of the key findings ([Table 3](#)) revealed that the thematic analysis ([Table 4](#)) is grouped around the following topics: (a) Preparedness/

Capacity, (b) Education/Training, (c) Role, (d) Willingness to Respond, (e) Health Hazards/Perception of Risk, and (f) Clinical Practice.

Preparedness/Capacity

Thirteen articles addressed preparedness for radiological disasters or the capacity of health care and other systems of governance to respond effectively in the aftermath of a radiological event. The studies chosen reflected a range of perspectives, disciplines, and settings, including Japan, Ireland, Australia, the United Kingdom, and the United States. Many of the articles shared a common theme emphasizing the overall lack of preparedness and capacity for responding to a disaster event involving a radiological device.

Preparedness

[Hick et al.'s \(2011\)](#) article describes a step-by-step play-book for emergency medical services and hospital staff following such an event, reviewing critical and secondary needs of patients. The authors warn that the first wave of patients will likely be those with burns or trauma, and stabilization of the largest number of victims possible and decontamination once immediate threats to life have passed are key takeaway points ([Hick et al., 2011](#)). The importance of planning for a radiological event is underscored by its high probability of occurrence and widespread impact on the U.S.

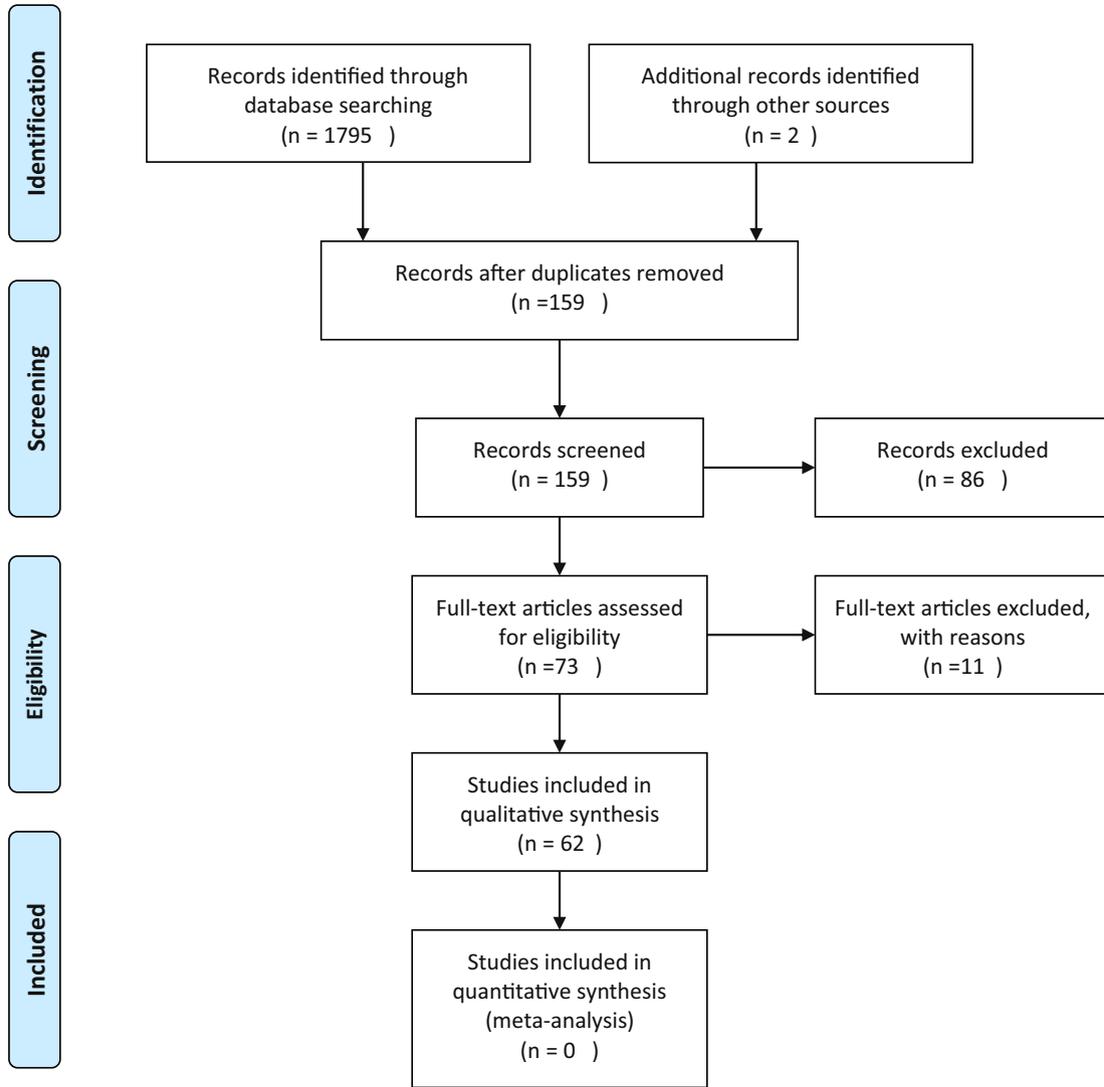


Figure 1 – PRISMA flow diagram.

population, according to [Tan, Barnett, Stolz, and Links \(2011\)](#), who presents a framework for local governments, using Baltimore as a case example. System

wide preparedness involves many sectors of a given municipality and drafting a workable plan ([Tan et al., 2011](#)). However, surveys of health care providers, all of

Inclusion and Exclusion Criteria	
Search Terms	
<ul style="list-style-type: none"> See Table 1 	
Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> Published in a peer-reviewed publication Focus on nursing workforce (nurses, advance practice nurses, emergency nurses) Purpose of the study was to address nurses role/readiness for radiation emergencies and/or nuclear events Focus on radiation dispersal events Dates Limited to 1979-2018 English language 	<ul style="list-style-type: none"> Outside the peer-reviewed publications Focus on other disasters (bioterrorism, pandemic influenza) Focus on other health care providers Focus on radiation therapy, radiation imaging Focus on health systems Publication date prior to 1979 Non-English language

Figure 2 – Inclusion and exclusion criteria.

Definitions

Disaster – A disaster is defined as: “a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts” (UNISDR, 2017).

Radiation Emergency - A radiation emergency is defined as any unplanned event involving nuclear materials or radiation producing devices that may result in an increased exposure of individuals to ionizing radiation (University of Pittsburg, 2018).

Nuclear Detonation - A nuclear blast releases massive amounts of energy, which dissipate as a [fireball](#), [blast forces/waves](#), [prompt radiation](#), [light and heat \(thermal energy\)](#), and [delayed ionizing radiation](#) (i.e. fallout: nuclear fragments created in the fission process which turn into radioactive elements). A nuclear emergency can involve the explosion of a nuclear weapon or improvised nuclear device (IND) (DHHS/REMMS, 2018).

Figure 3 – Definitions.

which included nurses, have returned results indicating that many providers and the systems in which they work do not have adequate plans in place for managing radiological disasters safely and effectively. One of the largest surveys of health care workers in the United States found that only 45% of 1,334 staff met the baseline criteria for preparedness using the CDC’s checklist for personal disaster preparedness (such as stockpiling water and a 3-day “Go Bag”) (Brice, Gregg, Sawyer, & Cyr, 2017). Another survey of 59 hospital staff at an urban emergency department (19% of whom were nurses) found overall knowledge and clinical competency related to radiological disaster management to be quite low (66%); with nurses scoring significantly lower than physicians on several domains of the survey instrument (Kotora, 2015). Knowledge about radiological disasters as part of a larger terrorist threat was also low among 95 nursing students, where Young and Persell (2004) found an incongruence between nursing faculty’s claims that chemical, biological, radiological, nuclear (CBRN) material was covered in their curriculum and the nursing students’ inaccurate understanding of the pathogenic nature of these agents.

Concerns about adequate preparedness for radiological events are not limited to the United States. Mitchell, Kernohan, and Higginson (2012) administered a questionnaire regarding preparedness for a CBRN event to 50 nursing staff working in three emergency departments across Northern Ireland. The authors identified several areas for improvement related to preparedness, foremost among which was decontamination procedures, knowledge of Incident Chain of Command, and appropriate usage of personal protective equipment (Mitchell et al., 2012). Tan and Fitzgerald (2002), in an article describing the capability of a CBRN to shut down an entire emergency department that does not have an adequate response plan in place, list critical needs as including personal protective equipment for all staff (and training on how to use this equipment), as well as drills involving decontamination and stockpiling supplies of materials and medicines. However, the authors indicated that the majority of

emergency departments in Australia lack these supplies (Tan & Fitzgerald, 2002). In New Zealand, a survey of 911 acute care providers (88% of whom were nurses) found that confidence in dealing with CBRN events was associated with strong overall preparedness of acute care providers to respond to a mass emergency (Al-Shaqsi, Gauld, McBride, Al-Kashmiri, & Al-Harthy, 2015). Nurses were less likely than paramedics to have had formal training in mass emergency events (46.9% nurses vs. 79.2% paramedics), and fewer nurses had participated in a mass emergency drill than paramedics (54% vs. 80.7%, respectively) (Al-Shaqsi et al., 2015). System wide preparedness is also an issue: in the U.K., 16 (89%) of 18 health districts with nuclear sites in their catchment areas had plans for the distribution of stable iodine in the event of a nuclear disaster, yet the majority of these plans concentrated only on a small area around the site. Plans typically involved distributing tablets to local centers for distribution by community nurses and did not describe the role of emergency medical services; meanwhile, two districts did not have any plans whatsoever (Millership, 1998). Finally, Wilkinson (2006) describes the need for nurses to remain attuned to a chemical agent as a possible cause for a patient presenting with mysterious symptoms, a chemical agent could be causative, using the poisoning of former spy Alexander Litvinenko as a case example.

Capacity

A crucial step toward preparedness for radiological emergencies is assessing organizational or system capacity for managing such an event. Here, three studies—one from the United States and two from Japan—demonstrate several of the challenges associated with identifying gaps and building adequate capacity for radiological events. An overall lack of familiarity with radiological disasters was identified by Bayram et al. (2013) as a possible explanation for the high degree of variance and lack of consensus among a panel of 23 interdisciplinary health care experts, including five (21.7%) nurses, who participated in mock exercises representing four different disaster scenarios, and then worked together to identify critical hospital resources for that

Table 2 – Research Report Type, Purpose, Methods, and Sample Characteristics

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Adair (2005)	The Washington State Department of Health provided ongoing training for radiological events to first responders.	Symposium Presentation	West Coast USA	N/A training designed for first responders	IV	N/A
Adams and Berry (2012)	To discuss the need for essential personnel in a health care setting following a disaster, and to review the literature related to adequate disaster staffing. The article includes an examination of the ability and willingness of health care personnel to report to work during a disaster.	Descriptive, exploratory study using an instrument (Qureshi's Disaster Survey) to assess willingness and ability to report to work during a disaster (N = 1,342). Respondents were nurses and other clinical and nonclinical health care staff at a community-based health care network consisting of 6 inpatient facilities.	Midwestern USA	Stratified; convenience; snowball	III	N/A
Adelman et al. (2014)	To inform nurses who may have little experience dealing with victims of a radiological disaster how to set up a response area that protects the hospital and staff from radiation exposure, which includes establishing a knowledge base of the different types of exposure and the treatment of each.	Review of literature and relevant task force guidelines/reports.	United States	N/A—directed at nurses/hospital staff	IV	N/A
Alder-Collins (2013)	To comment and offer a critical reflection on the role of nurses in the Fukushima Dai-ichi disaster.	Commentary	Japan/International	N/A	V	N/A
Al-Shaqsi et al. (2015)	To assess the self-reported training and experience of New Zealand acute care providers to respond to mass emergencies and the factors associated with strong preparedness.	Cross-sectional national survey of 1,500 acute care providers (doctors, nurses, and paramedics) between 2009 and 2010 which assessed experience, training, and self-reported preparedness.	New Zealand	Stratified; convenience	III	90%
Arbon et al. (2013a)	To explore Australian nurses' willingness to attend work during a disaster and the factors that influenced their decision.	Qualitative, descriptive study involving five focus groups (N = 41) and interviews (N = 13) of RNs from four emergency departments.	Australia	Convenience	III	95%
Arbon et al. (2013b)	To determine the extent to which Australasian emergency nurses are willing to attend their workplace in a disaster.	Exploratory and descriptive study design using online and paper-based surveys of emergency nurses from two emergency nursing colleges and four Australian hospitals.	Australia	Stratified; convenience	III	95%
Balicer et al. (2011)	To understand hospital-based providers' willingness to report to work during an influenza pandemic, using Witte's Extended Parallel Process as a framework for examining scenario-specific willingness to respond among hospital staff.	An anonymous, online EPPM survey about attitudes and beliefs was distributed to all 18,612 employees of Johns Hopkins Hospital, and was completed by 3,426 employees (one-third of whom were health care professionals).	Baltimore, MD, United States	Convenience	III	100%
Bayram et al. (2013).	To identify critical hospital resources required in four specific catastrophe scenarios: pandemic influenza, radiation, explosive, and nerve gas.	Expert consensus panel of 23 health providers (nurses and physicians), administrators, emergency planners, and specialists to examine the four disaster scenarios and asked to consider 132 hospital patient care resources in order to identify the ones most critical to patient care.	United States	Purposive	IV	N/A

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Beauchamp (2016)	Review article on the fear of all hazards disaster with an emphasis on radiation disasters	The article presents two scenarios” (a) a sealed source that is open and exposes workers, and (b) a workplace accident victim is presenting to the emergency department from a radioactive waste disposal center. A detailed overview of the necessary response, safety measures, and treatment is provided.	United States	N/A	V	N/A
Becker and Middleton (2008).	To understand how clinicians in the emergency department perceive the threat of terrorist incidents involving radioactive materials.	A series of 10 focus groups with 77 participants total who were all Emergency Department (ED) physicians and nurses in 3 parts of the US. Participants considered hypothetical scenarios involving a “dirty bomb” and discussed their perceptions, concerns, information needs, preferred information sources, and views of current guidance and informational materials	United States	Purposive	III	90%
Ben-Ezra et al. (2013)	To compare the reactions of hospital personnel and civilians after exposure to a unique disaster that combines natural and nuclear disaster.	Exploratory study utilizing a brief questionnaire tapping into post-traumatic stress disorder (PTSD) symptoms, subjective health, coping, life satisfaction, and meaning in life administered to a matched sample of 34 nurses and 39 civilians exposed to the 2011 Tohoku earthquake and tsunami. Descriptive statistics and t-tests revealed differences between the two groups on measures of interest.	Japan	Purposive	III	95%
Brice et al. (2017)	To understand personal disaster preparedness for disaster among hospital staff, as previous studies have shown low intent of staff to report to work in the event of a large-scale disaster.	Cross-sectional surveys distributed to 1,334 hospital staff via paper or Web. Descriptive, bivariate, and multivariate analyses measured associations between demographic factors, personal preparedness, and willingness to work.	United States	Convenience	III	97.5%
Cabrera and Beaton (2009).	To describe the hazards related to radiological dispersal devices (RDDs) and provide resources to support the roles of occupational health nurses in the event of an RDD disaster occurring at or near their workplace.	Literature review describing characteristics of an RDD and outlining the role of occupational health nurses in planning and preparing for an RDD event, responding to an RDD event, and recovery from RDD.	United States	N/A	V	N/A
Dainiak et al. (2006).	To provide specific information and guidance for the efficient management of radiation victims during their early encounter in a hospital. in a practical manual for clinicians	Expert consensus panel convened to write a practical manual for clinicians (radiation oncologists, ED physicians, and nursing staff), hospital administrators, safety officers, and others involved in the care and treatment of radiation victims and/or radiation monitoring to use for evaluation and management of radiation injury.	United States	N/A	IV	N/A

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Goto et al. (2014)	Evaluate the efficacy of a health literacy training program on the ability to augment communication skills in order to change communication practices and norms among public health nurses and improve access to information for community residents	Post-test assessments completed by 26 nurses who were in attendance of the learning sessions.	Japan	Post-test	II	80%
Goto et al. (2015).	To evaluate a training program to increase health literacy for postdisaster management among public health nurses at multiple sites in Japan.	Pre- and post-training assessment of nurses' training satisfaction, self-evaluation of achievements regarding training goals, and the application of learned skills via quantitative and qualitative methods.	Japan	Cluster	II	95%
Goto (2016)	To examine postdisaster public health activities with a primary focus on parenting support following the Fukushima disaster.	Observational study and report of the provision of parental support services based on a secondary analysis of data collected by the Fukushima Health Management Survey and the direct observation of public health nurses working to support families affected by the disaster in Fukushima Prefecture.	Japan	Convenience	III	97.5%
Goto et al. (2018)	To evaluate a series of health literacy workshops provided to public health nurses following the Fukushima disaster, where misinformation and a lack of guidance from the central government led to widespread mistrust of health officials in the community.	Development of a toolkit for public health nurses via (a) drafting a glossary of key terms and an index; (b) rigorous pilot testing among nurses for needed clarification and revision, and (c) field testing the packed materials (glossary and index) in practice.	Japan	Purposive	II	77.5%
Heinrichs et al. (2010)	To determine whether a virtual emergency department populated with virtual patients suffering from a radiological "dirty bomb" blast and others suffering from exposure to chemical nerve toxin is an effective clinical training environment for ED physicians and nurses.	Observation, evaluation, and postscenario questionnaire of 10 physicians and 12 nurses who participated in a virtual practice scenario with patients who had been exposed to a nerve toxin or radioactive blast.	United States	Purposive	II	100%
Hick et al. (2011)	To describe how a nuclear detonation incident may unfold for the various components of the health and medical systems and outline discipline-related actions related to state and local planning.	Report based on response principles, triage and initial trauma care, emergency medical services, health care facility response including hospital impact and radiologic injury and decontamination, and subsequent hospital response issues related to unaccompanied minors, transportation infrastructure, and coordination with the public health system.	United States	Expert review	IV	N/A
James (2006)	To describe effective response activities among hospital nursing staff and radiology nurses in the event of a radioactive accident or terrorist event.	Discussion of Nursing's role in response to radiological disasters and radiological events.	United States	Literature review	IV	N/A

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Kako et al. (2014)	To review the Japanese literature and present, in English, key themes related to nursing roles in the postdisaster management of the Fukushima nuclear plant explosion.	Thematic analysis following a systematic review of the Japanese medical and nursing literature, with 44 articles meeting inclusion criteria and 3 key themes emerging from the analysis.	Japan	Systematic	III	100%
Kawasaki et al. (2015)	To describe public health nurses' experiences in caring for patients following the Fukushima nuclear incident.	Questionnaire of 44 nurses before a radiation workshop and subsequent interviews using qualitative analysis.	Japan	Purposive	II	100%
Kenar and Karayilano-glu (2004)	To describe the goal of forming a team of physicians, nurses, and paramedics assigned to military medical intervention units and the practical application of the team in a chemical attack scenario.	Report of simulated scenario involving a chemical attack.	Turkey	Purposive	IV	N/A
Kinugasa (2007).	To report on the successful education and training of clinicians in Japan regarding treatment of emergency cases involving radiation accidents.	Description of a report on a training program for clinicians over a 5-year period in Japan regarding treatment of emergency cases involving radiation accidents/exposure.	Japan	N/A	II	87.5%
Konishi et al. (2016)	To report on the development and implementation of a class on radiation education offered to undergraduate public health nursing students in Japan.	Case study of a 90-min radiation class in an undergraduate public health nursing course in Tokyo. The class involved lectures and discussion on technical and environmental aspects necessary for basic radiation knowledge. Sixty-one students participated in a free writing exercise about their class experience, which was qualitatively analyzed.	Japan	Purposive	II	100%
Kotora (2015)	To evaluate the preparedness of physicians, nurses, and other health care providers to treat victims of chemical, biological, radiologic, nuclear, and explosive agents in an urban emergency department.	Retrospective, observational survey study of 59 health care providers using a previously constructed questionnaire instrument assessing the knowledge and level of preparedness of physicians, nurses, and midlevel providers.	United States	Stratified; random	II	97.5%
Litchfield (2011)	To address individuals' fear of radiation and provide resources to occupational health nurses so they can answer patients' questions and dispel myths.	Commentary on the state of the science discussing fear of radiation and clinical practice guidelines for occupational health nurses	United States	N/A	IV	N/A
Matsunari; Nakao (2013)	To describe the situation with respect to nursing care conducted immediately before and after the atomic bombing Nagasaki in 1945.	Voluntary participation of nurses to be interviewed regarding their experience around the time around the time of the atomic bombing	Nagasaki, Japan	Purposive	III	NA
McKay (1989)	To discuss the lack of coverage of nuclear issues in nursing journals and professional nursing literature.	Discussion of the importance of educating nurses on nuclear events	United States	N/A	V	N/A
Millership (1998)		Nuclear emergency plans from health districts with nuclear sites in their boundaries were	United Kingdom	Cluster	IV	N/A

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Mitchell et al. (2012)	To examine alternative solutions to some of the practical problems revealed by an emergency exercise involving a nuclear incident. To examine emergency department staff preparedness in responding to a chemical, biological, radiological, nuclear, and explosive incident and to identify where nurses require training in order to improve their preparedness for such an event.	reviewed and categorized according to a pre-defined list of criteria. Questionnaire assessing competency distributed to 50 nursing staff in emergency departments in Northern Ireland. Descriptive statistics and content analysis were used to analyze the surveys.	Ireland	Stratified	III	100%
Nair et al. (2017)	To provide an overview for medical professionals how to manage victims with radiation injuries involving step-by-step evaluation of the damage, the kind of treatment required, and the regular monitoring of the patient.	Clinical practice guidelines for the management of victims of nuclear events	India	N/A	IV	N/A
Niska and Burt (2006)	To determine which hospital characteristics are associated with providing terrorism-preparedness training to clinical staff using an estimation of baseline data.	Retrospective secondary analysis of the Bioterrorism and Mass Casualty Supplement to the 2003 and 2004 National Hospital Ambulatory Medical Care Survey to provide national estimates of variations in terrorism-preparedness training according to eight hospital characteristics.	United States	Stratified	III	100%
Noto et al. (2013)	To describe the activities of the Radiation Exposure Research Team and the role of nurses in a nuclear disaster, following the Fukushima disaster.	Case scenario of the Radiation Exposure Research Team's day-to-day activities in the wake of the Fukushima nuclear incident.	Japan	N/A	V	N/A
Nomura et al. (2016)	To assess associations between evacuation and mortality after the Fukushima nuclear incident; and to present discussion points on disaster planning, with reference to vulnerable elderly populations.	Data were mined from a previous survival analysis from five of eight care homes in Minamisoma. 1215 residents admitted to elder care facilities that are located 20 to 40 km from the nuclear plant in a 5-year period before the incident. Records were assessed for demographic and clinical characters were evaluated and hazard ratios assessed in evacuees vs. nonevacuees.	England	Retrospective case-control	II	95%
Ochi et al. (2016)	Fear of radiation exposure after the Fukushima incident led many hospital staff members to fail to report to work. The authors measured the shortage in hospital staff and to compare the difference by categories of hospital staff in seven hospitals around the site of the Fukushima incident.	Retrospective records were extracted from seven hospitals and change in the number of staff was analyzed.	Japan	Convenience	III	95%

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Qureshi et al. (2005).	To understand responsiveness of an urban health care system in the event of a catastrophic disaster by surveying providers in New York City to determine their ability and willingness to report for work during various disaster events that would create surge capacity needs.	Cross-sectional survey of 6,428 health care workers from 47 health care facilities in New York City and the surrounding metropolitan area.	New York, NY., United States	Cluster; random	III	95%
Ross (1984)	Description of the Royal College of Nursing's thoughts on the implications that a nuclear war or mass nuclear event would have on the nursing workforce	Review of the Royal College of Nursing's working party on nuclear events	London, England	N/A	V	N/A
Salazar et al. (1999).	To describe occupational health hazards at 10 Department of Energy sites given the mission of the U.S. Department of Energy has recently changed from nuclear weapons production to site remediation.	Cross-sectional survey distributed to employees at 10 Department of Energy sites to describe and compare (a) the primary hazards associated with the site activities, (b) the occupational safety and health structure, and (c) the occupational health and safety functions.	United States	Convenience	III	92.5%
Sato et al. (2015).	To clarify the factors associated with nurses' intention to leave their jobs during the radiation emergency caused by the Fukushima Dai-ichi nuclear power plant accident.	Cross-sectional, prospective survey of 345 nurses about intention to leave after the accident, demographic factors, living situation, working status, and knowledge of radiation health effects.	Japan	Convenience	III	95%
Shabanikiya et al. (2016)	Aimed to identify characteristics of hospital administrators that are important in the effective management of surge capacity in disasters.	Qualitative study using semi-structured interviews with 28 hospital administrators who had experienced working in surge situations. Framework analysis was used to analyze the data.	Iran	Purposive	III	100%
Skorga et al. (2003)	To describe the assessment and treatment regimens of caring for victims of radiological injuries from a nursing perspective, with an emphasis on considering the psychological aspects and needs of pediatric and geriatric patients.	Clinical practice guidelines for patients who are victims of nuclear events and radiation exposure	United States	N/A	IV	N/A
Subbarao et al. (2006)	To assess whether a high-fidelity, mannequin-based (HFMB) educational modality including simulation and clinical vignettes is an effective means of training first responders in the event of a chemical, biological, radiological, nuclear, and explosive (CBRNE) event.	HFMB simulation and video clinical vignettes were used to create a simulation-based CBRNE course. The participants were evaluated using a 43-item pre- and post-test that employed 12 video clinical vignettes as scenarios for the test questions. Results were analyzed according to the various medical training backgrounds of the participants, who were all first responders and receivers.	United States	Purposive	II	100%

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Suzuki and Kim (2012)	To review the aftermath of the Fukushima Dai-ichi power plant disaster and its ramifications for local networks providing community mental health support to survivors.	Historical account of mental health care system following the 2011 earthquake, tsunami, and nuclear power plant accident in Japan.	Japan	N/A	IV	N/A
Tan et al. (2011)	To provide a starting framework for local governmental efforts toward developing a response plan for radiological incidents in their communities by describing in detail the stepwise approach Baltimore City took toward developing their own plan for radiological preparedness.	Evidence-based synthesis/literature review and stepwise approach to developing a framework and protocol for preparing city planners and responders for radiological emergencies.	Baltimore, MD., United States	Systematic	IV	N/A
Tan and Fitzgerald (2002)	To demonstrate how an emergency department in a tertiary referral center can implement a chemical, biological, and radiological (CBR) response, and to heighten awareness of CBR response among the medical community in Australia.	Review of guidelines and protocols from the U. S. and Israel, and expert consultation from committee representatives of the hospital's Infectious Diseases unit, Nuclear Medicine and Radiation Safety officers, the Engineering Department, Medical Administration, the Manager for Workplace Health and Safety, and the Emergency Response and Workcover Officer.	Australia	N/A	IV	N/A
Veenema and Karam (2003)	To describe the low levels of risk typically posed by radiation and the care of individuals exposed to radiation. Universal precautions should be used, and it is often safe for nurses to ensure hemodynamic stability before initiating decontamination and other radiation-related therapies.	Literature review describing basic radiation physics and health effects from radiation exposure.	United States	N/A	IV	N/A
Veenema et al., 2008	To develop and apply a rapid survey evaluating hospital-based nurses' knowledge, self-assessed clinical competence, perception of personal safety, and willingness to respond in the event of a radiological emergency.	Cross-sectional survey using a purposive sample of 668 hospital-based nurses to respond to the Radiation Survey, a rapid, self-administered questionnaire developed to assess knowledge, attitudes, and behavior with regard to radiation emergencies.	New York, U.S.	Purposive	III	100%
Veenema; Thornton (2015a)	To examine the peer-reviewed literature on nursing clinical guidance for managing radiation/nuclear disasters.	Integrative literature review to produce clinical practice guidelines and evidence-based interventions for victims of radiation exposure	United States	N/A	III	97.5%
Veenema and Thornton (2015b)	To provide guidance for the optimal management of a patient surge after a radiologic disaster, which is lacking in nursing schools or professional development programs. Nurses require a substantive body of knowledge of skill on which to base public health as well as acute response efforts.	Overview of clinical practice guidelines for nursing's response to radiation events and discusses and discusses nursing's role in the overall response to nuclear events	United States	N/A	IV	N/A

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Waeckerle et al. (2001)	To assess the needs, demands, feasibility, and content of training for civilian emergency medical responders (paramedics, nurses, and physicians) for nuclear, biological, and chemical (NBC) terrorism.	Task force/expert consensus panel consisting of key stakeholders and professional disciplines conducted an iterated instructional-design analysis on the feasibility and content of such training with input from educational professionals. Six previously developed training courses were analyzed to examine congruence with expert recommendations.	United States	Systematic	IV	N/A
Wetta-Hall et al. (2006)	To evaluate the effectiveness of a terrorism-preparedness training program on the perceptions, attitudes, and beliefs of nurses in a continuing education setting.	A 1-day training program addressed the HRSA four core competences outlining nursing response to terrorism. A volunteer sample of 15 nurses participated in a focus group after the training to discuss their perceptions of the training.	Kansas, United States	Stratified; convenience	II	100%
Wilkinson (2006)	To describe the risks posed by “mystery” illnesses and the importance for nurses to be prepared to treat patients who present with strange symptoms, using the poisoning of Alexander Litvinenko as a case example.	The case of Alexander Litvinenko, a former spy who was poisoned with polonium-210 and treated by hospital staff for three weeks before anyone discovered what was causing his illness, is presented as a case vignette with descriptions of the biological and chemical properties of the agent, resources for learning more about radiation exposure and effects, precautions, and decontamination.	United Kingdom	Vignette/ case example	V	N/A
Williams and Williams (2010)	To summarize the likely series of events following a radiological dispersal device or “dirty bomb” explosion and implications for emergency nursing staff.	Integrative review of peer-reviewed literature and agency guidelines to describe the properties of a radiological dispersal device, the likely sequence of events following an explosion (likely involving multi-agency coordination between the military, police, and bomb disposal experts), and the nursing tasks that ED staff can expect to carry out.	United Kingdom	N/A	IV	N/A
Willis and Coleman (2003)	To describe the processes nurses taking care of adults need to understand in order to appropriate care for patients of radiation blast injuries and radiation exposure.	Discussion of clinical practice guidelines in caring for victims of a dirty bomb	United States	N/A	IV	N/A
Yamada et al. (1999)	To describe the prevalence of dementia and its subtypes in Japan and to investigate the relationship of risk factors, such as demographic features and disease history.	Longitudinal cohort study of atomic-bomb survivors and controls recruited from Hiroshima and Nagasaki using the 1950 Japan census and an atomic-bomb survivors’ survey. Subject data included biennial medical examinations and screening for cognitive impairment.	Japan	Stratified; random	III	97.5%

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Table 2 – (Continued)

Study	Study Purpose	Methods	Geographic Area	Sample Design	LOE	CAG
Yamshita et al. (2016)	To describe the steps taken by the Fukushima Health Management Survey to monitor and characterize the levels of radiation exposure sustained by the population of Fukushima following the power plant explosion.	Descriptive narrative of steps taken and detailed surveys administered to residents of Fukushima prefecture.	Japan	N/A	IV	N/A
Yoshida et al. (2016)	To assess radiation-related anxiety and stress among public health nurses in the Fukushima prefecture after the nuclear power plant explosion.	Cross-sectional survey administered via mail to 430 public health nurses in Fukushima asking them to rate their level of anxiety about radiation according to the Sense of Coherence scale. High and low levels of anxiety were classified according to answers about radiation.	Japan	Simple random	III	100%
Young and Persell (2004)	To identify how nursing students might practice as caregivers for victims of chemical, biological, or nuclear terrorism.	Descriptive study utilizing cross-sectional survey of 95 junior and senior baccalaureate students in nursing. The questionnaire consisted of 19 items that identified demographics and perceptions and concerns regarding willingness to work, preparedness, expectation of future terrorist events, effect on lifestyle, and other fears related to terrorism or caring for the victims of it.	Southern United States	Convenience	III	100%
Yuko et al. (2008)	To clarify the nursing care conducted just prior and just after the atomic bombing of Hiroshima in 1945.	Face-to-face interviews with five surviving nurses who provided care to victims following the atomic bomb drop in Hiroshima.	Japan	Purposive	III	92.5%

Table 3 – Key Findings

Year	Study	Key Findings
2005	Adair	The Washington State Department of Health provided ongoing training for radiological events to first responders. The training and the method of delivery is discussed.
2012	Adams & Berry	Ability to report to work during a disaster scenario ranged from a low of 71.1% for tornado/flooding to 90.6% for an explosion with mass casualties. Willingness to report ranged from a low of 69.1% to a radiologic event to 93% for an explosion with mass casualties. Responsibility for children produced the highest number of significant and meaningful differences, but responsibility for pets/livestock, elder care, type of position at the health care setting, and having a spouse or partner expected to report to work during the same scenario also produced significant differences between respondents' ability and willingness to report to work.
2014	Adelman, Theiss & Goudounis	The article discusses the role of the hospital-based nurse in responding to various situations emanating from a radiological disaster, including (a) detonation of explosives with dirty bombs; (b) placement of radiation materials in public places; (c) attacks on nuclear sites or release of radiation from a power plant; (d) accidents involving vehicles transporting radioactive isotopes; (e) contamination of water or food supplies, and (f) detonation of a nuclear explosive device. Staff may have to deal with two types of victims, including those who were at the scene but decontaminated there and those who were not. Setting up a triage depending on known vs. unknown exposure is then discussed.
2013	Alder-Collins	The author concludes that it is not enough to rely on the courage and selflessness of health professionals to manage and respond to disasters. Training and learning from previous disasters is a responsible way to plan for future threats, be they natural or man-made.
2015	Al-Shaqsi et al.	Nurses had the highest response rate of acute health providers surveyed. Only 29.2% of respondents reported previous experience with a mass emergency event. Slightly over half (53%) reported they had formal training in dealing with mass emergencies, and 58% stated they were aware of their role during a health care mass emergency response. Factors associated with self-reported strong preparedness to deal with mass emergencies included being a paramedic, having received previous training, participation in a disaster drill, willingness to report to work during an infection or man-made emergency, ability to triage, and general awareness of professional role during a mass emergency.
2013a	Arbon et al.	Three major themes emerged related to uncertainty of the situation (i.e., type of disaster), preparedness of the workplace, and choices based on home and work circumstances/responsibilities. Nurses' willingness to work is affected by complex personal, work-related, and professional factors that can change depending on the type of disaster, preparedness of the work environment, the nurses' personal responsibilities at the time of the emergency.
2013b	Arbon et al.	Of 451 nurses surveyed, results indicated that nurses were more willing to attend work during a conventional disaster if they worked full time, had received formal education pertaining to disasters, had a family disaster plan, did not have children, and worked in an environment in which they perceived their colleagues, managers, and organization to be prepared for a disaster.
2011	Balicer et al.	Perception of the threat from a dirty bomb had little impact on willingness to respond among hospital workers. Thirty-nine percent of hospital workers were not willing to respond to an RDD scenario if asked but not required to do so. Respondents who perceived their peers were likely to work in an RDD emergency were 17 times more likely to respond to an RDD event if asked. Thus, radiological scenarios such as RDD are among the most dreaded emergency events yet studied, and training to enable effective hospital response to an RDD event is warranted.
2013	Bayram et al.	As few as 25 common resources may be considered critical to hospital surge capacity in four disaster scenarios involving pandemic influenza, radiation, explosive, and nerve gas. Experts agreed on several key resources for all four scenarios, including supplies, space, and staff. Other resources deemed critical varied depending on the disaster scenario. However, without adequate supplies, space, and staff, patient care in any disaster scenario may be compromised.
2016	Beauchamp	Fear can limit a person's willingness and ability to respond. Two scenarios are presented that delineate the appropriate response by hospital and first responder personnel and necessary treatment. Medical priorities, radioactive contamination, and delivering proper patient care are reviewed in detail.
2008	Becker & Middleton	ED physicians and nurses consistently expressed the perception that neither EDs nor hospital facilities in general were sufficiently prepared for a terrorist event involving radioactive materials. The main clinician concern involved the hospital being overwhelmed especially with staffing problems, preparedness problems, contamination, and the self-protection of hospital staff. All focus group participants expressed the need for further guidance and additional information pertaining to terrorist events involving radioactive materials, and disagreed with aspects of current guidelines and protocols.

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Table 3 – (Continued)

Year	Study	Key Findings
2013	Ben-Ezra et al.	The majority of nurses rated their health and life in general as better and had higher perceived coping and less fear of a future earthquake than did civilians. Nurses also presented with a lower level of PTSD symptoms. The authors conclude that nurses exhibited a higher level of resilience to the disaster event than civilians.
2017	Brice et al.	Factors associated with decreased willingness to report to work during a large-scale disaster included being female, having a child in the household younger than 6 years old, and having a child in school, whereas pet ownership, being a health care worker, and being familiar with the work emergency plan increased the likelihood. Respondents reported a low rate of willingness to work in a variety of disasters, and reported suboptimal personal preparedness for disaster.
2009	Cabrera & Beaton	Due to the increasing likelihood of terrorism using RDDs, occupational health nurses must prepare for RDD events in or near their workplace by practicing drills, understanding where and how to decontaminate and treat victims, and the role of the occupational health nurse in responding to and helping victims recover from an RDD event.
2006	Dainiak et al.	Emergency department supervisor nurse is responsible for activating the standard protocol for response and implementing the protocol. Treatment of exposed individuals is carried out without regard to exposure to radiation. Nurses will be expected to provide first aid and resuscitation, stabilize, and treat serious injuries while preventing or minimizing contamination. Medical treatment should be the same as if the patient was not exposed to radiation. Use standard universal precautions (surgical gloves, mask, shoe covers, disposable gowns). Perform clear and accurate documentation. Provide care with a calm and reassuring attitude. Remove foreign bodies from wounds, irrigate wounds with normal saline, treat wounds appropriately. Recognize serious exposure (nausea, vomiting, rash, fever, hypotension, neurologic deficits, impaired memory, cytopenias). Triage patients based on exposure, contamination, and injury. Participate in decontamination under the direction of the trauma physician, radiation safety officer, and/or radiation oncologist.
2014	Goto et al.	Inadequate risk communication on radiation in the Fukushima nuclear incident has resulted in multiple repercussions for mothers in the community. Public health nurses (PHNs) identified themselves as the information channels in the community, recommended the building of their risk communication capacities to support residents in making well-informed decisions, and advocated for self-measurement of radiation levels to increase residents' sense of control. PHNs also suggested a more standardized form of information dissemination and an expansion of community-based counseling services. Empowerment of local residents to assume more active roles in the understanding of their environment, increasing PHNs' capacity in communication, and an expansion of health services such as counseling will together better address risk communication challenges in postdisaster recovery efforts.
2015	Goto, Lai & Rudd	Self-evaluations of the workshop revealed that 45% of participants had increased confidence in assessing and revising written materials related to radiation exposure and other health effects postdisaster, and 47% stated they had applied skills they learned in the workshop during the 1-month follow-up period.
2016	Goto	Based on the author's observation and evaluation of the postdisaster situation in Fukushima as a public health physician and Fukushima Prefecture resident, he advises health literacy training for public health nurses around responding to a disaster and offering the resources and supports necessary to help people recover. These workshops for nurses are built around the core idea of developing the knowledge and skills to effectively communicate health information to the public.
2018	Goto et al.	The health literacy materials distributed to nurses provided the appropriate tools for public health nurses to effectively communicate information about health outcomes to the public in a postdisaster situation.
2010	Heinrichs et al.	Findings suggest that training health care teams in online, virtual environments with dynamic virtual patients is effective for management of mass casualty incidents involving radioactive exposure. This method may be more effective given that radiological exposure is an uncommon occurrence in the ED. A majority of the participants felt confident or very confident in managing radiological exposure victims following the training and reported that the scenarios were useful for improving health care team skills.
2011	Hick et al.	An effective response to the unprecedented challenges of a nuclear detonation involves a coordinated response by the medical and public health systems, including preplanning (leading to proper decision making during the event), effective communication, maintenance of a command/coordination structure, optimal resource management despite initial scarcity, and thoughtful application of medical triage guidance.
2006	James	The author describes how to properly identify and respond to victims who present to the ED or hospital with symptoms following radioactive exposure, including preserving forensic evidence in the event of a terrorist attack and decontamination of the patient. Notifying radiology

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Table 3 – (Continued)

Year	Study	Key Findings
		nurses or others specially trained is equally essential in estimating the radiation dose, decontamination of the exposed, patient assessment, and treatment.
2014	Kako et al.	Disaster education courses should include content related to nuclear incidents, and nurse-specific training might include information on safe patient transfer, psychosocial care, knowledge of specific medications, decontamination of affected people and the environment, and general health management after exposure to radiological substances. Previous reviews of the Fukushima disaster revealed that only one-quarter of renal dialysis clinics utilized their disaster manual to guide their practice.
2015	Kawasaki et al.	Participants described feeling powerless in the face of the nuclear disaster and could have benefited from prior education about radiation and radiation protection among nursing staff. Nurses also indicated the need for better communication between nurses and radiation specialists and long-term support by radiation specialists.
2004	Kenar & Karayilanoglu	Medical care providers should work in a specified “warm” zone of a nuclear incident site as first responding emergency personnel and must be familiar with the chemical agents used, know how to cope with and treat the victims, and know how to protect all people involved from further contamination. Training, proper protective equipment/gear, and the establishment of a coordinated medical emergency response is necessary.
2007	Kinugasa	The report is premised on the understanding that any response to a radiation accident must not discriminate workers of nuclear facilities from residents, and must involve a comprehensive system to deal with victims from any nuclear/radiological accidents.
2016	Konishi et al.	The key themes that emerged from the students’ evaluation of the radiation class were awareness of ignorance about radiation, problems produced by the mass media, becoming knowledgeable about radiation due to the class, public health nurses’ role in radiation emergencies.
2015	Kotora	The overall frequency of correct answers to the questionnaire was 66.3%, indicating a poor level of preparedness. The study instrument lacked precision and reliability, with a Cronbach’s alpha of 0.41. There were significant correlations between correct answers and the respondents’ gender, practice experience, and previous experience with a chemical incident. There was also significant variance between providers regarding how they believe casualties should be decontaminated, which drugs should be administered, and how to interpret facility-specific protocols. The author concludes that emergency care providers appear to be inadequately prepared to manage incidents involving chemical, biological, or radiological incidents.
2011	Litchfield	Due to misinformation and fear circulating around radiation exposure, occupational health nurses should be prepared to answer questions about radiation exposure, the safety of food and water supplies, and/or potassium iodide.
2013	Matsunari, Y.; Nakao, R.	Five participants indicated that on the day of the bombing, nursing care activities changed from moment to moment according to the condition of the radiation victims, the condition of the affected areas, and the relief systems in place. Under these conditions, nurses attempted to provide nursing care to victims of the bombing through any means possible, suggesting that nursing care must be flexible in critical situations.
1989	McKay	The author concludes that the nursing literature does not adequately reflect the level of activity and interest about nuclear issues that are occurring within nursing education and baccalaureate programs, and that the lack of coverage in the professional literature sends the message to students that nuclear issues are not important and nurses should not address them.
1998	Millership	The majority (16/18) districts had plans for the distribution of stable iodine in the event of a nuclear incident. Plans focused on the population around the nuclear site and did not consider more remote populations or special groups. The most common arrangements for the distribution of iodine was to present tablets to local centers that would be administered by nurses or the police. The remaining two districts did not have any plans, and only two with operating reactors had attempted field testing.
2012	Mitchell, Kernohan & Higginson	The training needs involved six key areas: waste management, triage, implementation of the incident chain of command, PODs, awareness of the range of personal protective equipment and its appropriate use, and the decontamination of people and the environment. The survey revealed a need for a standardized blueprint of role-specific competency criteria for a chemical/radiologic incident.
2017	Nair, Karan & Makhani	The management of victims of nuclear and radiation accidents is challenging and should be undertaken with a meticulous assessment of various factors including the likely result of radiation exposure—multi-organ system pathology.
2006	Niska & Burt	Of 739 hospitals, those with Joint Commission accreditation were more likely to provide terrorism-preparedness training to all types of clinical staff, and it was also the most consistent factor associated with providing training for all nine types of exposure studied (smallpox, anthrax, chemical and radiological exposures, botulism, plague, tularemia, viral encephalitis, and hemorrhagic fever).

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Table 3 – (Continued)

Year	Study	Key Findings
2013	Noto et al.	The activities of the Radiation Exposure Research Team included preliminary specialized training in radiation emergency medicine prior to being dispatched to the study site. The participants scanned the entire body of each person at the site over the clothes to gauge level of exposure and the roles of the nurses in a nuclear disaster were categorized as (a) providing flexible support depending on individual circumstances, (b) setting up a site for the contamination survey and supporting activities, (c) conducting a contamination survey involving children, and (d) providing an opportunity to answer questions and express anxiety in words.
2016	Nomura et al.	The study employed data from 1,215 residents of elder care facilities, finding that the average number of evacuations of the residents ranged from 1 to 3.1 depending on the facility and its proximity to the Fukushima Dai-ichi power plant. Using Cox regression, the authors found that evacuation had a significant impact on mortality (hazard ratio: 1.83, 95% confidence interval: 1.22–2.70), after controlling for covariates. Results also showed a significant effect of initial evacuation vs. no evacuation on mortality, suggesting that any subsequent evacuations had less impact on mortality or that those who survived the initial evacuation did not survive long enough to experience additional evacuations.
2016	Ochi et al.	Staff shortages at seven hospitals around Fukushima reached their peak 1 month after the disaster, with less than half (47%) of staff reporting to work. The shortage of clerks was the most severe (38% at work), followed by nurses (48% at work). Shortages persisted for up to 18 months after the disaster. The authors concluded that massive support of human resources in the acute phase of the disaster and a smaller volume of support in the mid-term phase are likely required.
2005	Qureshi et al.	Health care workers were most able to report for work during a mass casualty event (83%), environmental disaster (81%), and chemical event (71%), and were least able during a smallpox epidemic (69%), radiological event (64%), or severe snow storm (49%). They were most willing to report to work during a snow storm (80%), mass casualty event (86%), and environmental disaster (84%), and least willing during a SARS outbreak (48%), radiological event (57%), smallpox outbreak (61%), and chemical event (68%). The most common barriers to ability were transportation problems, child care, elder care, and pet care obligations; barriers to willingness included fear and concern for family and self, and personal health problems.
1984	Ross	The report issued by the Royal College of Nursing (London) on the findings of a working party to identify the implications of a nuclear war for nursing. Drawing on evidence of the nuclear explosions on Hiroshima and Nagasaki, the report finds that the scale of death and injury, the destruction of medical facilities and supplies, contamination of water, and the breakdown of communications would result in such catastrophic destruction that there would be nothing nurses could offer except possibly comfort and basic hygiene education. The report makes the case that planning is futile and fails to address the moral question of whether nurses should remain with their families or assist in futile crisis care.
1999	Salazar et al.	Findings revealed that, although explosions and radiological agents were identified as the hazards with the greatest associated risks, workers at these sites were most likely to be exposed to physical hazards, ergonomic hazards, and/or chemicals (including asbestos). Physicians accounted for 2.4% of service providers, nurses for 5.5%, industrial hygienists for 12.2%, safety personnel for 11.8%, and health physicists for 64.9%. An imbalance between the most important hazards and the types of health and safety personnel at these sites is thus indicated.
2015	Sato et al.	The factors independently associated with nurses' intention to leave their jobs during the radiation emergency involved living with preschoolers (OR = 1.87), consideration of evacuation from Fukushima after the accident (OR = 2.42), anxiety about life in Fukushima after the accident (OR = 5.55), consideration of the possible radiation health effects in children (OR = 1.90), and anxiety about relationships with colleagues in the hospital after the accident (OR = 3.23). The percentage of nurses with knowledge about radiation health effects was relatively low among those who had intention to leave the job and among those who did not intend to leave. Findings suggest the need for an education program regarding radiation health effects for nurses.
2016	Shabanikiya, H et al.	Of the 28 hospital employees interviewed, all were male. The majority believed that regardless of the type of disaster, the ability to lead and manage a team is a necessary skill for hospital administration during a surge capacity. The participants strongly agreed with each other than full knowledge of hospital surge capacity is the most important managerial requirement during the time of a surge. Other themes, such as personal characteristics and specific requirements, were incumbent upon the administrator to know and manage ahead of a disaster. The majority of participants also agreed that an autocratic management style was necessary during a hospital surge.
2003	Skorga et al.	Lymph tissue and bone marrow are the most radiation-sensitive tissues, and the most sensitive organs are the skin, intestines, kidneys, and gonads. Nurses should ensure their own protection from radiation before providing care to exposed victims by disposing of contaminants properly and controlling the spread of radioactivity. Using strict isolation procedures to care for victims, safely preserving clothing or specimens for forensic evidence,

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Table 3 – (Continued)

Year	Study	Key Findings
2006	Subbarao et al.	and performing acute assessments of adults may include treating burns, trauma from the initial blast, and radiation sickness. Psychological aspects may include anxiety about safety and security, post-traumatic stress disorder, or Acute Stress Disorder. The sample included 54 first responders/receivers including physicians, nurses, and paramedics who completed the course. The mean value of the precourse tests was 53.5% (SD = 12.7). The mean value of the post-test was 78.3% (SD = 10.9) and was significantly higher at all levels of learner. Results suggest that video clinical vignettes and HFMB simulation are effective methods of CBRNE training and evaluation.
2012	Suzuki, Y. & Kim, Y	This case study of the mental health care system after the East Japan earthquake of 2011 addressed the triple disaster of an earthquake, tsunami, and nuclear power plant accident. The article addresses the sequence of events, the response and recovery, and a comparison to other nuclear disasters. It concludes that it will be necessary to help residents make their own decision and take action based on sound information.
2011	Tan et al.	Components of the framework include (a) determining a project group and project manager, (b) understanding an ideal response capability, (c) identifying the current response capability and quantify and qualify the capability gap, (d) perform a risk-vulnerability assessment for the local jurisdiction, (e) determining the scope and limits of local response, (f) determine what support is needed from state and federal agencies and the accompanying thresholds for action, (g) determining a timeline and key milestones, and (h) determining the direction of strategic guidance, aligning the operational plan accordingly, and allowing this to guide the technical response.
2002	Tan & Fitzgerald	An emergency department response to CBR must consider the design of the department itself, with all entry and exit points secured and moved through the ED itself regulated. Clear labeling of contaminated and clean areas is needed when CBR response has been activated. Personal protective equipment is required, and hospitals must ensure that adequate staffing and training of staff has been put in place. Hospitals must also work to ensure a safe workplace by creating a specific planned response to external disasters and a surveillance system to record daily ED presentations of various diagnoses should be reviewed by medical control at the ED.
2003	Veenema & Karam	The authors first describe the basic physics of radiation and radiation exposure, and then cover the major health effects and bodily systems affected by varying degrees of radiological exposure (hematopoietic syndrome, gastrointestinal syndrome, etc.). Clinical responses to radiation victims include taking a radiation-exposure history, collecting specimens, triaging, and providing care to patients exposed—this last step may involve differentiating radiation burns from other types of burns.
2008	Veenema, T. et al.	This study focused on prepared the US health care workforce for radiological events. The two-phase study focused on nursing units likely to respond and phase two on members of the New York State ENA employed in hospitals. Six hundred and sixty-eight nurses were surveyed with a 45% overall response rate. It was found that baseline knowledge was inadequate. The majority of the participants believed they neither work nor lived within 10 mi of and EPZ of a nuclear facility among other findings. The study provided an assessment of the current state of knowledge in 2008 in the nurses surveyed. Among 668 nurses surveyed, baseline knowledge of radiation was found to be inadequate. Baseline knowledge, clinical competence, and perception of personal safety were all positively associated with willingness to respond in a radiation emergency, perception of safety appeared to be the primary determinant of willingness to respond. Baseline knowledge did not appear to be strongly associated with perception of personal safety.
2015a	Veenema & Thornton	The authors conducted an integrative review of the peer-reviewed literature on nursing care guidelines for patients involved in a radiological/nuclear event, finding that limited literature exists pertaining specifically to guidelines for the management of radiation events among APNs and all hospital-based nurses. The included articles—of which there were only 16—demonstrate a lack of cohesive and succinct guidelines that are specific to a nurse's role in this response. The authors compile a set of guidelines for hospital-based nurses from receiving the patient to wound decontamination and review clinical care management for APNs and the APN role in an emergency response. They conclude that nurses are involved in nearly every level of response to a radiological disaster, yet there are no current requirements for nurses to take courses on disaster preparedness, leaving ED staff unprepared to handle situations of this nature (including radiological disasters).
2015b	Veenema & Thornton	Nuclear disasters such as Three-Mile Island, Chernobyl, and Fukushima revealed glaring flaws in hospital disaster plans and radiation response protocols. As a result of the major organizational challenges posed by these disasters, hospitals and health care systems recognize that dedicated planning needs to be incorporated into mass casualty plans for urban areas in the event of a nuclear attack or malfunction at a nuclear reactor site. Nurses' role in these disasters will often be to assist with triage or treatment of victims, and must be prepared to take all precautions to avoid accidental exposure or uptake of radioactive materials. Nurses may also play a role in assisting with population screening or monitoring in conjunction with radiation safety experts, and must also be prepared for the specific needs of pediatric patients and those requiring psychosocial support.

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Table 3 – (Continued)

Year	Study	Key Findings
2001	Waeckerle et al.	Descriptions of learning groups, content and learning objectives, and barriers and challenges to NBC education foremost include access to training and sustainment of learning. Many of the courses analyzed by the task force did not meet all objectives and challenges addressed. Training programs and materials need to be developed to overcome challenges to learning for certain audiences, and NBC training should ideally be incorporated into standard training for emergency medical professionals.
2006	Wetta-Hall et al.	Nurses perceived that chemical spills or releases, weapons of mass destruction, bioterrorism, and contamination of the blood supply were several of the most pressing threats in rural Kansas counties. Participants rated the training as extensive, practical, detailed, and informative, and talked about how the training had led them to take more personal precautions against terrorism (stockpiling good and emergency medical kits at home, etc.). Nurses used the training manual and reference cards in their workplaces and others had pushed for systems-level changes such as school disaster drills and community-wide evacuation plans in the event of a terrorist threat.
2006	Wilkinson	Patients may present with unknown illness caused by accidental or deliberate release of biological, chemical or radioactive material or a new/emerging disease. Nurses must be aware of the protocols to follow to ensure their own safety and that of other patients. This article discusses the national advice in dealing with incidents or outbreaks of unusual illness.
2010	Williams & Williams	The authors present the likely sequence of events follow the blast from a radiological dispersion device in the UK. The nursing roles are necessary safety precautions are discussed. Specific attention is given to decontamination, sequence of care, and emergency department capacity.
2003	Willis & Coleman	The authors describe the types of injuries nurses are likely to encounter when a patient has sustained primary, secondary, or tertiary blast injuries and outline the emergency department preparations and personal precautions to avoid radiation exposure or contamination during triage. Patient management, delayed after-effects, and psychosocial care are also covered.
1999	Yamada et al.	Of 2,222 subjects aged 60 and older, the prevalence of dementia was 7.2%. The risk of dementia was associated with age, history of head trauma, and history of stroke and hypertension. However, neither type of dementia showed any significant effect of sex or radiation exposure.
2016	Yamashita et al.	The four detailed surveys being conducted among residents of Fukushima prefecture, who were all exposed to varying degrees of radiation from the Fukushima power plant explosion, involve (a) thyroid ultrasound examination, (b) comprehensive medical check-up, (c) mental health and lifestyle surveys, and (d) surveys on pregnant women and nursing mothers.
2016	Yoshida et al.	The majority of public health nurses (62%) were classified as having low anxiety about radiation. Higher levels of anxiety were associated with being a nurse at the time of the accident (OR: 2.37), being currently anxious about radiation (OR: 3.56), having in their possession materials to obtain knowledge about radiation (OR: 2.11), and having knowledge of the childhood thyroid cancer increase following the Chernobyl accident (OR: 1.69).
2004	Young & Persell	Nursing students' primary concern was for the safety of themselves and their families. Insofar as caring for victims, students were most concerned with having adequate protection for all types of terrorist agents and stated they would not be willing to care for victims if there was a lack of protection for themselves and/or family. Students did not demonstrate an accurate understanding of the pathogenic nature of many agents, despite the nursing school faculty having provided self-education information about terrorism.
2008	Yuko et al.	Interviewees reported that nursing care activities changed moment to moment following the bombing and their daily activities varied according to the patient care needs of those injured by the blast and exposed to radiation. Stricken areas and relief systems also presented new challenges to nursing care, making one of the most important factors in providing care to radiation victims following this event a strong mental attitude.

Table 4 – Thematic Analysis

Study	Study Purpose	Methods	Thematic Analysis
Adair (2005)	The Washington State Department of Health provided ongoing training for radiological events to first responders.	Symposium Presentation	Education/Training
Adams and Berry (2012)	To discuss the need for essential personnel in a health care setting following a disaster, and to review the literature related to adequate disaster staffing. The article includes an examination of the ability and willingness of health care personnel to report to work during a disaster.	Descriptive, exploratory study using an instrument (Qureshi's Disaster Survey) to assess willingness and ability to report to work during a disaster (N = 1,342). Respondents were nurses and other clinical and nonclinical health care staff at a community-based health care network consisting of 6 inpatient facilities.	Willingness
Adelman et al. (2014)	To inform nurses who may have little experience dealing with victims of a radiological disaster how to set up a response area that protects the hospital and staff from radiation exposure, which includes establishing a knowledge base of the different types of exposure and the treatment of each.	Review of literature and relevant task force guidelines/reports.	Education/Training
Alder-Collins (2013)	To comment and offer a critical reflection on the role of nurses in the Fukushima Dai-ichi disaster.	Commentary	Role
Al-Shaqsi et al. (2015)	To assess the self-reported training and experience of New Zealand acute care providers to respond to mass emergencies and the factors associated with strong preparedness.	Cross-sectional national survey of 1,500 acute care providers (doctors, nurses, and paramedics) in 2009 to 2010 that assessed experience, training, and self-reported preparedness.	Preparedness
Arbon et al. (2013a)	To explore Australian nurses' willingness to attend work during a disaster and the factors that influenced their decision.	Qualitative, descriptive study involving five focus groups (N = 41) and interviews (N = 13) of RNs from four emergency departments.	Willingness
Arbon et al. (2013b)	To determine the extent to which Australasian emergency nurses are willing to attend their workplace in a disaster.	Exploratory and descriptive study design using online and paper-based surveys of emergency nurses from two emergency nursing colleges and four Australian hospitals.	Willingness
Balicer et al. (2011)	To understand employee willingness to respond to work following a radiological disaster (specifically the terrorist use of an RDD or "dirty bomb").	An anonymous, online survey evaluating the willingness of hospital employees at Johns Hopkins was distributed to all 18,612 employees of the hospital, garnering an 18% response rate (3,426 employees).	Willingness
Bayram et al. (2013).	To identify critical hospital resources required in four specific catastrophe scenarios: pandemic influenza, radiation, explosive, and nerve gas.	Expert consensus panel of 23 health providers (nurses and physicians), administrators, emergency planners, and specialists to examine the four disaster scenarios and asked to consider 132 hospital patient care resources in order to identify the ones most critical to patient care.	Preparedness
Beauchamp (2016)	Review article on the fear of all hazards disaster with an emphasis on radiation disasters	The article presents two scenarios" (a) a sealed source that is open and exposes workers, and (b) a workplace accident victim is presenting to the emergency department from a radioactive waste	Hazards/Health Hazards Fear/Perception of threat

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Table 4 – (Continued)

Study	Study Purpose	Methods	Thematic Analysis
Becker and Middleton (2008).	To understand how clinicians in the emergency department perceive the threat of terrorist incidents involving radioactive materials.	disposal center. A detailed overview of the necessary response, safety measures, and treatment is provided. A series of 10 focus groups with 77 participants total who were all Emergency Department (ED) physicians and nurses in 3 parts of the US. Participants considered hypothetical scenarios involving a “dirty bomb” and discussed their perceptions, concerns, information needs, preferred information sources, and views of current guidance and informational materials	Hazards/Health Hazards Perception of threat
Ben-Ezra et al. (2013)	To compare the reactions of hospital personnel and civilians after exposure to a unique disaster that combines natural and nuclear disaster.	Exploratory study utilizing a brief questionnaire tapping into post-traumatic stress disorder (PTSD) symptoms, subjective health, coping, life satisfaction, and meaning in life administered to a matched sample of 34 nurses and 39 civilians exposed to the 2011 Tohoku earthquake and tsunami. Descriptive statistics and t-tests revealed differences between the two groups on measures of interest.	Hazards/Health Hazards Perception of threat
Brice et al. (2017).	To understand personal disaster preparedness for disaster among hospital staff, as previous studies have shown low intent of staff to report to work in the event of a large-scale disaster.	Cross-sectional surveys distributed to 1,334 hospital staff via paper or Web. Descriptive, bivariate, and multivariate analyses measured associations between demographic factors, personal preparedness, and willingness to work.	Preparedness
Cabrera and Beaton (2009)	To describe the hazards related to radiological dispersal devices (RDDs) and provide resources to support the roles of occupational health nurses in the event of an RDD disaster occurring at or near their workplace.	Literature review describing characteristics of an RDD and outlining the role of occupational health nurses in planning and preparing for an RDD event, responding to an RDD event, and recovery from RDD.	Role
Dainiak et al. (2006)	To provide specific information and guidance for the efficient management of radiation victims during their early encounter in a hospital. in a practical manual for clinicians	Expert consensus panel convened to write a practical manual for clinicians (radiation oncologists, ED physicians, and nursing staff), hospital administrators, safety officers, and others involved in the care and treatment of radiation victims and/or radiation monitoring to use for evaluation and management of radiation injury.	Clinical Practice
Goto et al. (2014)	Evaluate the efficacy of a health literacy training program on the ability to augment communication skills in order to change communication practices and norms among public health nurses and improve access to information for community residents	Post-test assessments completed by 26 nurses who were in attendance of the learning sessions. This was a qualitative analysis study utilizing two available data collected at the Fukushima City Health and Welfare Center and applying two analytical methods that are highly practical. Data were drawn from parenting counseling records and from peer discussions among public health nurses	Education/Training

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Table 4 – (Continued)

Study	Study Purpose	Methods	Thematic Analysis
Goto et al. (2015)	To evaluate a training program to increase health literacy for postdisaster management among public health nurses at multiple sites in Japan.	(PHNs). A total of 150 records from parenting counseling sessions conducted between PHNs and mothers who have attended mandatory 18-month health checkups for their children at the Fukushima City Health and Welfare Center in 2010, 2011 (year of disaster) and 2012 were examined. Discussion notes of three peer discussions among PHNs organized in response to the nuclear disaster in 2012 and 2013 were also analyzed. Pre- and post-training assessment of nurses' training satisfaction, self-evaluation of achievements regarding training goals, and the application of learned skills via quantitative and qualitative methods.	Education/Training
Goto (2016)	To examine postdisaster public health activities with a primary focus on parenting support following the Fukushima disaster.	Observational study and report of the provision of parental support services based on a secondary analysis of data collected by the Fukushima Health Management Survey and the direct observation of public health nurses working to support families affected by the disaster in Fukushima Prefecture.	Role
Goto et al. (2018)	To evaluate a series of health literacy workshops provided to public health nurses following the Fukushima disaster, where misinformation and a lack of guidance from the central government led to widespread mistrust of health officials in the community.	Development of a toolkit for public health nurses via (a) drafting a glossary of key terms and an index; (b) rigorous pilot testing among nurses for needed clarification and revision, and (c) field testing the packed materials (glossary and index) in practice.	Education/Training
Heinrichs et al. (2010)	To determine whether a virtual emergency department populated with virtual patients suffering from a radiological "dirty bomb" blast and others suffering from exposure to chemical nerve toxin is an effective clinical training environment for ED physicians and nurses.	Observation, evaluation, and postscenario questionnaire of 10 physicians and 12 nurses who participated in a virtual practice scenario with patients who had been exposed to a nerve toxin or radioactive blast.	Education/Training
Hick et al. (2011)	To describe how a nuclear detonation incident may unfold for the various components of the health and medical systems and outline discipline-related actions related to state and local planning.	Literature review and report based on response principles, triage and initial trauma care, emergency medical services, health care facility response including hospital impact and radiologic injury and decontamination, and subsequent hospital response issues related to unaccompanied minors, transportation infrastructure, and coordination with the public health system.	Preparedness
James (2006)	To describe effective response activities among hospital nursing staff and radiology nurses in the event of a radioactive accident or terrorist event.	Literature review	Role

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Table 4 – (Continued)

Study	Study Purpose	Methods	Thematic Analysis
Kako et al. (2014)	To review the Japanese literature and present, in English, key themes related to nursing roles in the postdisaster management of the Fukushima nuclear plant explosion.	Thematic analysis following a systematic review of the Japanese medical and nursing literature, with 44 articles meeting inclusion criteria and 3 key themes emerging from the analysis.	Role
Kawasaki et al. (2015)	To describe public health nurses' experiences in caring for patients following the Fukushima nuclear incident.	Questionnaire of 44 nurses before a radiation workshop and subsequent interviews using qualitative analysis.	Role
Kenar and Karayilanoglu (2004)	To describe the goal of forming a team of physicians, nurses, and paramedics assigned to military medical intervention units and the practical application of the team in a chemical attack scenario.	Report of simulated scenario involving a chemical attack on a nuclear site.	Role
Kinugasa (2007)	To report on the successful education and training of clinicians in Japan regarding treatment of emergency cases involving radiation accidents.	Description of a report on a training program for clinicians over a 5-year period in Japan regarding treatment of emergency cases involving radiation accidents/exposure.	Education/Training
Konishi et al. (2016)	To report on the development and implementation of a class on radiation education offered to undergraduate public health nursing students in Japan.	Case study of a 90-min radiation class in an undergraduate public health nursing course in Tokyo. The class involved lectures and discussion on technical and environmental aspects necessary for basic radiation knowledge. Sixty-one students participated in a free writing exercise about their class experience, which was qualitatively analyzed.	Education/Training
Kotora (2015)	To evaluate the preparedness of physicians, nurses, and other health care providers to treat victims of chemical, biological, radiologic, nuclear, and explosive agents in an urban emergency department.	Retrospective, observational survey study of 59 health care providers using a previously constructed questionnaire instrument assessing the knowledge and level of preparedness of physicians, nurses, and midlevel providers.	Preparedness
Litchfield (2011)	To address individuals' fear of radiation and provide resources to occupational health nurses so they can answer patients' questions and dispel myths.	Literature review/summary	Role
Matsunari and Nakao (2013)	To describe the situation with respect to nursing care conducted immediately before and after the atomic bombing of Nagasaki in 1945.	Individual interviews were conducted with five nurses who survived the bombing to describe the nursing care provided in the affected areas. The collected information was compared with official documents regarding the Nagasaki bombing.	Role
McKay (1989)	To discuss the lack of coverage of nuclear issues in nursing journals and professional nursing literature.	Literature review/summary	Education/Training
Millership (1998)	To examine alternative solutions to some of the practical problems revealed by an emergency exercise involving a nuclear incident.	Nuclear emergency plans from health districts with nuclear sites in their boundaries were reviewed and categorized according to a predefined list of criteria.	Preparedness
Mitchell et al. (2012)	To examine emergency department staff preparedness in responding to a chemical, biological,	Questionnaire assessing competency distributed to 50 nursing staff in emergency departments in	Preparedness

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Table 4 – (Continued)

Study	Study Purpose	Methods	Thematic Analysis
Nair et al. (2017)	radiological, nuclear, and explosive incident and to identify where nurses require training in order to improve their preparedness for such an event. To provide an overview for medical professionals how to manage victims with radiation injuries involving step-by-step evaluation of the damage, the kind of treatment required, and the regular monitoring of the patient.	Northern Ireland. Descriptive statistics and content analysis were used to analyze the surveys. Literature review	Clinical Practice
Niska and Burt (2006)	To determine which hospital characteristics are associated with providing terrorism-preparedness training to clinical staff using an estimation of baseline data.	Retrospective secondary analysis of the Bioterrorism and Mass Casualty Supplement to the 2003 and 2004 National Hospital Ambulatory Medical Care Survey to provide national estimates of variations in terrorism-preparedness training according to eight hospital characteristics.	Education/Training
Noto et al. (2013)	To describe the activities of the Radiation Exposure Research Team and the role of nurses in a nuclear disaster, following the Fukushima disaster.	Case scenario of the Radiation Exposure Research Team's day-to-day activities in the wake of the Fukushima nuclear incident.	Role
Nomura et al. (2016)	To assess associations between evacuation and mortality after the Fukushima nuclear incident; and to present discussion points on disaster planning, with reference to vulnerable elderly populations.	Data were mined from a previous survival analysis from five of eight care homes in Minamisoma. One thousand and two hundred fifteen residents admitted to elder care facilities that are located 20 to 40 km from the nuclear plant in a 5-year period before the incident. Records were assessed for demographic and clinical characters were evaluated and hazard ratios assessed in evacuees vs. nonevacuees.	Preparedness
Ochi et al. (2016)	Fear of radiation exposure after the Fukushima incident led many hospital staff members to fail to report to work. The authors measured the shortage in hospital staff and to compare the difference by categories of hospital staff in seven hospitals around the site of the Fukushima incident.	Retrospective records were extracted from seven hospitals and change in the number of staff was analyzed.	Willingness
Qureshi et al. (2005)	To understand responsiveness of an urban health care system in the event of a catastrophic disaster by surveying providers in New York City to determine their ability and willingness to report for work during various disaster events that would create surge capacity needs.	Cross-sectional survey of 6,428 health care workers from 47 health care facilities in New York City and the surrounding metropolitan area.	Willingness
Ross (1984)	Description of the Royal College of Nursing's thoughts on the implications that a nuclear war or mass nuclear event would have on the nursing workforce	Review of the Royal College of Nursing's working party on nuclear events	
Salazar et al. (1999)	To describe occupational health hazards at 10 Department of Energy sites given the mission of	Cross-sectional survey distributed to employees at 10 Department of Energy sites to describe and	Hazards/Health Hazards

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Table 4 – (Continued)

Study	Study Purpose	Methods	Thematic Analysis
Sato et al. (2015)	the U.S. Department of Energy has recently changed from nuclear weapons production to site remediation. To clarify the factors associated with nurses' intention to leave their jobs during the radiation emergency caused by the Fukushima Dai-ichi nuclear power plant accident.	compare (a) the primary hazards associated with the site activities, (b) the occupational safety and health structure, and (c) the occupational health and safety functions. Cross-sectional, prospective survey of 345 nurses about intention to leave after the accident, demographic factors, living situation, working status, and knowledge of radiation health effects.	Willingness
Shabanikiya et al. (2016)	Aimed to identify characteristics of hospital administrators that are important in the effective management of sure capacity in disasters.	Qualitative study using semi-structured interviews with 28 hospital administrators who had experienced working in surge situations. Framework analysis was used to analyze the data.	Clinical Practice
Skorga et al. (2003)	To describe the assessment and treatment regimens of caring for victims of radiological injuries from a nursing perspective, with an emphasis on considering the psychological aspects and needs of pediatric and geriatric patients.	Literature review	Clinical Practice/Role
Subbarao et al. (2006)	To assess whether a high-fidelity, mannequin-based (HFMB) educational modality including simulation and clinical vignettes is an effective means of training first responders in the event of a chemical, biological, radiological, nuclear, and explosive (CBRNE) event.	HFMB simulation and video clinical vignettes were used to create a simulation-based CBRNE course. The participants were evaluated using a 43-item pre- and post-test that employed 12 video clinical vignettes as scenarios for the test questions. Results were analyzed according to the various medical training backgrounds of the participants, who were all first responders and receivers.	Education/Training
Suzuki and Kim (2012)	To review the aftermath of the Fukushima Dai-ichi power plant disaster and its ramifications for local networks providing community mental health support to survivors.	Historical account of mental health care system following the 2011 earthquake, tsunami, and nuclear power plant accident in Japan.	Preparedness
Tan et al. (2011)	To provide a starting framework for local governmental efforts toward developing a response plan for radiological incidents in their communities by describing in detail the stepwise approach Baltimore City took toward developing their own plan for radiological preparedness.	Evidence-based synthesis/literature review and stepwise approach to developing a framework and protocol for preparing city planners and responders for radiological emergencies.	Preparedness
Tan; Fitzgerald (2002)	To demonstrate how an emergency department in a tertiary referral center can implement a chemical, biological, and radiological (CBR) response, and to heighten awareness of CBR response among the medical community in Australia.	Review of guidelines and protocols from the U.S. and Israel, and expert consultation from committee representatives of the hospital's Infectious Diseases unit, Nuclear Medicine and Radiation Safety officers, the Engineering Department, Medical Administration, the Manager for Workplace Health and Safety, and the Emergency Response and Workcover Officer.	Preparedness

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Table 4 – (Continued)

Study	Study Purpose	Methods	Thematic Analysis
Veenema and Karam (2003)	To describe the low levels of risk typically posed by radiation and the care of individuals exposed to radiation. Universal precautions should be used, and it is often safe for nurses to ensure hemodynamic stability before initiating decontamination and other radiation-related therapies.	Literature review describing basic radiation physics and health effects from radiation exposure.	Clinical Practice
Veenema et al., 2008	To develop and apply a rapid survey evaluating hospital-based nurses' knowledge, self-assessed clinical competence, perception of personal safety, and willingness to respond in the event of a radiological emergency.	Cross-sectional survey using a purposive sample of 668 hospital-based nurses to respond to the Radiation Survey, a rapid, self-administered questionnaire developed to assess knowledge, attitudes, and behavior with regard to radiation emergencies.	Willingness
Veenema and Thornton (2015a)	To examine the peer-reviewed literature on nursing clinical guidance for managing radiation/nuclear disasters.	Integrative literature review	Clinical Practice
Veenema and Thornton (2015b)	To provide guidance for the optimal management of a patient surge after a radiologic disaster, which is lacking in nursing schools or professional development programs. Nurses require a substantive body of knowledge of skill on which to base public health as well as acute response efforts.	Literature review/conceptual review	Clinical Practice
Waeckerle et al. (2001)	To assess the needs, demands, feasibility, and content of training for civilian emergency medical responders (paramedics, nurses, and physicians) for nuclear, biological, and chemical (NBC) terrorism.	Task force/expert consensus panel consisting of key stakeholders and professional disciplines conducted an iterated instructional-design analysis on the feasibility and content of such training with input from educational professionals. Six previously developed training courses were analyzed to examine congruence with expert recommendations.	Education/Training
Wetta-Hall et al. (2006)	To evaluate the effectiveness of a terrorism-preparedness training program on the perceptions, attitudes, and beliefs of nurses in a continuing education setting.	A 1-day training program addressed the HRSA four core competences outlining nursing response to terrorism. A volunteer sample of 15 nurses participated in a focus group after the training to discuss their perceptions of the training.	Education/Training
Wilkinson (2006)	To describe the risks posed by "mystery" illnesses and the importance for nurses to be prepared to treat patients who present with strange symptoms, using the poisoning of Alexander Litvinenko as a case example.	The case of Alexander Litvinenko, a former spy who was poisoned with polonium-210 and treated by hospital staff for three weeks before anyone discovered what was causing his illness, is presented as a case vignette with descriptions of the biological and chemical properties of the agent, resources for learning more about radiation exposure and effects, precautions, and decontamination.	Preparedness/Clinical Practice

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Table 4 – (Continued)

Study	Study Purpose	Methods	Thematic Analysis
Williams and Williams (2010)	To summarize the likely series of events following a radiological dispersal device or “dirty bomb” explosion and implications for emergency nursing staff.	Integrative review of peer-reviewed literature and agency guidelines to describe the properties of a radiological dispersal device, the likely sequence of events following an explosion (likely involving multi-agency coordination between the military, police, and bomb disposal experts), and the nursing tasks that ED staff can expect to carry out.	Role
Willis and Coleman (2003)	To describe the processes nurses taking care of adults need to understand in order to appropriate care for patients of radiation blast injuries and radiation exposure.	Literature review	Clinical Practice
Yamada et al. (1999)	To describe the prevalence of dementia and its subtypes in Japan and to investigate the relationship of risk factors, such as demographic features and disease history.	Longitudinal cohort study of atomic-bomb survivors and controls recruited from Hiroshima and Nagasaki using the 1950 Japan census and an atomic-bomb survivors’ survey. Subject data included biennial medical examinations and screening for cognitive impairment.	Health Hazards
Yamshita et al. (2016)	To describe the steps taken by the Fukushima Health Management Survey to monitor and characterize the levels of radiation exposure sustained by the population of Fukushima following the power plant explosion.	Descriptive narrative of steps taken and detailed surveys administered to residents of Fukushima prefecture.	Role/Health Hazards
Yoshida et al. (2016)	To assess radiation-related anxiety and stress among public health nurses in the Fukushima prefecture after the nuclear power plant explosion.	Cross-sectional survey administered via mail to 430 public health nurses in Fukushima asking them to rate their level of anxiety about radiation according to the Sense of Coherence scale. High and low levels of anxiety were classified according to answers about radiation.	Willingness/Health Hazards
Young and Persell (2004)	To identify how nursing students might practice as caregivers for victims of chemical, biological, or nuclear terrorism.	Descriptive study utilizing cross-sectional survey of 95 junior and senior baccalaureate students in nursing. The questionnaire consisted of 19 items that identified demographics and perceptions and concerns regarding willingness to work, preparedness, expectation of future terrorist events, effect on lifestyle, and other fears related to terrorism or caring for the victims of it.	Willingness
Yuko et al. (2008)	To clarify the nursing care conducted just prior and just after the atomic bombing of Hiroshima in 1945.	Face-to-face interviews with five surviving nurses who provided care to victims following the atomic bomb drop in Hiroshima.	Role/Clinical Practice

Table 5 – Clinical Resources for Radiation Emergencies

Centers for Disease Control and Prevention, Radiation Emergencies https://emergency.cdc.gov/radiation/index.asp
NLM Disaster Information Management Research Center https://disaster.nlm.nih.gov/
Radiation Emergency Assistance Center/Training Center https://orise.orau.gov/reacts/
Radiation Injury Treatment Network https://ritn.net/
U.S. Department of Health and Human Services Assistant Secretary for Emergency Preparedness ASPER Technical Resources Assistance Center Information Exchange (TRACIE) https://asprtracie.hhs.gov
U.S. Department of Health and Human Services. Radiation Emergency Medical Management, 2018 https://www.remm.nlm.gov/index.html
UNISDR (United Nations International Strategy for Disaster Reduction), 2017 University of Pittsburg, 2018

particular disaster event. Of 132 hospital resources evaluated, 25 were considered critical in all four scenarios by a >50% margin; panelists achieved consensus on only 51 (39%) for radiation exposure (Bayram et al., 2013). Two retrospective studies of the Fukushima Dai-ichi nuclear power plant accident underscored the inadequate planning and strains on local health care capacity to adequately cope with populations needing special attention: the elderly and those with mental health disorders. A comparative analysis between evacuees and nonevacuees of residential facilities for the elderly in Fukushima Prefecture demonstrated a drop in postdisaster survival in the areas closest to the power plant explosion (Nomura et al., 2016). Residents in these facilities were subject to between one and three evacuations on average. Suzuki and Kim (2012) described the fragility of community psychiatric services due to the Fukushima Dai-ichi disaster, in which the continuation of psychiatric care and supplies of necessary medication were disrupted for months after the event due to accessibility problems (e.g., debris blocking roads, concerns about radiation exposure, many health care workers unable to commute or choosing to remain at home). Notwithstanding the acute mental disorders that may be brought on or exacerbated by a disaster, the authors conclude that capacity for the uninterrupted provision of mental health services is frequently overlooked in discussions of disaster nursing and disaster preparedness—of particularly grave concern in a nation with already high rates of suicide and depression (Suzuki & Kim, 2012).

Education/Training

Developing a radiation competent workforce requires considerable education and training effort and 13 of the articles in this review addressed some aspect of preparing nurses and other health care providers for radiation and/or nuclear events. Radiation education and training was frequently imbedded into broader programs that addressed chemical, biological, radiological, nuclear, and explosive incidents. Some

studies were descriptive (e.g., Adair, 2005; Kinugasa, 2007), several were specific to evaluations of different types of education and training programs (including face-to-face, online and simulation programs) (e.g., Heinrichs, Youngblood, Harter, Kusumoto, & Dev, 2010; Subbarao, Bond, Johnson, Hsu, & Wasser, 2006; Wetta-Hall, Fredrickson, Ablah, Cook, & Molgaard, 2006), and others proposed competencies and content for inclusion in educational programming.

Waeckerle et al. (2001) reported on the work of a task force convened by Department of Health and Human Services (DHHS) Office of Emergency Preparedness that developed objectives, content, and competencies for training emergency health care providers (emergency medical technician (EMTs), physicians, and nurses) to care for casualties resulting from nuclear, biological, or chemical incidents. Of the Japanese studies, Kinugasa (2007) reported that education and training for radiation emergency medical management in 35 cities and towns over 5 years in Japan reached over 6,000 practitioners, improving their knowledge and skills and confidence to manage traumatized patients with radiation exposure. Goto, Rudd, Lai, and Yoshida-Komiya (2014) published three studies evaluating a series of health literacy training programs in Japan to improve communication practices between public health nurses and the community at large, to increase health literacy for disaster management in public health nurses (Goto, Lai, & Rudd, 2015), and finally to develop a toolkit for public health nurses post-Fukushima (Goto et al., 2018). Konishi et al. (2016) reported on radiation education offered to undergraduate public health nursing students in Japan.

Heinrichs et al. (2010) found that training health care teams in online, virtual environments with dynamic virtual patients are effective for management of mass casualty incidents involving radioactive exposure and may be more effective given that radiological exposure is an uncommon occurrence in the emergency department (ED). Subbarao et al. (2006) published a pilot study suggesting that video clinical vignettes and high-fidelity mannequin-based simulation are

effective methods for chemical, biological, radiological, nuclear, and explosive training and evaluation. [Wetta-Hall et al. \(2006\)](#) and [Niska and Burt \(2006\)](#) both addressed training for terrorism events. The first study conducted a focus group study to evaluate the effectiveness of a Human Resources and Services Administration sponsored terrorism-preparedness training program in Kansas. The 15 participants rated the training as extensive, practical, detailed, and informative, and talked about how the training had led them to take more personal precautions against terrorism (stockpiling good and emergency medical kits at home, etc.). [Niska and Burt \(2006\)](#) reported an analysis that showed that hospitals with Joint Commission accreditation were more likely to provide terrorism training to all clinical staff, including nurses. [Adelman, Theiss, and Goudounis \(2014\)](#) provided content for teaching hospital-based nurses to care for patients presenting with radiation contamination.

[McKay \(1989\)](#) wrote of the need to include nuclear-related issues, nuclear war prevention strategies in nursing education and that the nursing profession “should make its voice heard” (p. 157). She noted that both the American Public Health Association and the American Nurses Association had issued position statements that “nuclear war presents a grave threat and perhaps an overwhelming one for public health...that efforts to prevent nuclear war are the urgent responsibility of all public health workers (p. 157).”

Role

Past experiences in response to large-scale radiologic events has taught us that nurses must clearly understand their role in both preparedness and response. It is not enough for nursing to rely on their courage alone to respond, but they must also rely on their clinical expertise and past education in order to prepare for future threats ([Alder-Collins, 2013](#)). Interviews with nurses who have previously responded to nuclear events reveals an ongoing need to understand clinical knowledge of decontamination, personal protective equipment use, adherence to laws and ethical principles of disaster response, health literacy training, clinical training, and mental health resiliency training ([Goto, 2016](#); [Kako, Ranse, Yamamoto, & Arbon, 2014](#); [Kawasaki, Omori, Ono, Konishi, & Asahara, 2015](#); [Kenar & Karayilanoglu, 2004](#)). During RDD events, nurses are likely to also be the victims of terrorist attacks or be exposed to the damaging effects of radiation themselves and be expected to care for others while also coping with the event and caring for their own injuries ([Matsunari & Nakao, 2013](#); [Yuko et al., 2008](#)).

All nurses should be aware of the role they play in disaster preparedness and response. Certain nursing roles may offer increased opportunities to prepare for these disasters. For example, occupational health nurses should be aware of threats of terrorism and incorporate practicing drills for RDD events into the workplace ([Cabrera & Beaton, 2009](#)) and be prepared to

mitigate fear mongering and panic from employees about misinformation regarding exposure and safety of food and water supplies ([Litchfield, 2011](#)). Public health nurses will be expected to appropriately communicate needs and instructions to the communities in which they work ([Goto, 2016](#)). Emergency department and first responding nurses will be responsible for immediate triage, rapid focused physical assessments, radiation surveys, decontamination, preservation of forensic evidence, and coordination of a nuclear disaster response ([James, 2006](#); [Noto et al., 2013](#); [Williams & Williams, 2010](#); [Yamshita, 2016](#)).

Immediately after a nuclear event, nurses can be expected to conduct disaster triage, perform nuclear decontamination of patients, allocate scarce resources appropriately, and care for patients while also caring for themselves ([Matsunari & Nakao, 2013](#); [Ross, 1984](#)). Adherence to strict isolation policies and use of personal protective equipment can mitigate the effects of radiation exposure to themselves and in spreading opportunistic infections or exposing others to radiation ([Skorga et al., 2003](#)).

Willingness to Respond

Ten articles examined health care providers' willingness to report to work following a disaster event involving radiation. [Qureshi et al. \(2005\)](#) developed a survey instrument that revealed that radiation emergencies were one of the disaster scenarios to which health care workers were least willing to report to work (57% willing vs. a high of 80% for a snowstorm). Reasons cited for lack of willingness to report to work were fear and concern for self and family as well as personal health problems. Subsequent surveys examining ability and/or willingness to report to work or respond during a radiation disaster have revealed strikingly similar findings, chief among them that radiation emergencies regularly top the list of scenarios to which health care providers are least willing to respond. A two-phase study involving nursing units likely to respond in the event of a radiation disaster involving the use of an RDD, ([Veenema, Walden, Feinstein, & Williams, 2008](#)); the authors found that baseline knowledge of radiation exposure was inadequate and did not appear to be strongly associated with perception of personal safety. Perception of personal safety, however, was the primary determinant of willingness to respond following an RDD emergency ([Veenema et al., 2008](#)).

A survey of 3,426 employees at Johns Hopkins Hospital found that 39% of hospital workers were not willing to respond to a RDD scenario if asked but not required to do so ([Balicer et al., 2011](#)). [Adams and Berry \(2012\)](#) found that among health care staff at a Midwestern community hospital (the majority of whom were nurses), overall willingness to report to work ranged from a low of 69.1% for a radiologic event to 93% for an explosion with mass casualties. Hospital personnel were more willing to report for work during a natural disaster, such as a

tornado or earthquake, than in the event of a CBRN disaster, with 39% of health care workers willing to come in to work following a radiological disaster (Brice et al., 2017). A survey of 451 Australian nurses found that respondents were more significantly more willing to attend work during a conventional disaster, such as an earthquake, fire, or flood (97.7%) vs. a nonconventional one, such as a pandemic, chemical, biological or radiological event (86.3%) (Arbon et al., 2013a). Finally, a descriptive study of 95 nursing students revealed that the majority of these future nurses would not be willing to care for victims of terrorist attacks involving radiation if there was not adequate protection for both themselves and their families (Young & Persell, 2004).

Participants in many of the above-listed studies identified common barriers to their willingness to report to work during a radiological emergency. Being female and having children or elder care responsibilities were among the most frequently cited reasons for unwillingness to work (Adams & Berry, 2012; Balicer et al., 2011; Brice et al., 2017). Focus groups with 41 Australian nurses revealed that the type of disaster was one of the most significant factors above others that emergency nurses would consider as they weighed the risks of going to work, with biohazards and terrorist attacks involving CBRN devices topping the list of no-go scenarios (Arbon et al., 2013b).

The Fukushima Dai-ichi power plant accident offers a compelling yet grim example of health care providers' unwillingness to work following a radiological disaster. Following the explosion at Fukushima, hospital staff shortages were widespread due to fear about radiation exposure (Ochi et al., 2016). Staff shortages at seven hospitals in the Soso district of Fukushima Prefecture reached an apex within 1 month of the disaster, where only 48% of nurses reported to work (Ochi et al., 2016). In a sample of nurses split between those who had an explicit intention to leave following the accident (154, 44.6%) vs. those who had no intention of leaving (191, 55.4%), Sato et al. (2015) found several factors associated with nurses' intention to leave their jobs. Similar to those cited by health care workers in the United States responding to disaster surveys, factors associated with intent to leave included living with preschoolers, anxiety about life in Fukushima City after the disaster, concerns about the health effects of radiation—especially for children, and the need to evacuate (Sato et al., 2015).

Health Hazards

Ongoing health monitoring is crucial following a radiation event, and a surveillance program has been implemented in Japan following the nuclear accident at Fukushima Dai-ichi. Yamshita (2016) reported on a surveillance system implemented in the wake of Fukushima Dai-ichi that includes detailed surveys about thyroid ultrasound examinations, comprehensive health checkups, mental health checkups, and a survey on pregnant women and nursing mothers. The report also noted that evacuees listed psychological

stress associated with radiation anxiety as one of their top health concerns following the accident. Interestingly, Ben-Ezra, Palgi, Hamama-Raz, Soffer, and Shrira (2013) found that, compared with civilians exposed to the Tohoku earthquake and subsequent Fukushima Dai-ichi power plant explosion, nurses were less likely to report symptoms of post-traumatic stress disorder.

Japan is also the site of the atomic bomb detonations in Hiroshima and Nagasaki in 1945. Survivors were tracked through biennial medical examinations in the nation's Adult Health Study, established after the disaster; to determine risk of vascular dementia vs. Alzheimer's disease in over 2,000 subjects, 15.4% of whom had some form of dementia and 12.2% of whom had high scores on a cognitive impairment measure (Yamada et al., 1999). There was not a significant association between type of dementia and radiation exposure; however, the prevalence of dementia (7.2%) was higher than what has been previously reported in Japan (Yamada et al., 1999).

Perception of Risk

Fear regarding radiation exposure and contamination is widespread among health care workers, but Beauchamp (2016) argues that such fears are often based on faulty assumptions or a low level of knowledge about radiologic agents themselves. His article describes the basic safety principles necessary for health care settings to establish, based on a quantity–time–distance–shielding formula: quantity (reducing the quantity of potential contamination), time (limiting time in a radiation area), distance (increase distance from the radiation source), and shielding (wearing appropriate protective gear at all times) (Beauchamp, 2016). Focus groups with a nationally representative sample of nurses ($n=42$) and physicians ($n=35$) revealed key concerns in descending order: the hospital being overwhelmed, the safety of loved ones, possible staffing challenges, lack of readiness, contamination, and self-protection (Becker & Middleton, 2008). A lack of training, particularly around radiological scenarios or radiological content in training exercises, was also cited as a key concern for many staff (Becker & Middleton, 2008). In contrast, a survey of 10 Department of Energy sites, representing nearly 60,000 employees total (5.5% of whom were nurses), suggested that respondents are well aware of the dangers of radiological agents but rate explosions and radiation exposure near the bottom of their list of concerns (Salazar et al., 1999), likely due to perceptions that such an occurrence would be rare.

Clinical Practice

Nurses are involved in nearly every aspect of clinical care provided to patients who have been involved in a radiological disaster (Veenema & Thornton, 2015a). Understanding how to best treat these patients requires knowledge of how radiation exposure leads to injury and illness (Veenema & Karam, 2003). Radiation exposure causes bone marrow suppression

(cytopenias), gastrointestinal syndrome (nausea and vomiting), lymph tissue dysfunction, burns, rashes, and gonadal dysfunction (Dainiak et al., 2006; Skorga et al., 2003; Veenema & Thornton, 2015a). Patients involved in explosions, as seen with RDDs, use of nuclear weapons, or reactor explosions, may also present with severe burns, crush injuries, or trauma compounded by radiation exposure or contamination (Willis & Coleman, 2003). They may present with unknown illnesses caused by accidental or purposeful radiation exposure (Wilkinson, 2006).

Protocols and recommendations exist for health care workers to take in order to minimize radiation exposure to themselves, and it is the responsibility of the clinical nurse to understand these protocols (Wilkinson, 2006). The use of standard universal precautions and appropriate personal protective equipment still applies to radiation victims (Skorga et al., 2003; Dainiak et al., 2006).

Nurses will be expected to be at the forefront of triaging patients who are brought to or self-present to the hospital emergency department (Veenema & Thornton, 2015b). After ensuring their own safety, nursing will triage patients based on exposure, contamination, and injury (Dainiak et al., 2006). Collecting a detailed and rapid history is essential in aiding in triage and clinical treatment (Veenema & Karam, 2003). Managing patients of radiation exposure requires acute and focused assessment of multiorgan pathology and has proven to be rather challenging (Nair, Karan, & Makhani, 2017). Treating life-threatening injuries always takes precedent over decontamination. The rapid provision of first aid and resuscitation, stabilization, and intervention in traumas produces the most optimal clinical outcome (Dainiak et al., 2006). Medical treatment, especially of life-threatening conditions, should be the same as if the patient was not exposed to radiation.

Once the patient is stabilized, decontamination begins. Most hospitals have appointed radiation safety officers to oversee and manage aspects of decontamination. (Dainiak et al., 2006; Veenema & Thornton, 2015b). Nurses will be involved in the removal of contaminated clothing and foreign bodies, irrigating and cleaning wounds, and bathing patients (Veenema & Thornton 2015a; Veenema & Thornton 2015b). After decontamination is complete, care is largely focused on supportive measures. Hydration, prevention of infection, management of nausea/vomiting, and treatment of trauma/injuries/burns are per standard of care (Skorga, et al. 2003; Veenema & Karam, 2003; Veenema & Thornton 2015b).

During the time of a large-scale radiation exposure, the stress and anxiety of the general population, and patient population, will be very high. Nurses, a holistic care providers, should work with their team in providing psychosocial and psychological care to their patients (Skorga, et al. 2003; Dainiak et al., 2006; Veenema & Thornton, 2015a; Veenema & Thornton, 2015b). Nurses functioning in leadership roles will have to call upon managerial skills to assist their colleagues during these stressful times (Shabanikiya,

Gorgi, Seyedin, & Jafari, 2016). Nurses caring for victims of the atomic bomb dropped on Hiroshima have recalled that care activities change moment to moment and that each patient will present a new challenge in care (Yuko et al., 2008).

Summary of Evidence

The research team sought to answer the question “Are nurses ready and willing to respond to an RDD event?”, yet few of the studies we identified addressed this question directly. The results were not definitive in their findings but suggest an overall lack of nurse preparedness and capacity for responding to a disaster event involving a radiological device. The studies acknowledge that nurses have had and will in the future have a critical role in managing patients presenting with radiation contamination following an RDD event (e.g., trauma and burn care, decontamination, triage, and mental health care). Empirical evidence related to nurse readiness is predominately descriptive in nature and address the roles and responsibilities nurses *would* need to fill but fail to provide quantitative attestation to support that nurses *are able and willing* to serve in these roles. Description of the actual roles and responsibilities of nurses in disaster response and recovery following a radiation emergency or nuclear event was limited to historical reports of the clinical care provided following Hiroshima, Nagasaki, and Fukushima Dai-ichi.

Limitations

The primary limitation involves study design. Systematic analysis of the 62 manuscripts included in this review revealed a range of levels of evidence from II to V, with the majority of the studies III, IV, and V. The studies varied widely in their focus of inquiry and addressed themes related to nurse readiness but did not measure readiness itself.

Conclusion

There is much research that needs to be done to identify the specific roles and responsibilities of nurses in radiation emergency and nuclear response and to ascertain in greater detail quantitative measurement of the level of national nurse readiness for these large-scale radiation emergency and nuclear events. Future research should also identify strategies for nursing workforce development in this critical area in order to support U.S. National Security (Table 5).

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Supplementary material

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.outlook.2018.10.005>.

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