INTRODUCTION TO NUCLEAR / RADIATION ACCIDENTS, INCIDENTS AND EVENTS

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National Cancer Institute

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

National Institutes of Health

In this presentation, I will examine some of the varied ways that nuclear accidents take place.

Organization of Presentation

- Definitions of Accidents, Incidents, and Terrorism Events
- Examples of events
- Some observations and generalizations
- Some very brief measurement findings from Fukushima

What is a NUCLEAR ACCIDENT, NUCLEAR INCIDENT, or ACT OF NUCLEAR TERRORISM?

There are numerous definitions available. These are probably as good as any.

A nuclear **accident, incident, or act of terrorism** is an unpredictable, unusual and unwanted event involving radiation and/or radioactive materials which results in occupational or public exposures and /or contamination of structures, property, or persons.

Nuclear Accidents: Causes are not deliberate, malicious, or malevolent. True accidents can be viewed as acts of nature or acts of god, but likely include failures of equipment and systems.

Nuclear Incidents: Causes can include deliberate actions but these are generally non-malicious and non-violent; may be due to poor judgment, wrong information coupled with malfunctions or other accident conditions, etc.

Nuclear Terrorism: A form of political violence that is designed to induce terror and psychic fear through the violent victimization and damage of noncombatant targets. These events usually exploit the media in order to achieve maximum attainable publicity as an amplifying force. Massive economic damage is possible and is usually an intended outcome while substantial (or any) radiation injury to persons may or may not be involved.

The Major Recognized Categories of Accidents and Incidents:

1. Industrial radiography
2. Industrial irradiation facilities
3. Medical procedures (primarily associated with therapy)
4. Loss of control of radiation sources
5. Nuclear testing-related activities (combat not included)
6. Nuclear energy (fuel production, fuel storage, nuclear power plant operation)
7. Terrorism

INDUSTRIAL RADIOGRAPHY

High activity ^{192}Ir sources are typically used to radiograph welds in pipes.

Portable radiography devices are often used with little training and little enforcement about good radiation protection practices.

Extremely high, localized doses can result from improper handling and use of sources.

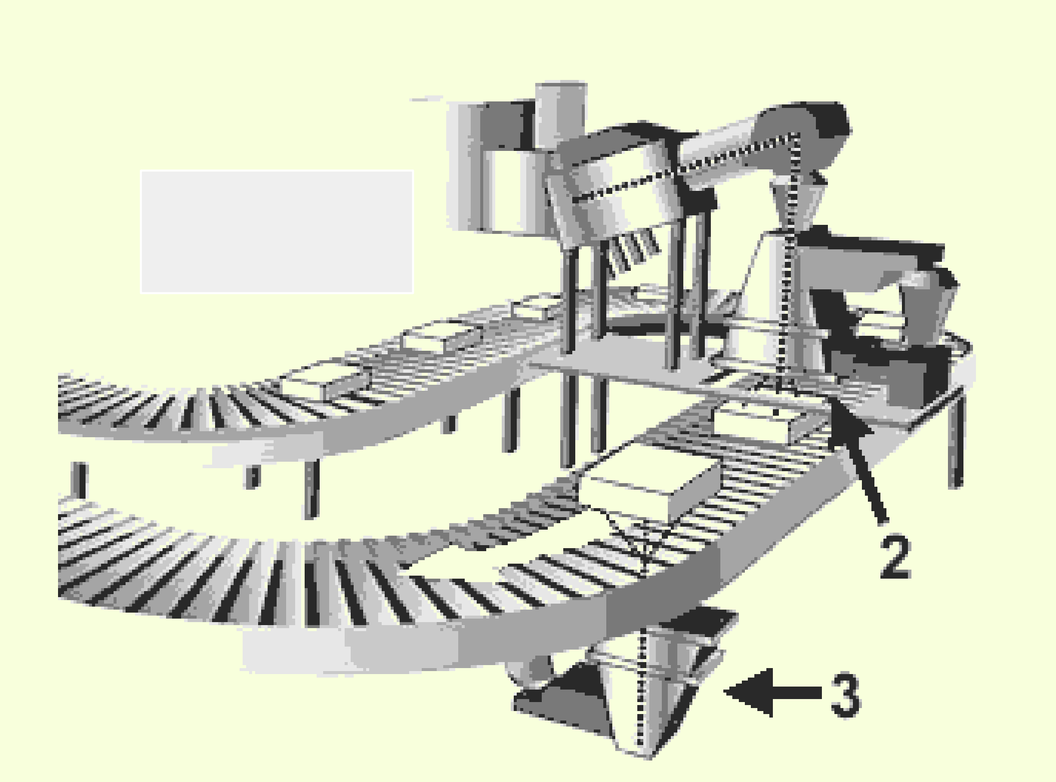
INDUSTRIAL RADIOGRAPHY

Year	Country	Dose	Number exposed
1980	FRG	23 Gy (hand)	1
1985	Brazil	410 Sv (localized)	1
1985	Brazil	160 Sv (localized)	2
1996	Iran	2-3 Gy (whole body)+ 100 Gy (chest)	1
1999	Peru	Up to 100 Gy (locally)	1

Source: A. Gonzalez, IAEA Bulletin, 1999

INDUSTRIAL IRRADIATION FACILITIES

Facilities use intense radiation sources for sterilization of foods, surgical instruments, and other items.



Unintended exposures result from radiation sources not properly returning into shields or failures of staff to know sources are deployed.

INDUSTRIAL IRRADIATION FACILITIES

Year	Country	Nuclide Used	Dose	Number exposed (# deaths)
	USSR	Co-60	1.5 (local, head)	1 (0)
1975	USSR	Cs-1371968	3-5 Gy (total)+30 Gy (hand)	1 (0)
1977	USSR	Co-60	50 Gy (local, legs)	1 (0)
1980	USSR	Co-60		1 (0)
1989	El Salvador	Co-60	3-8 Gy	3 (1)
1990	Israel	Co-60	>12 Gy	1 (1)
1991	Belarus	Co-60	10 Gy	1 (1)

Source: A. Gonzalez, IAEA Bulletin, 1999

MEDICINE

Accidents and incidents are generally over-exposures due to equipment malfunctions, lack of proper training, poor judgment or combinations.

Serious overexposures leading to acute radiation effects occur more often in therapeutic procedures while modest overexposures leading to increases in cancer risk probably occur more often in diagnostic procedures.

Overexposures range from a few times larger than appropriate in diagnostic imagine to levels causing severe acute effects.

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NEWS

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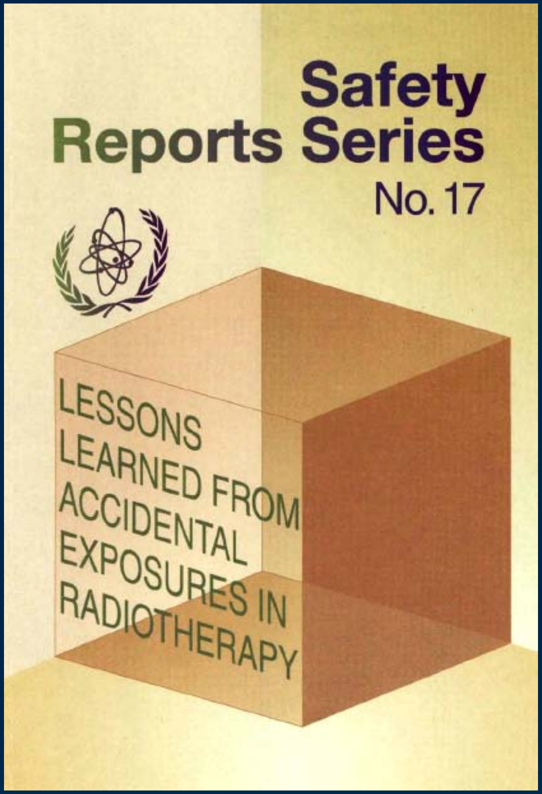
Medscape Medical News

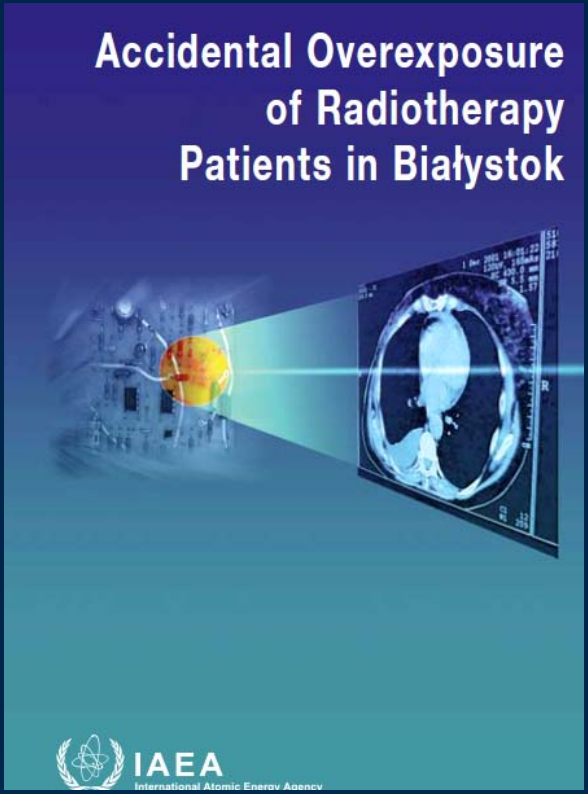
FDA Warns of Radiation Overexposure With Brain CT

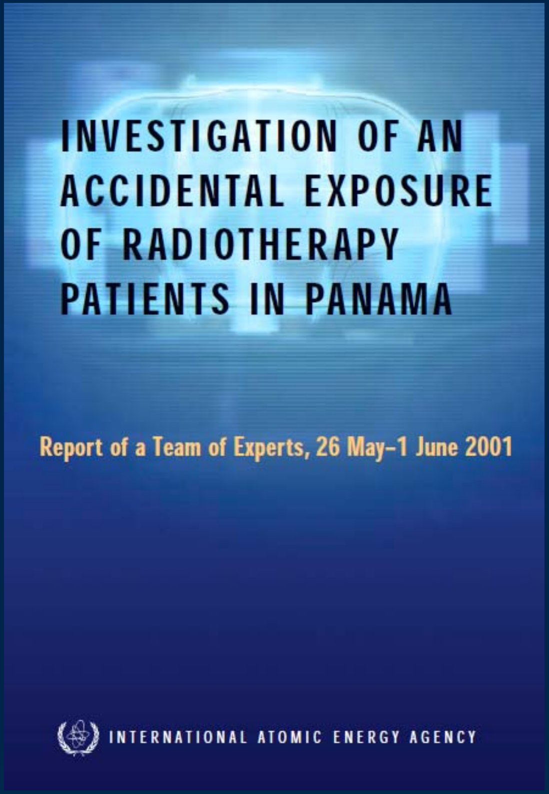
October 10, 2009 — The US Food and Drug Administration (FDA) is reporting cases of radiation overexposures during brain perfusion computed tomography (CT) imaging. The overexposures took place at a single institution but may reflect a more widespread problem regarding CT quality assurance programs.

During an 18-month period, the agency found that 206 patients received radiation doses that were approximately 8 times the expected level.

MEDICINE







Good information available on a number of international radiotherapy incidents. See IAEA website.

MEDICINE

Ortiz et al. IRPA 10, 2001

TABLE 2. MAJOR REPORTED ACCIDENTS INVOLVING RADIOTHERAPY PATIENTS

Country	Year	No of patients affected	Causes and main contributing factors
USA	1974-76	426	Co-60 dose calculations based on erroneous decay chart (varying overdoses) No independent verification of decay charts and dose calculations More than two years without beam measurements Physics manpower and attention shifted to other tasks, such as a new accelerator
Germany	1986-87	86	Co-60 dose calculations based on erroneous dose tables (varying overdoses) No independent determination of the dose rate
UK	1988	207	Error in the calibration of a Co-60 therapy unit (25% overdose) No independent calibration of the beam
UK	1988-89	22	Error in the identification of Cs-137 brachytherapy sources (-20 to +10% dosimetry errors) No independent determination of source strength
Spain	1990	27 (18 deaths from radiation)	Error in the maintenance of a clinical linear accelerator. Procedures for transferring machine from and to maintenance (informing physicists) not followed. Conflicting signals and displays ignored Procedures for periodic beam verifications (QA) not implemented Overdosage ranging from 200% to 700%
UK	1982-91	nearly 1,000	Inappropriate commissioning of a computerized Treatment Planning System (5-30% underdosage) No written procedures for commissioning and use
USA	1992	1 (death from radiation)	Brachytherapy source (High Dose Rate) left inside the patient. Source dislodged from equipment Conflicting monitor signals and displays ignored
Costa Rica	1996	115 (at least 17 deaths from radiation)	Error in calculation during the calibration of Co-60 therapy unit Lack of independent calibration and of QA Recommendations from an external audit ignored Overdosage about 60%

Loss of Control of Radiation Sources

"Orphaned sources" is a problem worldwide due to lack of record keeping on source owners and locations of use, little regulation on stewardship, and lack of institutional memory and controls.

Since 1983, there have been about 60 known incidents of radiation sources being lost, melted down, and usually reformed into steel rebar construction materials.

Melted radiation sources 1 of 2:

Meltings of Radioactive Materials: International Overview

Year	Metal	Location	Isotope	Activity (GBq)
since 1910[a]	Gold	New York	polonium-210, lead-210, bismuth-210	Unknown
1983	Steel	Auburn Steel, NY	cobalt-60	930
1983	Iron/steel	Mexico[b]	cobalt-60	15 000
1983	Gold	Unknown, NY	americium-241	Unknown
1983	Steel	Taiwan, China [b]	cobalt-60	>740
1984	Steel	US Pipe & Foundry, AL	caeium-137	0.37–1.9
1985	Steel	Brazil[b]	cobalt-60	Unknown
1985	Steel	Tamco, CA	caesium-137	56
1987	Steel	Florida Steel, FL	caesium-137	0.93
1987	Aluminium	United Technology, IN	radium-226	0.74
1988	Lead	ALCO Pacific, CA	caesium-137	0.74–0.93
1988	Copper	Warrington, MO	Accelerator	Unknown
1988	Steel	Italy[b]	cobalt-60	Unknown
1989	Steel	Bayou Steel, LA	caesium-137	19
1989	Steel	Cytemp, PA	thorium	Unknown
1989	Steel	Italy	caesium-137	1000
1989	Aluminium	Russian Federation	Unknown	Unknown
1990	Steel	NUCOR Steel, UT	caesium-137	Unknown
1990	Aluminium	Italy	caesium-137	Unknown
1990	Steel	Ireland	caesium-137	3.7
1991	Steel	India[b]	cobalt-50	7.4–20
1991	Aluminium	Alcan Recycling, TN	thorium	Unknown
1991	Aluminium	Italy	caesium-137	Unknown
1991	Copper	Italy	americium-241	Unknown
1992	Steel	Newport Steel, KY	caesium-137	12
1992	Aluminium	Reynolds, VA	radium-226	Unknown
1992	Steel	Border Steel, TX	caesium-137	4.6–7.4
1992	Steel	Keystone Wire, IL	caesium-137	Unknown
1992	Steel	Poland	caesium-137	Unknown

Source: A. Gonzalez, IAEA Bulletin, 1999

Melted radiation sources 2 of 2:

Year	Metal	Location	Isotope	Activity (GBq)
1992	Copper	Estonia/Russian Federation	cobalt-60	Unknown
1993	Unknown	Russian Federation	radium-226	Unknown
1993	Steel (?)	Russian Federation	caesium-137	Unknown
1993	Steel	Auburn Steel, NY	caesium-137	37
1993	Steel	Newport Steel, KY	caesium-137	7.4
1993	Steel	Chaparral Steel, TX	caesium-137	Unknown
1993	Zinc	Southern Zinc, GA	depleted uranium	Unknown
1993	Steel	Kazakhstan[b]	cobalt-60	0.3
1993	Steel	Florida Steel, FL	caesium-137	Unknown
1993	Steel	South Africa[c]	caesium-137	<600 Bq/g
1993	Steel	Italy	caesium-137	Unknown
1994	Steel	Austeel Lemont, IN	caesium-137	0.074
1994	Steel	US Pipe & Foundry, CA	caesium-137	Unknown
1994	Steel	Bulgaria[b]	cobalt-60	3.7
1995	Steel	Canada[d]	caesium-137	0.2–0.7
1995	Steel	Czech Rep.	cobalt-60	Unknown
1995	Steel (?)	Italy	caesium-137	Unknown
1996	Steel	Sweden	cobalt-60	87
1996	Steel	Austria	cobalt-60	Unknown
1996	Lead	Brazil[b]	polonium-210, lead-210, bismuth-210	Unknown
1996	Aluminium	Bluegrass Recycling, KY	thorium-232	Unknown
1997	Aluminium	White Salvage Co., TN	americium-241	Unknown
1997	Steel	WCI, OH	cobalt-60	0.9 (?)
1997	Steel	Kentucky Electric, KY	caesium-137	1.3
1997	Steel	Italy	caesium-137/cobalt-60	200/37
1997	Steel	Greece	caesium-137	11 Bq/g
1997	Steel	Birmingham Steel, AL	caesium-137/americium-241	7 Bq/g
1997	Steel	Brazil[b]	cobalt-60	<0.2
1997	Steel	Bethlehem Steel, IN	cobalt-60	0.2
1998	Steel	Spain	caesium-137	>37
1998	Steel	Sweden	iridium-192	<90

Source: A. Gonzalez, IAEA Bulletin, 1999

Contamination of Co-60 Steel in Taiwan

Contaminated steel used to construct about 1700 apartments in >180 buildings in 1982. Discovered in 1992.More than 10,000 were likely exposed.

TABLE 1

Annual and accumulated doses

Cohort	Number of people	Mean annual dose in first year 1983 (mSv)	1983 to 2003 individual dose (mSv)
High	1,100	525	4000
Medium	900	60	420
Low	8,000	18	120
Averaged	10,000	74	600
Adjusted	10,000	49	400

*From July 1996, 50% of residents relocated.

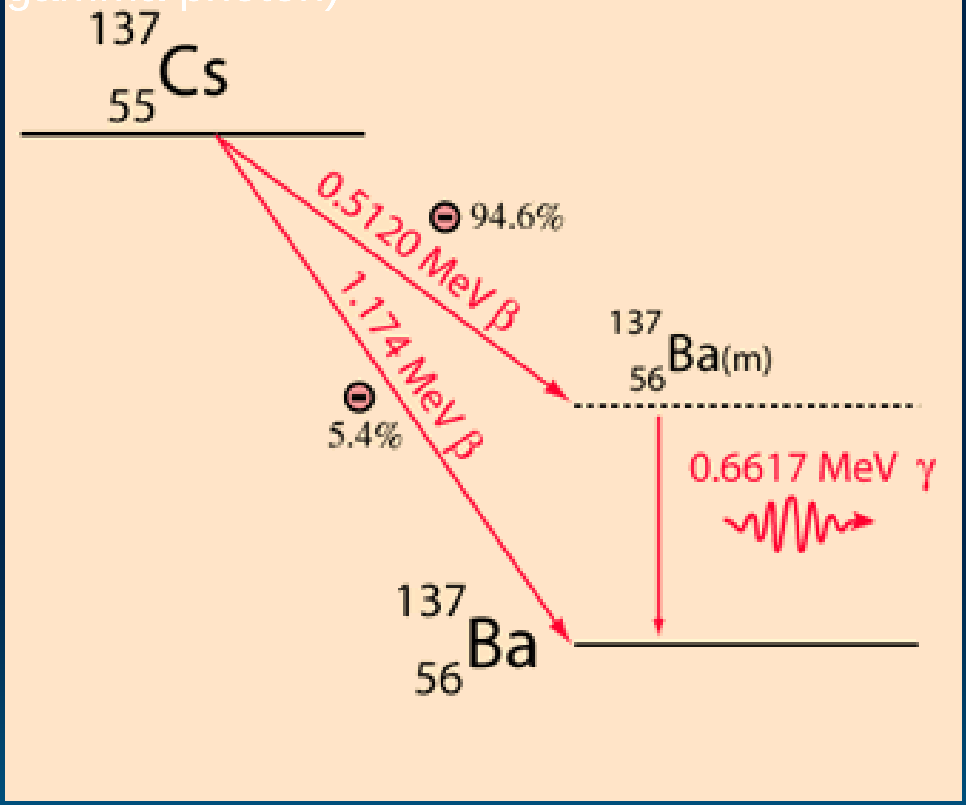
Chen et al. 2007. J of Dose Response.

Goiania, Brazil
September 1987

- Abandoned Cancer Clinic discarded canisters from radiotherapy machine
- Junkyard worker opened canisters revealing blue powder
- Citizens contaminated with radioactive Cesium-137

1,350 Ci (5×10^{15} Bq!) CsCl source removed from the protective housing of a radiotherapy machine and subsequently punctured, causing release of free CsCl powder, which was spread from person to person over two weeks.

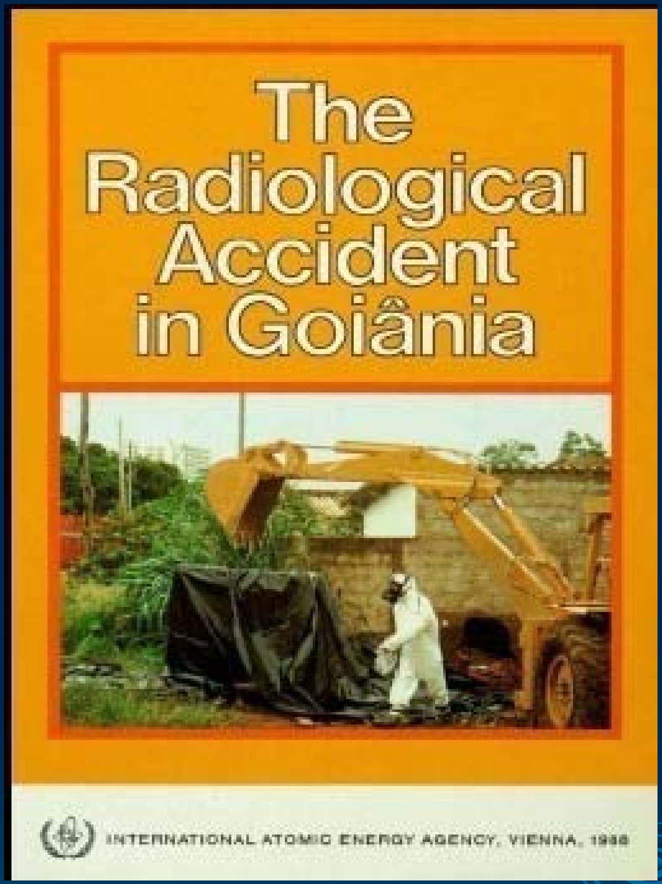
Reminder of decay scheme of Cs-137 (beta decay with 30 year half-life to Ba-137m with 2.5 min half-life (primary radiation is 0.662 MeV) gamma photon)



Mass of 1,350 Ci source is about 10 g

Consequences:

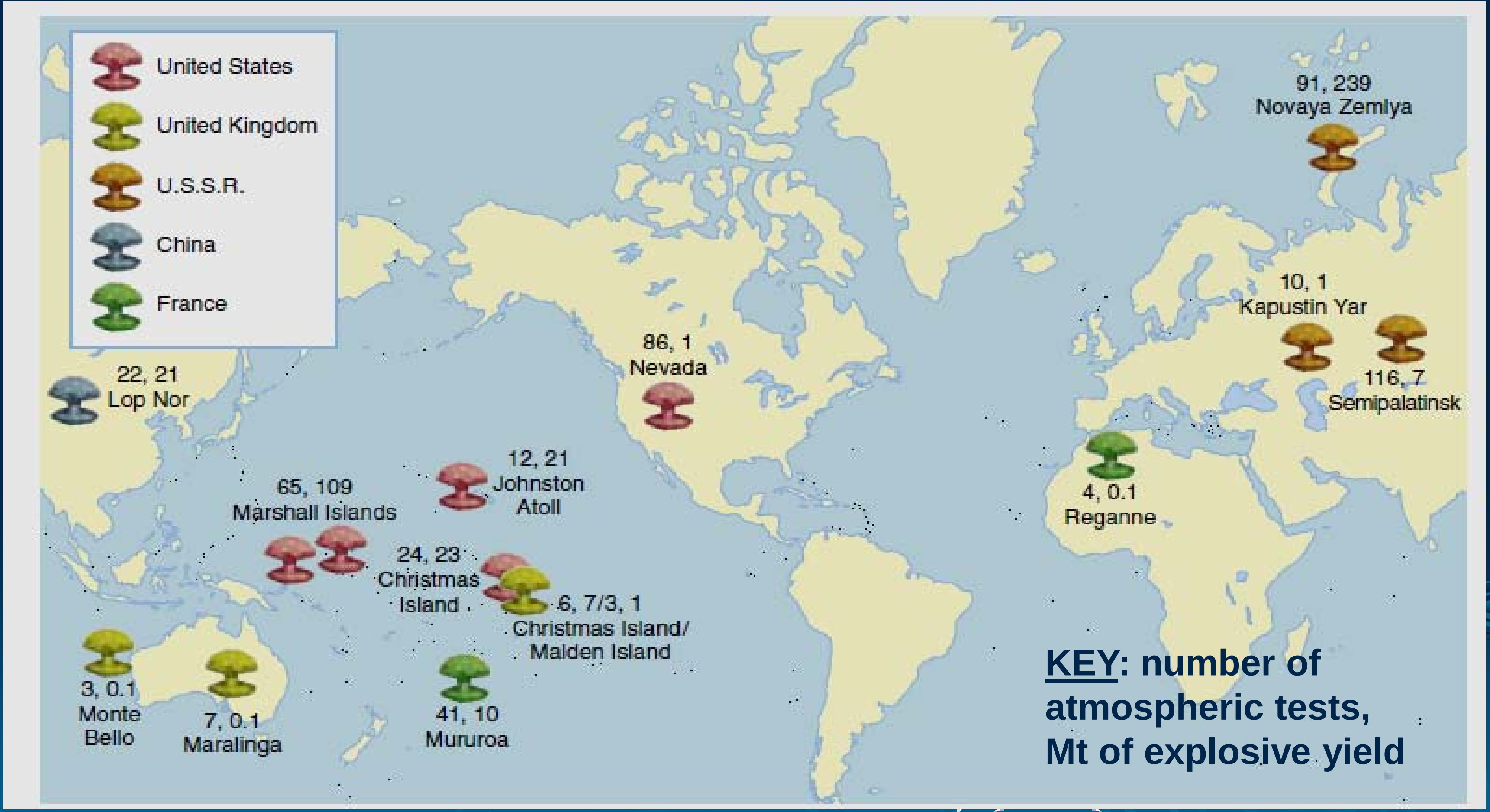
- Required monitoring of 112,000 persons for contamination (10% of local population)
- 249 people contaminated
- 151 contaminated internally and externally
- 49 hospitalized (20 with doses ranging from 1 to 8 Gy)
- 28 with radiation burns
- 5 deaths (including 6-year-old girl internally contaminated with 5.2 mCi)



NUCLEAR TESTING-RELATED INCIDENTS

Q: Where was there atmospheric nuclear testing conducted?

A: All over the globe



Simon et al. Am Sci, 94:48-57, 2006.

Palomares B-52 Accident

January 17, 1966, a B-52 bomber of the USAF Strategic Air Command collided with a tanker airplane during mid-air refueling at 31,000 feet (9,450 m) over the Mediterranean Sea, off the coast of Spain. The tanker was completely destroyed when its fuel load ignited, killing all four crew members.

The B-52 broke apart, killing three of the seven crew members aboard. Three of four Mk28 type hydrogen bombs were found on land near the small fishing village of Palomares. The non-nuclear explosives in two of the weapons detonated upon impacting the ground, resulting in the contamination of a 2-square-kilometer (490-acre) (0.78 square mile) area with radioactive plutonium. The fourth weapon, which fell into the Mediterranean Sea, was recovered intact, at 3,000 foot depth, after a 2½-month-long search.

Palomares Accident con't.

Contaminated soil held in barrels for disposal near Palomares.
Cost of clean-up and health impact is not known (to me).

Johnston Atoll Incident

In 1962, the US military conducted 36 nuclear detonations at Christmas Island and Johnston Atoll (Operation Dominic) in a rush effort to beat the 1963 Partial Test Ban Treaty.

The test codenamed Bluegill Prime on 25 July 1962 malfunctioned on the launch pad, leading officials to destroy the rocket before it lifted off.

The explosion of the Thor missile and the 1.4 Mt warhead contaminated the island with plutonium.

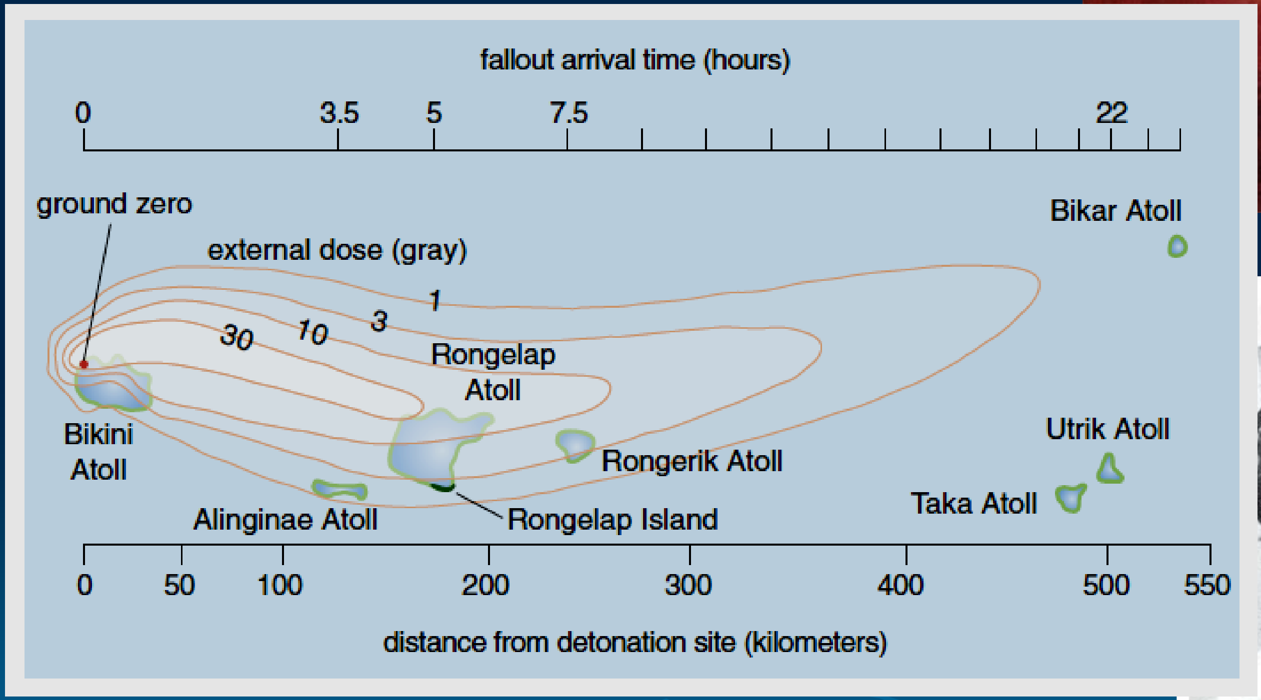
Squadron members present during that episode claimed an 85% casualty rate in subsequent years due to cancer and related diseases: non-Hodgkin's lymphoma was the biggest killer plus thyroid cancer, throat cancer, oesophageal cancer, kidney cancer, multiple myaloma, and various skin cancers. 30% of the crew experienced reproductive inefficiency up to and including stillbirth and deformities.

Johnston Atoll Accident

One of the most contaminated pieces of land on earth, it has been a station for military personnel for many decades and is home to migrating seabirds under stewardship of the Fish and Wildlife Service.

BRAVO nuclear test – Bikini Atoll, Marshall Islands
March 1, 1954

Highly exposed 64 people on Rongelap, 18 on Ailinginae, 159 on Utrik Atolls due to a combination of unexpected nuclear yield and wind direction.



Simon et al. American Scientist, 94:48-57, 2006
Health Physics 99(2), August 2010

BRAVO nuclear test – Bikini Atoll, Marshall Islands
March 1, 1954

Medical findings in first 35 years after exposure:

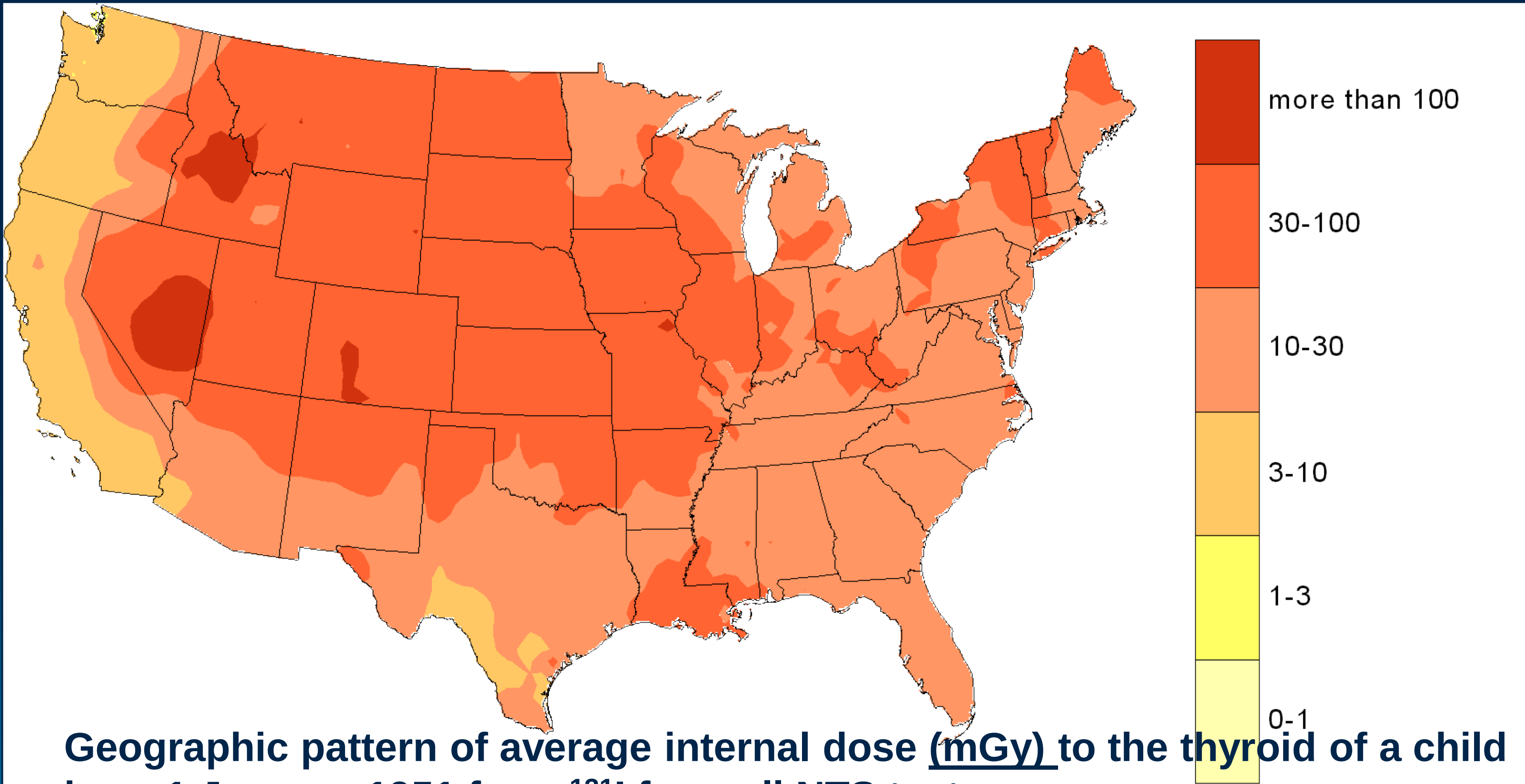
- First nodule in Rongelap (child) found in 1963 (after 9 yrs).
- First nodule in Utrik (adult) in 1969 (after 15 yrs)
- Evidence developed for a dose-dependent latency period.
- In Rongelap: 25% developed nodules, 7% developed papillary cancer.
- In Ailinginae: 21% developed nodules, 5% had occult cancer.
- In Utrik: 6% developed nodules, 2% papillary cancer, <1% follicular cancer, 4% occult cancer.
- Comparison group: 2% developed nodules, <1% developed papillary cancer, <1% occult cancer.

64 people on Rongelap,
18 on Ailinginae,
159 on Utrik.

Nevada Test Site and Exposure of the American Public:

Testing of about 100 nuclear devices from 1951 to 1862 in the atmosphere at the NTS exposed military and public.

Only a few accidents at the NTS are known of but, in retrospect, testing resulted in unintended exposure of 160 million persons to 20 mGy on average.



Geographic pattern of average internal dose (mGy) to the thyroid of a child born 1 January 1951 from ^{131}I from all NTS tests

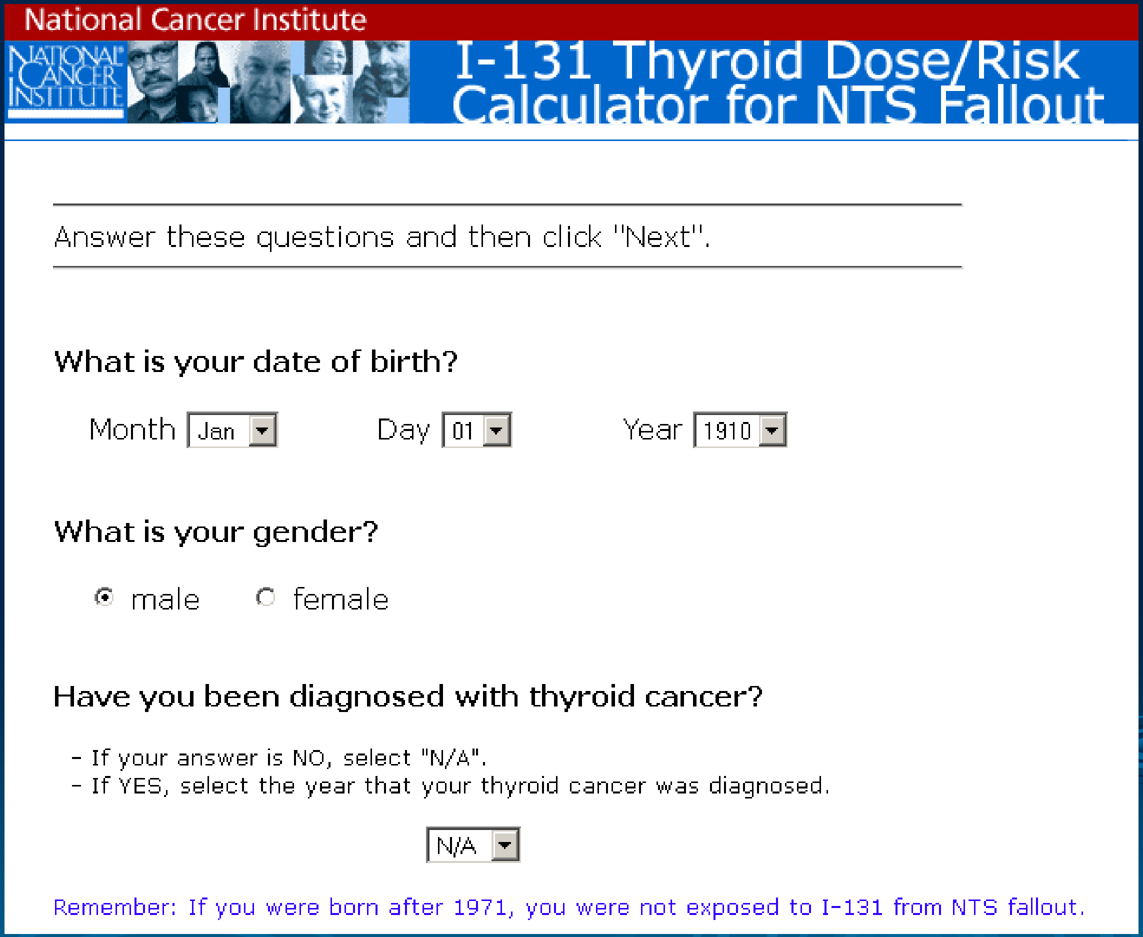
Source: NCI

Nevada Test Site and Exposure of the American Public:

NCI predicted 49,000 thyroid cancers resulted from exposure to NTS fallout (95% CI: 11,000 – 212,000).

If you were born in the U.S. before 1971, you can estimate your NTS fallout dose and thyroid cancer risk:

https://ntsi131.nci.nih.gov/



National Cancer Institute

I-131 Thyroid Dose/Risk Calculator for NTS Fallout

Answer these questions and then click "Next".

What is your date of birth?

Month Jan Day 01 Year 1910

What is your gender?

male female

Have you been diagnosed with thyroid cancer?

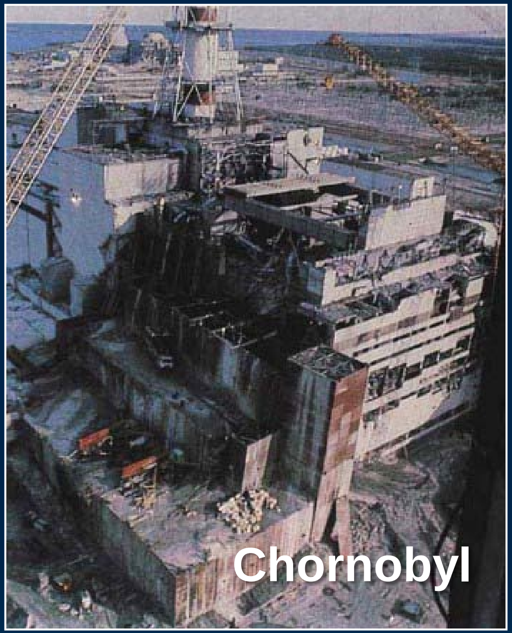
- If your answer is NO, select "N/A".
- If YES, select the year that your thyroid cancer was diagnosed.

N/A

Remember: If you were born after 1971, you were not exposed to I-131 from NTS fallout.

NUCLEAR ENERGY-RELATED

Nuclear energy-related accidents involve more than operating reactors, though those are probably the most well known.



Other nuclear energy-related exposures have occurred among workers at facilities and among the public exposed to emissions from those facilities. These circumstances include facilities in the U.S., Russia (Mayak, Techa River), Japan (Tokaimura) and elsewhere.

Accidents at TMI and Chornobyl will be discussed more in the next talk by M. Hatch and V. Drozdovitch.

NUCLEAR ENERGY-RELATED

An interesting class of accidents are termed criticality accidents which are unintended and uncontrollable chain reactions . Since 1945 there have been at least 60 criticality accidents recorded which have caused at least 21 deaths: 7 in the US, 10 in the Soviet Union, 2 in Japan, 1 in Argentina, and 1 in Yugoslavia.

Two well-known criticality accidents:

Los Alamos, NM: On 21 May 1946, Los Alamos scientist, Louis Slotin, accidentally irradiated himself during an instantaneous criticality accident in the Manhattan project, where he was working with a sphere of pure plutonium. The procedure in use at that time, called Tickling the Dragons Tail, result ed in his demise when the experiment went awry. He died of ARS after 9 days.

Tokaimura nuclear accident: Accident in 1999, resulted in two deaths. The accident was a criticality accident and occurred as three workers were preparing a small batch of fuel for an experimental fast breeder reactor using uranium enriched to 18.8%. Criticality continued for 20 hours.

RADIOLOGICAL TERRORISM

A form of political violence using radiation and/or radioactive materials that is designed to induce terror and psychic fear through the violent victimization and damage of noncombatant targets.

Fortunately, the number of events to-date have been few, but the likelihood of future events is depressingly likely.

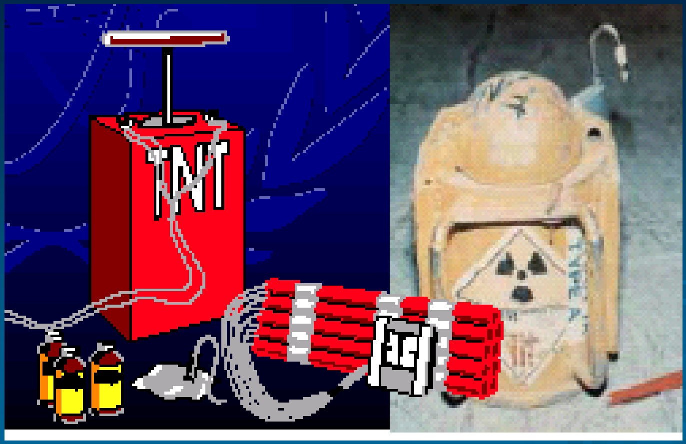
Some possible means of Radiological Terrorism

Targeted attack on nuclear facility

Improvised nuclear device

Radionuclide poisoning

Dirty bomb



Hidden radiation source

RADIOLOGICAL TERRORISM

Alexander Litvinenko

Former KGB officer wrote two books where he accused the Russian secret services of staging Russian apartment bombings and other terrorism acts to bring Vladimir Putin to power.

On 1 November 2006, Litvinenko suddenly fell ill and was hospitalized. He died three weeks later, becoming the first confirmed victim of lethal ^{210}Po-induced acute radiation syndrome and possibly the first documented case of radiological terrorism.

Symptoms appeared consistent with administered activity of 2 GBq (50 mCi, about 10 μg mass).

NCRP (2001) made estimates of gamma ray whole-body doses that might be received by improvised nuclear explosions

Approximate distance (m) over which a 4 Gy dose from prompt radiation might be received.

Yield (kt)	Distance (m)
0.01	250
.1	460
1	790
10	1,200

How many people might live within a radius of 460 m?

Answer: Depends on the city, of course. About 6,000 in NYC, however, the average rush hour density of people in Times Square is about 30x the living density. Special events, e.g., New Year's Eve would exceed even the rush hour density by many times.

SOME GENERALIZATIONS ABOUT RADIATION INCIDENTS

(my own interpretations…blame me if you don't agree)

Not all types of accidents are described here.

The number of nuclear or radiation accidents number in the many hundreds (at least).

Only a few incidents have resulted in many directly-related deaths or can be associated with confirmed cancer cases.

Most incidents are associated with radiation exposures and acute effects to only a small number of people.

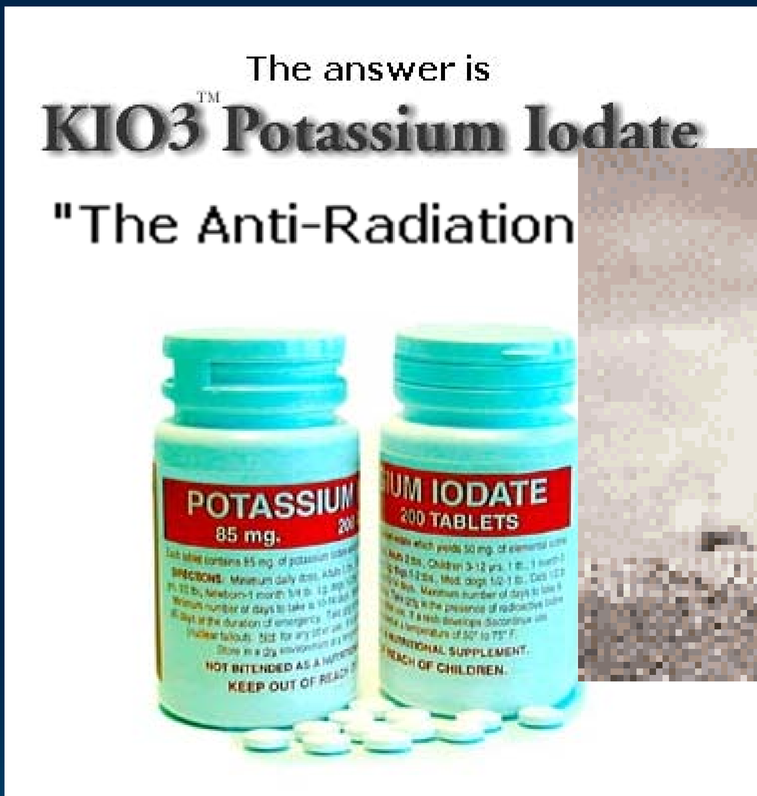
Several incidents, however, are associated with a large numbers of projected cancers.

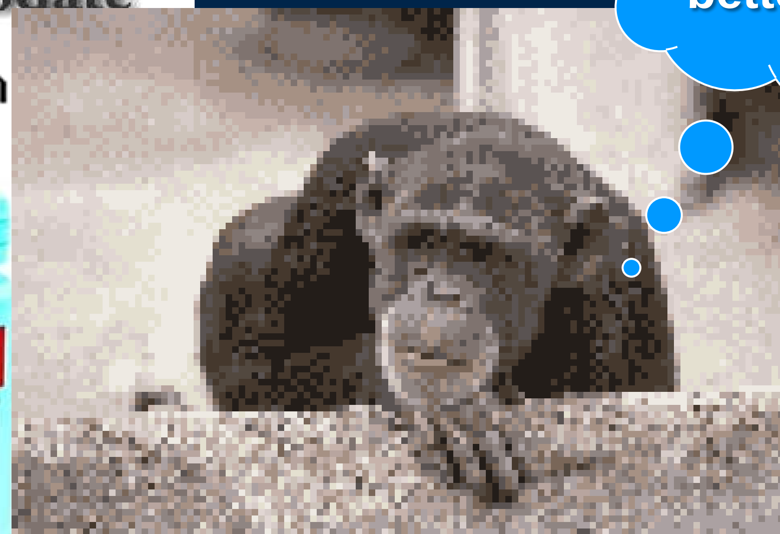
Numerous incidents are associated with moderately high to very large dollars costs (>$100 M).

Incidents which result in environmental releases can affect, by far, the most people.

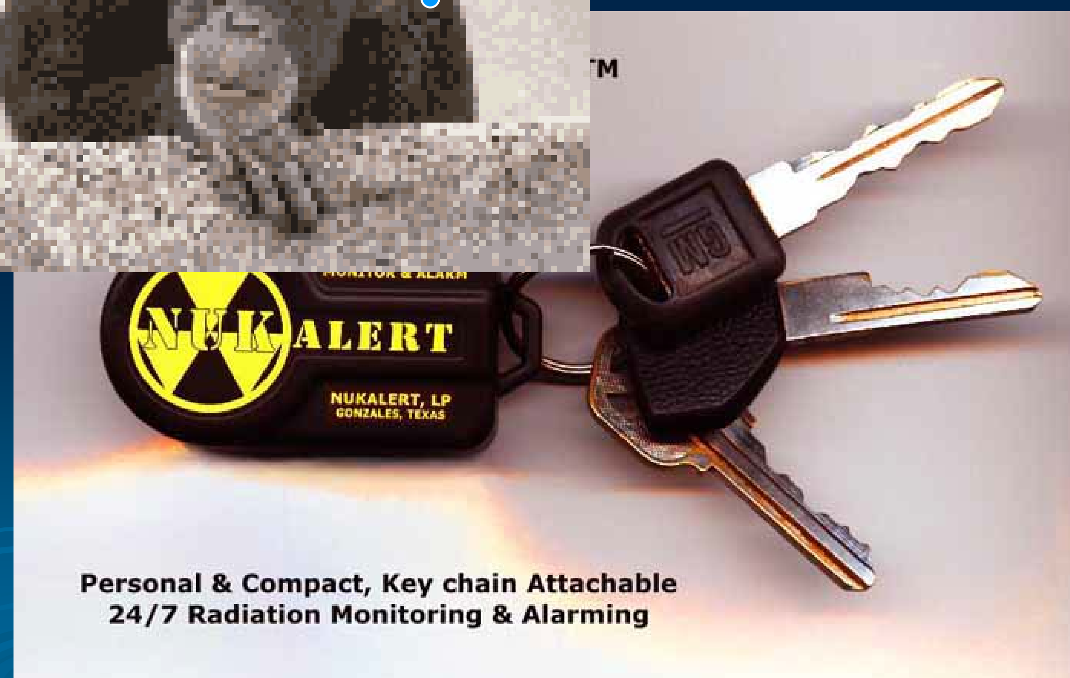
Incidents (even within the category of commercial power reactors) vary substantially in terms of their specific conditions and the environment in which they release radioactive materials that may affect the public.

There are numerous dubious products for the terrorism-fearful person to buy.





Surely you know better.



The Fukushima Nuclear Crisis

A comparison of estimates of Iodine-131 released to the environment by nuclear testing and various reactor incidents including **Fukushima**.

I-131 (Ci) Released	I-131 (Bq) Released	Site	Time Period
7.5×10^{9}	2.8×10^{20}	Marshall Islands	1946-1958
1.5×10^{8}	5.6×10^{18}	Nevada Test Site	1952-1970
5×10^{7}	1.9×10^{18}	Chernobyl (FSU)	1986
$\sim 5 \times 10^{6}$ **	1.9×10^{17}	Fukushima NPP (Japan)	2011
7.4×10^{5}	2.7×10^{16}	Hanford Reservation, WA	1944-1972
6×10^{4}	2.2×10^{15}	Savannah River Site, SC	1955-1990
$8 \times 10^{3} – 4.2 \times 10^{4}$	$3.0 \times 10^{14} – 1.6 \times 10^{15}$	Oak Ridge National Laboratory, TN	1944-1956
2×10^{4}	7.4×10^{14}	Windscale, UK	1957
15-21	5.5×10^{11} - 7.7×10^{11}	Three Mile Island, PA	1979

** approximation based on early reports

Source: ATSDR, NCI, Govt. of Japan and other sources

Aerial Measuring Results
Joint US/Japan Survey Data

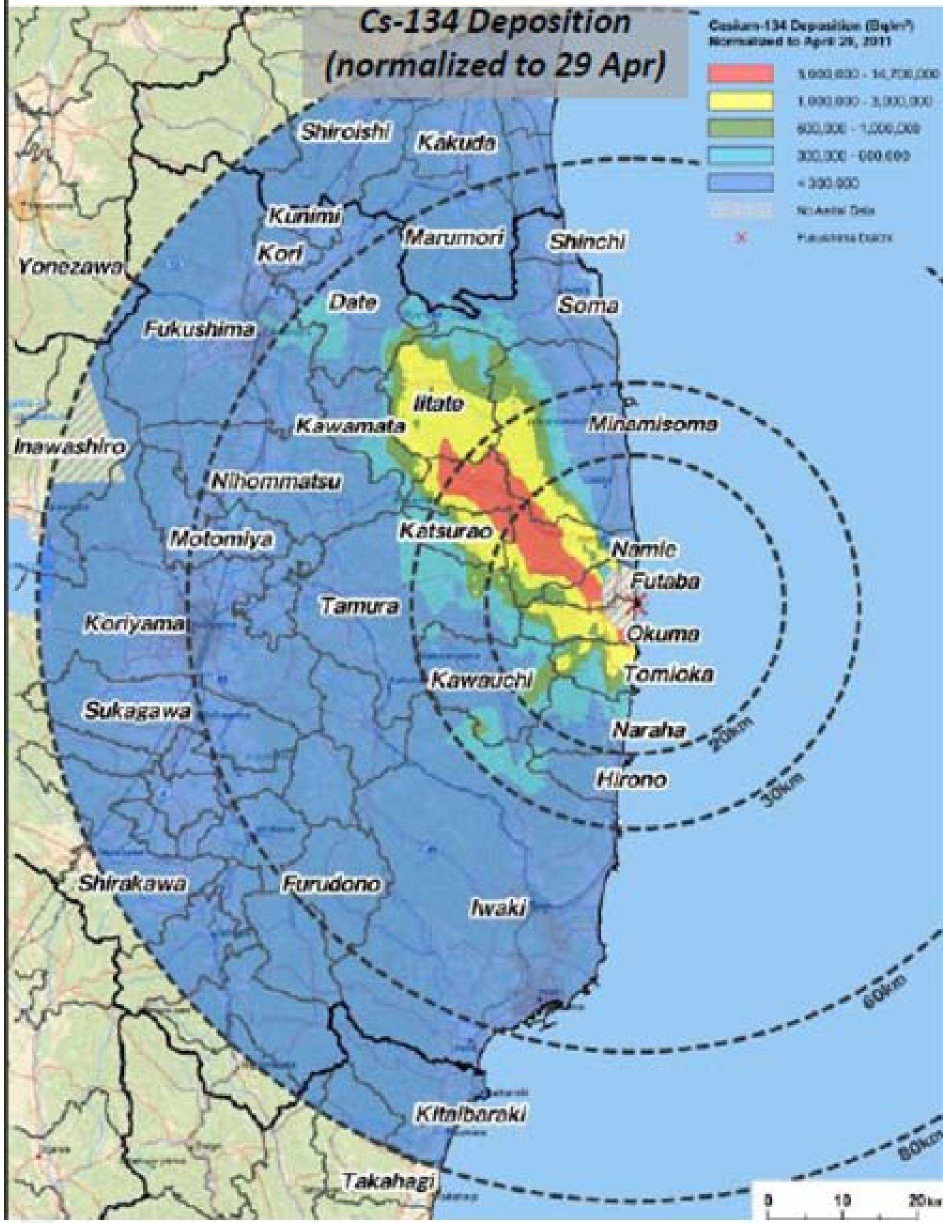
National Nuclear Security Administration

FUKUSHIMA DAIICHI JAPAN

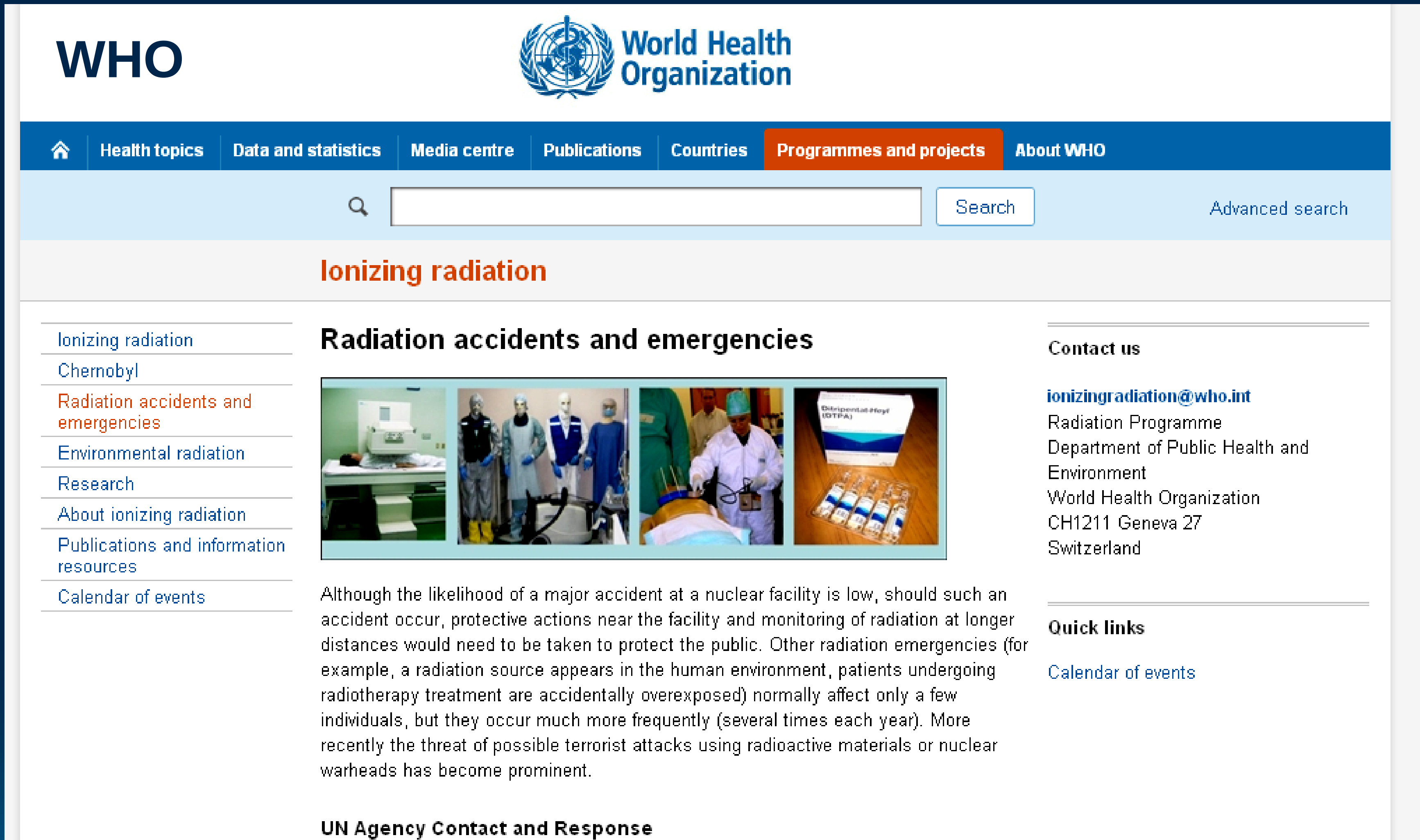
NNSA
National Nuclear Security Administration

Aerial Measuring Results
Joint US/Japan Survey Data

FUKUSHIMA DAIICHI
JAPAN



There are at least 5 excellent websites for good information on radiation accidents, emergency response and related subjects. These are a “must” if you are interested in this subject.



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Radiation accidents and emergencies

Although the likelihood of a major accident at a nuclear facility is low, should such an accident occur, protective actions near the facility and monitoring of radiation at longer distances would need to be taken to protect the public. Other radiation emergencies (for example, a radiation source appears in the human environment, patients undergoing radiotherapy treatment are accidentally overexposed) normally affect only a few individuals, but they occur much more frequently (several times each year). More recently the threat of possible terrorist attacks using radioactive materials or nuclear warheads has become prominent.

UN Agency Contact and Response

Contact us

ionizingradiation@who.int
Radiation Programme
Department of Public Health and Environment
World Health Organization
CH1211 Geneva 27
Switzerland

Quick links

Calendar of events

http://www.who.int/ionizing_radiation/a_e/en/

IAEA

http://iaea.org/

U.S. DEPARTMENT OF HEALTH & HUMAN SERVICES

REMM

RADIATION EMERGENCY MEDICAL MANAGEMENT

Guidance on Diagnosis & Treatment for Health Care Providers

WHAT KIND OF EMERGENCY? | INITIAL EVENT ACTIVITIES | PATIENT MANAGEMENT | MANAGEMENT MODIFIERS | TOOLS & GUIDELINES

WHAT KIND OF EMERGENCY?

- Radiological Dispersal Devices: Dirty Bomb, Other Dispersal Methods
- Radiological Exposure Devices: Hidden Sealed Source
- Nuclear Explosions: Weapons, Improvised Nuclear Devices
- Nuclear Reactor Accidents
- Transportation Accidents
- Discovering an Incident

INITIAL EVENT ACTIVITIES

- On-site Activities
- Triage Guidelines
- Transport Victims to Appropriate Venue(s)
- Hospital Activities

OTHER AUDIENCES

- First Responders in the Field
- Mental Health Professionals
- Hospitals
- Public Information Officers
- Radiation Safety and Protection

PATIENT MANAGEMENT

- Choose Appropriate Algorithm: Evaluate for Contamination/Exposure
- Contamination
- Exposure (Acute Radiation Syndrome)
- Exposure + Contamination

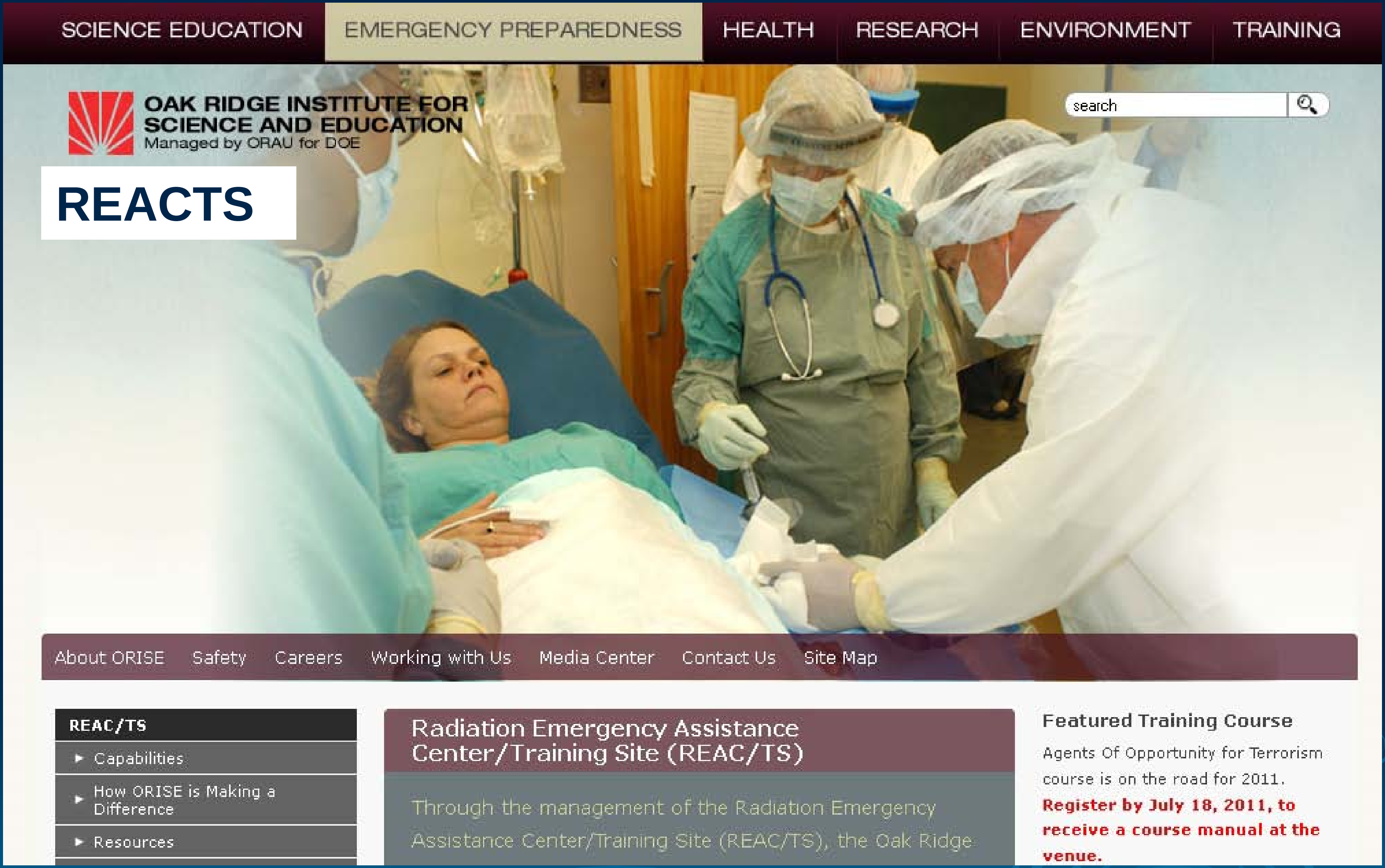
MANAGEMENT MODIFIERS

- Radiation + Trauma
- Burn Triage and Treatment
- Mass Casualty
- Psychological Issues
- At-Risk/Special Needs Populations

Tools and Guidelines

- Dose Estimator for Exposure
- Template for Hospital Orders
- Use of Blood Products
- Follow-up Instructions
- Population Monitoring
- Management of the Deceased
- Develop a Radiation Response Plan

http://www.remm.nlm.gov/



http://orise.orau.gov/reacts/


UNIFORMED SERVICES UNIVERSITY of the Health Sciences

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Search

AFFRI

Armed Forces Radiobiology Research Institute

A United States Department of Defense research laboratory

HOME BIODOSIMETRY EMERGENCY RESPONSE GUIDANCE MEIR COURSE RESEARCH SEMINARS

INFORMATION FOR

Emergency Responders
Biodosimetry tools
Guidance for managing radiation casualties
Planning guidance: Response to a nuclear detonation
Resources
Training

Medical Professionals
Guidance for managing radiation casualties
Publications
Biodosimetry tools
Training

Researchers
Programs
- Biological dosimetry
- Radiation injury combined with other trauma
- Internal contamination and metal toxicity
- Radiation countermeasures

Seminars

General Public
A-Z Index
Product Quick List
Seminars
Veterans' radiation exposure

INFORMATION ABOUT

Biodosimetry: Tools

Emergency Response Resources
Advisory team
Other resources

Medical/Operational Guidance
Policies
Depleted uranium (PDF)
» DU symposium (November 2010)
Potassium iodide (PDF)
Prussian blue (PDF)
» AFRRI guidelines
» Work sheet
» FDA label for Radiogardase™
» Q&A
Publications
Emergency radiation medicine response (PDF)
Management of radiological casualties (PDF)
Planning: Response to a nuclear detonation
» First Edition (June 2009; PDF)
» Second Edition (June 2010; PDF)
Quick reference: NCRP recommendations (PDF)
Textbook: Consequences of nuclear warfare

Medical Effects of Ionizing Radiation
Course description
Schedule/fees/registration
Course resources

Products
Quick List

QUICK LINKS

50 AFRRI

AFRRI 50th Annniversary events
» Countermeasures Symposium (June 15)

Medical Radiobiology Advisory Team: MRAT
Daytime: 301-295-2950/0316
Emergency (24 h): 301-295-0530

Biodosimetry: Tools

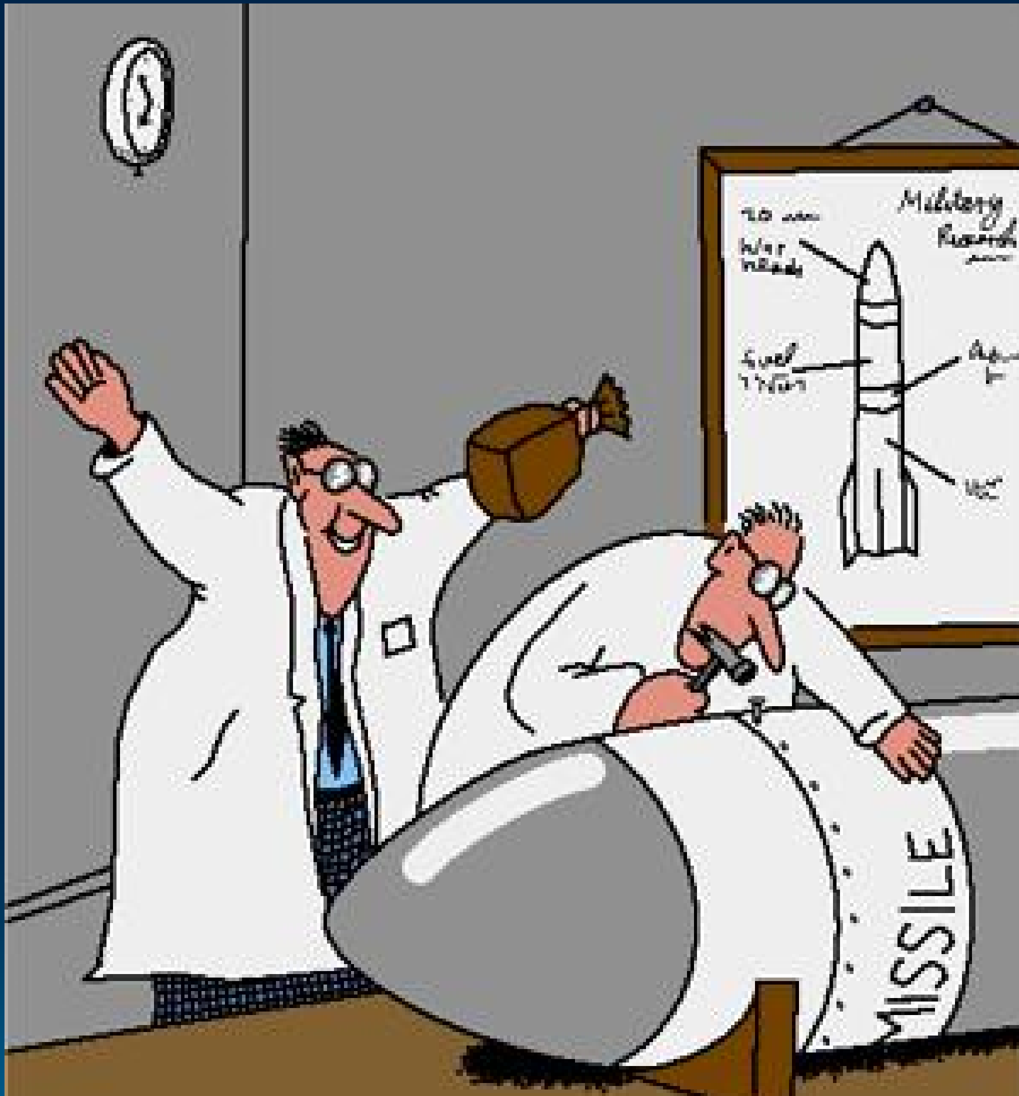
MEIR Course
Description
2011 schedule/fees/registration
» U.S. military & DoD civilians
» non-U.S. military & non-DoD civilians

Products
Quick List | A-Z Index | Seminars

Publications
Scientific journal articles (2011-1961)

Location

http://www.usuhs.mil/afrri/



Nuclear event planning committee.

That's all folks!