HHS Public Access
Author manuscript
*Biosecur Bioterror*. Author manuscript; available in PMC 2015 July 11.

Published in final edited form as:
*Biosecur Bioterror*. 2014 ; 12(4): 201–207. doi:10.1089/bsp.2014.0036.

# Public Health Emergency Planning for Children in Chemical, Biological, Radiological, and Nuclear (CBRN) Disasters

**Michael T. Bartenfeld**, **Georgina Peacock**, and **Stephanie E. Griese**
Michael T. Bartenfeld, MA, is a Public Health Analyst, and Georgina Peacock, MD, MPH, is a Medical Officer; both at the National Center on Birth Defects and Developmental Disabilities, Centers for Disease Control and Prevention, Atlanta, Georgia. Stephanie E. Griese, MD, MPH, is a Medical Epidemiologist, Office of Public Health Preparedness and Response, Centers for Disease Control and Prevention, Atlanta, GA

## Abstract

Children represent nearly a quarter of the US population, but their unique needs in chemical, biological, radiological, and nuclear (CBRN) emergencies may not be well understood by public health and emergency management personnel or even clinicians. Children are different from adults physically, developmentally, and socially. These characteristics have implications for providing care in CBRN disasters, making resulting illness in children challenging to prevent, identify, and treat. This article discusses these distinct physical, developmental, and social traits and characteristics of children in the context of the science behind exposure to, health effects from, and treatment for the threat agents potentially present in CBRN incidents.

Children are recognized as a potentially at-risk population in chemical, biological, radiological, and nuclear emergencies (CBRN), but data on children in some of these events are scarce. Despite our limited experience with some CBRN disasters, our understanding of children's physical, developmental, and social characteristics, together with our knowledge of general challenges associated with CBRN incidents, can inform us of the dangers children face and the difficulties in providing specialized care in these emergency situations. Children's unique needs in CBRN emergencies may not be well understood by those charged with providing care in these situations, including public health officials, emergency management workers, or even clinicians.[1] This article will inventory children's vulnerabilities and consider the unique implications for them in public health emergency planning and response. As we will illustrate, in comparison to adults, children are at higher risk of exposure, more susceptible to illness, and more challenging to provide care for in CBRN emergencies.



Address correspondence to: Michael Bartenfeld Centers for Disease Control and Prevention National Center on Birth Defects and Developmental Disabilities 1600 Clifton Road, MS-E86 Atlanta, GA 30333 vdv4@cdc.gov.

## Unique Characteristics of Children

Knowing how to better prepare for the needs of children requires an understanding of what makes them different. Children have physical, developmental, and social differences from adults.

### Physical

Most obviously, children are generally smaller than adults. They have thinner skin, less subcutaneous fat and tissue, lower blood volume, and a higher ratio of body surface area to body mass.[2] This means that children, and particularly infants, are more sensitive than adults to changes in body temperature and have an increased risk of hypothermia. Children have a higher metabolism and more active cell division as their bodies grow, and some organ-to-body-mass ratios are larger. They have higher respiratory rates than adults; on average, young children breathe twice as much per kilogram of body weight per day, while newborn babies breathe 3 times as rapidly.[3]

### Developmental

In addition to physical factors, children exhibit behaviors during development that can exacerbate their risk of adverse health effects during CBRN disasters. Children spend significantly more time engaging in higher energy physical activity than adults, increasing their heart and respiratory rates.[4,5] Young children, including those ages 0 to 8 years, spend 2 to 4 hours per day playing indoors,[6] which raises respiratory intake by over 20% from sitting.[7] Depending on the level of activity, outdoor respiratory rates can be even higher. Running children breathe 4 times faster than sitting children. On average, young American children spend 4 to 5 hours per day outdoors.[6] Young children touch dirt, smooth surfaces, and objects to their mouths multiple times per hour.[8,9] These behaviors may all contribute to an increased risk of physical exposure to agents, toxins, and other hazards during CBRN incidents. In addition, depending on age and development, children may not have the communication skills, motor skills, or judgment to effectively move toward safety in a dangerous situation.[10,11] In a state of panic, young children may not move, or they may simply begin crying or screaming.[12]

### Social

Children are dependent on caregivers, whether parents or others, at all hours of the day. As a result, children have a high number of personal contacts in their household and through school and childcare. In fact, children aged 5 to 19 years maintain higher personal contact rates per day than any other age group, with children 10 to 14 years old having the highest contact rates.[13] Children's complex social networks have important implications for the spread of contagious diseases. Furthermore, their dependence on caregivers to make informed healthcare decisions on their behalf creates challenges. Many medical countermeasures (MCMs) are rarely tested or approved for use in children, and some can be administered only under regulatory mechanisms such as an Emergency Use Authorization or an Investigational New Drug protocol. Abiding by these regulations, providing the necessary information to receive informed consent from caregivers, and trying to maximize MCM coverage in a pediatric population during a large-scale event will be difficult. While plans exist to conduct studies to evaluate the safety of MCMs in children, the process to collect these data will be long.[14]

## Integrating Pediatric Characteristics

Knowledge of children's unique characteristics provides a foundation for understanding their vulnerability to exposure, susceptibility to illness, and difficulty of treatment in CBRN events. They can differ from adults in their exposures to hazardous substances and may be more or less susceptible than adults based on the substance.[2]

### Biological

Biological agent exposure holds unique risks for children.[6,10] Young children spend approximately 4 to 5 hours per day outside, a particular concern with the airborne release of biological agents, such as *Francisella tularensis*, viral hemorrhagic fevers, or variola virus, which can survive from hours to days in the environment.[15] *Bacillus anthracis* spores will remain a viable inhalation risk for many hours while descending before settling on the ground after an airborne release,[16] and they can persist in the soil for centuries.[17] Given how spores of hardier organisms like *B. anthracis* spread, infiltrate indoors, and potentially reaerosolize after a release,[18–20] infants and toddlers crawling or playing on the ground could be at a higher risk of infection through multiple routes of exposure. A child's developmental level can also play a role in route of exposure, as younger children have frequent hand-to-mouth behavior. Studies show soil ingestion by young children in contaminated areas leads to higher intake of toxic substances than by older children.[21]

For contagious agents, household contacts are at the highest risk of secondary infection. Children, particularly young children or children with disabilities, require a high number of personal contacts for daily care. In epidemic models, a disease incidence peak forms in school-age children, with a smaller peak in middle-aged adults (parents), for this reason.[13] Smallpox has a nonspecific, noncontagious phase that confines an infected individual to home and bed rest. When the illness progresses to a more severe, contagious state, it raises the risk of infection of close contacts in the household. According to the WHO smallpox eradication campaign, males aged 5 to 20 were deemed “important in extrafamilial spread, since they moved between family groups more frequently and readily than other segments of the population.”[22] Breastfeeding and other close contacts can expose infants to infection from biological agents or as a consequence of treatment—for example, the development of cutaneous anthrax infection after close contact with a mother's untreated lesion[23] or inoculation with vaccinia virus while breastfeeding.[24] In fact, 62% of secondary vaccinia infections in the US during pre-1972 routine vaccination occurred in children under 5 years of age.[25]

Screening children for infection after they are exposed to biological pathogens is another challenge clinicians must face. Evidence-based screening algorithms are necessary for rapid triage and risk stratification. Adult screening criteria have been shown to be of limited value for evaluating children for anthrax infection.[26] Young children may have unusual presentations of disease. An infant was infected with anthrax during the 2001 US anthrax attacks and displayed symptoms unusual for cutaneous infection, thus delaying diagnosis.[27]

Young children may also have difficulty describing symptoms, particularly symptoms such as difficulty breathing, chest discomfort, muscle pain, nausea, and headache. Diseases caused by other biological agents, such as pneumonic plague, smallpox, and tularemia, may present as nonspecific febrile illnesses. Acute febrile illnesses are common in young children, promoting a low index of suspicion among clinicians of infection with bioterror agents. Acute care in surge settings is further complicated by children's tendency to appear well and then decompensate rapidly when they are sick.

Because of their physiology, children are particularly susceptible to the effects of severe illness. Children are vulnerable to fluid loss, a risk exacerbated by the hemorrhagic or diarrheal symptoms of many biological agents. Children have a higher metabolic rate, increasing their susceptibility to inhaled toxins. Dose-response activity of anthrax is not well understood, but animal data suggest that duration of infection until death may correlate with body weight.[28] Smaller body size also requires alternative dosing for medical countermeasures, as it is not recommended that children take a full adult dose. Many children cannot swallow pills; for postexposure prophylaxis against anthrax, the Food and Drug Administration (FDA) recommends crushing doxycycline tablets for children weighing less than 90 pounds,[29] which amounts to approximately 14% of the total US population.[30–32] The need for crushable pills, liquid suspensions, or another alternative dosing methods limits the types of medications children can take in an emergency.

## Radiological/Nuclear

Release of radioactive materials into the environment may happen in a variety of both unintentional and intentional ways. Japan's 2011 Fukushima disaster is just the most recent example illustrating the need for radiological emergency preparedness in countries with nuclear power. Terrorist use of a radiological dispersal device (be it explosive or nonexplosive) and the detonation of an improvised nuclear device remain concerns.

Explosive radiological dispersal devices (“dirty bombs”) and nuclear weapons represent a significant hazard. The danger to children from blast injuries—primary injuries from over-pressurization force (blast wave) that have an impact on the body surface; secondary injuries from projectiles; tertiary injuries from being thrown into other objects; quaternary injuries like crush injuries, burns, and toxic exposures[33]—is a consequence of several physiological factors. Thinner skin and a high body-surface-area-to-mass ratio make children particularly susceptible to the effects of blast and burn injuries. Open wounds from projectiles and burns coupled with acute radiation exposure lead to higher mortality in all populations from bone marrow stem cell damage, slow wound healing, and an ensuing high risk of secondary infection.[34,35] Combined injury with radiation exposure is a concern given children's risk of injury from blast and burn.

Beyond the immediate catastrophic damage and blast injuries that accompany a nuclear detonation, there is also the danger of exposure to ionizing radiation from the detonation and the resulting radioactive fission products. These fission products can travel long distances in the air plume, resulting in direct exposure to those below the plume and inhalation exposure to those inside it. Multiple exposure routes are possible when fission products settle on the ground as fallout. An improvised nuclear device detonated at ground level (known as a "ground burst") is capable of sending large amounts of fallout into the atmosphere. Children are at risk for becoming contaminated with radioactive material above background levels, both internally (ie, through inhalation and ingestion) as well as externally on their skin and clothing. When children play on the floor, for example, radioactive particle resuspension rates are 500% higher than in undisturbed areas.[36] In the post-plume phase of an event, children can also receive a higher dose of external radiation from the same environmental exposure than adults, because they are closer to the ground and their organs are closer to the radiation source. And their internal radiation dose from ingestion of fallout and inhalation of resuspended fallout can be higher because of children's higher respiratory rates, hand-to-mouth behaviors, and dietary habits (overall greater consumption of milk, in which radionuclides concentrate, than adults). After the disaster in Chernobyl, the FDA developed derived interventional levels (DILs) to provide radionuclide-specific concentration limits in food by age group, protecting sensitive individuals such as children from exposure through dietary intake.[37–39]

The behavior and developmental status of children are important determinants in their exposure to radioactive contamination; however, it is children's physiology that makes them particularly susceptible to adverse radiological health effects. The United Nations estimates that children carry a lifetime risk of cancer that is 2 to 3 times greater than that of the general population for a given radiation dose.[40] Children are considered to be at higher risk of breast cancer, brain cancer, thyroid cancer, non-melanoma skin cancer, and leukemia based on age at exposure. Children's growing bodies, more active cell division, greater milk consumption, and longer remaining life spans in which to express damage compared to adults lead to potentially greater radiation doses and increased lifetime cancer risk.[2] One such nuclide, radioactive iodine (I-131), can lead to thyroid cancer at high radiation doses. Other potential health effects include growth retardation, severe hypothyroidism, and thyroid gland nodules and neoplasms. These health effects were observed in children after the 1954 Castle *BRAVO* nuclear bomb test in the Marshall Islands.[2] Children's thyroid glands hold iodine concentrations that are 3 to 5 times higher than those in adults.[41] In a radiation emergency, I-131 will accumulate together with stable iodine in the thyroid, leading to an absorbed radiation dose 8 to 9 times higher in infants than in adults.[40]

Childhood and adolescent thyroid cancer incident rates increased markedly in the affected areas after the 1945 atomic bombings in Japan, the 1954 Castle *BRAVO* test, and after the 1986 nuclear power plant disaster in Chernobyl, Ukraine.[43] Nursing infants in the Marshall Islands received internal I-131 exposure from ingesting contaminated breast milk.[2] However, such cancer rates did not occur following the Three Mile Island (TMI) nuclear power plant accident in Pennsylvania.[43] This was attributed to stopping the consumption of locally produced milk, an effective public health action that did not occur in the Ukraine.[44]

Children are also at high risk of adverse health effects from exposure to radionuclides having much longer half-lives than I-131. Radioactive cesium isotopes Cs-134 and Cs-137 can remain on the ground for many years.[45] As with I-131, there have been historical examples of transfer of Cs-137 from mothers to their children through breast milk.[46] The prevailing winds blew most of the radioactivity from Fukushima out to sea, but limited amounts of fission products (particularly strontium-90 [Sr-90], I-131, Cs-134, and Cs-137) were blown inland across populated areas,[47] and high levels of these isotopes were recorded in rainfall, tap water, vegetation, and in the milk supply worldwide.[48] Affected populations in Japan (those living in affected areas who may have been exposed to and possibly contaminated with these radionuclides) are being monitored for long-term health effects; a large cohort representing all age groups will receive lifelong cancer screening services.[49] Sr-90, a fission product present in fallout, behaves chemically like calcium. It is absorbed from the gastrointestinal tract at a slightly higher rate in children and accumulates faster in growing bones, posing an increased risk to children.[50] Bone growth occurs in spurts. Infants and adolescents characteristically experience the most rapid growth of bone and are therefore most susceptible to the hazards posed by incorporation of radioactive strontium into the bone matrix.[40]

Radioactive elements need not be internalized in or deposited on the body to pose a health threat. Radiation exposure from nonfission radionuclides that could be used in a dirty bomb or nonexplosive radiological dispersion device (RDD), such as cobalt-60 (Co-60), holds risks for children as well. Co-60, a high-energy gamma source, is used commercially in various settings, including cancer treatment, and was recently involved in a theft in Mexico.[51] Few studies of the effects of Co-60 in children exist, but data in Taiwanese children following exposure suggest that boys raised in Co-60–contaminated apartments experienced less growth relative to their peers.[52]

### Chemical

While chemical agents are unlikely to affect as large a population as biological or nuclear weapons, they present significant challenges for children. Multiple reports of the August 2013 chemical weapons attack in Syria count a high percentage of children among the casualties,[53] with the American assessment counting 426 children out of 1,429 fatalities.[54] Young children with an underdeveloped sense of self-preservation may not run away from a cloud of white gas, even if others are doing so. Unlike most CBRN agents, some nerve agents can be absorbed through intact skin, leading to more severe exposure for young children who have more permeable skin and higher body-surface-area-to-mass ratio. Pulmonary agents like chlorine gas can be especially destructive to children, as children have narrower airways and twice the metabolic oxygen requirement as adults.[55] In addition, certain chemical agents, such as chlorine and sarin, are heavier than air, causing them to settle nearer to the ground where they are more easily inhaled by children. Children's higher respiratory and metabolic rates put them at higher risk for intake of these toxins. Additional considerations for children after a chemical attack include their requirement for smaller proportioned clothing after decontamination and the danger of hypothermia in a water-based decontamination effort.

## Discussion

While the unique physical, developmental, and social characteristics of children are not predictive of what specific health effects will occur in children in a given CBRN event, it is likely that children will significantly contribute to the healthcare burden after a disaster. Children are different from adults in size, constitution, respiratory rate, physical activity, hand-to-mouth activity, and number of personal contacts, and they can have underdeveloped communication skills and self-preservation instincts. Public health responses are further complicated by pediatric medical care and countermeasure considerations. Accounting for children requires a broad understanding of their vulnerabilities by those in the fields of public health, emergency management, and clinical care.

It is one step to check off what makes children different. It is another step for public health emergency officials to apply this knowledge in planning. Children's smaller size is an obvious difference from adults and leads to greater exposure risks, the need for different-sized medical equipment, and different dosing of medications. Children's behavior and developmental level, such as their playing habits and their need for care, point to a need for strong health communication to parents on how best to protect their children and to clinicians for screening and treatment of children in a CBRN event.

When developing tools for screening and triage, it is important to balance an understanding of children's frequent, nonspecific febrile illnesses with a need to consider biological threat agents in the differential diagnosis. For example, atopic dermatitis is a common condition in children,[56] and some cases are a potential contraindication to smallpox vaccination.[57] It may not be apparent to all clinicians which of those children diagnosed with atopic dermatitis should not get the smallpox vaccine. Therefore, procedures that effectively limit the over-identification of children at risk for complications from smallpox vaccination will be essential to ensure children are not referred down a different dispensing algorithm path than they need, whether this means receiving an inappropriate vaccine or no vaccine at all. Other factors, such as children's tendency to decompensate faster once ill should factor into triage algorithms in mass care settings. Moreover, confronting the regulatory and testing challenges of MCMs will require innovative collaboration with FDA.

CBRN disasters have been uncommon on a large scale, but when they happen, children can be expected to be disproportionately affected if their vulnerabilities are not considered ahead of time. Children are at high risk for exposure from biological agents, and children sick with illnesses caused by these biological agents may be challenging to identify and treat. Burns and mechanical injuries from a nuclear blast can injure a child more severely than an adult, making secondary infection more dangerous. After radiological releases, children are more at risk from exposure to and contamination with certain radionuclides than adults. Children's potential for high morbidity and mortality in chemical weapons incidents has already been seen in Syria. Moreover, child development plays a key role in determining risk factors for exposure and health effects; for example, infants are more likely to touch objects to their mouths, young children are more likely to play outside, and adolescents experience accelerated skeletal growth. Being mindful of these unique characteristics and vulnerabilities of children is important in order to reduce the potential for children to bear more of the health burden than they should in CBRN disasters.

## Acknowledgments

The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

## References


1. Stankovic C, Mahajan P, Ye H, Dunne RB, Knazik SR. Bioterrorism: evaluating the preparedness of pediatricians in Michigan. Pediatr Emerg Care. Feb; 2009 25(2):88–92. [PubMed: 19194343]
2. [Accessed April 10, 2014] US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. Toxicological Profile for Iodine. 2004. http://www.atsdr.cdc.gov/toxprofiles/tp158. pdf
3. Brochu P, Ducré-Robitaille JF, Brodeur J. Physiological daily inhalation rates for free-living individuals aged 1 month to 96 years, using data from doubly labeled water measurements: a proposal for air quality criteria, standard calculations and health risk assessment. Hum Ecol Risk Assess. 2006; 12(4):675–701.
4. US Centers for Disease Control and Prevention. [Accessed July 1, 2013] Youth Risk Behavior Surveillance System (YRBSS). 2011. updated June 12, 2014http://www.cdc.gov/HealthyYouth/yrbs/index.htm
5. US Centers for Disease Control and Prevention. [Accessed July 1, 2013] Behavioral Risk Factor Surveillance System. 2014. updated May 8, 2014http://www.cdc.gov/brfss/
6. Cohen Hubal EA, Sheldon LS, Burke JM, et al. Children's exposure assessment: a review of factors influencing children's exposure, and the data available to characterize and assess that exposure. Environ Health Perspect. Jun; 2000 108(6):475–486. [PubMed: 10856019]
7. Kawahara J, Tanaka S, Tanaka C, Aoki Y, Yonemoto J. Daily inhalation rate and time-activity/location pattern in Japanese preschool children. Risk Anal. Sep; 2012 32(9):1595–1604. [PubMed: 22384860]
8. Reed KJ, Jimenez M, Freeman NC, Lioy PJ. Quantification of children's hand and mouthing activities through a videotaping methodology. J Expo Anal Environ Epidemiol. Sep-Oct;1999 9(5): 513–520. [PubMed: 10554153]
9. Zartarian VG, Ferguson AC, Leckie JO. Quantified dermal activity data from a four-child pilot study. J Expo Anal Environ Epidemiol. 1997; 7(4):543–552. Erratum in: J Expo Anal Environ Epidemiol 1998 Jan-Mar;8(1):109. [PubMed: 9306237]
10. Gausche-Hill M. Pediatric disaster preparedness: are we really prepared? J Trauma. Aug; 2009 67(2 Suppl):S73–S76. [PubMed: 19667856]
11. American Academy of Pediatrics; Committee on Environmental Health and Committee on Infectious Diseases. Chemical-biological terrorism and its impact on children: a subject review. Pediatrics. Mar; 2000 105(3 Pt 1):662–670. [PubMed: 10699130]
12. Sugar, M. Disasters. In: Levine, MD.; Carey, WB.; Crocker, AC., editors. Developmental-Behavioral Pediatrics. 3rd ed.. W.B. Saunders Company; Philadelphia: 1999. p. 192-195.
13. Mossong J, Hens N, Jit M, et al. Social contacts and mixing patterns relevant to the spread of infectious diseases. PLoS Med. 2008; 5(3):e74. [PubMed: 18366252]
14. Presidential Commission for the Study of Bioethical Issues. Safeguarding Children: Pediatric Medical Countermeasure Research. DC: Presidential Commission for the Study of Bioethical Issues; Washington: 2013. http://bioethics.gov/sites/default/files/PCSBI_Pediatric-MCM_2.pdf [Accessed April 10, 2014]
15. Sinclair R, Boone SA, Greenberg D, Keim P, Gerba CP. Persistence of category A select agents in the environment. Appl Environ Microbiol. Feb; 2008 74(3):555–563. [PubMed: 18065629]
16. Levin DB, Valadares de Amorim G. Potential for aerosol dissemination of biological weapons: lessons from biological control of insects. Biosecur Bioterror. 2003; 1(1):37–42. [PubMed: 15040213]
17. De Vos V. The ecology of anthrax in Kruger National Park, South Africa. Salisbury Med Bull Suppl. 1990; 68:19–23.
18. Sextro, RG.; Lorenzetti, DM.; Sohn, MD.; Thatcher, TL. Modeling the spread of anthrax in buildings. Proceedings of the Indoor Air 2002; Conference, Monterey, CA. 2002.
19. Van Cuyk S, Deshpande A, Hollander A, et al. Transport of Bacillus thuringiensis var. kurstaki from an outdoor release into buildings: pathways of infiltration and a rapid method to identify contaminated buildings. Biosecur Bioterror. Jun; 2012 10(2):215–227. [PubMed: 22676846]

20. Kournikakis B, Ho J, Duncan S. Anthrax letters: personal exposure, building contamination, and effectiveness of immediate mitigation measures. J Occup Environ Hyg. Feb; 2010 7(2):71–79. [PubMed: 19916102]

21. Shalat SL, Donnelly KC, Freeman NC, et al. Nondietary ingestion of pesticides by children in an agricultural community on the US/Mexico border: preliminary results. J Expo Anal Environ Epidemiol. Jan; 2003 13(1):42–50. [PubMed: 12595883]

22. Fenner, F.; Henderson, DA.; Arita, I.; Je zek, Z.; Ladnyi, ID. Smallpox and Its Eradication. World Health Organization; Geneva: 1988.

23. Akbayram S, Doğăn M, Akgün C, et al. Clinical findings in children with cutaneous anthrax in eastern Turkey. Pediatr Dermatol. 2010; 27(6):600–606. [PubMed: 21083757]

24. Garde V, Harper D, Fairchok MP. Tertiary contact vaccinia in a breastfeeding infant. JAMA. Feb 11; 2004 291(6):725–727. [PubMed: 14871916]

25. Neff JM, Lane JM, Fulginiti VA, Henderson DA. Contact vaccinia—transmission of vaccinia from smallpox vaccination. JAMA. Oct 16; 2002 288(15):1901–1905. [PubMed: 12377090]

26. Place RC, Hanfling D, Howell JM, Mayer TA. Bioterrorism-related inhalational anthrax: can extrapolated adult guidelines be applied to a pediatric population? Biosecur Bioterror. 2007; 5(1): 35–42. [PubMed: 17437350]

27. Freedman A, Afonja O, Chang MW, et al. Cutaneous anthrax associated with microangiopathic hemolytic anemia and coagulopathy in a 7-month-old infant. JAMA. Feb 20; 2002 287(7):869–874. [PubMed: 11851579]

28. Ivins BE, Ristroph JD, Nelson GO. Influence of body weight on response of Fischer 344 rats to anthrax lethal toxin. Appl Environ Microbiol. Aug; 1989 55(8):2098–2100. [PubMed: 2506815]

29. US Food and Drug Administration. [Accessed July 1, 2013] How to Prepare Doxycycline for Children and Adults Who Cannot Swallow Pills. http://www.fda.gov/downloads/Drugs/EmergencyPreparedness/BioterrorismandDrugPreparedness/UCM131001.pdf

30. US Centers for Disease Control and Prevention. [Accessed November 2, 2012] 2–20 years: Boys. Stature-for-age and Weight for age percentiles. 2000. http://www.cdc.gov/growthcharts/data/set1clinical/cj41l021. pdf

31. US Centers for Disease Control and Prevention. [Accessed November 2, 2012] 2–20 years: Girls. Stature-for-age and Weight for age percentiles. 2000. http://www.cdc.gov/growthcharts/data/set1clinical/cj41l022. pdf

32. US Census Bureau. [Accessed November 2, 2012] American Fact Finder. 2011. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml

33. US Centers for Disease Control and Prevention. [Accessed April 10, 2014] Blast Injuries: Fact Sheets for Professionals. http://www.bt.cdc.gov/masscasualties/pdf/blast_fact_sheet_professionals-a.pdf

34. Kiang JG, Garrison BR, Burns TM, et al. Wound trauma alters ionizing radiation dose assessment. Cell Biosci. Jun 11.2012 2(1):20. [PubMed: 22686656]

35. Alpen EL, Sheline GE. The combined effects of thermal burns and whole body X irradiation on survival time and mortality. Ann Surg. Jul; 1954 140(1):113–118. [PubMed: 13159151]

36. Healy, JW. Surface Contamination: Decision Levels. LA4558-MS. Los Alamos Scientific Laboratory; Los Alamos, NM: 1971. Cited in: National Research Council. Reopening Public Facilities After a Biological Attack: A Decision Making Framework. Washington, DC: National Academies Press; 2005

37. US Food and Drug Administration. [Accessed April 10, 2014] FDA/ORA CPG 7119.14 Sec. 560.750. Guidance Levels for Radionuclides in Domestic and Imported Foods (CPG 7119.14). 2005. updated March 25, 2013http://www.fda.gov/food/food borneillnesscontaminants/chemicalcontaminants/ucm078331. htm

38. US Food and Drug Administration. [Accessed April 10, 2014] Supporting Document for Guidance Levels for Radionuclides in Domestic and Imported Foods. 2004. updated March 25, 2013http://www.fda.gov/food/foodborneillnesscontaminants/chemicalcontaminants/ucm078341.htm

39. US Food and Drug Administration. [Accessed April 10, 2014] FDA Derived Intervention Level (DIL) or Criterion for Each Radionuclide Group. http://www.fda.gov/downloads/NewsEvents/Public HealthFocus/UCM251056.pdf

40. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, Effects and Risks of Ionizing Radiation: UNSCEAR 2013 Report: Volume II: Scientific Annex B: Effects of Radiation Exposure of Children. United Nations; New York: 2013. http://www.unscear.org/docs/reports/2013/UNSCEAR2013Report_AnnexB_Children_13-87320_ Ebook_web.pdf [Accessed April 10, 2014]

41. Kirichenko VA, Kirichenko AV, Werts DE. Consequences and countermeasures in a nuclear power accident: Chernobyl experience. Biosecur Bioterror. Sep; 2012 10(3):314–320. [PubMed: 22853775]

42. Cardis E, Howe G, Ron E, et al. Cancer consequences of the Chernobyl accident: 20 years on. J Radiol Prot. Jun; 2006 26(2):127–140. [PubMed: 16738412]

43. Levin RJ, De Simone NF, Slotkin JF, Henson BL. Incidence of thyroid cancer surrounding Three Mile Island nuclear facility: the 30-year follow-up. Laryngoscope. 2013; 123(8):2064–2071. [PubMed: 23371046]

44. World Health Organization. [Accessed April 10, 2014] Health effects of the Chernobyl accident: an overview. Apr. 2006 http://www.who.int/ionizing_radiation/chernobyl/backgrounder/en/

45. Fushuki S. Radiation hazards in children – lessons from Chernobyl, Three Mile Island and Fukushima. Brain Dev. Mar; 2013 35(3):220–227. [PubMed: 23063247]

46. US Agency for Toxic Substances and Disease Registry. Toxicological Profile for Cesium. US Agency for Toxic Substances and Disease Registry; Atlanta, GA: 2004. http://www.atsdr.cdc.gov/toxprofiles/tp157.pdf [Accessed April 10, 2014]

47. Boice JD Jr. Radiation epidemiology: a perspective on Fukushima. J Radiol Prot. Mar; 2012 32(1):N33–40. [PubMed: 22395193]

48. Thakur P, Ballard S, Nelson R. An overview of Fukushima radionuclides measured in the northern hemisphere. Sci Total Environ. Aug 1.2013 458–460:577–613.

49. Bird WA. Fukushima health study launched. Environ Health Perspect. Oct; 2011 119(10):A428–A429. [PubMed: 22069777]

50. US Agency for Toxic Substances and Disease Registry. Toxicological Profile for Strontium. US Agency for Toxic Substances and Disease Registry; Atlanta, GA: 2004. http://www.atsdr.cdc.gov/toxprofiles/tp159.pdf [Accessed April 10, 2014]

51. Simpson, C. [Accessed April 10, 2014] A truck filled with radioactive material was stolen in Mexico. Global Security Newswire. Dec 4. 2013 http://www.nti.org/gsn/article/truck-filled-radioactive-material-was-stolen-mexico/

52. US Agency for Toxic Substances and Disease Registry. Toxicological Profile for Cobalt. US Agency for Toxic Substances and Disease Registry; Atlanta, GA: 2004. http://www.atsdr.cdc.gov/toxprofiles/tp33.pdf [Accessed April 10, 2014]

53. [Accessed April 10, 2014] Syria chemical attack: what we know. BBC. Sep 24. 2013 http://www.bbc.co.uk/news/world-middle-east-23927399

54. [Accessed April 10, 2014] The White House. Government Assessment of the Syrian Government's Use of Chemical Weapons on August 21, 2013 [press release]. http://www.whitehouse.gov/the-press-office/2013/08/30/government-assessment-syrian-government-suse-chemical-weapons-august-21

55. Tracy MA. Kids and chemicals: a pediatric disaster. J Emerg Nurs. Jun; 2008 34(3):266–267. [PubMed: 18558269]

56. Levy ML. Atopic dermatitis: understanding the disease and its management. Curr Med Res Opin. Dec; 2007 23(12):3091–3103. [PubMed: 17971284]

57. Wharton M, Strikas RA, Harpaz R, et al. Advisory Committee on Immunization Practices; Healthcare Infection Control Practices Advisory Committee. Recommendations for using smallpox vaccine in a pre-event vaccination program. Supplemental recommendations of the Advisory Committee on Immunization Practices (ACIP) and the Healthcare Infection Control Practices Advisory Committee (HICPAC). MMWR Recomm Rep. Apr 4; 2003 52(RR-7):1–16. [PubMed: 12710832]