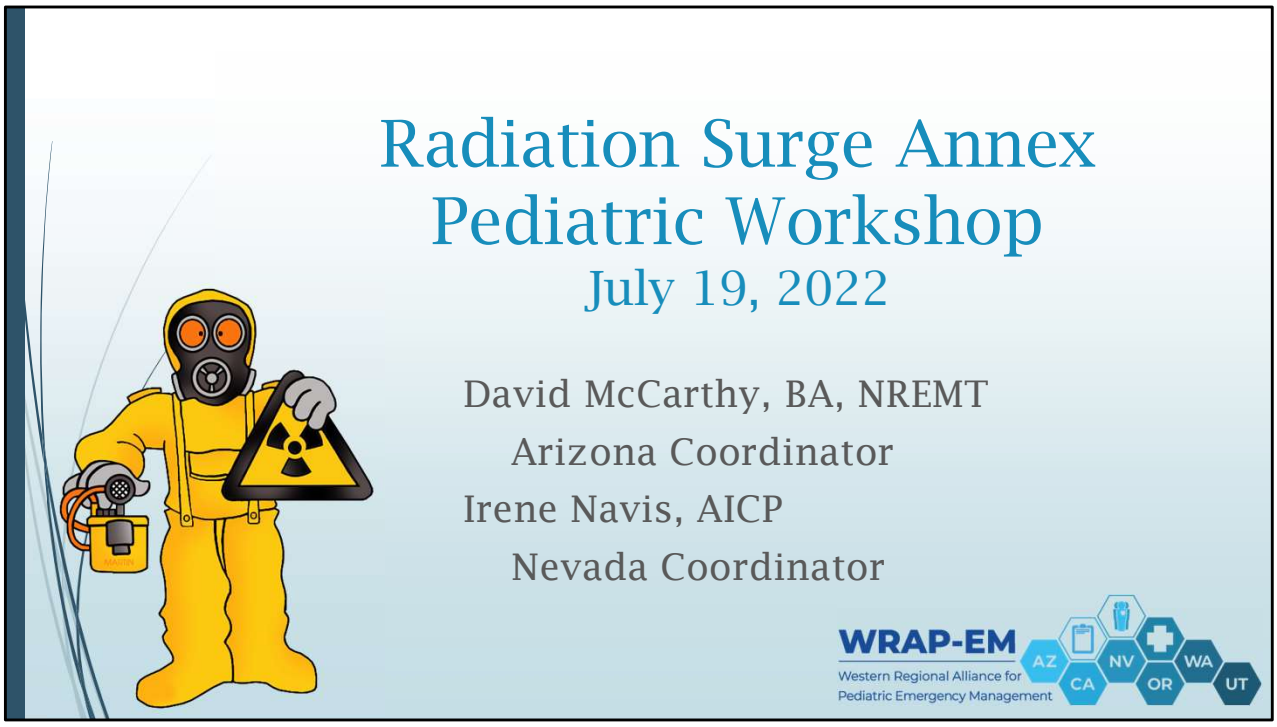


Please contact us if you have any questions or need assistance.

David McCarthy, David@epsolutionsaz.com

Irene Navis, NavisStrategicServicesLLC@gmail.com

What is WRAP-EM?

The Western Regional Alliance for Pediatric Emergency Management is an ASPR funded Center of Excellence that supports pediatric-focused initiatives to improve emergency pediatric disaster response capabilities. Initiatives are intended to produce helpful resources and guidance to address challenges that healthcare coalitions, facilities and their community partners may face in a crisis.

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management

AZ CA NV OR WA UT

Goal: To develop regional pediatric disaster planning and response capabilities – through collaboration between all levels of government and hospitals – that effectively match resources to needs for a catastrophic incident.

Funding & Disclaimer

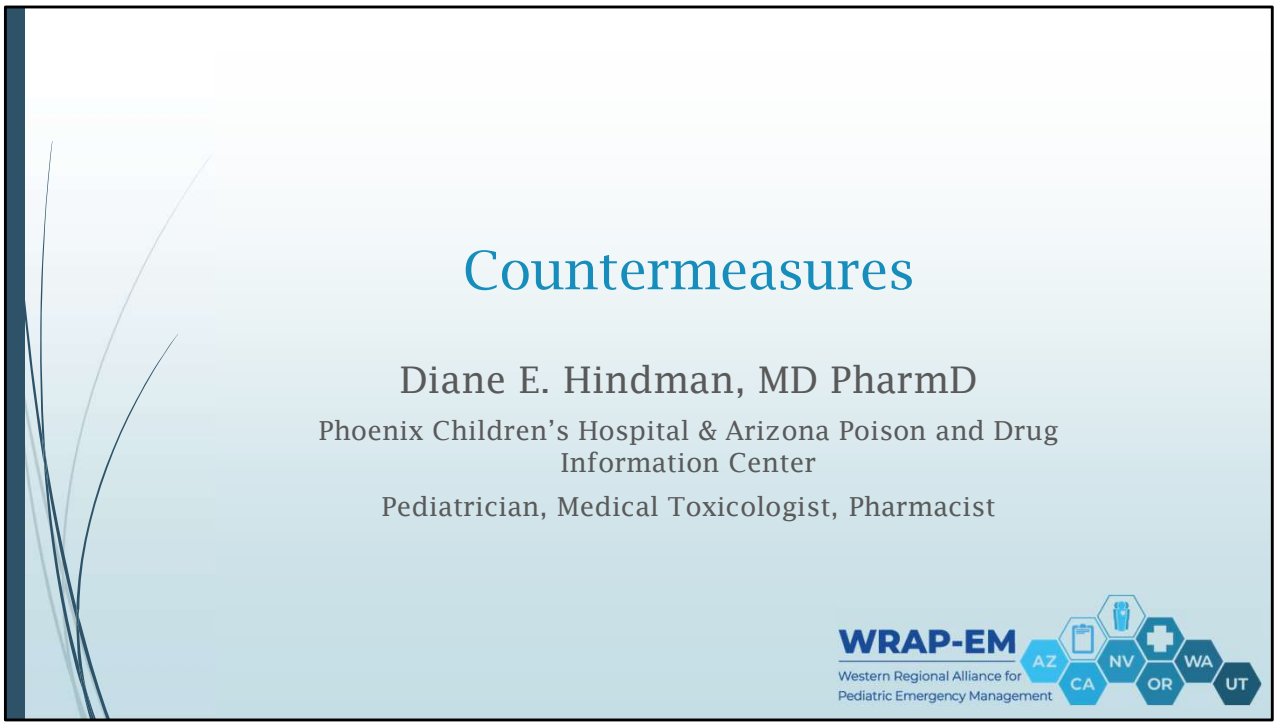
- The Western Regional Alliance for Pediatric Emergency Management is supported by Award Number 6 U3REP190616-01-02 from the Office of the Assistant Secretary for Preparedness and Response (ASPR).

- The content presented here and throughout the presentation is that of the authors and does not necessarily represent the official views of, nor an endorsement by ASPR, HRSA, HHS, or the U.S. Government.

Purpose of Workshop

- Provide pediatric focused content for HCCs to include in Radiation Response Annex
- Provide Pediatric focused resources and templates for inclusion in a Radiation Response Annex
- The workshop is being record and will be made available
- The PowerPoint and other materials will be made available

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT



Dr. Diane E. Hindman is a Board-Certified Pediatrician and Medical Toxicologist, and Registered
Pharmacist. She works as an Attending Physician and Chair of the Pharmacy and Therapeutics
Committee at Phoenix Children's Hospital in Phoenix AZ and Consulting Medical Toxicologist at
the Arizona Poison and Drug Information Center in Tucson AZ.

She received her pharmacy degrees from the University of Toronto Faculty of Pharmacy in Toronto ON and University of Colorado in Denver CO. After 25 years as a pharmacist with a diverse portfolio of pharmacy experiences, she pursued her medical degree at Trinity School of
Medicine in St. Vincent in the Grenadine Islands, and subsequently completed her residency in
pediatrics at Rainbow Babies and Children's Hospital in Cleveland OH and medical toxicology
fellowship at Emory University and the CDC in Atlanta GA. Dr. Hindman is currently completing
certification in clinical translational research at the University of Arizona Mel and Enid

Zuckerman College of Public Health in Tucson AZ.

Originally from Ontario Canada, she relocated to Arizona after completion of her medical training and enjoys the year-round sunshine and flip flop weather there. Her professional interests are varied and include medication safety, environmental toxicology, climate change, HAZMAT and radiation injury prevention and management, pediatric mental health, adolescent
addiction, antimicrobial stewardship, and medical trainee education and research.

Disclosures

I do not have any financial relationships to disclose

I do plan to discuss some FDA-unapproved or off-label uses of products as formal approval is not available in all cases managing radiation emergencies

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Objectives

01

Share the statistics and unique features of the pediatric population

02

Review the basics of radiation and exposure impact in humans

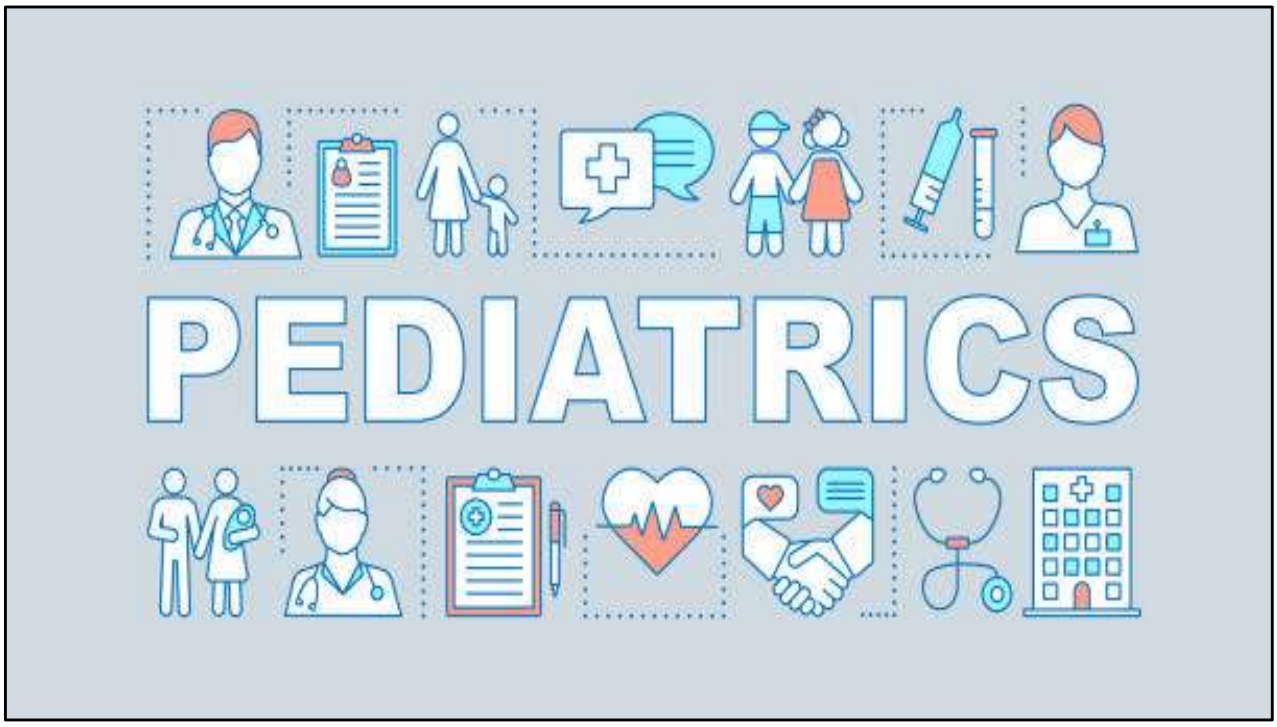
03

Discuss medical countermeasures (MCMs) with a focus on children

04

Highlight various online resources with helpful information for managing radiological emergencies

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management



Let’s talk a little about children.

Children Are Not Just Little Adults

- Unique needs
- Often combined with other diverse groups with "special needs"
- Needs differ by developmental stage, age, language proficiency, culture, socioeconomic status, and health status

US Pediatric Population (2020)	
Total	74.1 million
0–5 yo	23.4 million
6–11 yo	24.3 million
12–17 yo	25.1 million
Projected to increase by 5 million in the next 20 years	

WRAP-EM Western Regional Alliance for Pediatric Emergency Management — AZ, CA, NV, OR, WA, UT

Ref: https://www.aap.org/; https://www.abp.org/; https://www.aecf.org; https://www.childrenshospitals.org/; https://www.childstats.gov; Ve

Many past disasters and preparedness efforts neglected to consider children – we have learned the hard way.

Children comprised ~22% of the US population in 2019. About half are children of color (50.2%) as of 2020.
18% of children (nearly 13 million) live in poverty; at baseline, poverty elevates a child's risk of experiencing behavioral, social and emotional and health challenges.

Children have unique needs; they have important physical, physiologic, developmental and mental differences than adults that must be incorporated into any disaster planning process – their "special needs" are at risk of being overlooked when they are lumped together with many other diverse populations under the rubric of "special needs".

It is important to highlight the various needs of children by parameters such as developmental stage, age, SES and health status, among others.

Assessment and planning in advance of a disaster is more likely to avert the system being overwhelmed and unable to serve the pediatric population.

For example, there are only about 250 children's hospitals in the nation (~220 represented

by CHA) – that would mean that each would need to manage ~296k children in a disaster which isn't very realistic. Similarly, there are on average 1,267 pediatric physicians per state in the US.
Consequently, many other facilities and providers will need to help manage pediatric patients in any significant disaster scenario.

Ref: Pediatric population: https://www.childstats.gov/americaschildren/tables/pop1.asp
Ref: Children of color: Vespa, Medina, Armstrong. Demographic Turning Points for the United States: Population Projections
for 2020 to 2060 (February 2020)
Ref: Children in poverty: https://www.aecf.org/topics/child-poverty?gclid=Cj0KCQjwwJuVBhCAARIsAOPwGAT_ZZmnp9YuJcRbyzahrSOgS4yd56ckaMf3vOna6_kLkh-RCfeeAdsaAsgyEALw_wcB
Ref: AAP Pediatric Preparedness Resource Kit: https://www.aap.org/en/patient-care/disasters-and-children/professional-resources-for-disaster-preparedness/pediatric-preparedness-resource-kit/ (The Youngest Victims: Disaster Preparedness to Meet Children's Needs)
Ref: Children's hospitals in the US: https://www.childrenshospitals.org/
Ref: # of pediatricians: https://www.abp.org/content/us-map-general-pediatricians-state

Pediatric Vulnerabilities in Any Disaster

- Physical/Physiological
  - Faster respiratory rate
  - Closer to the ground
  - Hand-mouth behaviors
  - Thinner skin
  - Larger skin surface-to-body mass ratio
  - Rapid cell division
  - Less body fluid reserve
- Developmental
  - Motor skills
  - Cognitive abilities
- Psychological
  - Mental health impact

- Care Needs
  - Supervision and protection
  - Care facilities
  - Immediate and ongoing medical needs
  - Medications and equipment

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Ref: https://www.aap.org/; Gardner et al (2019)

Children's differences from adults put them at increased risk in any disaster in a number of ways.

The manner in which toxic agents can adversely impact children is very closely related to their physical and physiologic characteristics. Agents that are aerosolized will expose children to a higher dose because of their increased respiratory rate. As well, any agents that are heavier than air will accumulate close to the ground where small children reside because of their shorter stature. Hand-mouth behaviors also increase likelihood of internal contamination in children as does their thinner skin and larger relative skin surface. Children also have smaller circulating blood volumes which result in higher toxic agent blood concentrations as well as a more delicate balance to transition from dehydration to compensated and uncompensated shock then death, particularly in scenarios of vomiting or diarrhea. Additionally, their cells divide more rapidly so will be more impacted by agents that affect cell division.

From a developmental perspective, children vary across the age spectrum in their motor skills and cognitive abilities. This is amplified in children with abnormalities in either, such as those who are wheelchair-bound or intellectually-delayed. Even in normal children who can walk and talk, they may not have the knowledge or ability to escape from danger, know where to seek assistance or be able to communicate symptoms they are having.

We have learned too well the adverse impact COVID-19 has had on children's mental health. In any disaster, we have to consider the psychological trauma that children may face and how that can vary based on the situation and spectrum of pediatric characteristics. Beyond the actual event, further trauma can occur through media impact and interactions with providers and other adults responsible for care of children.

Care needs of children affected by disaster are diverse. Direct supervision, protection from hazards, assistance with feeding and ADLs, safe shelters with child-specific supplies and furniture, specialized medical care and treatment, and individualized medication preparation and dosing are among the considerations. These components span not only health care, but also school, daycare and home (wherever that may be).

Ref: AAP Pediatric Preparedness Resource Kit: https://www.aap.org/en/patient-care/disasters-and-children/professional-resources-for-disaster-preparedness/pediatric-preparedness-resource-kit/ (The Youngest Victims: Disaster Preparedness to Meet Children's Needs)
Ref: Gardner et al (2019)
Ref: Picture: https://www.factretriever.com/chernobyl-facts

Communication and Strategic Partnerships

- Pandemic experience – H1N1 (2009), COVID-19
- Clinicians overwhelmed
  - Patient volumes
  - Questions for various sources
  - Helping patients/families understand
- Communication and strategic partnerships are key
  - Rapidly changing information
  - Effective communication systems
  - Before the disaster to protect before, during and after
    - Preparedness, mitigation, response, recovery

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Ref: Krug et al (2012); Lurie & Khan (2013)

The 2009 H1N1 influenza pandemic was really the first current-world exercise in addressing a major infectious disease outbreak that disproportionately affected children. COVID-19 continues to give us opportunities to strengthen our approach. I recognize that infectious outbreaks are somewhat different from a radiation disaster, but the lessons learned in the pandemics can help us improve future planning.

Clinicians became quickly overwhelmed, not only with unmanageable patient volumes, questions from numerous audiences and information overload. Educating the public about when to seek care, and handling questions and visits from patients who did not have pertinent symptoms or were not at increased risk of complications created significant challenges in both pandemics.

It has become clear that effective communication and strategic partnerships are key. You can't start to plan when the disaster is upon you; information and the situation will evolve too rapidly to create effective communication systems then. Appropriate planning needs to start well before a disaster in order to protect the population before harm, during the incident and afterward. The 4 main areas will involve preparedness, mitigation, response and recovery.

Ref: Krug et al (Improving pediatric preparedness performance through strategic partnerships – 2012)
Ref: Lurie & Khan (Ensuring the health security of America's children – 2013)

Communication and Strategic Partnerships

- 2009 H1N1 pandemic
  - CDC EOC: Children's Health Team, Children's Health Desk
  - AAP: FluPeds
- Simple and timely messages from a trusted source
  - Reassure and steps to reduce risk
- Promote 2-way communication
  - Not just information dump
- Prepare for, respond to, and recover from
  - Resilience is important
- Engage local pediatric experts and youth
  - Address unique needs, risks and challenges in the population/region
- Identify gaps in pediatric readiness

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Ref: Kim-Farley (2019); Krug et al (2012); Lurie & Khan (2013)

In an editorial in the AJPH in 2019, Kim-Farley refers to the importance of focusing preparedness work to enable communities to address public health emergencies. He reminds us that community health resilience is essential and by definition is "the ability of a community to use its assets to strengthen the public health and health care systems and to improve the community's physical, behavioral, and social health to withstand, adapt to and recover from adversity". Resilience is important beyond individuals' ability to prepare, for example, like stocking up with extra days of food and water. As the African cultural proverb states, "It takes a village to raise a child"; measures such as pre-identifying local shelters is a consideration for community resilience.

Several key responses during the 2009 H1N1 pandemic should serve as successful experiences in future pediatric and other disaster plans. For the first time, CDC activated both a Children's Health Team and a Children's Health Desk within the CDC Emergency Operations Center. Their efforts also identified crucial capacity-building components through strategic partnerships to address at-risk groups.

The AAP established FluPeds, involving a multidisciplinary response team of staff and pediatrician leaders; expertise in emergency medicine, critical care and disaster preparedness; childcare facilities, schools and primary care practices. This team, through AAP's leadership, was able to promote collaborative discussions and decision-making,

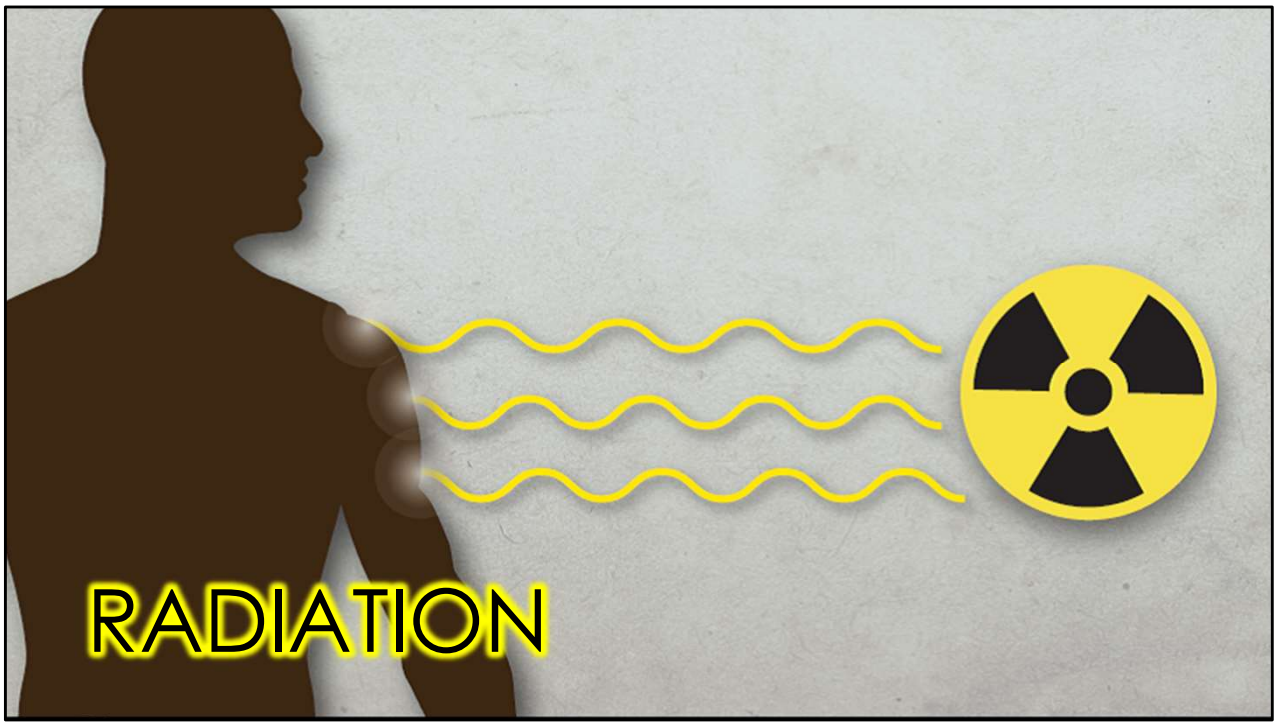
address member concerns, and provide efficient responses to requests throughout the pandemic.

Jointly, the CDC and AAP developed an Influenza-Like Illness algorithm for use by clinicians to aid in determining which symptomatic children should receive a medical evaluation, be given antiviral medications, or have close medical follow up. Consideration was given for caregivers who were at high risk of influenza complications, identified strategies to reduce infectious spread, and emphasized monitoring and follow-up in the child's medical home with their PCP.

Many additional comprehensive policies and guidance documents came out of the flu experience. In addition, emphasis of a pediatric focus in preparing for future disasters has been stressed. Critical benefits of having the right complement of people at the table in advance is that high-risk groups can be identified, and ways to improve access to care and decision-making on allocation of resources can be strategized while cooler heads prevail.

Communication and messaging are important components of an effective strategic response in a disaster. Messages during a crisis need to be simple and timely. They should be delivered by a trusted source in a manner that will reassure and/or offer concrete steps to reduce risk. Communication is not just a pipeline where information flows, rather it offers an exchange of information and 2-way communication. Engaging local pediatric experts and others who are familiar with the unique needs, risks and challenges in the area and its population will result in a more effective plan. Incorporating youth in the preparedness exercise will enlighten the impact on them as survivors, but also engage a group who can contribute to community response and recovery.

Ref: Krug et al (Improving pediatric preparedness performance through strategic partnerships – 2012)
Ref: Lurie & Khan (Ensuring the health security of America's children – 2013)
Ref: Kim-Farley (editorial: Community preparedness: "It takes a village" – AJHP suppl 4 (2019), vol 109: s256-s257)

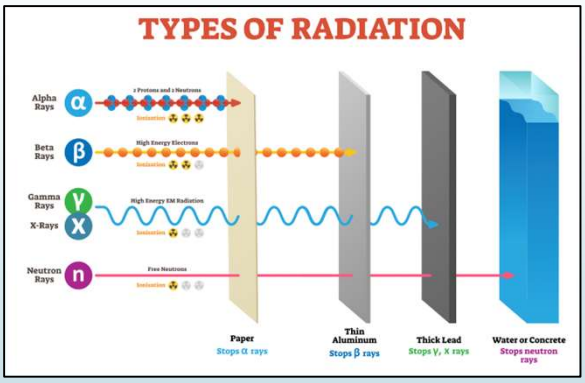


I am not sure what everyone's knowledge base is on radiation. I will cover some basics that will be important to appreciate further discussions.

Ref: https://www.cdc.gov/nceh/radiation/health.html

Radiation Basics

- Radiation: waves or particles of energy travelling over a distance
- Ionizing radiation: addition or removal of electrons if radiation energy is sufficiently high
  - Embryos and bone marrow most sensitive
  - WBCs affected at low doses
  - CNS impact at very high doses



WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Ref: AHLS (2020); cdc.gov/nceh/radiation/emergencies/contamination.htm

Radiation is energy that is released as waves or particles and can travel over a particular distance.

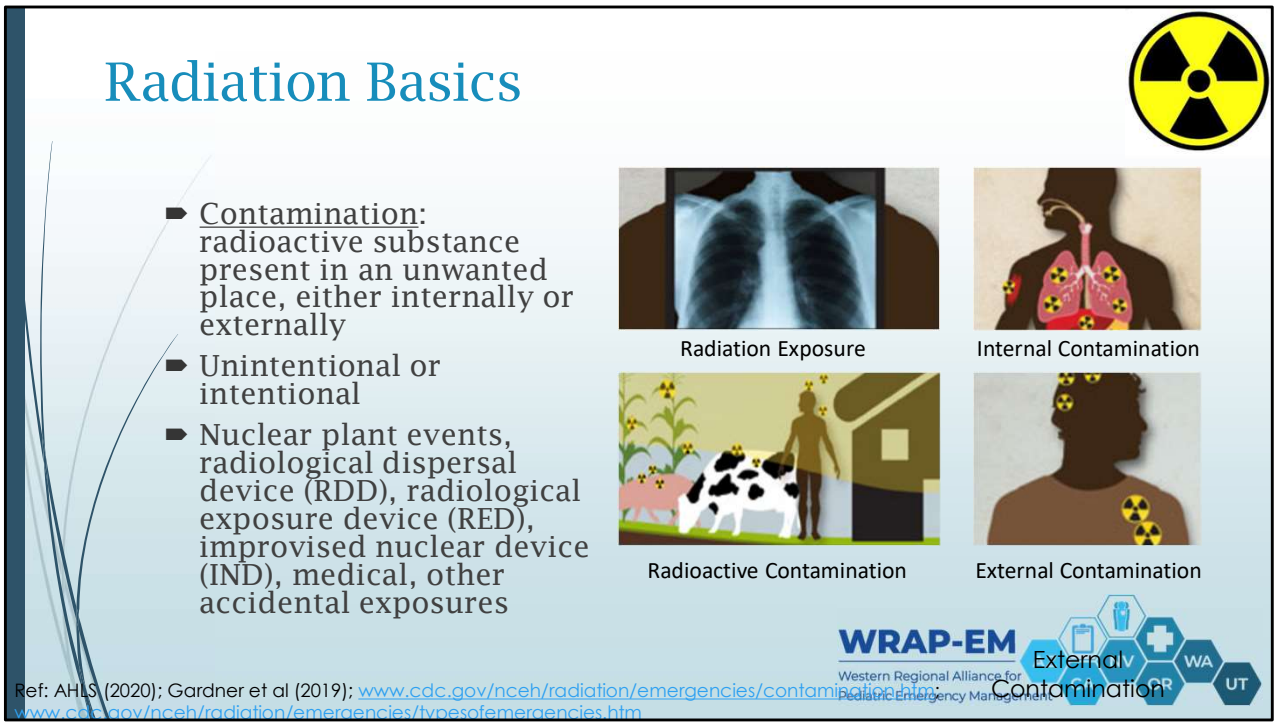
Ionizing radiation occurs when the radiation energy is high enough to add or remove electrons from an atom. Non-ionizing radiation, such as electromagnetic radiation, occurs when electrons get excited, but the energy isn't sufficient for the electron to leave the atom's orbit.

Non-ionizing radiation can still cause a harmful biologic effect, such as an infrared burn if one gets too close to the source. However, we are generally more concerned with the biologic effects of ionizing radiation. These effects can damage chromosomes or intracellular components or cause other chemical changes due to cellular water being impacted.

Human cell sensitivity to radiation depends on the type of cell and the amount of ionizing radiation exposure. The most sensitive cells are embryos and blood-forming tissue in bone marrow. WBCs are also affected at low doses. Hair and skin follicles will show hair loss and redness, respectively, at higher doses. The CNS will be affected by very high doses when death is probable.

The graphic on this slide reminds us of the various types of ionizing radiation particles and waves. You can see what protection is needed to stop the various radiation.

Ref: AHLS for Radiological Incidents and Terrorism, 5th edition (2020); p4, 2, 5, 9
Ref: diagram (types radiation) - https://www.ans.org/nuclear/radiation/
Ref: diagrams (contamination, exposure) - https://www.cdc.gov/nceh/radiation/emergencies/contamination.htm



We are exposed to radioactive materials and some radiation regularly. For example, radon is a gas that occurs naturally in some areas and can be found in the air, soil and underground water. Bananas contain radioactive potassium (K-40). Cosmic rays occur in space and make their way to earth. When we are exposed to radiation, the energy penetrates our body, such as during a chest xray. A person exposed to radiation isn't necessarily contaminated with radioactive material.

Radioactive contamination occurs when a radioactive substance ends up in an unwanted place, such as on food that animals and people consume. External contamination occurs outside the body, such as clothing and skin. Internal contamination occurs through percutaneous absorption, inhalation or ingestion of radioactive substances.

The release of radioactive materials into the environment may occur intentionally or unintentionally.

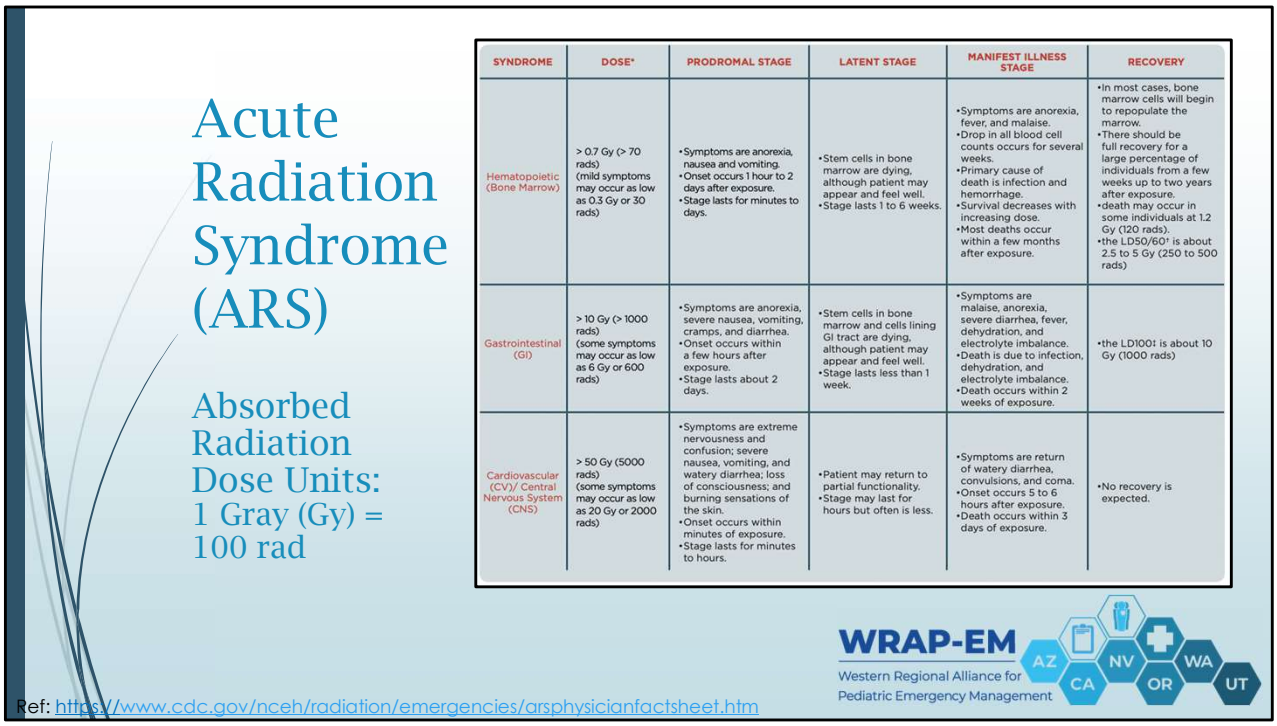
Numerous worldwide unintentional radiation accidents have occurred, including nuclear power plant incidents at the Fukushima plant in Japan in 2011, Chernobyl in Ukraine in 1986, and Three Mile Island in Pennsylvania in 1979. Various other well-known accidents have included the Goiania accident in Brazil in 1987 when an old radiotherapy source was stolen from an abandoned hospital, the Moroccan incident in 1984 from radiation exposure

to a lost Iridium-192 source, and the 1990 incident in the Clinic of Zaragoza in Spain when cancer patients were overexposed to external beam radiotherapy.

In the day of terrorist attacks, we also have to worry about intentional radiological exposures through RDDs (aka “dirty bombs”), concealed exposure from REDs, and nuclear weapon detonation such as INDs.

Transportation and occupational accidental exposures are also possible.

Ref: AHLS for Radiological Incidents and Terrorism, 5th edition (2020); p4, 2, 5, 9, 40
Ref: diagram (types radiation) - https://www.ans.org/nuclear/radiation/
Ref: diagrams (contamination, exposure) - https://www.cdc.gov/nceh/radiation/emergencies/contamination.htm
Ref: types of radiation disasters - https://www.cdc.gov/nceh/radiation/emergencies/typesofemergencies.htm
Ref: Gardner et al (Medical countermeasures for children in radiation and nuclear disasters: Current capabilities and key gaps – 2019)
Ref: Linet et al (Pediatric considerations before, during, and after radiological or nuclear emergencies; AAP Technical Report – Pediatrics dec 2018;142(6):e20183001)



You will see various units of radiation as you refer to related documents. Rad and Gray are both units signifying the absorbed radiation dose. Gray is the international (SI) unit of an absorbed dose. 1 Gray (Gy) = 100 rad.
Rem (roentgen equivalent man) measures the biological effect from different types and quantities of radiation. Sievert is the international (SI) unit of dose equivalent. 1 sievert (Sv) = 100 rem..

Acute Radiation Syndrome (ARS) is an acute illness caused by irradiation of the entire or most of the body by a high dose of penetrating radiation (specifically high energy Xrays, gamma rays and neutrons), usually from an external source outside the patient's body in a very short period of time (usually a matter of minutes).

"High dose" is usually considered >0.7 Gy, but mild symptoms may be observed in doses as low as 0.3 Gy. In rare situations, some effects of ARS have occurred in internal contamination.

The major cause of this syndrome is depletion of immature parenchymal stem cells in specific tissues.

The three classic ARS Syndromes are Bone Marrow, GI, and Cardiovascular/CNS Syndrome.

Bone marrow syndrome (sometimes referred to as hematopoietic syndrome, H-ARS)

-usually occurs with a dose of 0.7–10 Gy though mild symptoms may occur as low as 0.3 Gy

-survival from this syndrome decreases with increasing doses of radiation with the primary cause of death being bone marrow destruction, resulting in infection and hemorrhage

Gastrointestinal (GI) syndrome

-usually occurs with doses >10 Gy although some symptoms may occur at doses as low as 6 Gy

-survival is extremely unlikely with this syndrome; destruction and irreparable changes in the GI tract and bone marrow usually cause infection, dehydration, and electrolyte imbalance

-death usually occurs within 2 weeks

Cardiovascular (CV)/ Central Nervous System (CNS) syndrome

-usually occurs with doses >50 Gy but some symptoms may occur at doses as low as 20 Gy

-death typically occurs within 3 days, most likely due to collapse of the circulatory system and increased intracranial pressure as a result of increased fluid content caused by edema, vasculitis, and meningitis

The four stages of ARS are:

Prodromal stage (N-V-D stage): The classic symptoms for this stage are nausea, vomiting, as well as anorexia and possibly diarrhea (depending on dose), which occur from minutes to days following exposure. The symptoms may last (episodically) for minutes up to several days. This is concerning in most patients, but children are at greater relative risk due to their lower body fluid volumes, and associated dehydration, electrolyte imbalance and consequent shock.

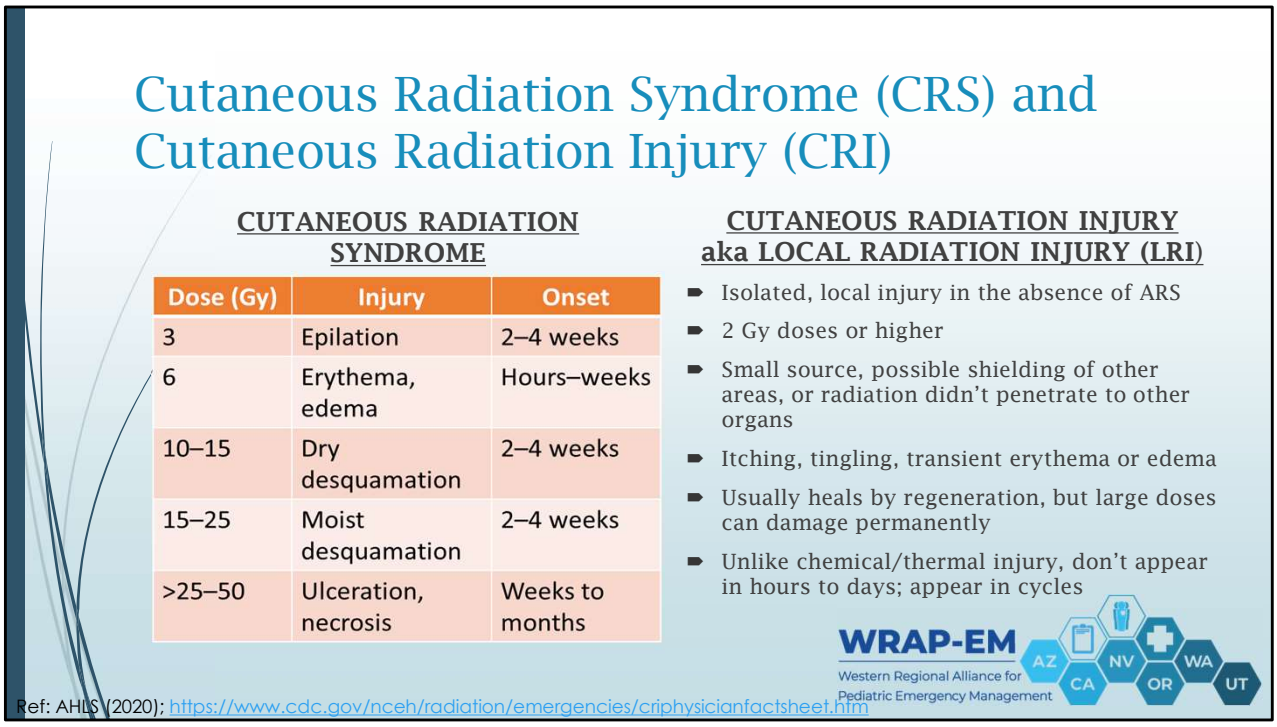
In this stage, the sooner signs and symptoms occur, a greater radiation dose is likely. For example, vomiting occurring after 2 hours from exposure suggests a 1–2 Gy exposure, whereas vomiting that occurs in <10 minutes is likely associated with radiation exposure of >8 Gy. There are tables that also correlate other signs and symptoms with time and radiation exposure in the prodromal phase.

Latent stage: In this stage, the patient looks and feels generally healthy for a few hours or even up to a few weeks.

Manifest illness stage: The symptoms in this stage depend on the specific syndrome and last from hours up to several months.

Recovery or death: Most patients who do not recover will die within several months of exposure. The recovery process lasts from several weeks up to two years.

Ref: https://www.cdc.gov/nceh/radiation/emergencies/arsphysicianfactsheet.htm
Ref: Medical management of radiation injuries, safety reports series #101; INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA, 2020 (printed by IAEA in Austria, May 2020)
Ref: https://remm.hhs.gov/ (Radiation Emergency Medical Management, REMM; US Department of Health and Human Services. Guidance on Diagnosis and Treatment for Healthcare Providers



Dry desquamation = skin flaking
Wet desquamation = blistering

Cutaneous Radiation Syndrome (CRS) occurs in a patient with ARS, when a large portion of the core body was irradiated. Skin changes can also be seen in the area of irradiation.

CRS follows the 4 stages of ARS. Prodromal signs include local erythema and edema that resembles a sunburn, initially within hours after exposure, followed by secondary erythema in 2-4 weeks. Manifest illness of the skin results in temporary loss of hair (epilation) at low doses, progressing to permanent epilation, blistering, ulceration, and skin necrosis.

Cutaneous radiation injury (CRI) can occur when there is a large external dose of radiation, but without symptoms of ARS. This often results in cases of beta radiation or low-energy xrays since they are less penetrating and less likely to damage internal organs than gamma radiation. CRI can occur with radiation doses as low as 2 Gy and the symptom severity will worsen with increasing doses. The visible skin effects depend on the magnitude of the dose as well as the depth of penetration of the radiation.

Most cases of CRI have occurred when people inadvertently had contact with unsecured radiation sources from food irradiators, radiotherapy equipment, or well depth gauges. In

addition, cases of CRI have occurred in people who were overexposed to x-radiation from fluoroscopy units.

Early signs and symptoms of CRI are itching, tingling, or a transient erythema or edema without a history of exposure to heat or caustic chemicals. In most cases, healing occurs by regenerative means; however, large radiation doses to the skin can cause permanent hair loss, damaged sebaceous and sweat glands, atrophy, fibrosis, decreased or increased skin pigmentation, and ulceration or necrosis of the exposed tissue.

Unlike skin lesions caused by chemical or thermal damage, the radiation-related lesions won't appear for hours to days after exposure, and burns and other skin effects tend to appear in cycles.

The key treatment issues with CRI are infection and pain management.

OPTIONAL:

Stages and Grades of CRI

CRI will progress over time in stages and can be categorized by grade, with characteristics of the stages varying by grade of injury, as shown in Table 1. Appendix A gives a detailed description of the various skin responses to radiation, and Appendix B provides color photographs of examples of some of these responses.

Prodromal stage (within hours of exposure)—This stage is characterized by early erythema (first wave of erythema), heat sensations, and itching that define the exposure area. The duration of this stage is from 1 to 2 days.

Latent stage (1–2 days postexposure)—No injury is evident. Depending on the body part, the larger the dose, the shorter this period will last. The skin of the face, chest, and neck will have a shorter latent stage than will the skin of the palms of the hands or the soles of the feet.

Manifest illness stage (days to weeks postexposure)—The basal layer is repopulated through proliferation of surviving clonogenic cells. This stage begins with main erythema (second wave), a sense of heat, and slight edema, which are often accompanied by increased pigmentation. The symptoms that follow vary from dry desquamation or ulceration to necrosis, depending on the severity of the CRI (see Table 1).

Third wave of erythema (10–16 weeks postexposure, especially after beta exposure)—The exposed person experiences late erythema, injury to blood vessels, edema, and increasing pain. A distinct bluish color of the skin can be observed. Epilation may subside, but new ulcers, dermal necrosis, and dermal atrophy (and thinning of the dermis layer) are possible.

Late effects (months to years postexposure; threshold dose ~10 Gy or 1000 rads)—Symptoms can vary from slight dermal atrophy (or thinning of dermis layer) to constant ulcer recurrence, dermal necrosis, and deformity. Possible effects include occlusion of small blood vessels with subsequent disturbances in the blood supply (telangiectasia); destruction of the lymphatic network; regional lymphostasis; and increasing invasive fibrosis, keratosis, vasculitis, and subcutaneous sclerosis of the connective tissue. Pigmentary changes and pain are often present. Skin cancer is possible in subsequent years.

Recovery (months to years)

Ref: https://www.cdc.gov/nceh/radiation/emergencies/criphysicianfactsheet.htm
Ref: Medical management of radiation injuries, safety reports series #101; INTERNATIONAL ATOMIC ENERGY AGENCY VIENNA, 2020 (printed by IAEA in Austria, May 2020)
Ref: https://remm.hhs.gov/ (Radiation Emergency Medical Management, REMM; US Department of Health and Human Services. Guidance on Diagnosis and Treatment for Healthcare Providers)
Ref: AHLS p48

Let's move now to discuss medical countermeasures.

Ref: https://www.medicalcountermeasures.gov/

The National Response Framework's Emergency Support Function #8 outlines the public health and medical services coordinated and provided by the US Department of Health and Human Services (HHS) following a mass casualty incident. One of the many roles of HHS is to oversee the distribution of medical countermeasures.

Medical countermeasures (MCMs) are life-saving medicines and medical supplies, such as vaccines, antiviral drugs, antibiotics, antitoxins, and chemical antidotes, used to effectively prevent, mitigate, or treat adverse health effects of an intentional, accidental, or naturally occurring public health emergency.

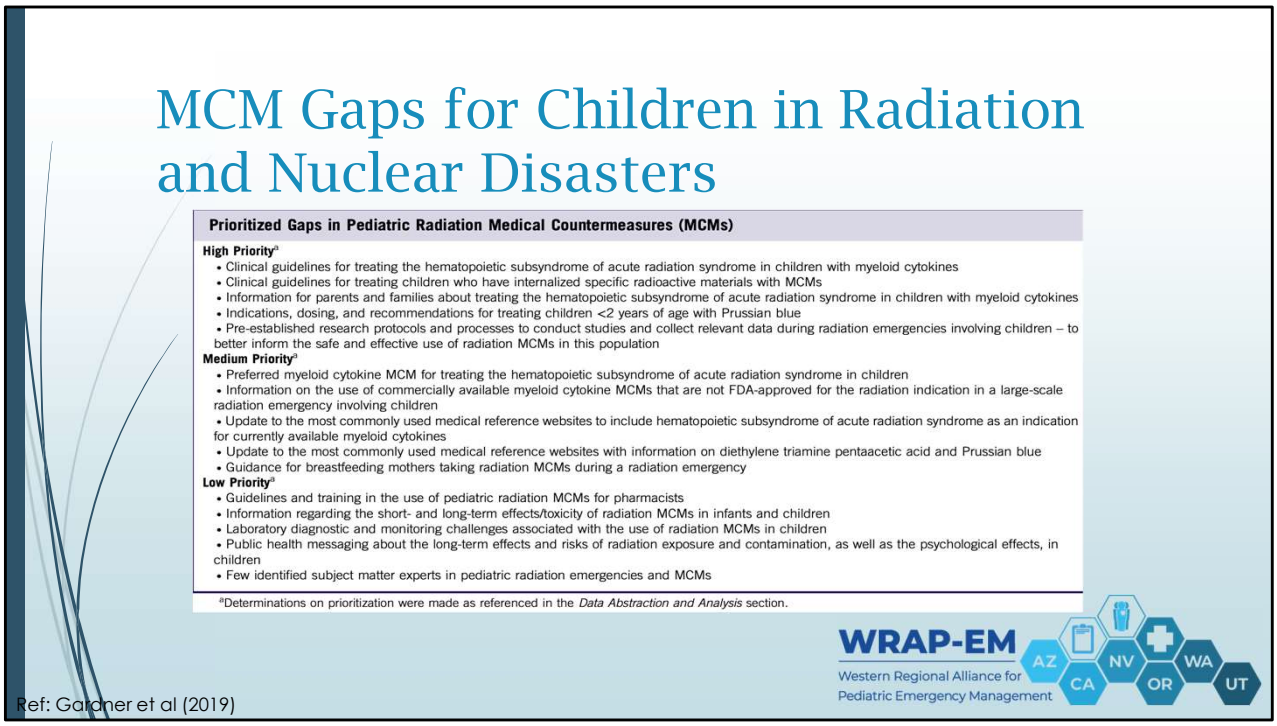
The Strategic National Stockpile (SNS) is the largest supply of MCMs available for such use in the nation. In a public health emergency, jurisdictions would request assistance after state and local resources have been exhausted or are unavailable, after which HHS and CDC would determine whether to deploy SNS assets or other assistance to the affected jurisdiction.

Through the Public Health Emergency Preparedness (PHEP) program, CDC collaborates with jurisdictions to ensure plans and processes are in place to receive and provide medicines and supplies needed in a public health emergency.

CDC also has a Cities Readiness Initiative (CRI), which is a federally funded program designed to augment preparedness in the nation's largest population centers, where nearly 60% of the population resides, to effectively respond to large public health emergencies where life-saving medicines and medical supplies would be needed. There are currently 72 cities and metropolitan statistical areas (MSAs) with at least one CRI city in every state. In AZ, Phoenix is the one city that has such an agreement in place.

Ref: https://www.cdc.gov/cpr/readiness/capabilities.htm (Public Health Emergency Preparedness and Response Capabilities. National Standards for State, Local, Tribal and Territorial Public Health, Updated January 2019; CDC Center of Preparedness and Response. State and Local Readiness)
Ref: CDC Center for Preparedness and Response. State and Local Readiness. **Fact Sheet: Medical Countermeasures (MCM) and Points of Dispensing (POD) Basics**
https://www.cdc.gov/cpr/readiness/healthcare/closedpodtoolkit/factsheet-mcm.htm. Page last reviewed: September 18, 2020, 04:20 PM Content source: Center for Preparedness and Response, National Center for Environmental Health
Ref: Strategic National Stockpile https://www.phe.gov/about/sns/Pages/default.aspx
Ref: https://www.cdc.gov/cpr/readiness/mcm-readiness.html
Ref: https://www.cdc.gov/cpr/readiness/mcm/cri.html
Ref: MCM picture - https://www.fda.gov/emergency-preparedness-and-response/about-mcmi/what-are-medical-countermeasures

MCM Gaps for Children in Radiation and Nuclear Disasters



Prioritized Gaps in Pediatric Radiation Medical Countermeasures (MCMs)

High Priority[a]
- Clinical guidelines for treating the hematopoietic subsyndrome of acute radiation syndrome in children with myeloid cytokines
- Clinical guidelines for treating children who have internalized specific radioactive materials with MCMs
- Information for parents and families about treating the hematopoietic subsyndrome of acute radiation syndrome in children with myeloid cytokines
- Indications, dosing, and recommendations for treating children <2 years of age with Prussian blue
- Pre-established research protocols and processes to conduct studies and collect relevant data during radiation emergencies involving children – to better inform the safe and effective use of radiation MCMs in this population

Medium Priority[a]
- Preferred myeloid cytokine MCM for treating the hematopoietic subsyndrome of acute radiation syndrome in children
- Information on the use of commercially available myeloid cytokine MCMs that are not FDA-approved for the radiation indication in a large-scale radiation emergency involving children
- Update to the most commonly used medical reference websites to include hematopoietic subsyndrome of acute radiation syndrome as an indication for currently available myeloid cytokines
- Update to the most commonly used medical reference websites with information on diethylene triamine pentaacetic acid and Prussian blue
- Guidance for breastfeeding mothers taking radiation MCMs during a radiation emergency

Low Priority[a]
- Guidelines and training in the use of pediatric radiation MCMs for pharmacists
- Information regarding the short- and long-term effects/toxicity of radiation MCMs in infants and children
- Laboratory diagnostic and monitoring challenges associated with the use of radiation MCMs in children
- Public health messaging about the long-term effects and risks of radiation exposure and contamination, as well as the psychological effects, in children
- Few identified subject matter experts in pediatric radiation emergencies and MCMs

[a]Determinations on prioritization were made as referenced in the *Data Abstraction and Analysis* section.

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Ref: Gardner et al (2019)

Gardner et al performed a literature review and gap analysis to gain a better understanding of current pediatric capabilities and shortfalls to effectively use radiation MCMs. Their message was aimed at a diverse group of players in the hope of being better prepared to manage pediatric needs in the event of a radiation emergency, particularly as children would be expected to be disproportionately affected for many of the pediatric-specific features mentioned previously.

From a pharmacologic perspective, drug considerations would be:
-formulations approved and available with appropriate dosing for children; oral suspensions, crushable tablets or other forms that could readily be administered to children of the ages affected

Educational resources and references for clinicians would need to be pediatric-specific, readily available and easy to use by clinicians (many of whom would have little or no experience with radiation emergencies and MCMs).

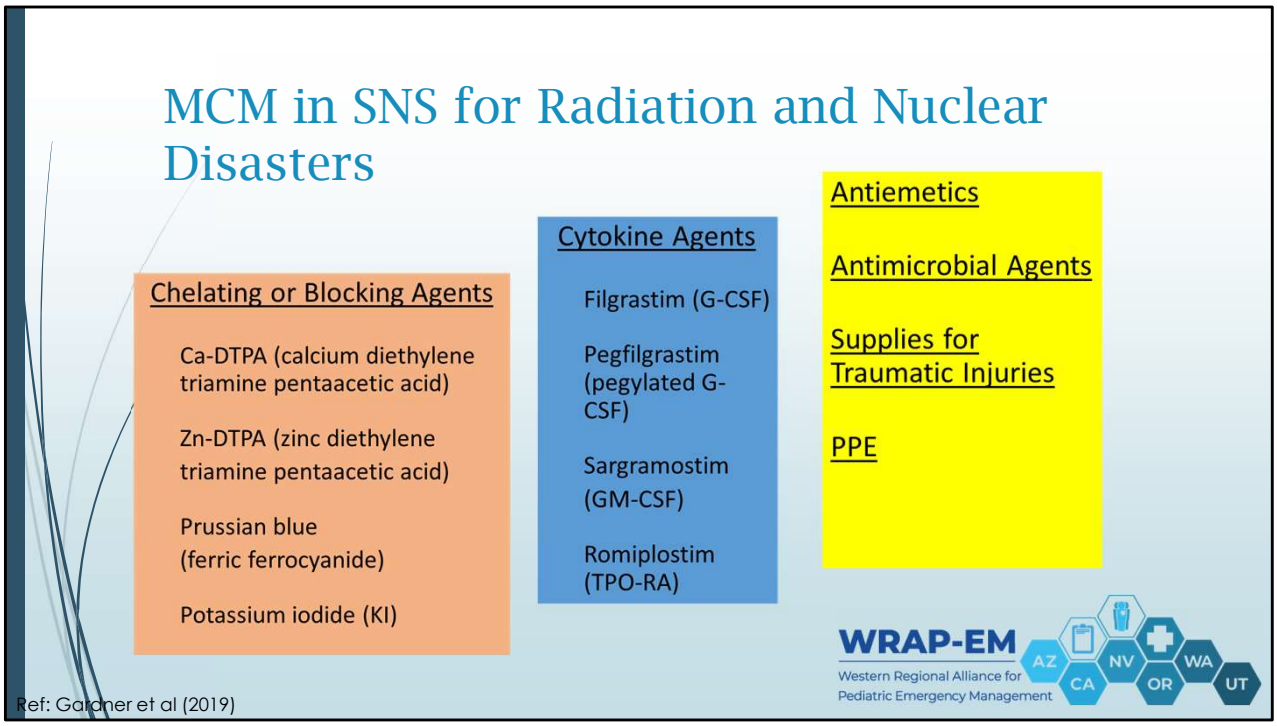
Educational resources and references for parents and families would also need to be available, and include aspects such as pediatric-specific dosing and administration instructions, FAQs, infographics and instructional videos in languages appropriate for the population. These aspects would be crucial to ensure appropriate response to and home

management of possible radiation injuries, and to minimize false information and unnecessary emotional distress.

Pharmacist educational resources and references with pertinent information and support were also seen as critical. Pediatric-specific dosing and administration guidelines, FAQs, online training and toolkits were deemed essential, particularly as pharmacists may be required to do mass dispensing of MCMs in radiation emergencies. They may also serve as a key resource on radiation MCMs for clinicians, parents and patients with limited or no prior experience in such emergencies.

The study identified 15 key gaps related to the use of radiation MCMs in the pediatric population. You can see the ranking of the deficits on this slide. The gaps considered high priority included areas that lacked clinical guidelines, patient and family information, indications for use in the youngest children, and pre-established research protocols to improve the knowledge base.

Ref: Gardner et al (Medical countermeasures for children in radiation and nuclear disasters: Current capabilities and key gaps – 2019)



If a nuclear detonation or other mass casualty radiation emergency occurred, MCMs in the SNS that would be released include:
-chelating or blocking agents to remove internalized radioactive material or to block their uptake into organs
-myeloid cytokines for treating those at risk of developing the hematopoietic subsyndrome of acute radiation syndrome (H-ARS)
-antiemetics to address the nausea and vomiting caused by the radiation exposure
-antimicrobial agents to prevent and treat infection
-supplies to treat traumatic injuries caused by the incident, such as burns and lacerations
-PPE

The drugs included have various names. I have only shown their common and generic names.

I will not go into detail about the specific antiemetics, antimicrobial or other supplies in the SNS today.

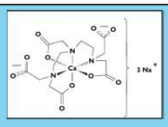
I will now provide a brief review of the commonly used radiation chelating or blocking and cytokine agents. I will not be discussing doses, other than to remind that for most pediatric drug dosing, the dose is calculated on the child's weight in kg. It's important to note that

most pediatric doses administered in radiation emergencies have been extrapolated from adult doses and scaled down to a per kg dose for children.

Later in my presentation, I will provide recommended resources that address dosing information.

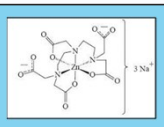
Ref: Gardner et al (Medical countermeasures for children in radiation and nuclear disasters: Current capabilities and key gaps – 2019)

Radiation Chelating or Blocking Agents



Ca-DTPA

- FDA: Plutonium, americium, curium
  - Non-FDA: Californium, berkelium, cobalt, iron
- Administer ASAP
  - More effective than Zn-DTPA
  - IV, IO, inhalation, topical
- Safety concerns in pediatrics and pregnancy; lactation
- Allergy, severe hemochromatosis, asthma, binds trace metals, suppress hematopoiesis, renal insufficiency



Zn-DTPA

- FDA: Plutonium, americium, curium
  - Non-FDA: Californium, berkelium, cobalt, iron
- Administer ASAP
  - After initial Ca-DTPA dosing in pediatrics
  - Initiate with Zn-DTPA in pregnancy unless high internal radioactive contamination
  - IV, IO, inhalation
- Safety concerns in pediatrics and pregnancy; lactation
- Allergy, asthma, binds endogenous metals, renal insufficiency

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Ref: AHLS (2020)

Ca-DTPA is approved by the FDA for treating individuals with known or suspected internal contamination with plutonium, americium or curium. It has also been recommended by other agencies and experts for use in internal contamination with transuranic elements (those with a higher atomic number than uranium (92)), such as californium and berkelium; and other metals, such as cobalt and iron. In France, Ca-DTPA is approved for topical treatment of wounds contaminated with plutonium, americium, curium, cobalt and iron.

It is NOT effective in uranium, neptunium or radioactive iodine internal contamination. In uranium or neptunium incidents, Ca-DPTA may enhance bone and other tissue deposition and will not enhance elimination of the radionuclides from the body.

As with many medical problems, treatment should be initiated ASAP to prevent worse outcomes. It is recommended for administration by IV, IO or inhalation; based on France's experience, it may also be used topically.

Ca-DTPA chelates with metal ions, exchanging calcium for metal ions of greater binding affinity. The chelated radionuclide is then excreted by glomerular filtration into the urine.

Ca-DTPA is more effective in cases of high internal radioactive contamination in the first 24 hours, but it has also been shown to be teratogenic in animal studies, and binds zinc which

may impact DNA and RNA synthesis if Zn becomes depleted. Although it is not recommended as first line in pregnancy, it may be used for the first dose along with Zn supplementation in such cases after evaluating risk to mother and baby. Similarly, in children, an initial dose of Ca-DTPA may be given. It is unclear if it is excreted in breast milk, but since various radionuclides are, breastfeeding is not recommended in women with known internal radionuclide contamination; precautions for discarding breast milk should also be utilized because of radionuclide content.

Cautions include allergy to Ca-DTPA, risk of death from prior reports in severe hemochromatosis although causality hasn't been proven, exacerbation of asthma if given by nebulization, Zn/Mn/Mg binding by calcium leading to loss of the minerals, and reduced rate of removal of radiocontaminants by Ca-DTPA in renal failure so high efficiency high flux HD may be necessary; if dialysis is done, radiation precautions will also be needed because of radionuclide elimination into the dialysis fluid.

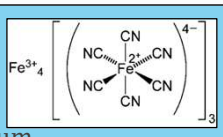
Zn-DTPA has a similar profile as Ca-DTPA but the zinc chelates with the noted radionuclides when given by IV, IO or inhalation. It is also NOT effective in uranium, neptunium or radioactive iodine internal contamination; and has the same warnings about risk of such use as Ca-DTPA.

Zn-DTPA is the preferred chelator in internal contamination in pregnancy except as noted previously for high dose exposure, and for doses beyond the first in pediatric patients. Lactation recommendations are the same as for Ca-DTPA.

Zn-DTPA can lead to depletion of body stores of Mg and Mn, so repletion may be necessary if long-term use of Zn-DTPA is required. The same allergy, asthma and renal insufficiency cautions should be considered when Zn-DTPA is utilized.

Ref: AHLS (2020) p72-75,80-81

Radiation Chelating or Blocking Agents



Prussian blue

- FDA: Cesium, thallium
- PO
  - OK to mix with food/liquid
- Safety concerns in pregnancy and <2 yo; lactation
- GI hypomotility/obstruction, cardiac arrhythmias, electrolyte abnormalities, hepatic impairment, drug binding; blue feces, mouth/teeth
- CN content not clinically significant; artists' blue dye NOT the same

Potassium iodide

- Radioactive iodine
- Administer ASAP
  - PO
- Safety in pregnancy, pediatrics and lactation
- Iodized salt, seaweed, tincture of iodine NOT effective

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Ref: AHLS (2020)

Prussian blue is an oral insoluble and either minimally absorbed or non-absorbed RX-requiring capsule that is FDA-approved for treating patients with internal contamination from radioactive cesium and either radioactive or non-radioactive thallium. Although it is blue, and may stain feces, mouth and teeth, it is different than the blue powder artists use, so the two should not be interchanged. It is not effective for managing internal contamination with other radionuclides. The drug molecule does contain cyanide, but this has been found to not be clinically significant when Prussian blue is used as recommended.

Prussian blue has been used successfully in the Goiania Brazil radiation disaster. There it was shown to decrease the half-life of radioactive cesium in the body by 69%.

Only capsules are available, but their contents can be mixed with food or beverages for dosing those who can't swallow the capsule. There is also suggestion that bile production and the enterohepatic circulation of the drug is enhanced when given with food. This has potential to increase its effectiveness in returning cesium or thallium to the intestine, after which it gets excreted in the stool.

As Prussian blue can adversely impact those with GI hypomotility or obstruction, a high fiber bowel regimen or laxative during treatment is important. Electrolyte abnormalities may also occur, such as hypokalemia, so monitoring and replenishing electrolytes is critical

to avoid electrolyte depletion and associated cardiac arrhythmias. No renal precautions are necessary aside from reminding patients that their urine (and their stool) will contain radionuclides that are excreted. Patients with hepatic impairment may encounter reduced effectiveness with Prussian blue because of reduced biliary elimination of cesium and thallium. Certain medications, such as tetracyclines, may be bound by Prussian blue, and would hence be less effective.

Dosing is approved by the FDA in humans over 2 yo. Pregnancy and lactation cautions should be considered as for Zn-DTPA.

Potassium iodide is useful in protecting the thyroid gland from radioactive iodine exposure, such as occurred in the Fukushima Japan and Chernobyl Ukraine nuclear reactor incidents. Radioactive iodine species, such as I-131, are fission products of uranium. Exposure can occur by both inhalation and ingestion of contaminated food, milk and water.

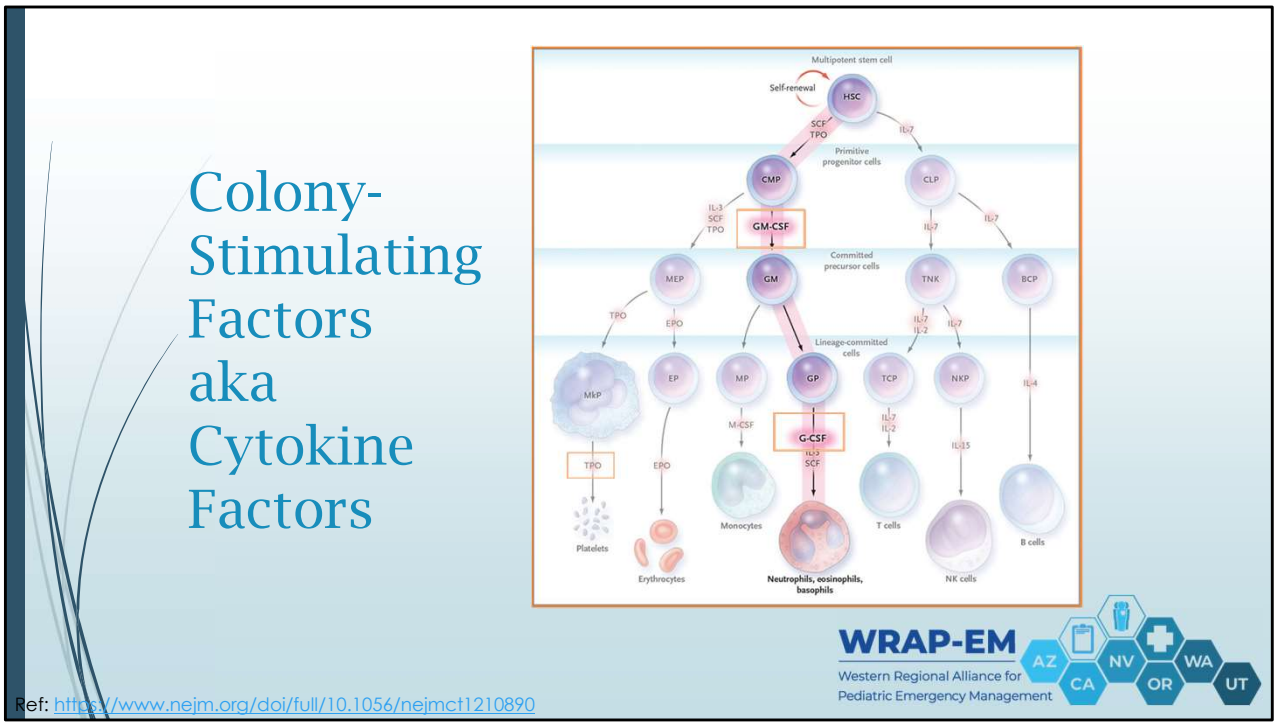
KI is most effective if taken prior to or at the time of internal contamination by radioactive iodine, hence many states have developed plans for ready access to it within 10 miles of nuclear reactors. It must be taken orally and is available in both tablet and oral solution formulations. Patients will not be protected by taking iodized salt, seaweed or tincture of iodine.

Taking recommended doses of oral KI will saturate the thyroid gland with iodine and hence prevent it from absorbing radioactive iodine for 24 hours, but it cannot prevent internal radioactive contamination or reverse its effects once the exposure has occurred. It is not effective against any other radioactive isotopes.

Children will be more at risk of radioactive iodine risks than adults over 40 yo. However, there are also risks of administering too much KI especially to neonates, and pregnant women because of fetal exposure; hypothyroidism can adversely impact fetal and neonatal cognitive development, so close monitoring will be imperative. As KI is secreted into breast milk, precautions should also be considered for lactating mothers who continue to breast feed their baby, especially if repeated KI doses are required.

Iodine hypersensitivity and current or past thyroid disease are considered contraindications to KI. However, it is also important to recognize that many people who report iodine allergy are in fact not allergic. The following are not considered to be evidence of KI allergy according to the American Academy of Allergy Asthma and Immunology; such patients can safely receive KI as long as they don’t have an IgE-mediated allergy to other components in the KI product:
-anaphylactoid reactions to radiocontrast media
-contact dermatitis from povidone-iodine (Betadine) or other iodine-containing antibacterial preparations
-allergy to seafood.

Ref: AHLS (2020) p86-90, 94-98



Colony stimulating factors are growth factors within the cytokine class of proteins endogenously. Both endogenously and as drugs formed by recombinant technology, they stimulate the particular hematopoietic stem cell progenitor causing proliferation and differentiation into the desired cell type.

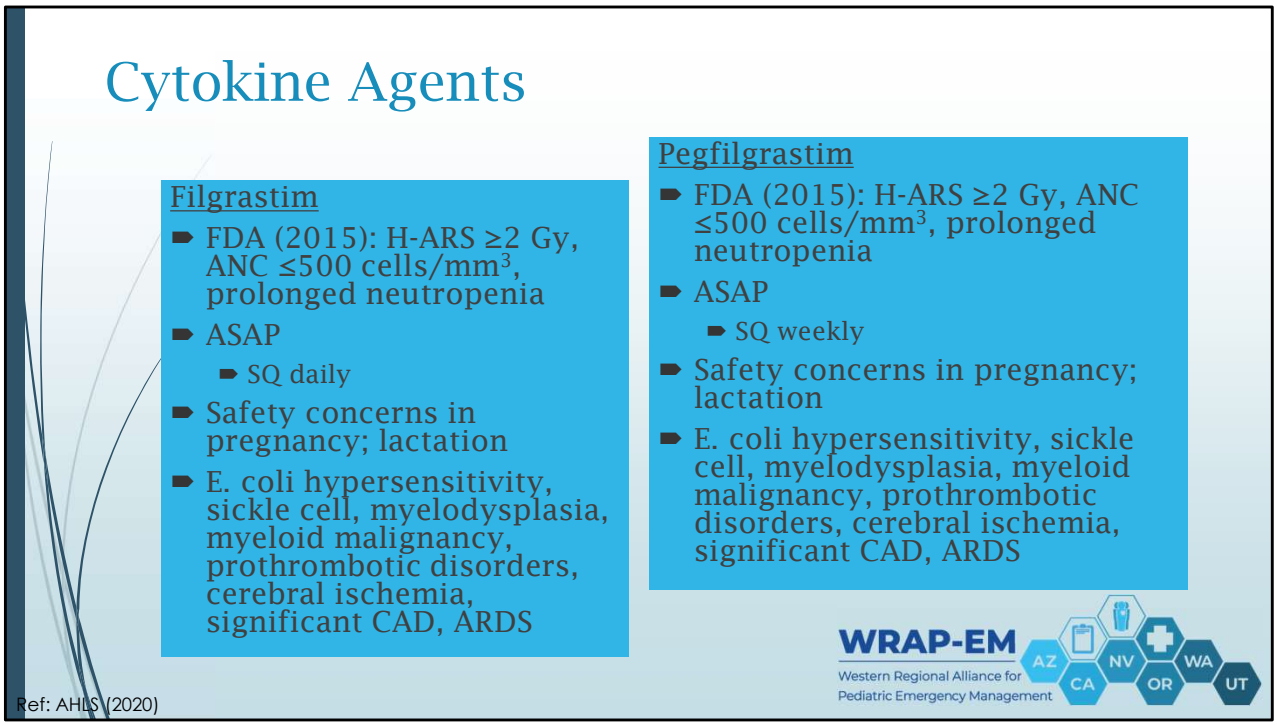
GM-CSF, G-CSF and TPO are the 3 areas on this graphic we will discuss as shown by the orange boxes.

As drugs these agents are used to boost the immune system in patients with various forms of immunosuppression.

Hematopoietic-ARS (H-ARS) aka bone marrow syndrome results in infection, bleeding and poor wound healing leading to death despite antibiotics, transfusions and other supportive care.

As we know, ARS is more clinically significant after whole body exposure of ≥2 Gy of ionizing radiation. These are the patients in whom CSFs will typically be administered.

Ref: https://www.nejm.org/doi/full/10.1056/nejmct1210890 (diagram)



Filgrastim (Neupogen)
Pegfilgrastim (Neulasta)

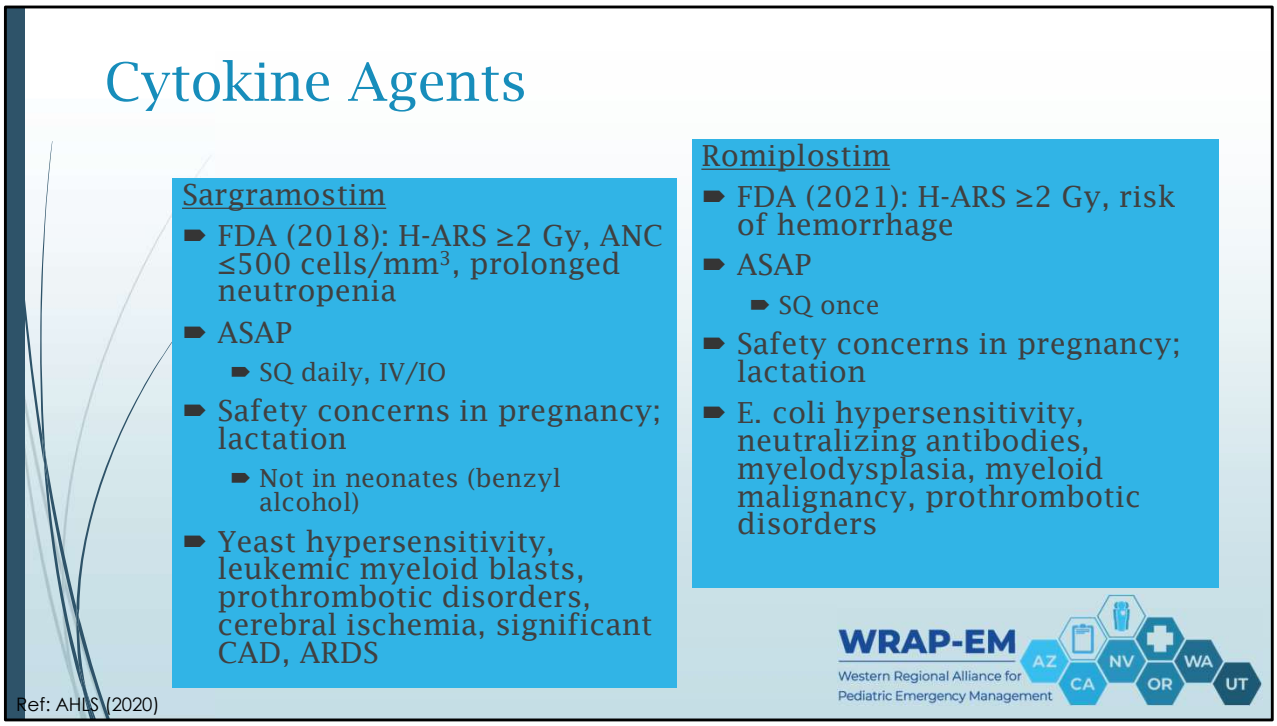
Filgrastim and pegylated filgrastim were both approved by FDA in 2015 for use in H-ARS where patients had suspected or confirmed exposure to at least 2 Gy of ionizing radiation, and in cases where the ANC was 500 or less or patients had prolonged neutropenia. Filgrastim and pegfilgrastim are also used in sulfur mustard emergencies where patients have neutropenic fever, and severe, potentially lethal inhalation or skin injuries. They work as G-CSF.

Either drug should be given ASAP. Both are given SQ, but the main difference between them is the duration of action and frequency for repeating doses. Pegylation of the filgrastim molecule serves to extend its duration of action.

Filgrastim does cross the placenta but has not been found to be associated with adverse pregnancy outcomes. It also enters breast milk but hasn't been found to be absorbed by infants when administered orally or had any associated infant adverse effects. Adverse events were observed in animal reproductive studies with pegfilgrastim, but there isn't evidence available to address use in lactation.

Both products are produced by E. coli bacteria through recombinant DNA technology; allergy to either E. coli-derived proteins or other product components are considered absolute contraindications. Sickle cell crises and development or worsening of myeloid malignancies, and thrombotic-related events deserve risk consideration; development of pulmonary infiltrates during treatment warrants therapy cessation to prevent ARDS.

Ref: AHLS (2020) p62-68



Sargramostim (Leukine)
Romiplostim (NPlate)

Sargramostim is slightly different than filgrastim or pegfilgrastim as it works as a GM-CSF. It was approved by the FDA for similar H-ARS and neutropenia indications as the G-CSFs in 2018.

It is also recommended to be given SQ, and although it may be given IV or IO, there are no particular advantages by these routes. Like filgrastim, it is given daily.

Data in pregnancy and lactation are limited currently. Sargramostim does contain benzyl alcohol as a preservative, and for this reason should be avoided in neonates due to the potential for causing gasping syndrome as has been previously identified with benzyl alcohol exposure in this age group.

Cautions with sargramostim are similar as for the G-CSFs aside from the potential hypersensitivity from yeast-derived proteins used in the recombinant DNA technology during its production.

Romiplostim is the newest agent approved in 2021 for use in H-ARS similar to the agents

already discussed. It is a CSF but acts as a thrombopoietin-receptor agonist which means it affects thrombocyte (or platelet) production which reduce the risk of hemorrhage in affected patients.

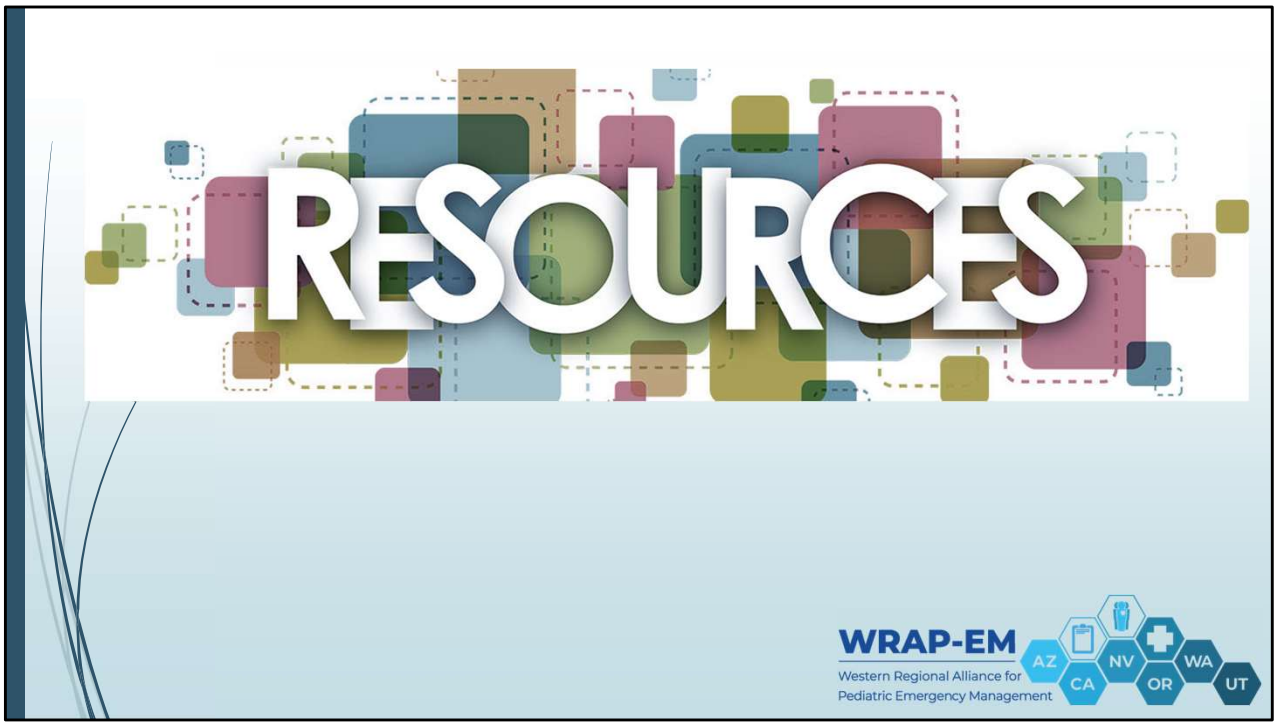
It should be given SQ ASAP, even before CBC results if they aren't readily available, but is only given once.

Animal studies show fetal harm in reproductive studies, but human data is limited. In treating immune thrombocytopenia (ITP), it is not recommended except in very serious cases and could be considered if a TPO-RA was needed in the third trimester near delivery if other therapies have failed. Lactation data is limited and its presence in breast milk is unknown.

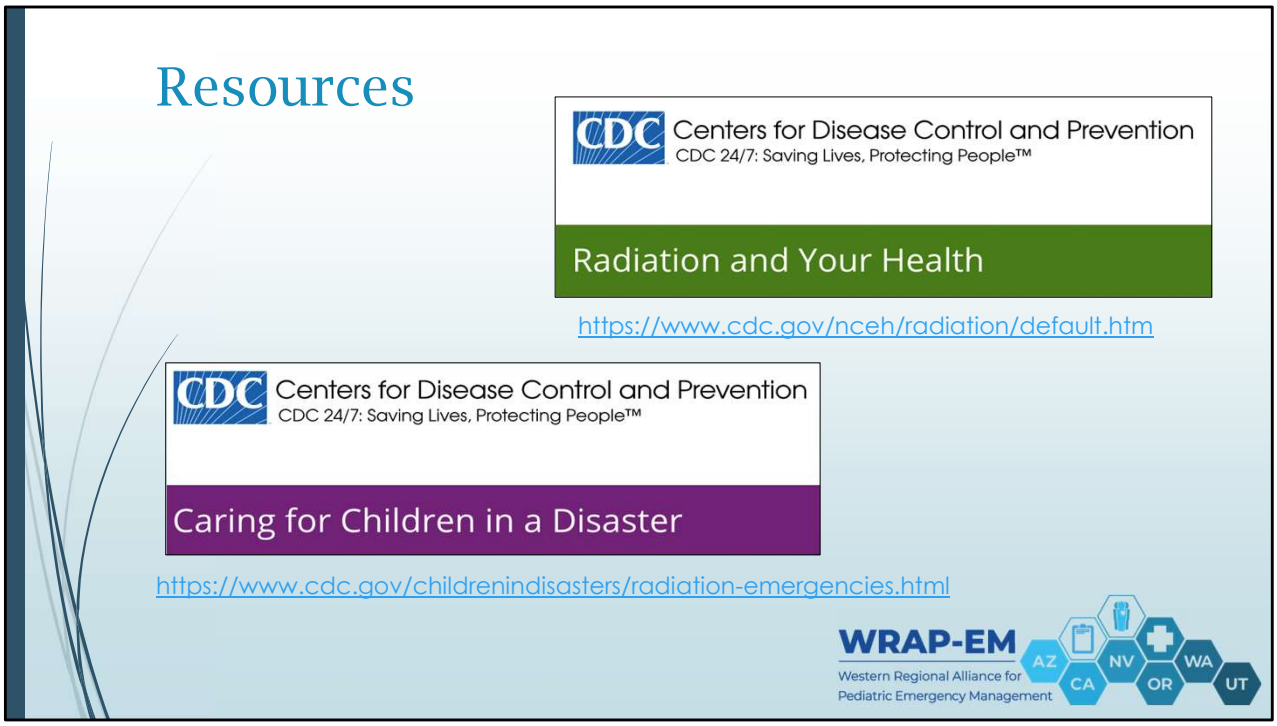
The precautions for use of romiplostim are similar to those for the G-CSFs.

With all the MCMs we've discussed, it is not surprising that cautions and limited data are the norm. In patients with ARS, the benefits associated with using any of these agents will most likely outweigh the risks, particularly if exposure was to higher radiation doses. However, when supplies are limited relative to the population in need, triage decisions should reserve treatment for those with a higher likelihood of survival.

Ref: AHLS (2020) p62-68



Now I would like to share a number of resources that your teams may find helpful as you develop your Pediatric Radiation Surge plan.

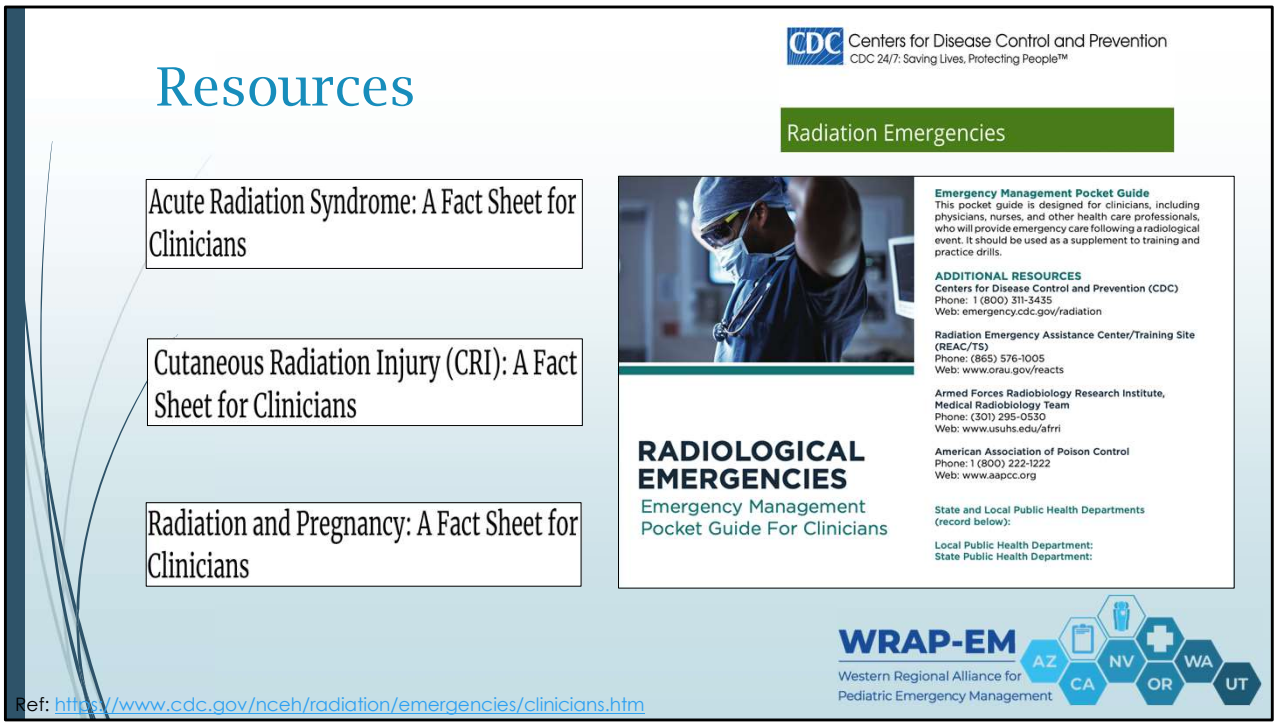


These website will be useful to many levels of planners, professionals and patients or families.

Ref: Radiation and Your Health https://www.cdc.gov/nceh/radiation/default.htm (last reviewed 8/6/21)
-Radiation in Your Life, Health Effects of Radiation, Radiation Basics, Radiation Emergencies, Radiation Dictionary, Radiation Resources and References, Fact Sheets on Radiation Related Topics
-Infographics: Where to Go in a Radiation Emergency; Decontamination for Yourself and Others; How Potassium Iodide Works; How Prussian Blue Works; Improvised Nuclear Device (IND); Nuclear Power Plant Incident; Nuclear Weapon; Radiation Contamination vs. Exposure; Radiation Emergencies and Pregnancy; Radiological Dispersion Device (RDD); Radiological Exposure Device (RED); Transportation Accidents; Workplace Radiation Incidents
-FAQs About Radiation Emergencies

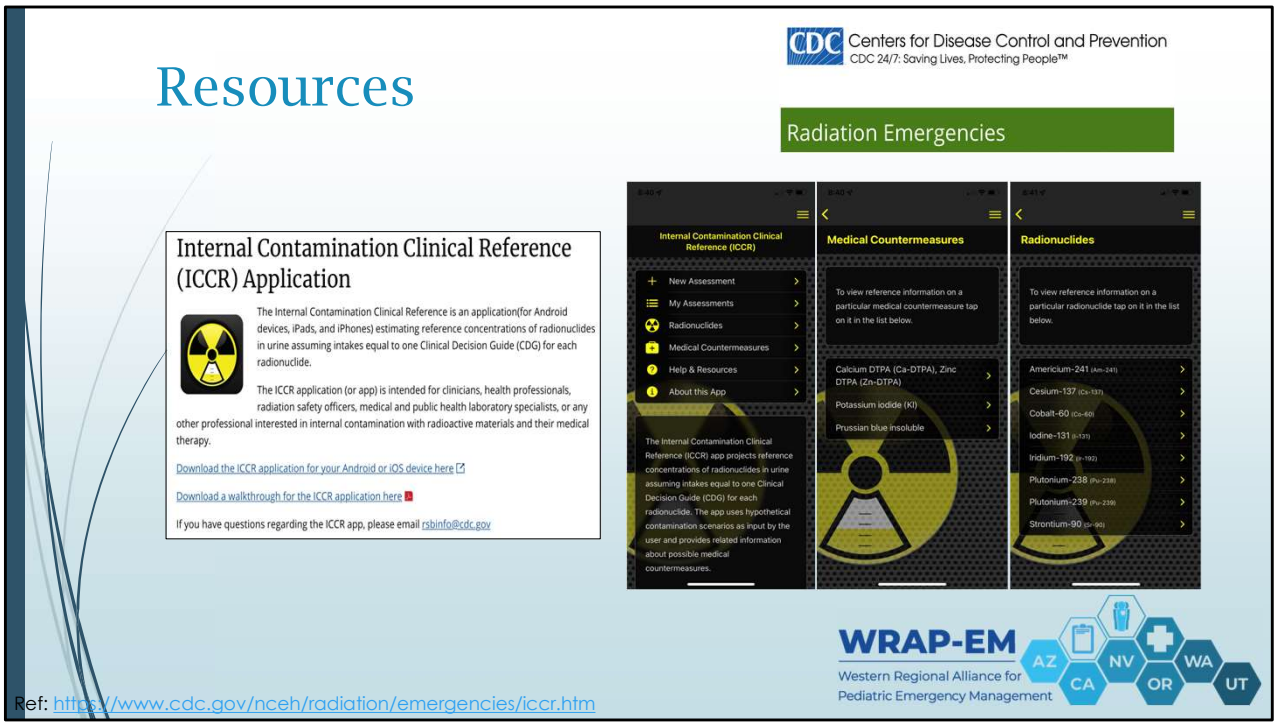
Ref: Caring for Children in a Disaster – Radiation Emergencies https://www.cdc.gov/childrenindisasters/radiation-emergencies.html (last reviewed 9/1/20)
-Radiation Emergencies and Children, Health Effects of Radiation, Protecting Children in a

Radiation Emergency, Why Children are More Vulnerable to Radiation, Treating Radiation Exposure, Additional Resources
-How Children are Different
-Children in a Disaster Specific Threats – Chemical Threats, Radiation Emergencies, Biological Threats, Severe Weather Emergencies
-Children in a Disaster Tools and Resources – Teachers and Childcare, Kids and Families, Health Professionals, Emergency Kit Checklists, Emergency Planners



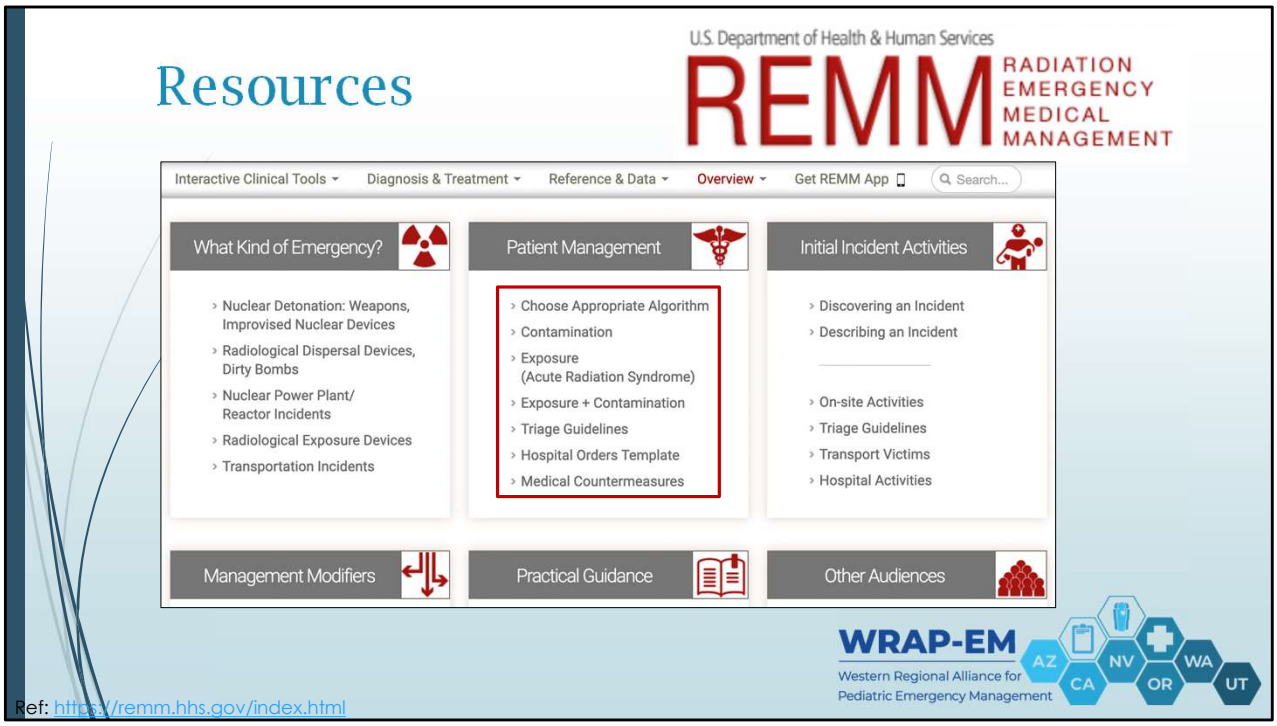
This CDC website also have many resources and links. I have highlighted several that may per pertinent to clinicians.

Ref: https://www.cdc.gov/nceh/radiation/emergencies/clinicians.htm



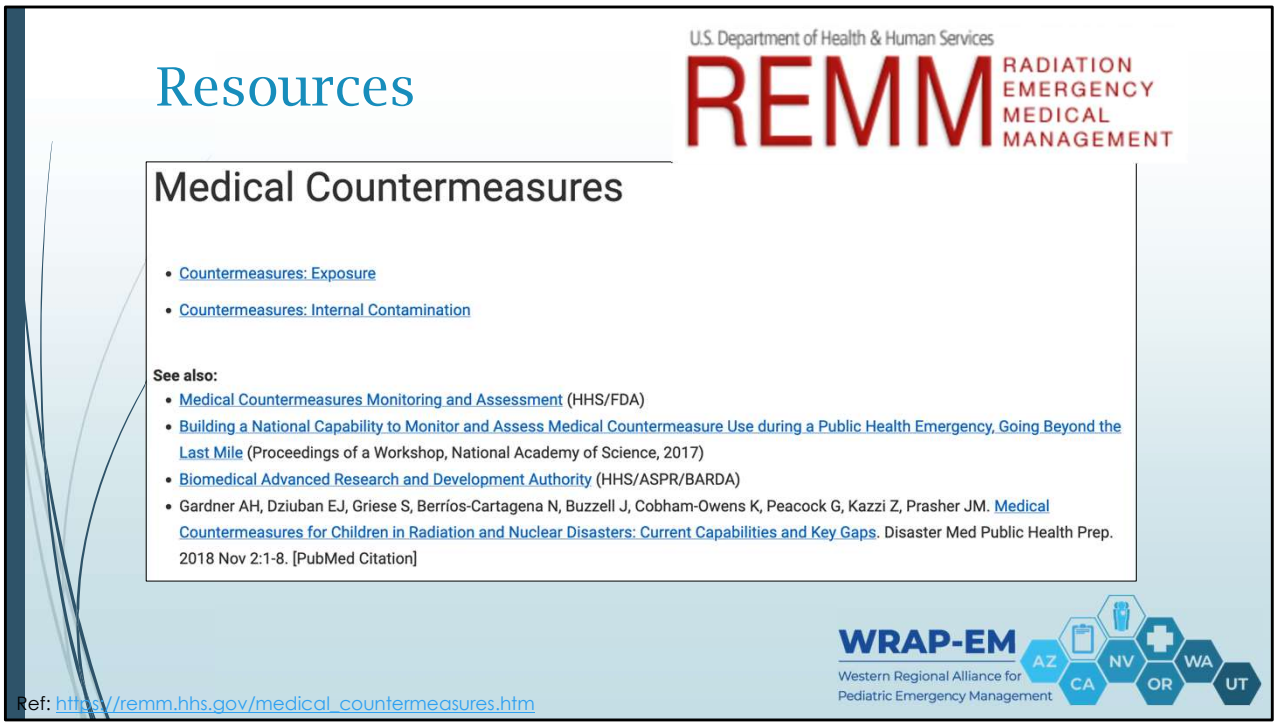
This shows the ICCR mobile device application and how to access it. The 3 screenshots on the right give you an idea of the various information that is accessible.

Ref: https://www.cdc.gov/nceh/radiation/emergencies/iccr.htm



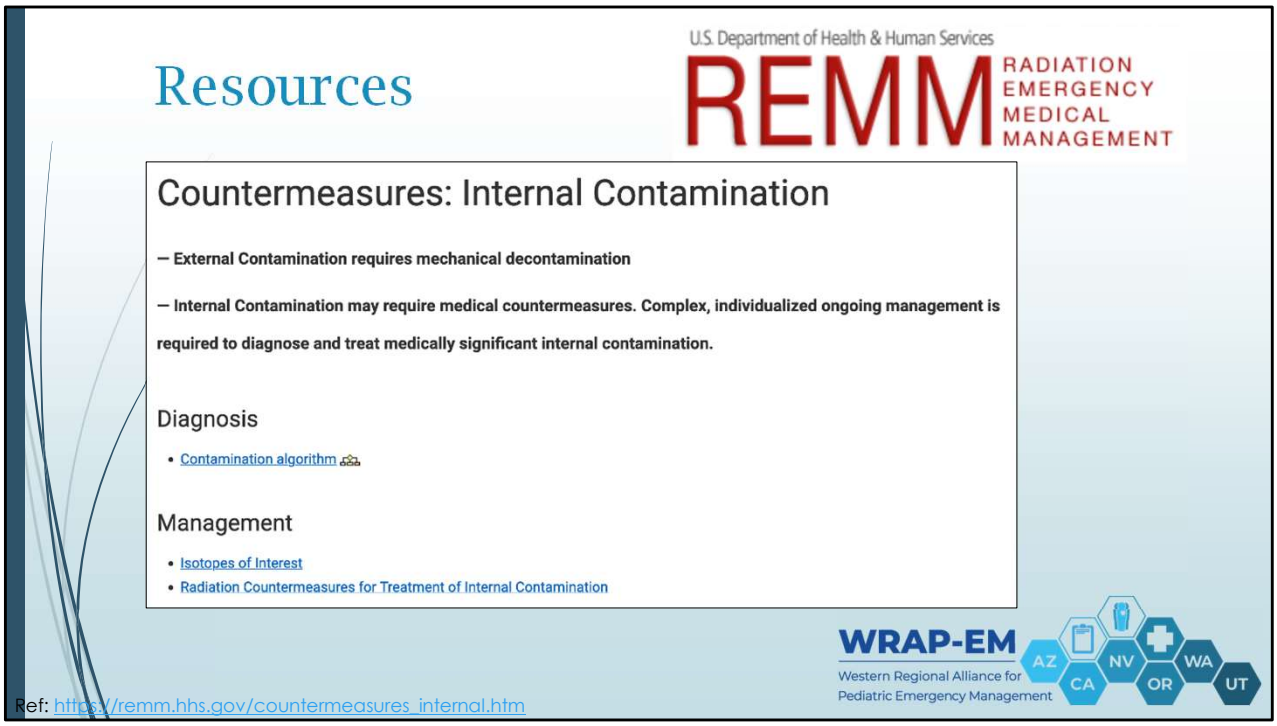
The Radiation Emergency Medical Management (REMM) website or mobile app offer a robust amount of information. This slide shows many of the links and topics available. In terms of patient management, I have highlighted in the orange box, some of the key resources accessible.

Ref: https://remm.hhs.gov/index.html Radiation Emergency Medical Management (REMM)



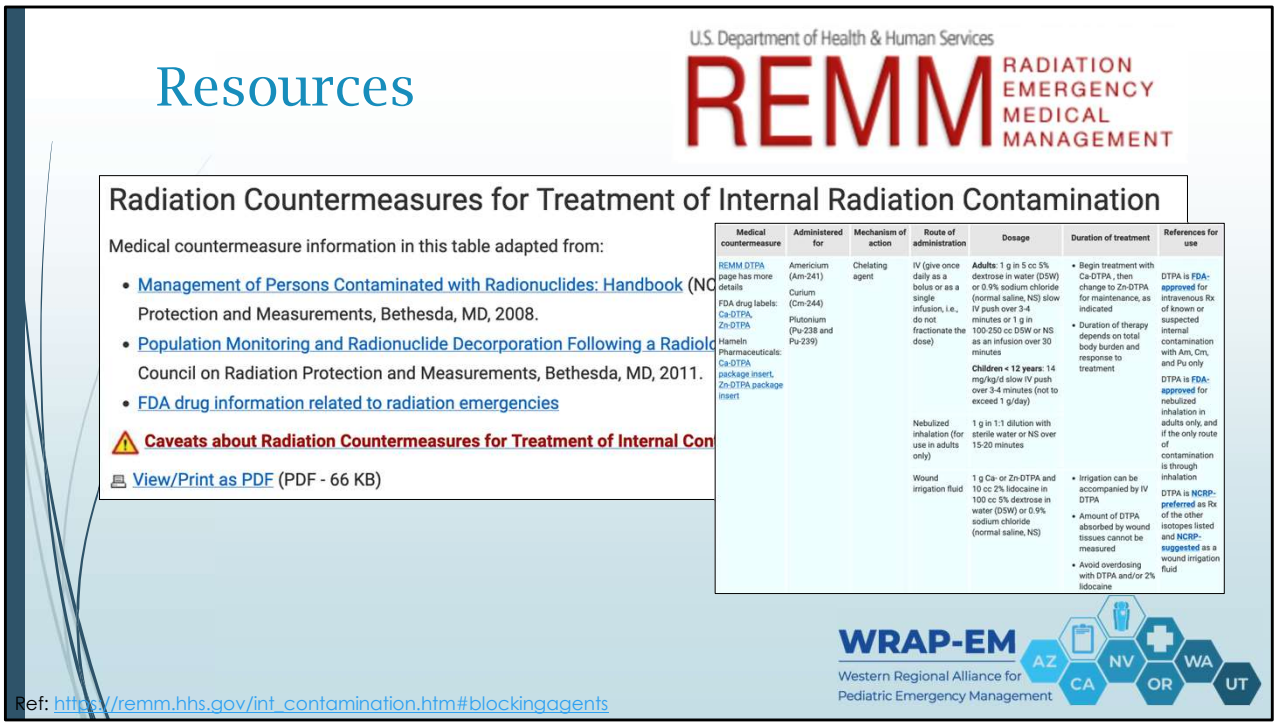
On the next few slides, I have copied partial webpages showing resource links. For example, the Medical Countermeasures page links to both exposure and internal contamination. Other documents pertinent to the topic are also available.

Ref: https://remm.hhs.gov/medical_countermeasures.htm



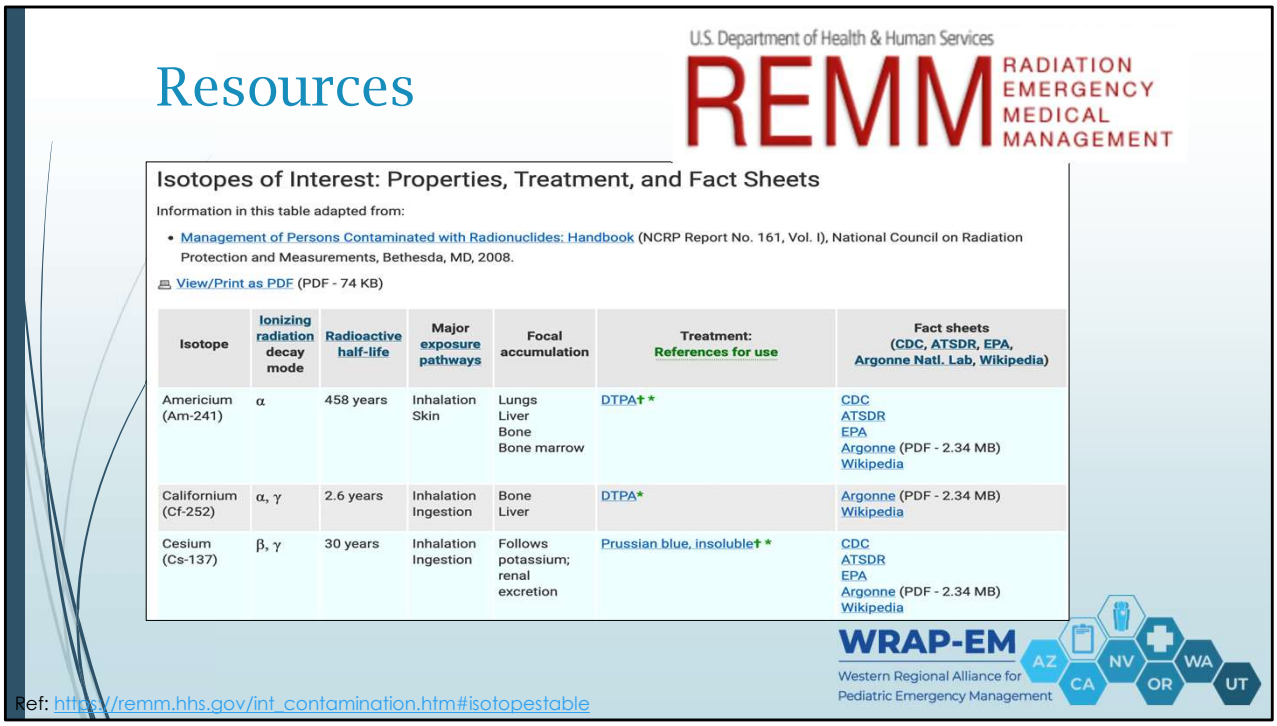
This shows the MCM internal contamination webpage. The algorithm as well as a summary of relevant isotopies and MCM treatments are accessible.

Ref: https://remm.hhs.gov/countermeasures_internal.htm



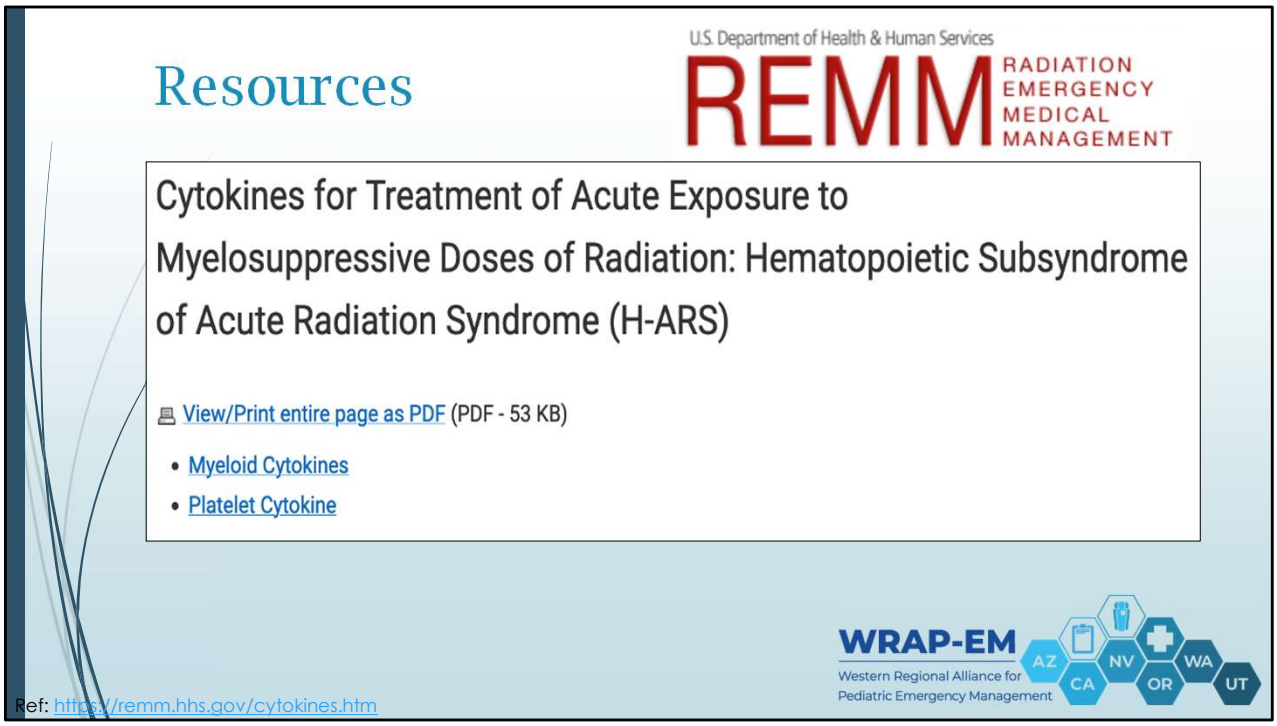
This shows the internal contamination link and on the right side a snippet of the table showing details regarding Ca- and Zn-DTPA.

Ref: https://remm.hhs.gov/int_contamination.htm#blockingagents



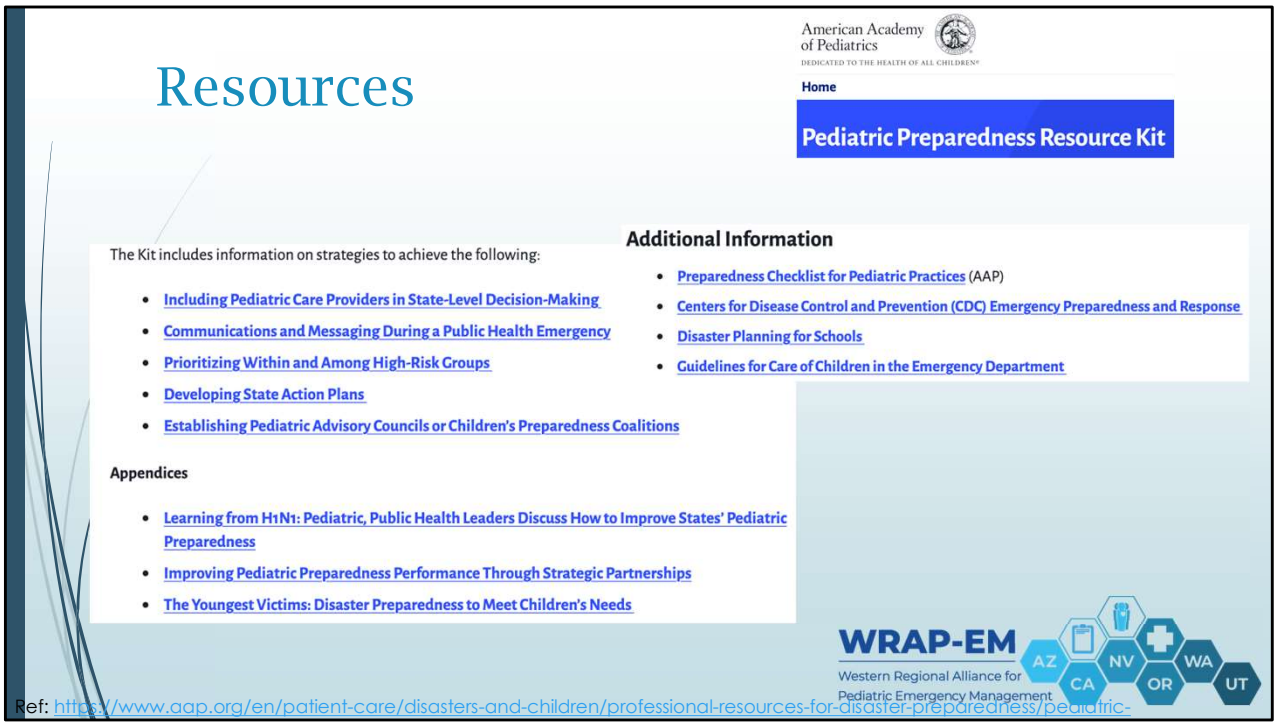
This graphic gives an idea of what the isotopes of interest webpage offers. You will notice on the right column there are various fact sheets available from several agencies; the information is readily accessible and should mitigate a need to create your own documents from scratch.

Ref: https://remm.hhs.gov/int_contamination.htm#isotopestable



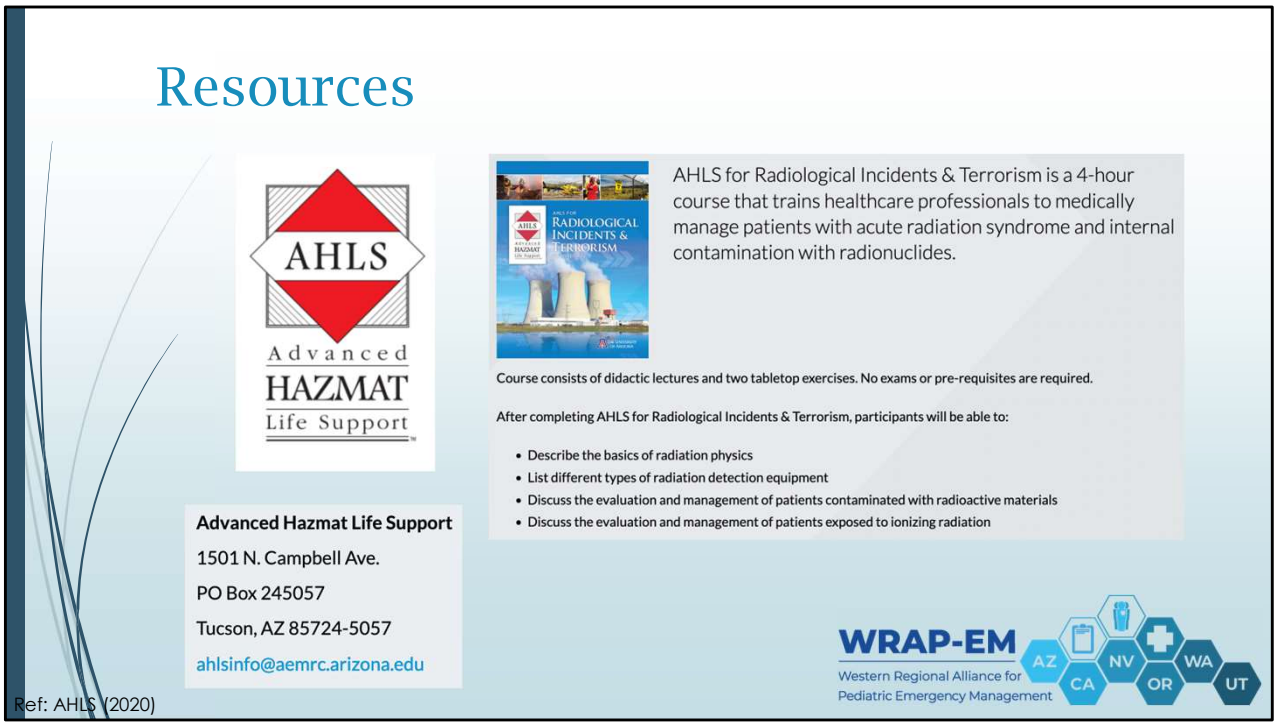
The cytokine agents page is shown here with links to both the myeloid and platelet CSFs we discussed. Note that PDFs of many of the documents are available by a link on REMM.

Ref: https://remm.hhs.gov/cytokines.htm



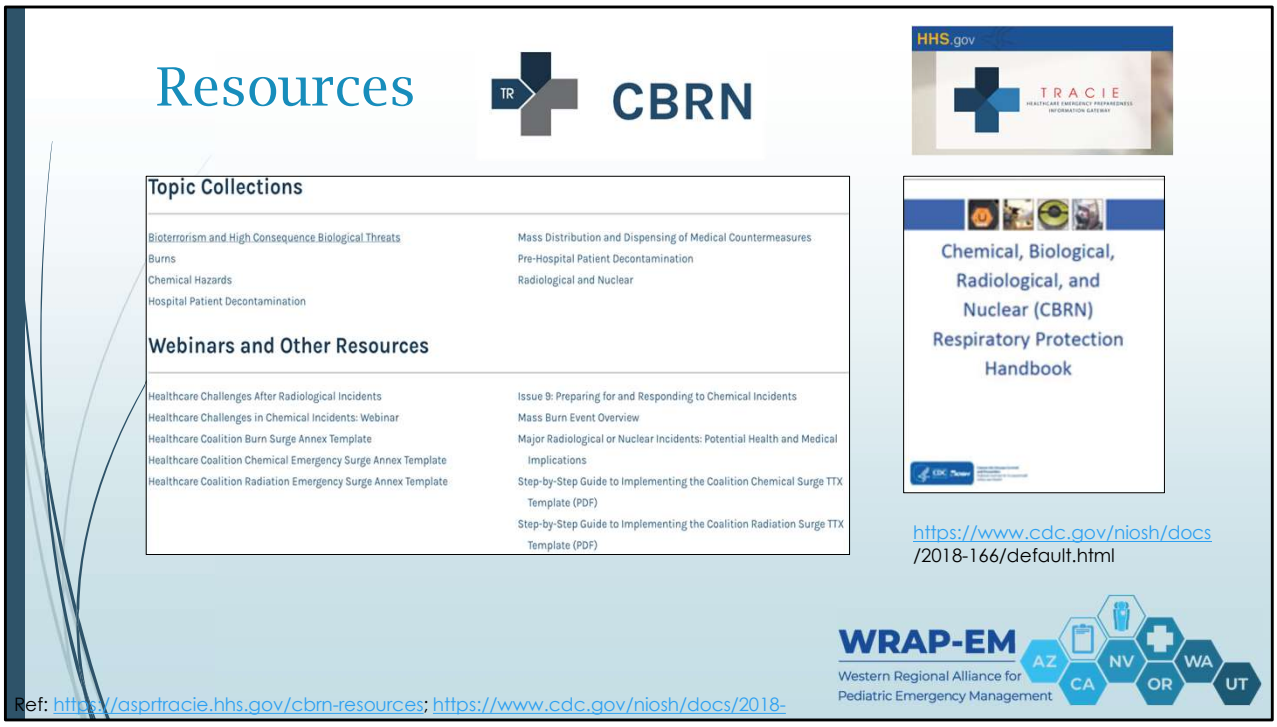
The American Academy of Pediatrics (AAP) has a Pediatric Preparedness Resource Kit available as shown. Communications and messaging, developing state action plans and disaster planning for schools are just a few of the topics addressed.

Ref: https://www.aap.org/en/patient-care/disasters-and-children/professional-resources-for-disaster-preparedness/pediatric-preparedness-resource-kit/



The Advanced HAZMAT Life Support (AHLS) program offers training and guidance in Radiological Incidents & Terrorism as shown. Feel free to contact them if you have folks who would benefit from such training.

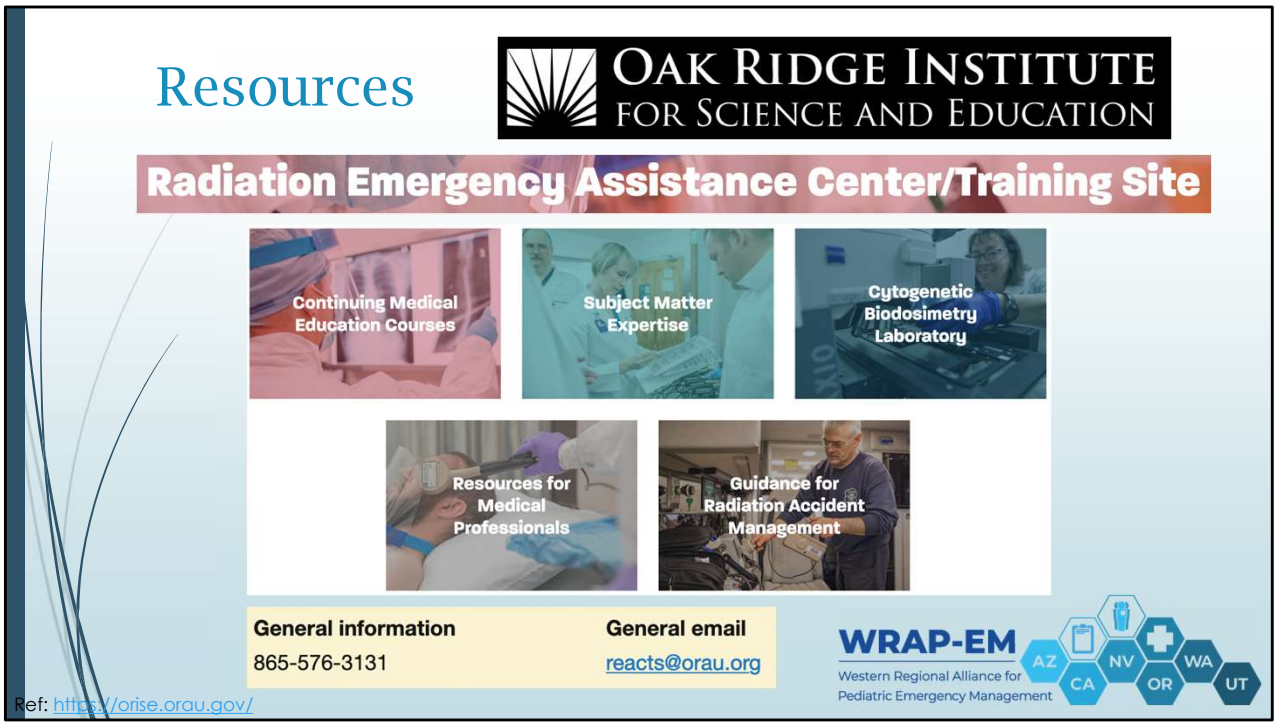
Ref: AHLS (2020)



The HHS (Health and Human Services) ASPR (Assistant Secretary for Preparedness and Response) TRACIE (Technical Resources, Assistance Center, and Information Exchange) website offers a wealth of informational resources and assistance on all disasters. The slide shows their CBRN (Chemical Biological Radiological Nuclear) webpage.

The slide also shows the link to the CBRN Respiratory Protection Handbook published by CDC/NIOSH in 2018 that is accessible on the internet.

Ref: https://asprtracie.hhs.gov/cbrn-resources
Ref: https://www.cdc.gov/niosh/docs/2018-166/default.html



The Oak Ridge Institute for Science and Education (ORISE) has a Radiation Emergency Assistance Center/Training Site (REACTS) that offers much expertise in radiation-related topics. Check out their website or contact them if you are interested in learning more about their courses or other ways they can assist.

Ref: https://orise.orau.gov/

Summary

- Children aren't just little adults
  - They have unique aspects of care in radiation and other disasters
- Advance preparation for any radiation incident is essential
- Time is tissue in managing radiation exposures
- Numerous drugs available, including through the SNS
  - Chelators, blockers, and cytokine agents are key
  - Cautions to use of drugs → risks and benefits must be addressed
- Numerous resources to aid in education and management

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

References – Publications

- Bennett CL, Djulbegovic B, Norris LB, Armitage JO. Colony-stimulating factors for febrile neutropenia during cancer therapy. N Engl J Med. 2013;368:1131–1139. DOI: 10.1056/NEJMct1210890.
- Gardner AH, Dziuban EJ, Griese S, Berrios-Cartagena N, et al. Medical countermeasures for children in radiation and nuclear disasters: Current capabilities and key gaps. Disaster Med Public Health Prep. 2019;13:639–646. DOI: 10.1017/dmp.2018.112.
- Kazzi Z, Nemhauser Captain JB, Walter FG, editors. AHLS for radiological incidents and terrorism, 5th edn. Arizona Board of Regents (2020). ISBN 978-0-9899175-9-9.
- Kim-Farley RJ. Community preparedness: "It takes a village". AJPH. 2019;109(54, Suppl 4):S256–S257.

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

References – Publications

- Krug SE, Needle S, Schonfeld D, Aird L, Hurley H. Improving pediatric preparedness performance through strategic partnerships. Disaster Med Public Health Prep. 2012;6(2):94–96. DOI: 10.1001/dmp.2012.27.
- Linet MS, Kazzi Z, Paulson JA, COEH. Pediatric considerations before, during, and after radiological or nuclear emergencies. Technical report. Pediatrics. 2018;142(8):e20183001.
- Lurie N, Khan AS. Ensuring the health security of America's children. J Pediatr. 2013;163(1):274–276.

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

References – Websites

- AAP: Pediatric Preparedness Resource Kit: https://www.aap.org/en/patient-care/disasters-and-children/professional-resources-for-disaster-preparedness/pediatric-preparedness-resource-kit/
- ANS (American Nuclear Society): https://www.ans.org/nuclear/radiation/
- CDC: Caring for Children in a Disaster: https://www.cdc.gov/childrenindisasters/radiation-emergencies.html
- CDC: Radiation and Your Health: https://www.cdc.gov/nceh/radiation/health.html
- CDC: Radiation Emergencies: https://www.cdc.gov/nceh/radiation/emergencies/
- CDC: State and Local Readiness: https://www.cdc.gov/cpr/readiness/index.htm

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

References – Websites

- FDA: What are Medical Countermeasures?: https://www.fda.gov/emergency-preparedness-and-response/about-mcmi/what-are-medical-countermeasures
- HHS ASPR TRACIE: CBRN: https://asprtracie.hhs.gov/cbrn-resources
- HHS: Public Health Emergency: Medical Countermeasures: https://www.medicalcountermeasures.gov/
- HHS: Public Health Emergency: Strategic National Stockpile: https://www.phe.gov/about/sns/Pages/default.aspx
- HHS: REMM (Radiation Emergency Medical Management): https://remm.hhs.gov/index.html
- ORISE: https://orise.orau.gov/

WRAP-EM
Western Regional Alliance for Pediatric Emergency Management
AZ CA NV OR WA UT

Thank you Dr Walter