

What do BEIR VII and UNSCEAR Mean to You ?

Presented by:
Dr Douglas B. Chambers

Presented to:
NMA / NRC
Uranium Recovery Workshop
Denver May 16, 2007

Why do we care about BEIR and UNSCEAR?

- ◆ International and National Authorities rely on the work of UNSCEAR, BEIR (NAS), NCRP and others for their evaluation of the scientific information on the health effects of exposure to ionizing radiation
- ◆ Over time, the findings of these Committees do affect international and national regulation
 - ◆ ICRP radiation protection guidance
 - ◆ IAEA Transport Regulations
 - ◆ NRC
 - ◆ EPA

Overview of Presentation

- ◆ **Radiation and Radioactivity**
- ◆ Basis for estimating risks from ionizing radiation
- ◆ BEIR VII and UNSCEAR
 - ◆ Risks of Cancer
 - ◆ Effects other than Cancer
 - ◆ Hereditary Effects of Radiation
- ◆ Summary Observations

NMA / NRC - Uranium Recovery Workshop

Radioactivity

The diagram illustrates the penetration of three types of radiation through different materials:

- Alpha Particle:** Represented by a red sphere with a minus sign, it is stopped by a **Sheet of Paper**.
- Beta Particle:** Represented by a green sphere with a plus sign, it passes through a sheet of paper but is stopped by a **Sheet of Plywood**.
- Gamma Rays:** Represented by yellow wavy lines, they pass through both a sheet of paper and a sheet of plywood, but are stopped by **1 Metre of Concrete**.

25 Years of Environmental Excellence SENES Consultants Limited 4

NMA / NRC - Uranium Recovery Workshop

Background Levels of Radiation

Natural Background 82%

Nuclear Fuel Cycle 1%

Other (17%)

- Medical X-Ray 10.3%
- Nuclear Medicine 3.8%
- Consumer Products 2.7%
- Miscellaneous 0.2%

After BEIR VII

25 Years of Environmental Excellence SENES Consultants Limited 5

NMA / NRC - Uranium Recovery Workshop

Background Radiation is Everywhere

INTERNAL 100 µSv

COSMIC 488 µSv

TERRESTRIAL 300 µSv

RADON 228 µSv

After UNSCEAR 2000

25 Years of Environmental Excellence SENES Consultants Limited 6

Average Radiation Dose From Natural Sources

Source	Worldwide Average Annual Effective Dose (mSv)	Typical Range (mSv)
External Exposure		
Cosmic rays	0.4	0.3 – 1.0 ^a
Terrestrial gamma rays	0.5	0.3 – 0.6 ^b
Internal Exposure		
Inhalation (mainly radon)	1.2	0.2 – 10 ^c
Ingestion	0.3	0.2 – 0.8 ^d
Total	2.4	1-10

a Range from sea level to high ground elevation
 b Depending on radionuclide composition of soil and building materials
 c Depending on indoor accumulation of radon gas
 d Depending on radionuclide composition of foods and drinking water

Overview of Presentation

- ◆ Radiation and Radioactivity
- ◆ **Basis for estimating risks from ionizing radiation**
- ◆ BEIR VII and UNSCEAR
 - ◆ Risks of Cancer
 - ◆ Effects other than Cancer
 - ◆ Hereditary Effects of Radiation
- ◆ Summary Observations

Sources of Health Effects Data

- ◆ Studies of humans (epidemiology)
- ◆ Studies of animals and plants
- ◆ Studies of cells and cell components
- ◆ Need to understand interactions among these sources of data and limitations (uncertainty) of data

Epidemiology Data for Cancer Risks

- ◆ Life Span Study (Japanese Atomic Bomb Survivors)
- ◆ Patients exposed to radiation for therapeutic purposes (e.g., thorostrast, fluoroscopy)
- ◆ Workers exposed to radiation (e.g., miners, radium dial painters, nuclear workers)
- ◆ Individuals exposed to environmental radiation (e.g., residential radon)

Uncertainties in Extrapolation

- ◆ the exposed population for which risk estimates are developed
 - ◆ the cause-specific mortality and incidence rates and the age-structure of the population to which the rates are applied;
 - ◆ the methods used to transport excess cancer risks based on models for one population to another population;
- ◆ models used to describe the excess risks in this population;
 - ◆ the models used to describe risk at low doses;
 - ◆ the method used to extend the excess risk models beyond the period of observation
- ◆ the method used to allow for fractionation or dose-rate effects.

Effects at Low Doses - 1

- ◆ DNA is the major target for effects of ionizing radiation (more about this later)
- ◆ Ionizing radiation can damage DNA directly as the result of interactions with radiation or indirectly via the transfer of free radicals or chemical intermediates
- ◆ In general, a significant radiation effect is only detectable above (about) 100 mGy [BEIR VII, UNSCEAR 2007]

Effects at Low Doses - 2

ICRP Feb 2007

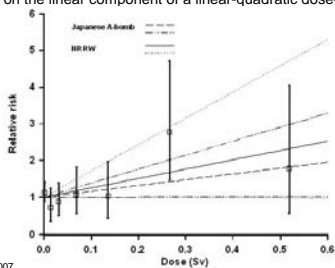
The LNT hypothesis is not universally accepted as biological truth, but rather, because we do not actually know what level of risk is associated with very low-dose exposure, it is considered to be a prudent judgement for public policy aimed at avoiding unnecessary risk from exposure.

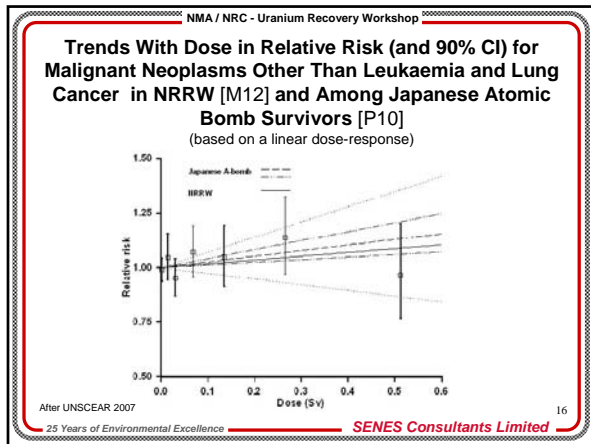
Effects at Low Doses - 3

- ◆ In extrapolating risks from high dose rates of LET to low dose rates use a DDREF
 - ◆ < 3 UNSCEAR 2000
 - ◆ 2 ICRP Feb 2007
 - ◆ 1.5 (95% CI: 1.1, 2.30) BEIR VII
- ◆ There is a continued need for judgment based on understanding of molecular and cellular mechanisms

Trends With Dose in Relative Risk (and 90% CI) for Leukaemia Excluding Chronic Lymphocytic Leukaemia in NRRW [M12] and Among Japanese Atomic Bomb Survivors [P10]

(based on the linear component of a linear-quadratic dose-response)





NMA / NRC - Uranium Recovery Workshop

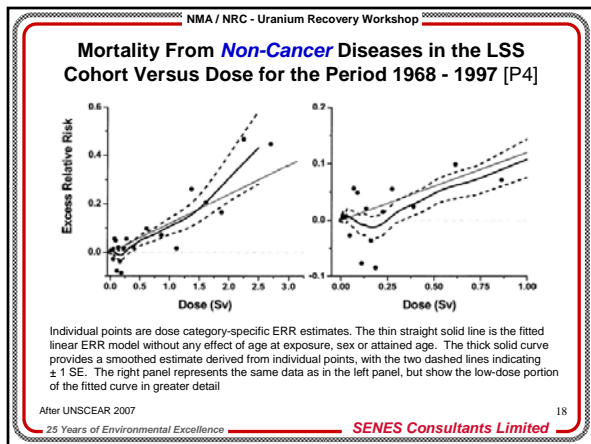
Life Span Study

- ◆ Major source of data
- ◆ Linear dose response for solid cancers
- ◆ Linear quadratic dose response for leukemia
- ◆ Lifetime Cancer risk 4-6 % per Sv

After UNSCEAR 2007

25 Years of Environmental Excellence **SENES Consultants Limited**

17



Overview of Presentation

- ◆ Radiation and Radioactivity
- ◆ Basis for estimating risks from ionizing radiation
- ◆ **BEIR VII and UNSCEAR**
 - ❖ Risks of Cancer
 - ❖ Effects other than Cancer
 - ❖ Hereditary Effects of Radiation
- ◆ Summary Observations

BEIR VII - 1

- ◆ BEIR VII Phase 2
 - ❖ 7th in series of reports from National Research Council prepared for U.S. government on the relationship between ionizing radiation and health
 - ❖ Intended to update BEIR V
 - ❖ Intended to develop best possible risk estimate for low-dose, low linear energy transfer (LET) radiation
 - ❖ Review recent evidence on genetic effects
 - ❖ Identify data gaps in knowledge e.t.c.

BEIR VII - 2

- ◆ *The Committee concludes that the current scientific evidence is consistent with the hypothesis that there is a linear no-threshold dose-response relationship between exposure to ionizing radiation and the development of cancer in humans.*

BEIR VII - 3

- ◆ Cancer risk estimates not changed much since 1990
- ◆ Cancer risk model based primarily on LSS study
- ◆ At doses below 100 mSv “*statistical limitations make it difficult to evaluate risk in humans*”

BEIR VII - 4

- ◆ LNT model “a computationally convenient starting point”
- ◆ Use DDREF of 1.5 to estimate risks of solid cancers (cancers other than leukemia)
- ◆ Use a linear –quadratic model to estimate risk of leukemia

Comparison of BEIR VII and UNSCEAR 2000 Risk Estimates*

Cancer Category	Males		Females	
	UNSCEAR 2000*	BEIR VII	UNSCEAR 2000	BEIR VII
Incidence				
Leukemia	50	100	50	72
All solid cancers	740	800	910	1,310
Mortality				
Leukemia	50	69	60	52
All solid cancers	380	410	660	610

* per 100,000 of all ages exposed to 0.1 Gy and DDREF of 1.5.

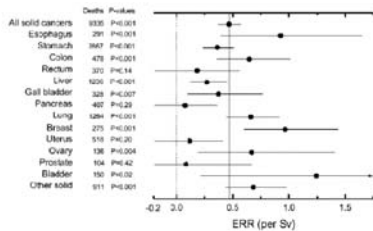
UNSCEAR

- ❖ **United Nations Scientific Committee on the Effects of Atomic Radiation**
- ❖ **Lead Agency for UN on health effects of ionizing radiation**
- ❖ **Reviews all scientific literature and synthesizes state of knowledge on a regular basis (~ every five years since 1955)**
- ❖ **The work of the Scientific Committee receives considerable leverage from contributions in kind provided by 58 [National Organizations](#) comprising the 21 national delegations to the Scientific Committee and by the 4 [International Organizations](#) that participate in its deliberations**

UNSCEAR 2007

- ❖ **UNSCEAR 2000 (Cancer, low dose, combined effects...) and 2001 (Hereditary)**
- ❖ **UNSCEAR 2007 Annexes**
 - **Epidemiology**
 - **Non-cancer**
 - **Non-targeted**
 - **Immune system**
 - **radon**

Estimates of the Site Specific Solid Cancer ERR with 90% Confidence Intervals and One-Sided P-Values for Testing the Hypothesis of No Dose Response



All estimates and P-values are based on a model in which the effects of age at exposure and of attained age were fixed at the estimates for all solid cancers as a group. The light dotted vertical line at 0 corresponds to no excess risk, while the dark solid vertical line indicates the sex-averaged risk for all solid cancers.

UNSCEAR 2007

- ◆ Risk estimates comparable to UNSCEAR 2000
 - ❖ Leukaemia - 0.5% Sv⁻¹
 - ❖ Solid cancer - 4-7.4% Sv⁻¹
- ◆ Lifetime risks of solid cancer to those exposed as children may be a factor of 2-3 higher than estimates for population exposed at all ages
- ◆ No clear evidence of non-cancer effects at low doses
- ◆ *Bystander effects appear limited to the irradiated organ, and since risk estimates are to an organ and not a cell, bystander effects are essentially encompassed in current radiation risk estimates for carcinogenesis*

Hereditary Effects - 1

- ◆ Appreciable background of spontaneous mutations in humans
- ◆ To date, there is no evidence of hereditary effects in radiation-exposed human populations
- ◆ Experimental studies in plant and animals show that radiation can induce hereditary effects
- ◆ UNSCEAR 2001 report a hereditary risk based on radiation risk in mice and spontaneous risk in people

Hereditary Effects - 2

- ◆ BEIR VII developed a doubling dose based on spontaneous mutations in humans and induced mutations in mice and recommended retaining 1 Gy for estimate of DD
- ◆ UNSCEAR 2001
 - ❖ Human/mouse model
 - ❖ DD OF 1 Gy
 - ❖ Risk of hereditary disorder of 3,000-4,700 cases per Gy for 1 million exposed
 - ❖ Represents 0.4 – 0.6 % of baseline frequency of hereditary disorders

Overview of Presentation

- ◆ Radiation and Radioactivity
- ◆ Basis for estimating risks from ionizing radiation
- ◆ BEIR VII and UNSCEAR
 - ◇ Risks of Cancer
 - ◇ Effects other than Cancer
 - ◇ Hereditary Effects of Radiation
- ◆ Summary Observations

ICRP 2007 - 1

- ◆ The most recent recommendations of the ICRP (Feb 2007) are based on its evaluation of the scientific literature developed since its previous recommendations of 1990 (ICRP 60, 1991). The main features of the most recent ICRP recommendations relevant to the current discussion are the following:
- ◆ The risk of cancer and of hereditary effects arising from exposure to low doses (up to about 100 mSv as single or annual doses) increase in simple proportion to increases in dose;

ICRP 2007 - 2

- ◆ Based on cancer incidence data, the revised nominal risk coefficients for cancer (previous values from ICRP 60 in brackets) are:
 - ◇ 4.1×10^{-5} per mSv (4.8×10^{-5} per mSv) for adult workers,
 - ◇ 5.5×10^{-5} per mSv (6.0×10^{-5} per mSv) for the whole population

ICRP 2007 - 3

- ◆ *Although no human studies provide direct evidence of radiation risk of hereditary disease, hereditary disease is seen in experimental animals; hence, it is reasonable to assume that radiation-related hereditary diseases can occur in people.*
- ◆ The ICRP suggests the following risks of hereditary disease (previous values from ICRP 60 in brackets):
 - ◆ 0.1 x 10⁻⁵ per mSv (0.8 x 10⁻⁵ per Sv) for adult workers,
 - ◆ 0.2 x 10⁻⁵ per mSv (1.3 x 10⁻⁵ per mSv) for the whole population.

Conclusions

- ◆ Current scientific evidence consistent with LNT
- ◆ Non Cancer effects occur at **high** doses
- ◆ Radiation exposure has never been demonstrated to cause hereditary effects in people but have been demonstrated in plants and animals, but prudent to assume occurs in people
- ◆ New biology (e.g. bystander effect) not affect risk estimates based on organs
- ◆ Threshold unlikely but **risk of radiation induced cancers is small at small doses**

Approximate Lifetime Risk After Exposure to 0.1 Sv

