POLICY STATEMENT Organizational Principles to Guide and Define the Child Health Care System and/or Improve the Health of all Children

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Pediatric Considerations Before, During, and After Radiological or Nuclear Emergencies

Jerome A. Paulson, MD, FAAP, COUNCIL ON ENVIRONMENTAL HEALTH

abstract

Infants, children, and adolescents can be exposed unexpectedly to ionizing radiation from nuclear power plant events, improvised nuclear or radiologic dispersal device explosions, or inappropriate disposal of radiotherapy equipment. Children are likely to experience higher external and internal radiation exposure levels than adults because of their smaller body and organ size and other physiologic characteristics, by picking up contaminated items, and through consumption of contaminated milk or foodstuffs. This policy statement and accompanying technical report update the 2003 American Academy of Pediatrics policy statement on pediatric radiation emergencies by summarizing newer scientific knowledge from studies of the Chernobyl and Fukushima Daiichi nuclear power plant events, use of improvised radiologic dispersal devices, exposures from inappropriate disposal of radiotherapy equipment, and potential health effects from residential proximity to nuclear plants. Policy recommendations are made for providers and governments to improve future responses to these types of events.

Department of Pediatrics, School of Medicine and Health Sciences and Department of Environmental and Occupational Health, Milken Institute School of Public Health, George Washington University, Washington, DC

Dr Paulson was responsible for all aspects of writing and revising this statement and has approved the final manuscript as submitted.

DOI: https://doi.org/10.1542/peds.2018-3000

Address correspondence to Jerome A. Paulson, MD, FAAP. E-mail: jerry@envirohealthdoctor.com.

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

To cite: Paulson JA and AAP COUNCIL ON ENVIRONMENTAL HEALTH. Pediatric Considerations Before, During, and After Radiological or Nuclear Emergencies. *Pediatrics.* 2018;142(6): e20183000

BACKGROUND

Children can be exposed to environmental radiation as a result of nuclear power, fuels reprocessing, and weapons production plant (hereafter designated "nuclear plant") events; from an improvised nuclear device or radiologic dispersal device; or from abandoned medical radiation equipment that could potentially result in substantial levels of radiation exposure and associated health effects. Because the radiation levels from these sources could lead to a radiation emergency, this term is used to refer to these types of exposures hereafter in this report. Children and their families are likely to be extremely anxious about such events and may turn to their medical professional for advice. Parents may also ask providers about concerns related to residential and school proximity to nuclear power plants. Health professionals are concerned

about these exposures because, in general, children are more sensitive to radiation and are more likely to develop the short-term and some of the long-term effects of radiation exposure. Children are likely to experience higher external and internal radiation exposure levels than adults because children are shorter and have smaller body diameters and organ sizes.[1] Children have a longer time to live, and, thus, more time in which to develop adverse outcomes. In addition, children may ingest radioactive material from picking up contaminated items and putting hands in their mouths when crawling,[2] ingesting soil,[3] or consuming milk from cows feeding on contaminated pastures or feed.[4]

An updated policy statement and a technical report[5] are needed that incorporate (1) new scientific knowledge from late effects studies of the Chernobyl accident, (2) lessons from the 2011 Fukushima Daiichi Japanese nuclear power plant accident, (3) information pertinent to the use of improvised radiologic dispersal devices and the specter of nuclear detonation in heavily populated regions, (4) radiation exposures from lack of appropriate disposal of older radiation therapy equipment, and (5) recommendations based on new knowledge from epidemiologic studies and from biokinetic models to address mitigation efforts. Although concerns have been raised about potential health effects associated with radiation exposures of children living or going to schools in proximity to nuclear power plants, the data related to these exposures and the outcome of leukemia are inconclusive and tend toward no association.[6]

Four major nuclear plant accidents have occurred: Windscale in Seascale, Cumbria, in the United Kingdom (1957); Three Mile Island in Pennsylvania (1979); Chernobyl in Ukraine (1986); and Fukushima Daiichi nuclear power plant in Fukushima Prefecture, Japan (2011). There were 504 open-air nuclear weapons tests in 13 sites around the globe between the years of 1945 and 1980. Events involving abandoned medical radiation equipment have resulted in acute radiation sickness and deaths as well as contamination of thousands of people and homes.[7]

It is important to recognize that some mental health effects of a radiation event may begin as soon as the public becomes aware of the event, but other mental health effects may be delayed. Physical health effects after radiation exposure include short-term effects that appear within days to months after radiation exposure and long-term effects that generally appear 18 months to many years later.[8] The types and severity of short-term effects are related in part to the level of exposure and the tissues exposed. In general, children are more sensitive to radiation and are more likely to develop the short-term and some of the long-term effects of radiation exposure.

TYPES OF RADIATION EMERGENCIES AND RELATED EXPOSURES

Detailed information about types of radiation emergencies and other types of exposures to radiologic materials can be found in the technical report.[5]

RECOMMENDATIONS TO PEDIATRICIANS AND THE HEALTH SECTOR

1. Much of the preparedness planning for radiologic or nuclear events is the same as the preparedness for all emergency events. Pediatricians and other providers should refer to information on the National Pediatric Readiness Project Web site (https://emscimprovement.center/projects/pediatricreadiness/) and on many American Academy of Pediatrics Web pages (https://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Children-and-Disasters/Pages/default.aspx);
2. Because mental health effects have been demonstrated to be among the most clinically important adverse outcomes subsequent to radiation and other disasters in subsets of the general population, but data are limited on short- and long-term health effects in exposed children, pediatricians should provide ongoing assessment, treatment, and specialist referrals for the mental health, behavioral, and developmental needs of patients and their parents or caregivers exposed to radiation emergencies and disasters;
3. Because the management of exposed children can potentially require monitoring for contamination, decontamination, and determination of the extent of contamination or exposure, this will need to be performed at a center equipped to perform these functions for a large number of victims. Pediatric providers should inquire from their local and state health departments about the location of community reception centers that may be designated, depending on the type of emergency, in real time. More information about population monitoring and community reception centers can be found at http://emergency.cdc.gov/radiation/pdf/population-monitoring-guide.pdf;
4. Information about when and how to use potassium iodide (KI) should be downloaded and kept in a place that will be accessible during an emergency. KI, like all medications, has risks as well

as benefits and should be given when there are, and according to, instructions from public health agencies. Information is available in Table 3 of the accompanying technical report.[5] Information about crushing and mixing KI tablets can be found on the US Food and Drug Administration Web site (https://www.fda.gov/Drugs/EmergencyPreparedness/BioterrorismandDrugPreparedness/ucm063814.htm);

5. When the risk of exposure to radioactive iodine is temporary, mothers can continue to breastfeed if appropriate doses of KI are given to her and the infant within 4 hours of the contamination; if not, mother and infant should then be prioritized to receive other protective measures like evacuation. Mothers who are breastfeeding should consider temporarily stopping breastfeeding and switching to either expressed milk (that was pumped and stored before the exposure) or ready-to-feed infant formula until the mother can be seen by a doctor for appropriate treatment with KI.[9,10] If no other source of food is available for the infant, the mother should continue to breastfeed after washing the nipple and breast thoroughly with soap and warm water and gently wiping around and away from the infant's mouth;
6. Pediatric medical centers should ensure that their facilities are properly equipped to receive and manage contaminated children. Planning also needs to consider adults who will accompany children and may be likewise contaminated;
7. Providers in the emergency department, the ICU, and other inpatient settings should have access to an application developed by the Centers for Disease Control and Prevention, the Internal Contamination Clinical Reference Application, which can be downloaded to a mobile device free of charge at http://emergency.cdc.gov/radiation/iccr.asp.[11] It would be prudent to download this information in hard copy and arrange to keep the material easily available before a radiologic emergency, when communication problems may make it difficult to do so;
8. Providers should refer to additional information on Radiation Emergency Medical Management at http://www.remm.nlm.gov/[12];
9. Accrediting agencies such as the Accreditation Association for Ambulatory Health Care and The Joint Commission should include a requirement for office training and preparedness for radiation emergencies, including KI administration to exposed children, in their accrediting standards; and
10. Training of all health professionals in the management of mental health issues associated with all emergency events should be expanded because demand will outstrip supply of mental health professionals.

RECOMMENDATIONS TO GOVERNMENT

1. Primary care providers are the medical home for children and families; therefore, these providers must be included in all aspects of preparedness training undertaken or funded by government entities;
2. Likewise, training in triage, acute management, and more importantly, long-term management of exposed children must be provided to primary care providers who create medical homes for children and families;
3. Because treatment with KI should be commenced immediately before or during the passage of a radioactive cloud in an event in which radioiodines are released, KI supplies need to be stored where readily available to the public. Storage in the National Strategic Stockpile will not allow for timely distribution of materials; KI should be stored in hospitals, public health departments, and other local sites;
4. Storage of KI should be standardized among the states to avoid confusion and miscommunication among people living near state borders who may receive information through the media from multiple state health departments;
5. Funding should be expanded for mental health services to meet the need for all types of disasters, including radiologic or nuclear emergencies; and
6. A list of child-appropriate decontamination procedures and service providers should be developed and disseminated to primary care providers, first responders, and emergency departments.

RECOMMENDATIONS FOR FAMILIES

1. Families should review the recommendations for preparation and behavior during major emergency events. The American Academy of Pediatrics and government agencies have prepared comprehensive information for families (https://www.healthychildren.org/English/safety-prevention/at-home/Pages/Family-Disaster-Supplies-List.aspx and https://www.ready.gov/nuclear-blast);

2. Preparations before a nuclear event are consistent with preparations for all types of major emergencies:
    - Build an emergency supply kit (nonperishable foods, water, flashlight, medical supplies), collect copies of prescriptions, and collect copies of important documents (driver's license, social security numbers, proof of residence, insurance policies, immunization records, etc);
    - Make a family emergency plan of a place to shelter; make plans for an out-of-town contact if not possible to connect by phone in a location; learn emergency plans for workplace, school, and child care; notify caregivers of plans; and make plans for pets; and
    - Obtain information from utility companies about emergency contact information if a power outage occurs;
3. Activities during a nuclear event are advised as follows:
    - Minimize exposure by increasing the distance between people and the source of radiation; this may involve remaining indoors or evacuating. Follow the recommendations of local public health authorities;
    - If told to evacuate, keep car windows and vents closed and use recirculation;
    - If advised to remain indoors, turn off air conditioners, ventilation fans, furnaces, and other air intakes;
    - Shield people by placing heavy, dense material between people and the radiation source; go to a basement or other underground area, if possible. Select an appropriate shelter location (http://emergency.cdc.gov/radiation/pdf/infographic_where_to_go.pdf)[13];
    - Do not use phones unless absolutely necessary so network congestion is decreased;
    - Stay out of the incident zone;
    - Take KI on the basis of advice from regional and local government sources;
    - Do not take KI unless advised to because of the potential for serious adverse effects;
    - If shelter is not possible in the family residence because of destruction or the family is far away from a residence, go to the designated public shelter (text SHELTER and zip code to 43312 (4FEMA) to find the nearest shelter;
    - Follow decontamination instructions from local authorities;
    - Change clothes and shoes and place contaminated clothes in plastic bags, which should be sealed and placed out of the way; and
    - Take a thorough shower, washing body and hair;
4. Activities after a nuclear or radiologic event are advised as follows:
    - Seek medical treatment of unusual symptoms (eg, nausea, vomiting, bleeding, etc);
    - Help neighbors, infants, children, the elderly, those with disabilities, and those with access problems;
    - Return home only when authorities say it is safe to do so; and
    - Keep food in covered containers or in the refrigerator, wash the outside of containers before use, only eat food in covered containers, and seek advice from local authorities on the consumption of uncovered foodstuffs.

ACKNOWLEDGMENTS

Dr Paulson thanks Martha S. Linet, MD, MPH, and Ziad Kazzi, MD, for their help in providing the technical information in the accompanying technical report, which informed the recommendations in this policy statement, and for their thoughtful input and reviews.

ABBREVIATION

KI: potassium iodide

FINANCIAL DISCLOSURE: The author has indicated he has no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The author has indicated he has no potential conflicts of interest to disclose.

COMPANION PAPER: A companion to this article can be found online at www.pediatrics.org/cgi/doi/10.1542/peds.2018-3001.

REFERENCES

1. Tracy BL. Would children be adequately protected by existing intervention levels during a radionuclear emergency? *Radiat Prot Dosimetry*. 2010;142(1):40–45
2. Binder S, Sokal D, Maughan D. Estimating soil ingestion: the use of tracer elements in estimating the amount of soil ingested by young children. *Arch Environ Health*. 1986;41(6):341–345
3. Simon SL. Soil ingestion by humans: a review of history, data, and etiology with application to risk assessment of radioactively contaminated soil. *Health Phys*. 1998;74(6):647–672
4. Simon SL, Bouville A, Land CE. Fallout from nuclear weapons tests and cancer risks: exposures 50 years ago still have health implications today that will continue into the future. *Am Sci*. 2006;94(1):48–57
5. Linet MA, Kazzi Z, Paulson JA; American Academy of Pediatrics, Council on Environmental Health. Pediatric considerations before, during, and after radiological/nuclear emergencies. *Pediatrics*. 2018;142(6):e20183001
6. Stather JW. Childhood leukaemia near nuclear sites: fourteenth report of the Committee on Medical Aspects of Radiation in the Environment (COMARE). *Radiat Prot Dosimetry*. 2011;147(3):351–354
7. Biddle W. *A Field Guide to Radiation*. New York, NY: Penguin Books; 2012
8. Mabuchi K, Fujiwara S, Preston DL, et al. Long-term health effects of radiation. In: Shrieve DC, Loeffler JS, eds. *Radiation Injury*. Philadelphia, PA: Lippincott, Williams and Wilkins; 2011:89–113
9. Centers for Disease Control and Prevention. Radiation emergencies: breastfeeding. Available at: http://emergency.cdc.gov/radiation/breastfeeding.asp. Accessed August 22, 2017
10. American Academy of Pediatrics. Infant feeding in disasters and emergencies. 2015. Available at: https://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/Breastfeeding/Documents/InfantNutritionDisaster.pdf. Accessed May 10, 2017
11. Centers for Disease Control and Prevention. Internal contamination clinical reference application. Available at: http://emergency.cdc.gov/radiation/iccr.asp. Accessed August 22, 2017
12. US Department of Health and Human Services; Radiation Emergency Medical Management. Guidance on diagnosis and treatment for healthcare providers. Available at: www.remm.nlm.gov/. Accessed August 22, 2017
13. Centers for Disease Control and Prevention. Where to go in a radiation emergency. Available at: http://emergency.cdc.gov/radiation/pdf/infographic_where_to_go.pdf. Accessed August 22, 2017

Pediatric Considerations Before, During, and After Radiological or Nuclear Emergencies

Jerome A. Paulson and COUNCIL ON ENVIRONMENTAL HEALTH

Pediatrics originally published online November 26, 2018;

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Pediatric Considerations Before, During, and After Radiological or Nuclear Emergencies

Jerome A. Paulson and COUNCIL ON ENVIRONMENTAL HEALTH

Pediatrics originally published online November 26, 2018;