Fukushima is Not Chernobyl --
What an Epidemiologist Should Know

John D Boice Jr
International Epidemiology Institute
Vanderbilt University Medical Center
June 23, 2011

A View from a Radiation Epidemiologist
Quick Summary

- Fukushima is not Chernobyl – doses much lower
- Japanese acted quickly – to reduce population dose
- “It is the dose that makes the poison” (Paracelsus)
- “… know which way the wind blows” (Dylan)
- “… and miles to go…” (Frost) – crisis is not over
- Health studies are contemplated
What happened?

Fukushima Dai-ichi Nuclear Power Plant
What does a reactor look like?

Reactor

Reactor Building - Top

Containment

Pear-shaped Dry-Well

Torus-shaped Wet-Well

Reactor vessel

spent fuel pool
Fuel overheated, melted, released radioactive steam and leaked water

Volatile elements

Water and deposits

New used and spent fuel pool

Heat exchanger

Core Melt

Water
What Caused the Fuel to Melt? -- The cooling pumps stopped

1- Earthquake knocked out offsite electricity.
2- Tsunami knocked out diesel generators.
3- Battery backups ran down.

Result → Fuel could not be cooled and melted – although contained mainly in reactor vessel.
How was the reactor fuel kept cool without electricity?
What happened to the water?

1 Sv (100 rem)/hr and 1 MBq (27 μCi) I-131/liter
How bad was the Hydrogen explosion?
Blew the top off Reactor Building – Not much radiation
Were people exposed?

Japanese authorities acted quickly to minimize adverse health consequences:

- Evacuation
- Recommend to stay indoors
- Food restrictions
- Monitoring, masks

- 1,080 children examined for thyroid dose – lower than the screening level.
Were Workers Exposed?

- Number of workers (23 May) 7,800
- Average exposure dose 7.7 mSv
- Number between 100-250 mSv (external) 30
- Number > 250 mSv (external + internal) at least 2
- Lifetime risk of developing cancer may be 1-2% for those > 100 mSv
- Why no reports of radiation sickness?
How did Japanese authorities respond?
200,000 evacuated from 20 km (12 miles)
Restricted distribution of contaminated foods
Approach to Protection

- Ingestion restriction of contaminated food and water (Bq/kg)

<table>
<thead>
<tr>
<th>Item</th>
<th>I-131</th>
<th>Cs</th>
<th>U</th>
<th>Pu, Am, Cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking water</td>
<td>300</td>
<td>200</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Milk</td>
<td>300</td>
<td>200</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>Vegetables, etc</td>
<td>2000</td>
<td>500</td>
<td>100</td>
<td>10</td>
</tr>
</tbody>
</table>

- Stable iodine prophylaxis – tablets or syrup
  - The combination of sheltering (or evacuation) with stable iodine

- Workers involved in emergency activities
  - Emergency Response Activities: 50 mSv
  - Rescue Activities: 100 - 250 mSv

Banana -- 300 Bq/kg
Extensive Offsite Monitoring

2B. Overview of radiation monitoring around 1F NPP

Parameters:
- Ambient dose rate
- Radioactive concentration of fallout
- Radioactive concentration of drinking water

Sea area Monitoring (10 -30 km off shore)

Aerial Monitoring (≤ 80 km)

Food & Drinks

Off-site Monitoring (≥ 20 km)

On-site Monitoring

Daily results of environmental monitoring by MEXT is updated at http://www.mext.go.jp/english/incident/1303962.htm
Extensive Population Screening (200,000)
Fukushima is not Chernobyl?

UNSCEAR 2011 (Feb)

“Fukushima is not Chernobyl”
CNN 3-21-11
http://www.youtube.com/watch?v=5XbitM9LiYk&list=SL
134 workers had Acute Radiation Sickness with doses > 2,000 mGy, some > 10,000 mGy, highest 16,000 mGy. 28 died in a few months.
530,000 Recovery Workers (liquidators) were used in the cleanup over 3 years – mean dose 100 mSv
Radioactive iodines in the environment caused epidemic of thyroid cancer

FIG. 3. Incidence rate of thyroid cancer in children and adolescents exposed to $^{131}$I as a result of the Chernobyl accident (after Jacob et al., 2005).
Fukushima radioactive fallout nears Chernobyl levels

17:14 24 March 2011 by Debora MacKenzie

For similar stories, visit the The Nuclear Age Topic Guide
Iodine-131 releases
(8 day half-life)

<table>
<thead>
<tr>
<th>Location</th>
<th>PBq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Mile Island</td>
<td>0.005 PBq</td>
</tr>
<tr>
<td>Fukushima</td>
<td>130 PBq</td>
</tr>
<tr>
<td>Chernobyl</td>
<td>1760 PBq</td>
</tr>
<tr>
<td>Atmospheric testing</td>
<td>675,000 PBq</td>
</tr>
</tbody>
</table>

PBq = Peta Bq = $1 \times 10^{15}$ Bq

1 PBq = 27kCi
Cesium-137 releases  
(30 year half-life)

<table>
<thead>
<tr>
<th>Location</th>
<th>PBq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three mile Island</td>
<td>0.0</td>
</tr>
<tr>
<td>Fukushima</td>
<td>6.1 PBq</td>
</tr>
<tr>
<td>Chernobyl</td>
<td>85 PBq</td>
</tr>
<tr>
<td>Atmospheric testing</td>
<td>948 PBq</td>
</tr>
</tbody>
</table>

PBq = Peta Bq = $1 \times 10^{15}$ Bq  
1 PBq = 27kCi
Plutonium-239 releases
(24,000 year half-live)

<table>
<thead>
<tr>
<th>Location</th>
<th>Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three mile Island</td>
<td>0.0</td>
</tr>
<tr>
<td>Fukushima</td>
<td>??*</td>
</tr>
<tr>
<td>Chernobyl</td>
<td>0.013 PBq</td>
</tr>
<tr>
<td>Atmospheric testing</td>
<td>6.52 PBq</td>
</tr>
</tbody>
</table>

*Soil: Fukushima 0.2-1.2 Bq/kg
Colorado 1.5 Bq/kg

PBq = Peta Bq = 1 x 10E15 Bq
Radiation was released at Fukushima but ..

- "the poison is in the dose" (Paracelsus)
- And population exposure appears low (at the moment)
Is the Reactor Crisis Over?
When will evacuated people return?

- Not clear
- Reactors not in shut-down
- Radioactive water and debris need to be cleaned up
- In some areas the wind blew the wrong way and projected doses are unacceptable, above allowable limits – reference limits (1-20 mSv/y)
- Concern is especially for the children, although authorities are following international guidelines
Did the wind always blow to the sea?

Suggests future institutional challenges and “uncertain” health consequences

You don’t need a weatherman
To know which way the wind blows
Should there be concern about Fukushima fallout in other countries?
Not Really

- Radiation releases diluted traveling 5,000 miles
- U.S. monitors can detect trace amounts of radiation of no public health consequence
- Milk 0.8 pCi/L (0.03 Bq/L). How much milk for 1 Bq?
- The amounts are only a tiny fraction of daily exposures from natural sources

“Is Fukushima radiation a threat to other countries?” MSNBC 4-2-11
http://www.youtube.com/watch?v=liB48G8E-cE
Should I take Iodide Tablets?

There are potential adverse health effects from taking KI pills and these risks have to be balanced against a nonexistent benefit. CDC, EPA and FDA in agreement.

CDC reported adverse reactions.

Only for the young and for the thyroid prior to I-131 exposure. Not a magic pill.
What about food from Japan?

Wait a minute! Do you come From Japan?
# 1C. Directives on foods and drinks

Provisional regulation values of radioactive materials in food.

<table>
<thead>
<tr>
<th></th>
<th>Provisional regulation values of radioactive materials in food in accordance with the Food Sanitation Act (Bq/kg)</th>
</tr>
</thead>
</table>
| Radioactive iodine $^{(131}\text{I})$ | Drinking water, Milk, dairy products*  
Vegetables, Fish | 300  
2,000 |
| Radioactive cesium (Sum of $^{134}\text{Cs}$ and $^{137}\text{Cs}$) | Drinking water, Milk, dairy products  
Vegetables, Grains, Meat, eggs, fish, etc. | 200  
500 |
| Uranium | Infant foods, Drinking water, Milk, dairy products  
Vegetables, Grains, Meat, eggs, fish, etc. | 20  
100 |
| Alpha-emitting nuclides of plutonium and transuranic elements ($^{238}\text{Pu}, ^{239}\text{Pu}, ^{240}\text{Pu}, ^{242}\text{Pu}, ^{241}\text{Am}, ^{242}\text{Cm}, ^{243}\text{Cm}, ^{244}\text{Cm}$) | Infant foods, Drinking water, Milk, dairy products  
Vegetables, Grains, Meat, eggs, fish, etc. | 1  
10 |

*) Provide guidance so that materials exceeding 100 Bq/kg are not used in milk supplied for use in powdered baby formula or for direct drinking.
We live in a radioactive world

Radiation Dose Comparisons (millisieverts)

- NRC Annual Worker Limit: 50 mSv
- Abd/Pelvic CT Scan: 10 mSv
- U.S. Ave. Annual Natural+ Medical: 6.2 mSv
- Denver Ave. Annual Natural: 4.5 mSv
- U.S. Ave. Annual Natural: 3.1 mSv
- Actual Annual Worker Dose NPP: 2.0 mSv
- Radioactive Elements in Body - from Food: 0.30 mSv
- Radioactive Elements in Body - from Food: 0.30 mSv
- Round Trip Dulles to Tokyo: 0.10 mSv
- Chest X-ray: <<0.10 mSv
- U.S. Possible Fukushima Dose: <0.10 mSv
People must weigh news of risks from cell phones to coffee to Styrofoam to Fukushima

Adapted from Associated Press,
Published: June 15 2011

Before your flight to Tokyo, you’re sitting in a freshly dry-walled house, drinking coffee from a Styrofoam cup, talking on a cell phone while fish from Japan is cooking on the grill.

Which of these is most likely to be a cancer risk? -- Better communication and understanding of (radiation) health effects needed.

Carcinogens are things that can cause cancer, but that label doesn’t mean that they will or that they pose a meaningful risk.

Cancer and the danger of risk perception. Sci Am Jun 1 2011
What Health Research should be conducted?
Population exposures appear low -- but

- To show compassion and provide assurance, health studies may be conducted
- Mental health problems most likely consequence
Aside: Are there major unanswered questions in radiation epidemiology?

- What is the level of risk when exposure received gradually over time and not briefly
- Being considered in U.S. by studying One Million Radiation Workers and Veterans

When Exposure Spread Over Time

One Million U.S. Radiation Workers and Veterans

- Manhattan Project
- Atomic veterans
- Nuclear utility workers
- Medical and other occupational
- Nuclear navy workers
Should I travel to Tokyo?
Gamma Dose Rates in 7 Prefectures
24 March – 4 May 2011

Natural Background: ~ 0.1 µSv/h
Wisdom from the young

Canadian singer Justin Bieber went to Japan in May to give moral support for the children that are victims of the March 2011 earthquake and tsunami crisis.

He had to convince his crew.

"Japan is one of my favorite places on earth. ... It's an incredible culture with amazing people.

My prayers go out to them.

We all need to help."

He added,

"#prayforjapan."
Domo - Arigato
Thank you
Special Thanks to

Dr FRED Mettler
Department of Radiology
New Mexico Federal Regional Medical Center
ALBUQUERQUE, NM

Dr SUMINORI Akiba
Kagoshima University
KAGOSHIMA, JAPAN

Dr LAKE Barrett
L Barrett Consulting LLC
ROCKVILLE, MD

Status of the Nuclear Power Plants after the Earthquake

The accident that brings environmental impact is going on at several units in Fukushima Daiichi nuclear power Station after the earthquake occurred on March 11th. Other nuclear power plants in Japan are in normal operation or safely shutdown.

- Accident with Nuclear Fuel Damage Suspected
- Accident without Nuclear Fuel Damage Suspected
- Safe
- Safe (Not affected by the quake)


Stone R. Fukushima cleanup will be drawn out and costly. Science 331:1507, 2011


Yonekura Y. Exposures from the events at the NPPs in Fukushima following the Great East Japan earthquake and Tsunami. The 58th session of United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 23rd May, 2011.


Summary

■ Fukushima is not Chernobyl with regard to possible health consequences.
■ Japanese authorities acted quickly to minimize adverse health consequences.
■ Mental health problems most likely consequence.
■ Better communication and understanding of radiation health effects needed.
■ Opportunities exist to study U.S. workers and veterans and directly measure radiation effects.
■ There will be no health consequences in the U.S. from Fukushima radiation.