Decision-making Under Uncertainty: The Case of Iodine-131

Immunization Safety Review Committee
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Define the Problem

- Public Health importance of the exposure of the American people to $^{131}\text{I}$ from NNT
- Excess thyroid cancers among American people exposed to $^{131}\text{I}$ from NNT
- Screening ($2^0$ prevention) to detect and treat thyroid cancers among American people exposed to $^{131}\text{I}$ from NNT
Figure 2.1. Location of the Nevada Test Site.
Measure Magnitude of Problem

• Total population at risk of exposure
• Vulnerable groups within that population
• Geographic areas of greatest susceptibility and distribution of population within areas
• Number of excess cases of thyroid cancer
• Quality Adjusted Life Years (QALYs) lost
Understand Key Determinants

- Amount of $^{131}$I released during each test
- Weather patterns at time of test
- Season of year at time of test
- Age of individual at time of exposure
- Residence of individual at time of exposure
- Dietary habits of individual - source of milk
- Other exposure to ionizing radiation
- Test characteristics of screening methods
Figure 2.5. Chronology of atmospheric releases of I-131 resulting from nuclear tests at the NTS.
Figure A1.1. Schematic depiction of the mushroom cloud and stem resulting from the test Simon, detonated April 25, 1953.
Figure A1.4. Schematic representation of stretching of the nuclear cloud caused by increasing wind speed with height. The cloud shown at time of detonation, at the left, and at two time intervals later. The time-dependent widening of the cloud is also indicated. A schematic unit column used for calculating the cloud's radioactive content is shown intercepting a portion of the highest layer of the cloud.
Figure A1.3. Outline of the meteorological reconstruction of the entire Simon nuclear cloud 36 hours after detonation.
Figure 3.15. Estimates of $^{131}$I deposition per unit area of ground derived from the gummed-film measurements by the kriging method on April 28, 1953 resulting from the test Simon detonated on April 25, 1953 for all counties of the contiguous United States.
Figure 3.21. Estimates of $^{131}$I deposition per unit area of ground derived by the kriging method from the gummed-film measurements on April 29, 1953 resulting from the test Simon detonated on April 25, 1953 for all counties of the contiguous United States.
Figure 3.3. Geographical coverage of the gummed-film network during the Upshot-Knothole test series. The diamonds represent the gummed-film stations operated by HASL. The approximate center of the Nevada Test Site is marked with a star.
Figure 4.25. Estimated time-integrated concentrations of $^{131}I$ in fresh cows’ milk in all counties of the contiguous U.S. resulting from all tests conducted at the Nevada Test Site.
Figure 8.9. Estimates of I-131 thyroid doses for persons born on January 1, 1940 (Average diet; average milk consumption)

(Counties) Dose in rads

- 0) 30+
- 12) 10 - 30
- 1318) 3 - 10
- 1431) 1 - 3
- 262) 0.3 - 1
- 22) 0.1 - 0.3
- 8) 0.01 - 0.1
- 0) 0.01
Figure 8.10. Estimates of I-131 thyroid doses for persons born on January 1, 1940 (Average diet; high milk consumption)
Figure 8.11. Estimates of I-131 thyroid doses for persons born on January 1, 1940 (Average diet; milk from "backyard cow")
Figure 8.12. Estimates of I-131 thyroid doses for persons born on January 1, 1940 (Average diet; no milk consumption)
Figure 8.45. Estimates of I-131 thyroid doses for persons born on January 1, 1956 (Average diet; average milk consumption)
Figure 8.53. Estimates of I-131 thyroid doses for persons born on January 1, 1958 (Average diet; average milk consumption)
Figure 8.57. Estimates of I-131 thyroid doses for persons born on January 1, 1959 (Average diet; average milk consumption)
Alabama-north

Total dry matter intake - 12.1 kg/day
Pasture season - 275 days

PASTURE CONSUMPTION RATE (kg/day)

JULIAN DAYS

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC

MONTHS
Alabama-south

Total dry matter intake - 12.1 kg/day
Pasture season - 365 days

PASTURE CONSUMPTION RATE (kg/day)

JULIAN DAYS

JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTHS
Milk distribution regions: Alabama
Figure A2.6. Identification of the pasture regions used in the dose assessment.
Figure A6.3. Thyroid gland weight as a function of age. Modified from Wellman et al. (1970).
Figure A6.5. Thyroid gland weight as a function of fetal age. Data from Eisenbud et al. (1963) and Evans et al. (1967).
Figure A6.7. Geographical distribution of daily dietary iodine intake in the U.S. between 1963 and 1966, as derived from radiiodine uptakes and renal clearance rates. Modified from Oddie et al. (1970).
Causal pathway: I-131 exposure and consequences with examples of sources of variation and uncertainty

Nevada Nuclear Tests, 1951-1962
- Test method, yield
- Weather patterns (jet stream, rainfall)

Fallout containing I-131
- Season of year
- Pasture characteristics

Concentration in milk
- Goats or cows
- Backyard or commercial dairy source
Causal pathway, continued

I-131 dose to thyroid
- diet, thyroid uptake
- biologic half-life of I-131

Probability of thyroid cancer
- gender
- biologic variability in oncogenesis potential
- co-exposures (childhood X-ray, background)

Detection of thyroid nodules
- community practice pattern variation
- clinical skill, test accuracy, rate of false positives and false negatives

Fine needle aspiration biopsy of detected nodules
Causal pathway, continued

Clinical skill, test accuracy
Nodule characteristic (size, location)

Negative biopsy for cancer
Positive biopsy for cancer
Indeterminate biopsy or repeated unsatisfactory sample

Surgery: thyroidectomy or lobectomy as appropriate given biopsy results

Potential for cure
Develop Prevention/Intervention Strategies

• Screen entire population exposed to $^{131}$I from NNTs for thyroid cancer

• Screen subset of exposed population (those born between 1940 and 1962 or those living in counties with high estimated exposure dose or those with high milk intake)

• Educate physicians and public about pros and cons of screening for thyroid cancer
Set Policy/Priorities

• No universal screening of exposed population
• Encourage shared decision-making for worried “down-winders”
• National Cancer Institute (NCI) to develop educational materials for concerned public
• Biopsy and treat appropriately all thyroid nodules detected clinically (3^0 prevention)
Implement and Evaluate

- NCI accepted Institute of Medicine recommendations regarding screening
- NCI convened stakeholder meeting in February 2000 to identify content of educational materials for public and health professionals
- Disseminate educational materials and monitor patients who request evaluation