Ionizing Radiation Exposure of the Population of the United States

David A. Schauer
Executive Director
Key Dates in NCRP's History

1929: U.S. Advisory Committee on X-ray and Radium Protection

1946: U.S. National Committee on Radiation Protection

1964: National Council on Radiation Protection and Measurements (NCRP) chartered by U.S. Congress (Public Law 88-376)
Key Elements of NCRP’s Charter Under U.S. Public Law 88-376

Cornerstones of role in radiation health protection:

1) Collect and analyze information and recommendations in the public interest about:
   a) protection against radiation; and
   b) radiation measurements, quantities and units.

2) Develop basic concepts of radiation protection;

3) Facilitate effective use of combined resources of organizations concerned with radiation protection; and

4) Cooperate with national and international governmental and private organizations; and

5) Disseminate the Council’s work.
Outline

- Overview of NCRP Reports on Population Dose in the United States
- Medical Exposures of Patients
  - Computed Tomography
  - Conventional Radiography and Fluoroscopy
  - Interventional Fluoroscopy
  - Nuclear Medicine
- Occupational Exposure from Medical Procedures
- Summary
Overview


\[ S \text{ or } E_{US} \text{ (percent of total), early 1980s} \]

- Background (83%)
- Occupational / industrial (0.3%)
- Consumer (2%)
- Medical (15%)
Overview

  • Main source of data on the estimates of the number of procedures:
    • commercial market benchmark reports by IMV
    • reports were supplemented by Medicare, Veterans Administration and a Large National Employer Plan.

- Effective doses for procedures were derived by a variety of methods, each of which is described in the respective discussion for the subcategories of medical exposure.
  - CT, data on dose length product and age and body region specific conversion coefficients were utilized;
  - conventional radiography and fluoroscopy, a published survey of effective dose was applied;
  - interventional fluoroscopy, data on \( KAP \) and protocol specific dose conversion coefficients were utilized; and
  - nuclear medicine, data on dose conversion coefficients expressed as effective dose per unit administered activity were utilized.

- Data reported as:
  - collective effective dose \((S)\) (person-Sv);
  - and effective dose per individual in the U.S. population \((E_{US})\) (mSv).
## Computed Tomography

<table>
<thead>
<tr>
<th>Category</th>
<th>Effective Dose per Scan (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>2</td>
</tr>
<tr>
<td>Chest</td>
<td>7</td>
</tr>
<tr>
<td>Abdomen &amp; pelvis</td>
<td>10</td>
</tr>
<tr>
<td>Extremity</td>
<td>0.1</td>
</tr>
<tr>
<td>Virtual colonography</td>
<td>10</td>
</tr>
<tr>
<td>Whole-body screening</td>
<td>10</td>
</tr>
<tr>
<td>Calcium scoring</td>
<td>2</td>
</tr>
<tr>
<td>Angiography – Head</td>
<td>5</td>
</tr>
<tr>
<td>Angiography – Heart</td>
<td>20</td>
</tr>
</tbody>
</table>
## Computed Tomography

<table>
<thead>
<tr>
<th>Categories</th>
<th>Scans (%)</th>
<th>$S$ (person-Sv)</th>
<th>$S$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>28.4</td>
<td>38,044</td>
<td>8.7</td>
</tr>
<tr>
<td>Chest</td>
<td>15.9</td>
<td>74,326</td>
<td>17.0</td>
</tr>
<tr>
<td>Abdomen/pelvis</td>
<td>31.7</td>
<td>212,538</td>
<td>48.6</td>
</tr>
<tr>
<td>Extremity</td>
<td>5.2</td>
<td>515</td>
<td>0.1</td>
</tr>
<tr>
<td>Angio – Heart</td>
<td>3.4</td>
<td>46,000</td>
<td>10.5</td>
</tr>
<tr>
<td>Angio – Head</td>
<td>3.0</td>
<td>10,000</td>
<td>2.3</td>
</tr>
<tr>
<td>Spine</td>
<td>6.2</td>
<td>41,369</td>
<td>9.5</td>
</tr>
<tr>
<td>Interventional</td>
<td>3.4</td>
<td>230</td>
<td>0.5</td>
</tr>
<tr>
<td>Cardiac</td>
<td>0.5</td>
<td>6,000</td>
<td>1.4</td>
</tr>
<tr>
<td>Others</td>
<td>2.5</td>
<td>8,500</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Computed Tomography

Annual Collective Effective Dose (S): 437,500 person-Sv
## Conventional Radiography and Fluoroscopy

<table>
<thead>
<tr>
<th>Examination</th>
<th>Effective Dose (mSv)</th>
<th>No. Exams (1000)</th>
<th>S (person-Sv)</th>
<th>S (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest</td>
<td>0.1</td>
<td>128,944</td>
<td>12,894</td>
<td>12.8</td>
</tr>
<tr>
<td>Breast</td>
<td>0.18 (0.42)</td>
<td>34,500</td>
<td>6,210 (14,490)</td>
<td>6.2</td>
</tr>
<tr>
<td>Cervical Spine</td>
<td>0.2</td>
<td>5,800</td>
<td>1,160</td>
<td>1.2</td>
</tr>
<tr>
<td>Thoracic Spine</td>
<td>1.0</td>
<td>2,590</td>
<td>2,590</td>
<td>2.6</td>
</tr>
<tr>
<td>Lumbar Spine</td>
<td>1.5</td>
<td>11,197</td>
<td>16,796</td>
<td>16.7</td>
</tr>
<tr>
<td>Upper GI</td>
<td>6.0</td>
<td>4,044</td>
<td>24,264</td>
<td>24.1</td>
</tr>
<tr>
<td>Abdomen</td>
<td>0.7</td>
<td>14,964</td>
<td>10,475</td>
<td>10.4</td>
</tr>
<tr>
<td>Barium Enema</td>
<td>8.0</td>
<td>656</td>
<td>5,248</td>
<td>5.2</td>
</tr>
<tr>
<td>IVP</td>
<td>3.0</td>
<td>1,180</td>
<td>3,540</td>
<td>3.5</td>
</tr>
<tr>
<td>Pelvis &amp; Hip</td>
<td>0.6 – 0.7</td>
<td>19,963</td>
<td>13,156</td>
<td>13.1</td>
</tr>
<tr>
<td>Other exams</td>
<td>0.005 – 1.7</td>
<td>58,131</td>
<td>1,613</td>
<td>0.7</td>
</tr>
<tr>
<td>Dental</td>
<td>0.005 (0.21)</td>
<td>500,000</td>
<td>2,528 (10,500)</td>
<td>2.8</td>
</tr>
</tbody>
</table>
Conventional Radiography and Fluoroscopy

Annual Collective Effective Dose (S):

100,500 person-Sv

(116,800 person-Sv using ICRP 2007 weighting factors for breast and dental exposures)
Interventional Fluoroscopy

Interventional Fluoroscopy
Annual S (person-Sv)

Cardiac 68,226

Non-vascular 22,208
Noncardiac diagnostic 12,120
Noncardiac intervention 25,840
Interventional Fluoroscopy

Annual Collective Effective Dose (S):

128,400 person-Sv
Change in *In Vivo* Diagnostic Nuclear Medicine Procedures

![Graph showing the change in *In Vivo* Diagnostic Nuclear Medicine Procedures from 1973, 1982, and 2005.](Image)
Nuclear Medicine

Annual Collective Effective Dose (S):

220,500 person-Sv
Comparison of Medical Exposures of Patients

Medical Exposure of Patients
Collective $H_E$ (percent), early 1980s

- Radiographic (68 %)
- Computed tomography (3 %)
- Interventional (3 %)
- Nuclear medicine (26 %)

Medical Exposure of Patients
S (percent), 2008

- Computed tomography (49 %)
- Radiographic (11 %)
- Interventional (14 %)
- Nuclear medicine (26 %)
Six subcategories grouped by the nature of employment and associated type of source:

- medical;
- aviation;
- commercial nuclear power;
- industry and commerce;
- education and research; and
- government, DOE and military.
## Numbers of Workers and Doses

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitored workers</td>
<td>1,957,088</td>
<td>2,220,861</td>
<td>2,352,976</td>
<td>2,519,693</td>
</tr>
<tr>
<td>Workers with recordable dose</td>
<td>690,661</td>
<td>735,400</td>
<td>693,941</td>
<td>735,347</td>
</tr>
<tr>
<td>Collective effective dose (person-Sv)</td>
<td>508</td>
<td>559</td>
<td>546</td>
<td>549</td>
</tr>
<tr>
<td>Average effective dose (mSv)</td>
<td>0.74</td>
<td>0.76</td>
<td>0.79</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Population Dose (person-Sv) from Occupational Exposure

Occupational Exposure
S (percent), 2006

- Aviation (38%)
- Medical (39%)
- Government, DOE & military (3%)
- Research & education (4%)
- Industry & commerce (8%)
- Commerical nuclear power (8%)
## Radiation Exposures to U.S. Population in 2006

<table>
<thead>
<tr>
<th>Exposure Category</th>
<th>$S$ (person-Sv)</th>
<th>$E_{us}$ (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>933,000</td>
<td>3.11</td>
</tr>
<tr>
<td>Medical</td>
<td>899,000</td>
<td>3.00</td>
</tr>
<tr>
<td>Consumer, etc.</td>
<td>39,000</td>
<td>0.13</td>
</tr>
<tr>
<td>Industrial, etc.</td>
<td>1,000</td>
<td>0.003</td>
</tr>
<tr>
<td>Occupational</td>
<td>1,400</td>
<td>0.005</td>
</tr>
</tbody>
</table>
Radiation Exposure to U.S. Population in 2006

Annual Collective Effective Dose (S):

1,870,000 person-Sv

Effective dose per individual in the U.S. population ($E_{US}$):

6.2 mSv
NCRP Report No. 160, Ionizing Radiation Exposure of the Population of the United States

Early 1980s

- Background (83 %)
- Medical (15 %)
- Occupational / industrial (0.3 %)
- Consumer (2 %)

2006

- Background (50 %)
- Medical (48 %)
- Occupational / industrial (0.1 %)
- Consumer (2 %)

Collective effective dose (person-Sv)
- Early 1980s: 835,000
- 2006: 1,870,000

Effective dose per individual in the U.S. population (mSv)
- Early 1980s: 3.6
- 2006: 6.2
Exposed

Medical imaging delivers big doses of radiation

Americans are exposed to much more ionizing radiation (the most harmful type) than they were 50 years ago. Greater use of medical imaging, such as CT scans, accounts for almost all the increase. The tests can reveal serious health threats, of course, but they come with risks. "Radiologists recommend that the public receive less than 1 millisievert a year beyond natural background radiation (0.1 millisievert per year counting medical tests. As shown, common sources such as airport scanners fall far below that recommendation, suggesting that anxiety about certain technologies is unwarranted."

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Among medical tests, CT scans are the greatest concern. Studies indicate as many as one-third are prescribed unnecessarily. The average exposure for one scan is 72 millisieverts, according to David Bohrer, executive director of the National Council on Radiation Protection and Measurements. "There is growing consensus that CT manufacturers should reduce CT scans to less than 1 millisievert," he says, adding that as a February meeting, companies indicated new technology could make that possible."—Mark Fischetti

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**Average Exposure in U.S., (mSv, y)**

1980 (3.6 total)

- Natural background
- Mammographic medical
- Mammographic other

2006 (6.1 total)

**Worker exposure (mSv, y)**

- Nuclear power plant
- Pilot and crew
- Astronaut on space station

* Data are millisievert (mSv) or millisievert per year (mSv/yr)
Recent NCRP Publications
Reports (2010 & 2011)

170: Second Primary Cancers and Cardiovascular Effects After Radiation Therapy
- L.B. Travis, Chair
  J.D. Boice, Jr., Vice Chair

168: Radiation Dose Management for Fluoroscopically-Guided Interventional Medical Procedures
- Stephen Balter, Chair
  Beth A. Schueler, Vice Chair
  Donald L. Miller, Vice Chair