RADIOLOGICAL DISPERSAL DEVICE

“DIRTY BOMB”

Jordan H. Hankins, M.D.
University of Nebraska Medical Center
Omaha
A dirty bomb is a “normal” bomb that contains radioactive material as well as explosives.

After the initial blast of the explosives, radioactive material is dispersed, spreading out radiation and contamination (that’s where the word “dirty” comes from).
Why is the Dirty Bomb a Concern?

- Relatively easy to make
- Effects from radiation could be more long-lasting than other types of agents used in terrorism
- Could result in panic as well as major economic, social impact
Health Concerns of a Dirty Bomb

- The initial blast from the explosive could kill people.

- The radioactive material released in the blast may deposit on (contaminate) people, their clothing, and the ground surface.
Radioactive Dispersal Device (RDD)

Radioactive material

Conventional explosive (e.g. fertilizer, semtex)

Time fuse

Detonator
Topics that we will cover

- What is ionizing radiation?
  How is it harmful?
- Radiation threat scenarios
- Appropriate medical responses
- Psychological aspects
- Resources
Radioactivity

The Electromagnetic Spectrum
Photon Radiation

Gamma and X-rays
- Electromagnetic – like light
- Gamma from a radioactive nucleus
- X-rays from a device
- Penetrating
  - Responsible for whole body radiation
  - Cause of almost all radiation deaths
Particulate Radiation
(from a radioactive nucleus)

- **Alpha**
  - Range is less than a cell length
  - No damage on the skin surface
  - If absorbed potential for injury

- **Beta**
  - Range is <1mm ~1cm in tissue
  - Can produce a “beta burn” on skin

- **Neutron** – not a factor in the past
Alpha, beta and gamma rays
The “Dirty Bomb”

What are the radioisotopes?
- I-131  8 days
- Ir-192  74 days
- Co-60  5 years
- Sr-90  28 years
- Cs-137  30 years
- Ra-226  1620 years
- C-14  5730 years
How Does Radiation Injure Biological Tissue

- Produces free radicals
- Breaks chemical bonds in DNA
- May start programmed cell death known as apoptosis

There are repair mechanisms which can repair single strand breaks in DNA
Interaction of alpha, beta, gamma rays with matter: Ionization
When is Radiation Harmful?

<table>
<thead>
<tr>
<th>Dose (Acute Exposure)</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 Rem</td>
<td>First physical effects (white blood cell count)</td>
</tr>
<tr>
<td>100 Rem</td>
<td>Threshold for radiation sickness (e.g., nausea, anorexia, vomiting)</td>
</tr>
<tr>
<td>450 Rem</td>
<td>50% will die within 30 days without medical treatment</td>
</tr>
</tbody>
</table>
Radiation Dose Comparisons

- Average background radiation dose is 0.3 rem/year
- A mammogram produces about 1.0 mrem
- A CT scan produces about 1.0 rem
Sources of Radiation

- Background
  - Cosmic
  - Terrestrial
  - Internal

- Industrial and Therapy
  - Devices
  - Sources
# Example Radiation Doses

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Dose (mrem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Dental x-ray</td>
<td>5 – 10</td>
</tr>
<tr>
<td>Flying RT from LA to Paris</td>
<td>10</td>
</tr>
<tr>
<td>Hip X-ray</td>
<td>80</td>
</tr>
<tr>
<td>Annual Dose to the Average</td>
<td>300</td>
</tr>
<tr>
<td>American from natural background radiation</td>
<td></td>
</tr>
<tr>
<td>Heart Scan (Rest/Stress)</td>
<td>1200</td>
</tr>
<tr>
<td>Whole Body CT</td>
<td>3000</td>
</tr>
<tr>
<td>Annual Dose Limit for Workers</td>
<td>5000</td>
</tr>
<tr>
<td>Threshold Dose for Radiation Sickness</td>
<td>100,000</td>
</tr>
</tbody>
</table>
Dose Effect Relationships

- **Background radiation** ~ 300 milli rem/yr
- Below 10 rad no laboratory effect found
- Below 50 rad no clinical effect
- Above 120 rad nausea
- Above 170 rad vomiting
- $\text{LD}_{50} \sim 400$ rad without treatment
- $\text{LD}_{100} \sim 600$ rad without treatment
Comparable Risks

<table>
<thead>
<tr>
<th>TEDE Dose</th>
<th>Comparable Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Rem</td>
<td>Working in a &quot;Safe&quot; Industry (e.g., Office Setting)</td>
</tr>
<tr>
<td>3 Rem</td>
<td>Average Radiation an American Receives in 10 Years from Natural Background Radiation</td>
</tr>
<tr>
<td>2 Rem</td>
<td>Smoking 14 Packs of Cigarettes</td>
</tr>
<tr>
<td>1 Rem</td>
<td>Living in New York City for 6 Months (Pollution)</td>
</tr>
<tr>
<td>0.5 Rem</td>
<td>Driving from LA to Atlanta</td>
</tr>
<tr>
<td>0 Rem</td>
<td></td>
</tr>
</tbody>
</table>
TEDE Dose Effects

- **700 Rem**: Survival Improbable Without Medical Treatment (CRC)
- **450 Rem**: LD 50/30 - Death of 50% of Population Within 30 Days Without Medical Treatment (CRC)
- **100 Rem**: Early Effects of Acute Radiation Syndrome. Survival 100% Without Medical Treatment (CRC)
- **0 Rem**: 25 Rem - Lifesaving Activities (EPA) 5 Rem - Annual Rad Worker Limit (NRC)
# Fluoro-Induced Skin Injuries

<table>
<thead>
<tr>
<th>Effect</th>
<th>Single Dose Threshold</th>
<th>Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Transient Erythema</td>
<td>200 rad</td>
<td>2 – 24 hr</td>
</tr>
<tr>
<td>Temporary Epilation</td>
<td>300 rad</td>
<td>3 Weeks</td>
</tr>
<tr>
<td>Permanent Epilation</td>
<td>700 rad</td>
<td>3 Weeks</td>
</tr>
<tr>
<td>Dry Desquamation</td>
<td>1400 rad</td>
<td>4 Weeks</td>
</tr>
<tr>
<td>Moist Desquamation</td>
<td>1800 rad</td>
<td>4 Weeks</td>
</tr>
<tr>
<td>Secondary Ulceration</td>
<td>2400 rad</td>
<td>&gt; 6 Weeks</td>
</tr>
<tr>
<td>Ischemic Dermal Necrosis</td>
<td>1800 rad</td>
<td>&gt; 10 Weeks</td>
</tr>
<tr>
<td>Dermal Atrophy</td>
<td>1000 rad</td>
<td>&gt; 12 Weeks</td>
</tr>
<tr>
<td>Dermal Necrosis</td>
<td>&gt; 1200 rad</td>
<td>&gt; 1 Yr</td>
</tr>
</tbody>
</table>
#### Chernobyl Acute Radiation Syndrome Patients

<table>
<thead>
<tr>
<th>rad</th>
<th>Hours to</th>
<th># N &amp; V</th>
<th># Pts</th>
<th># Died</th>
<th># Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>80-200</td>
<td>&gt;2</td>
<td>31</td>
<td>0</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>200-400</td>
<td>1-2</td>
<td>43</td>
<td>1</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>400-600</td>
<td>0.5-1</td>
<td>21</td>
<td>7</td>
<td>16-48</td>
<td></td>
</tr>
<tr>
<td>600-1600</td>
<td>0.5</td>
<td>20</td>
<td>20</td>
<td>10-91</td>
<td></td>
</tr>
</tbody>
</table>

115 28
Results of Significant Whole Body Radiation Exposure Rapidly Delivered

- **Prodromal symptoms**
  - Delayed 1 to 6 hours
  - Duration 48 hours

- **Latent period**
  - For 2 to 3 weeks there is no outward sign

- **Acute Radiation Syndromes**
Topics that we will cover

- What is ionizing radiation?
  How is it harmful?
- Radiation threat scenarios
- Appropriate medical responses
- Psychological aspects
- Resources
Radiation Threat Scenarios

- Nuclear device
- Damage to nuclear power plant
- Dirty bombs
Nuclear Device

Risk
- Exposure to $\gamma$ rays and neutrons
- Fallout of fission products
  (including short-lived iodine isotopes)

Outcome
- Large number of acute deaths
- Long-term carcinogenesis

Likelihood
- Remote
Attack on a nuclear power plant

Risk
- Attack on the reactor itself:
- Attack on stored used fuel elements
  - Release of fission products: I-131, Cs-137, etc

Outcome
- Unlikely to involve acute deaths
- Long-term carcinogenesis

Likelihood
- Extremely unlikely
Dirty Bombs
(Radioactive dispersal devices, RDD)

Risk
- Release of radioactive cesium, cobalt or americium
- Small number of contaminated people
- Large number of very slightly contaminated people
- Psychological chaos (many frightened people)

Outcome
- Unlikely to result in acute deaths
- Risk of long-term carcinogenesis

Likelihood
- Likely
December 1998

Argun, Chechnya – A container filled with radioactive materials found attached to an explosive mine hidden near a railway line. It is safely defused.

The location is Argun, near the Chechen capital of Grozny, where a Chechen group, led by Shamil Basayev, operated an explosives workshop.
June 2002

Chicago, Illinois -- Jose Padilla, a US citizen with links to Al Qaeda, is arrested in Chicago airport on suspicion of planning to build and detonate a dirty bomb.

F.B.I agents suspect Padilla had recently undergone training in Pakistan, where he allegedly studied the mechanics of dirty-bomb construction, including how to wire explosive devices and how to optimize bombs for radiological dispersion.
Herat, Afghanistan -- Based on evidence uncovered in Herat, including detailed diagrams and computer files, British intelligence agents conclude that Al Qaeda has succeeded in constructing a small dirty bomb, though the device has not been found.
August 1994

Three people arrested at Munich airport having flown on a Lufthansa flight from Moscow carrying 363 grams of plutonium
Moscow, Russia -- A group of Chechen rebels contacts a Russian TV station to claim that they have buried a cache of radiological materials in Moscow's Ismailovsky Park. There, the authorities find a partially buried container of radioactive cesium.
March 1998

Greensboro, North Carolina

- Nineteen small tubes of cesium are taken from a locked safe in Moses Cone Hospital. The total activity was 22 Gbq (0.6 Ci).

Each tube was three-quarters of an inch long by one-eighth of an inch wide and were used in the treatment of cervical cancer. The cesium is never recovered.
March 2002
Nucor Steel Mill, Hertford, NC

- 2 Ci cesium industrial gauge found on scrap metal conveyer belt
- Traced back to a batch of four belonging to a bankrupt Baltimore chemical company. Three have been located....
Quick Tidbit

Industrial Radiography accounts for half of all reported serious radiation accidents worldwide in both developing & non-developing countries.
Moisture Density Gauges, contain small quantities of americium-241 and cesium-237. About 22,000 in use in the US. About 50 per year reported as missing.

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**U.S. Nuclear Regulatory Commission**

**Operations Center**

**Event Reports For**


**** EVENT NUMBERS **

40006 40007 40012 40013

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<table>
<thead>
<tr>
<th>General Information or Other</th>
<th>Event Number: 40006</th>
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</thead>
</table>

**REP ORG:** LANG BROTHERS, Inc.  
**LICENSEE:** LANG BROTHERS, Inc.  
**CITY:** Parkersburg  
**COUNTY:**  
**STATE:** WV  
**REPORT DATE:** 07/21/2003  
**EVENT DATE:** 07/21/2003  
**REGION:** 2  
**EVENT TIME:** 07:30 [EDT]  
**NOTIFICATION DATE:** 07/21/2003  
**NOTIFICATION TIME:** 09:39 [EDT]  
**AGREEMENT:** N  
**PERSON:** ANNE BOLAND  
**ORGANIZATION:** LANG BROTHERS  
**PERSON:** ROBERTA WARREN  
**OPS OFFICER:** JOHN MacKINNON  
**EMERGENCY CLASS:** NON EMERGENCY  
**10 CFR SECTION:**  
**EL10 20 2001(a)(1)(ii) LOST/STOLEN LAM:1000X**

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**EVENT TEXT**

STOLEN TROXLER MOISTURE DENSITY GAUGE

On Monday morning, July 21, 2003 around 0730 EDT it was discovered that a Troxler Model # 3440 (serial # 18905) moisture density gauge had been stolen from a work site in Parkersburg, WV. The Troxler moisture gauge had been double locked inside a cabinet. Workers reporting to the job site had found that both locks had been pried off and the moisture density gauge was missing. The gauge was last seen Friday evening, July 18, 2003. The moisture density gauge is owned by Lang Brothers, Inc. which is located in Bridgeport, WV. The Radiation Safety Officer (RSO) did not have the license number of the stolen moisture density with him. He did say that he would notify the local police that the moisture density gauge had been stolen. Troxler Model # 3440 contains 10 millcuries of cesium-137 and 40 millcuries of americium-241/beryllium.
Goiânia, Brazil, 1987
Population 1.3 million
Goiania Brazil Incident

- Physicians abandon cancer clinic in 1985

- Also abandoned is an old (1950’s) teletherapy unit containing about 1400 curies of Cesium-137

- September 13, 1987; two scavengers removed the lead cylinder from the device

- Cylinder sold to junkyard dealer; canister opened containing luminescent blue stones
Goiania, Brazil 1987

- Therapy machine 1,400 Ci Cs-137
- Sold to junk dealer who saw a glow
- He exposed source, invited neighbors
- 20 significant exposures
  - 8 Acute Radiation Syndromes
  - 4 deaths
  - 6 year old girl ate ~ 27 mCi and died
Chronology - Goiania

- Sept 10 – 13: Two scavengers got to disused clinic & dismantle the rotating assembly; take the shiny casing to one of their houses
- Sept 13: Both scavengers vomiting but assumed it was something they had eaten
- Sept 14: One scavenger has diarrhea & one hand visibly swollen
- Sept 15: Scavenger seeks medical attention, told it was some type of allergic reaction to something he ate
Chronology - Goiania

Sept 18: Under a mango tree the source capsule’s 1 mm window punctured & some source is removed, source wheel is removed

Sept 18: Pieces of the rotating assembly sold to junkyard owner who places in garage that night
- Notices a blue glow & takes capsule into house.
- Over the next 3 days relative & acquaintances were invited to see the capsule
Sept 21: Friend of junkyard owner removes fragments who gave some to his brother & took the rest home (junkyard dealer also distributed fragments to family). Several individuals daub powder onto their skin.

Sept 21-23: Wife of junkyard owner vomiting with diarrhea & goes to hospital. Told allergic reaction to something she ate. Mother comes to care for her for 2 days before returning to her home taking a significant amount of contamination with her.
Chronology - Goiania

- Sept 22-24: Junkyard workers work on extracting lead from rotating assembly
- Sept 23: Scavenger admitted to hospital & then transferred to Tropical Diseases Hospital
- Sept 24: Brother of junkyard owner takes some source fragments home & placed on table during a meal – 6 year old daughter handles fragments while eating
- Sept 25: Lead & remnants sold to another junkyard
Sept 28: Significant number of people ill. Wife of junkyard owner is convinced glowing powder causing sickness.

- Has an employee go to other junkyard to put remnants in a bag
- They take the bag (by bus) to hospital & she places bag on desk of a physician & declares it is “killing her family”
- Wife & employee take to health center & initially diagnosed as contracting a tropical disease
- One physician suspects patients’ skin lesions caused by radiation damage; physicians propose that a medical physicist look at the suspicious package
Chronology - Goiania

Sept 29: Medical physicist arrives early & borrow a dose rate meter from a government agency
  – At some distance away from hospital turns on meter & goes to high scale irrespective of direction meter is pointed; assumed it is defective & goes back to fetch a replacement

  – In the interim physician at hospital calls in fire brigade

  – Physicist determines there is a major source of radiation at hospital & stops fire brigade from dumping source into river
Sept 29: Plans made for receiving contaminated persons in the city’s Olympic stadium
- Over 112,000 people monitored for radioactivity
- 249 contaminated; 22 people identified at the stadium as highly exposed
- Total of 4 deaths (2 men, 1 woman, 1 child)
Chernobyl
27 April 1986
The Worlds Largest Dirty Bomb

- Operator error and confusion combined with an unforgiving outdated design
- A major steam explosion followed by fire
Chernobyl

- The explosion blew out and ruptured fuel rods
- The fire sent major radioactivity into the smoke
- Firemen sent to put out the fire with water wore canvas clothes which were permeable to water and carried the radioactivity to the skin surface
Chernobyl Health Consequences

- 444 workers on site
  - 268 construction workers
  - 176 staff members
- In 30 minutes 29 admissions to medical station
- Stripped off water soaked clothes
- One death from trauma
- One death in 5 hrs from thermal burn
### Chernobyl Acute Radiation Syndrome Patients

<table>
<thead>
<tr>
<th>rad (rad)</th>
<th>Hours to Death</th>
<th># N &amp; V</th>
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<th>Day of Death</th>
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Total: 115 patients, 28 deaths
Triage for acute radiation syndrome was based on vomiting from 1 to 6 hours after accident:

- Vomiting indicated > 170 rad
  - These people need a white count
- No vomiting, no significant radiation

Delay in vomiting was reliable in predicting who needed hospitalization.
Chernobyl

- At destination all clothes removed
- Showers and new clothes
- Average of 12 rem to 135,000
- At evacuation of Pripyat exposure rate was 12 rem/hour
- Even frame houses provided protection from fallout
- There is use for duct tape and plastic sheeting
Chernobyl

- 135,000 people lived within 30 km
- The town of Pripyat (45,000) was not immediately evacuated
- This was a correct decision that reduced the population dose
- 1500 buses evacuated 45,000 in 3 hours
- Special polymer to “oil” the roads
Chernobyl

- 16,000 cancers expected normally
- Estimated 300 to 700 fatal cancers will be undetectable in the background of 16,000
- Radiation induced cancers are undetectable in the large number of naturally occurring cancers
Topics that we will cover

- What is ionizing radiation?
  How is it harmful?
- Radiation threat scenarios
- Appropriate medical responses
- Psychological aspects
- Resources
Radioactive Material Use at UNMC/The Nebraska Medical Center

- Radiation Oncology/Nuclear Medicine Departments
- Designated Cancer Center (numerous therapies involving higher amounts of radioactive material)
- Over 90 research labs with ~ 350 individuals working with radioactive material
- Dedicated Radiation Safety Office with many types of equipment used for radiation measuring/detection
- Radiation Health Center
An incident caused by nuclear terrorism (accident) may create large numbers of contaminated people who are not injured and worried people who may not be injured or contaminated.

Measures need to be taken to prevent these people from overwhelming the emergency room – which is the purpose of the Evaluation/Decontamination Center.
Consideration for Decon Location Selection

- Shower & locker room facilities (M/F) highly desirable
- Parking
- Ability to secure site
- EMS and transport capabilities

Possible Candidates: Schools, Colleges, Community and Civic Centers
UNMC’s onsite decon center located at its student life building, but might also use UNO’s field house and student recreation center.
Basic Setup

- All individuals initially monitored for contamination (e.g., portal monitor)
- Individuals NOT contaminated (e.g., setting off monitor) are sent home
- Individuals who are contaminated are directed for decontamination & further monitoring
Major Instrumentation Used

- **Portal Monitor** – Used to quickly determine if an individual is contaminated.

- **Survey Meter** – Can also be used to determine if an individual is contaminated and to pinpoint the location of the contamination.

- **Personnel Dosimeters** – Used by the emergency response personnel to measure their radiation dose from the radiation given off by contaminated individuals.
Portal Monitors/Survey Meters

- Portal monitors at entrance & exit of the RHC will be used to determine if victims are “clean”, or, have been decontaminated (might also use one to clear ambulance & personnel)

- Portal monitors are the best option for monitoring a large number of individuals

- Detects low amounts of gamma radioactivity as the individuals walk through (can use survey meters to localize areas of contamination)
Portal Monitor Specifications

- Can detect as low as 1 uCi of Cs-137 at normal walking speed
- Radiation detectors run vertically within PVC posts
- Easy to setup
- Can run on “D” batteries if necessary

Kit provided allows monitor to be used to survey vehicles
However, the major advantage of the portal monitor over survey meters is SPEED.
Decon Center Flowchart

Portal Monitor

Alarm?

No

Send Home

May Also Wish to:
- Document Individuals

Yes

If able, Survey Individual with Meter, Is Contamination Localized?

No

- Bag clothing & personnel items
- Shower & don new clothing
- Go through portal monitor
- Decon further if needed
- Document Individual

Yes

Direct or Perform Local Decontamination

Resurvey (Meter or Portal Monitor)
Decon further if needed
Document Individual
Gym Area Setup

- Alarm (Shower)
- No Alarm
- "Clean" Checkout Desk
- Dividing Curtain
- Gate
- Minimum Distance = 6 ft
- Carpet
- Don Booties
- Entrance Point
- Exit Point
- Security

Decon Storage Room
Showering Sequence
1. Undress
2. Clothing placed in labeled plastic bag
3. Personal items in smaller labeled plastic bag
4. Shower (lukewarm)
5. Towel off, don tyvek suits
6. Take personal items, exit locker room, go to portal monitor

Shower Setup

From Gym

Rope

Gate

Spot Survey

Checkout Desk

Security

EXIT POINT
Goiânia incident: Equivalent to large-sized dirty-bomb scenario in Manhattan

- 130,000 people (10%) came to ER / temporary screening locations
- 250 (0.2%) were contaminated
- 20 (0.01%) required treatment
UNMC Facilities Used for Radiation Accidents/Terrorism

Decontamination Room & Radiation Health Center (RHC)

Evaluation/Decontamination Center(s)
Nebraska legislature in the early 1970’s required that a Radiation Health Center be established as the Fort Calhoun & Cooper Nuclear Stations were coming online.

Purpose of the RHC was primarily to treat individuals injured at the nuclear power plants who were radioactively contaminated or exposed to high levels of radiation (e.g., only a few individuals).
New ER Decontamination Room

Hixson-Lied Center for Clinical Excellence has recently opened

Decontamination Room, near the entrance of ER, designed to decontaminate individuals contaminated with chemicals or injured victims contaminated with radioactivity

Will be used as the new location of the Radiation Health Center
Exposure vs. Contamination

External Exposure: irradiation of the body from external source

Contamination: radioactive material on patient (external) or within patient (internal)
Removing internal contamination is more problematic
Decontamination room located adjacent to the new ER (covered parking for ambulance)
Grated floor allows collection of rinse (sump pump into a 55 gallon barrel)
Hose reel for additional decon capability (e.g. decon gurney)

Bathroom in Decon Room (e.g., for excreta collection, hand decon)
Radioactive “clean” victims can then be sent directly in the ER
Patient Management - Priorities

- Standard medical triage is the highest priority
  - don’t delay giving critical care because a patient is contaminated

- Radiation exposure and contamination are secondary considerations
Staff radiation protection

- Fundamental Principles
  - Time
  - Distance
  - Shielding

- Personnel Protective Equipment

- Contamination Control
Maximize Distance

Radiation dose rate drops off significantly as you increase your distance from the source.
Summary

“Dirty Bomb”
- Remove radioactive debris from body
  - Remove imbedded radioactivity in wounds

Become proficient with your radiation detection equipment

At 1rad/hour you can work within guidelines for ~ 5 hours
We’re All in the Same Boat Together!

- The UNMC Radiation RHC/Decon Room cannot handle large quantities of victims

- Everyone (hospitals) needs to be capable of handling radioactively contaminated victims
Topics that we will cover

✓ What is ionizing radiation?
  How is it harmful?
✓ Radiation threat scenarios
✓ Appropriate medical responses
✓ Psychological aspects
✓ Resources
Dirty Bomb

Actual health effects from the radioactivity are likely minimal – the terror is based on people’s psychological fear of radiation ...... a dirty bomb is NOT a nuclear bomb

Might be more appropriately called a “Weapon of Mass Disruption”
There Has Been a Fear of Radiation Beyond its Capability

- Radiation is an excellent terror weapon
  - Fear of the “dirty bomb”
  - Fear of a nuclear explosion at a nuclear power plant

- Actually, it is inefficient to kill humans with radiation, short of a nuclear explosion
Goiania Brazil Incident

Food and clothing products of Goiás were not accepted by people outside Goiania for several weeks after GRI because of contamination fears.

Reported that the important clothing and other industries in Goiânia suffered reduced sales of about 40% during the months of October and November.

Travelers from Goiânia were occasionally refused rooms hotels in other states of Brazil.

<table>
<thead>
<tr>
<th>No. of People</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
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</tr>
<tr>
<td>4</td>
<td>100 – 200 Rem</td>
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<tr>
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<td>500 – 600 Rem</td>
</tr>
<tr>
<td>1</td>
<td>700 Rem</td>
</tr>
</tbody>
</table>
THREE MILE ISLAND

PENNSYLVANIA

March 28 – 31, 1979

Average dose to nearest 2 M – 1 mrem
Average Yearly Deaths

- Radiation accidents: 2
  - World wide including Chernobyl
- Automobile: 50,000
  - Just for USA
- Fire: 8,000
  - Just for USA
Our Radiation Mindset

- “China Syndrome”
- Three Mile Island
- “On The Beach”
- Chernobyl
- “Deadly Radiation” not just radiation
- The concept that every bit of radiation is carcinogenic
Our Radiation Mindset

- Radiation cures cancer
- Radiation causes cancer
- Godzilla – T Rex with sense of humor
- Them – giant ants from Nevada sites
- Atomic Mary - face melted with stress
- The Hulk- radiation experiment
- Spiderman - radioactive spider bite
Selected Further Information

CDC and OSHA have good starting websites:
www.bt.cdc.gov/radiation/index.asp
www.osha.gov/SLTC/emergencypreparedness/rdd_tech.html

Documents
American College of Radiology:
“Disaster Preparedness for Radiology Professionals”
Download at
www.acr.org/departments/educ/disaster_prep/dp_primer.html

National Council on Radiation Protection and Measurement
Report No. 138, 2001
“Management of Terrorist Events Involving Radioactive Material”
Support Agencies

- Oak Ridge Radiation Emergency Assistance Center (REAC/TS) 865.576.3131/1005
- Nuclear Regulatory Commission (NRC) 24 Hour Operations Center
- Nebraska Emergency Management Agency (NEMA)
- State of Nebraska Health & Human Services
Topics that we covered

- What is ionizing radiation?
- How is it harmful?
- Radiation threat scenarios
- Appropriate medical responses
- Psychological aspects
- Resources