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NIRS Briefing Paper

ATOMIC RADIATION IS MORE HARMFUL TO WOMEN

A woman is at significantly greater risk of suffering and dying from radiation-induced cancer than a man who gets the same dose of ionizing radiation. This is *news* because data in the report on the biological effects of ionizing radiation published in 2006 by the National Academy of Sciences (NAS)¹ has been under-reported. It is more often acknowledged that children are at higher risk of disease and death from radiation, but it is rarely pointed out that *the regulation of radiation and nuclear activity (worldwide) ignores the disproportionately greater harm to both women and children.*²

The goal of this briefing paper is to help the lay reader understand the data on radiation impacts to women presented in the NAS radiation report. Other researchers indicate that the effects may be even greater than the NAS findings.³ This is because the NAS report covers only radiation doses that are from sources outside the body (gamma and X-rays)--leaving out doses from radioactivity taken inside the body. These internal effects result from contamination inhaled in air, and ingested food and water and confirm that the overall assessment by the NAS is not complete.

Nonetheless, the NAS report is stunning enough: it finds that harm to women (cancer) is 50% higher than the comparable harm to men from radiation doses that fall within the legal limit to the public over a lifetime. Let's be clear: radiation kills men--but it kills significantly **more** women. *Both cancer incidence and death are 50% higher for women.* Non-cancer health impacts were not included in the analysis.

NAS also looked at a second group receiving annual radiation dose levels that were ten times higher than the first group (still under the legal limits for a nuclear worker) during ages 18 - 65, as might occur from occupational exposures or adults living in contaminated zones like parts of Japan, Ukraine, Belarus, Russia, Scotland, Australia, Kazakhstan, Mongolia, U.S. (and other contaminated zones). The reported incidence of cancer in women in this group is also 50%

¹ Biological Effects of Ionizing Radiation (BEIR) VII, Phase 2 report, "Health Risks from Exposure to Low Levels of Ionizing Radiation," published by the National Academy Press in 2006, Washington, DC.

² The background for some recommendations include calculations of the different radiation effects on women and children but the final, "allowable" doses to the public do not incorporate this information.

³ ECRR European Committee on Radiation Risk reports 2003 and 2010 <http://www.euradcom.org/2011/ecrr2010.pdf> ; Independent researchers include the towering giants, Dr John Gofman, Dr Rosalie Bertell, Dr Alice Stewart and Dr Steven Wing in the United States and an even larger circle in Europe and Russia.

higher when compared to men who got the same dose level. Women in this group were 40% more likely to die of their cancer than men in this group. The overall cancer rate (both incidence and mortality for both men and women) is higher in this more highly exposed group. For more details on this data⁴ see “An Explanation...” section below.

The fact that this information has not been widely reported has deprived women of our right to know about this threat and protect ourselves from this harm. ***In addition to the “right to know,” women have the right to protection.*** The U.S. Constitution guarantees “equal protection under the law.” International “allowable” radiation levels do not reflect disproportionate harm to women – or the extent to which they say they do, they are not protective.

In the U.S. it may be necessary to depart from the international radiation regime in order to deliver constitutional rights to the more than 150 million females in the United States.

Further, this situation violates the Right to Free Prior and Informed Consent as recognized throughout the UN Declaration on the Rights of Indigenous Peoples and other international human rights instruments, norms and standards;⁵ particularly Article 19:

States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their free, prior and informed consent before adopting and implementing legislative or administrative measures that may affect them.

To our knowledge, no women, indigenous or otherwise, have given “informed consent” to a striking lack of protection from ionizing radiation.

Children

It has long been understood that children and the unborn are at greater risk from exposure to ionizing radiation than adults of either gender. During the rapid cell division in growing young bodies DNA is more vulnerable to damage from radiation. It is more difficult to find reports on gender-specific data comparing differences in harm to boys and girls or to embryos exposed to ionizing radiation.⁶

No Safe Dose

It is vital to keep in mind that there is no “safe” dose of radiation to anyone of either gender, or any age.⁷ This is because any radioactive emission has the potential to cause damage that over time becomes cancer. Cancer is harm--and many cancers have the potential to be lethal. The cells of our bodies have repair mechanisms that in some cases can reverse the damage caused by radiation--but the amount of exposure, type of exposure (internal, external), timing of exposure and presence of other carcinogens and stressors impact this function. There is evidence that

⁴ [See Note 1] Table 12D-3 on page 312 of the BEIR VII report called “**Lifetime Attributable Risk of Solid Cancer Incidence and Mortality.**” The original is available on-line from the National Academy press at:

http://www.nap.edu/openbook.php?record_id=11340&page=312

⁵ United Nations Declaration on the Rights of Indigenous Peoples Adopted by General Assembly Resolution 61/295 on 13 September 2007, posted on-line at: <http://www.un.org/esa/socdev/unpfi/en/drip.html>

⁶ See “Radiation and Children: The Ignored Victims” web posted at: <http://www.nirs.org/radiation/radiationhome.htm> and included in “Transforming Terror, Remembering the Soul of the World” 2011, edited by Susan Griffin and Karin Lofthus Carrington, University of California Press (p 34 – 36).

⁷ All the BEIR reports of the National Academy of Science affirm this finding. The Environmental Protection Agency states in the Safe Drinking Water Standards that there is no safe concentration of any radioactive material. The radiation standards of the US Nuclear Regulatory Commission are also based on the “linear no threshold” model which states that in order to have zero risk, there must be zero dose.

individual bodies vary in capacity to carry out correct repair. It is not clear if there is a gender difference in the repair mechanism, but the NAS findings underscore that should be investigated.

Not Only Cancer

Radiation harm includes not only cancer and leukemia, but reduced immunity and also reduced fertility, increases in other diseases including heart disease, birth defects including heart defects, other mutations (both heritable and not). When damage is catastrophic to a developing embryo spontaneous abortion or miscarriage of a pregnancy may result.⁸

Precaution

It is not clear whether further research is being done to unravel the basis for disproportionate radiation impacts on women; however, the Principle of Precaution dictates that we protect first, study second.

Increased harm to women is not fully understood but it is known that reproductive tissue is more sensitive to radiation damage, and females have a larger mass of reproductive tissues than males. There are multiple, complex factors that make reproductive tissue unique, and also multiple, complex modes of radiological damage. The Principle of Precaution dictates that protective action must be taken once a potential (in this case actual and ongoing) harm is identified. Research may follow, but precaution dictates that protective action not be postponed pending future research results.

Radiation is a Privileged Pollutant

The world's radiation standards were originally developed to *allow exposure* rather than to prevent it. This makes sense given the historical context: the need for such regulation arose in the early 20th Century when exposure to human-concentrated or human-generated radioactivity was rare. The Manhattan Project, the all-out national effort to develop the first atomic bombs, was one of the original "drivers" pushing the development of "permissible" radiation exposure levels. It is also the origin of assuming the individual receiving a radiation dose is a male--a Manhattan Project worker. With the advent of nuclear energy and the facilities that produce nuclear fuel and handle waste, these standards have become evermore generalized to a larger and larger public.

The current limits for most industrial radiation in the U.S. allow fatal cancer among members of the general public at a rate that is between 300--3000 times higher than the legal rate of harm from most other industrial hazards.

A hazardous industry has traditionally been defined as one that causes cancer in one individual in a million. The Environmental Protection Agency's goals for clean-up of contamination on industrial Super Fund sites is a risk of one in a million exposed getting cancer, with exceptions down to 1 cancer in 10,000 people exposed. The U.S. Nuclear Regulatory Commission now "allows" radiation levels to the general public that it projects would result in 1 *fatal* cancer in every 286 people (well, actually, adult men) exposed over a lifetime.⁹ However, this is "apples" compared to "oranges." EPA regulations reference cancer incidence. NRC references deaths; if

⁸ Non-cancer health effects are documented in classic works of John Gofman, for instance *Radiation and Human Health* (Random House 1982) and digital documents available: <http://www.ratical.org/radiation/overviews.html#CNR> and Dr. Rosalie Bertell's classic work "No Immediate Danger" Summer Town Books, 1986.

⁹ See the Expanded Policy Statement on Below Regulatory Concern of the US Nuclear Regulatory Commission published in the Federal Register in 1990.

non-fatal cancers were included by NRC, the comparison would be even “worse.” We are less protected by NRC radiation standards than the regulation of other toxic hazards by EPA.

The NRC limit of 100 millirems a year is comparable to the NAS 100 millirad study level. NRC’s risk assessment of 1 fatal cancer in every 286 exposed does not reflect the NAS findings that radiation at this level to women results in 1 fatal cancer in every 201 women. The NRC equation underestimates the risk to women by nearly 40%. Since NRC does not differentiate between men and women in its regulations, it does not regulate to specifically protect women. Thus women are not equally protected where such standards are in place.

Since 1992 there has been further relaxation of regulations: the amount of radioactivity legally released to the environment under NRC regulations has gone up, however the stated dose of radiation from those revised levels remains unchanged. This paradox is contrary to NRC's own principle that there is no safe level of radiation, which should dictate tightening, not the reverse.

Following is a more detailed presentation and deconstruction of the NAS report, additional commentary and a brief history of the regulation of radiation.

An Explanation of NAS BEIR VII – TABLE 12D-3:

The balance of this paper will unfold the analysis of radiation’s impact on women found in the U.S. National Academy of Sciences Biological Effects of Ionizing Radiation (BEIR) VII, Phase 2 report, *Health Risks from Exposure to Low Levels of Ionizing Radiation*, published by the National Academy Press in 2006.

Following is selected information from: Table 12D-3 on page 312 of the BEIR VII report called *Lifetime Attributable Risk of Solid Cancer Incidence and Mortality*.¹⁰

Units: Rads are a statement of the amount of radiation—and assumes, as NAS states, only radiation from external sources (X-rays, gamma rays). A millirad (mrad) is 1/1000 of a rad.

The table reports the impacts of *100 mrad per year over a lifetime* AND also *1 rad a year from age 18 – 64* (these are doses in addition to natural background radiation exposures). **The cancer rates are per 100,000 people exposed.**

The 100 mrad level corresponds to the U.S. Nuclear Regulatory Commission’s overall goal for members of the public (100 millirem a year). The higher 1 rad a year is in the range of occupational levels of radiation exposure (the US limit for workers is 5 times higher, 5 rems).

From BEIR VII, Table 12D-3 Lifetime exposure to 100 mrad:

MALES – all cancers:

incidence = 621 in 100,000; this is the same as 1 in 161 (numbers simplified by this author)
and deaths = 332 in 100,000; this is the same as 1 in 302

¹⁰ The original is available on-line from the National Academy press at:
http://www.nap.edu/openbook.php?record_id=11340&page=312

FEMALES—all cancers:

incidence = 1019 in 100,000; this is the same as 1 in 98

This cancer rate in females is 60% higher compared to the rate in males reported above and deaths = 497 in 100,000; this is the same as 1 in 201

This cancer death rate in females is 50% higher than the cancer death rate in males reported above.

From U.S. Nuclear Regulatory Commission¹¹:

No differentiation for males v females, 70 year (lifetime) at 100 mrems/year (comparable to mrad if only consider external radiation) NRC states:

3.5 fatal cancers in every 1000 exposed; this is the same as 350 fatal cancers per 100,000 (to compare to the BEIR VII) and also the same as 1 fatal cancer in 286 people so exposed. (incidence is not reported)

The NRC generic assignment of risk of fatal cancer to both genders is a 42% under-report for women compared to the cancer death rate for females in the NAS findings above.

BEIR VII -- Annual exposure to 1 rad, for ages 18 – 64

[note: this radiation exposure is 10 times higher per year than the group above, but still only 1/5 of what nuclear workers can legally be exposed to per year]

MALES – all cancers:

incidence = 3059 in 100,000; this is the same as 1 in 33

and deaths = 1700 in 100,000; this is the same as 1 in 59

FEMALES – all cancers:

incidence = 4295 in 100,000; this is the same as 1 in 23

This cancer rate is 40% higher than the cancer rate in males reported above

and deaths = 2389 in 100,000; this is the same as 1 in 42

This cancer death rate is 40% higher than the cancer death rate in males reported above

Commentary:

Adding in Background Radiation

Federal agencies have repeatedly altered their assessments of how much “background” radiation people in the U.S. get on an annual basis.¹² “Natural background” radiation refers to that received from terrestrial sources (primarily uranium and its decay progeny in rocks and earth) and non-terrestrial sources. The reported levels have stayed relatively constant at 80-100

¹¹ In 1990 the NRC published the Expanded Below Regulatory Concern policy, in which its assessment of risk from radiation was published. The NRC reports that in its view, 100 millirems a year for a lifetime results in 3.5 fatal cancers per 1000 people exposed--or 1 in 286 (with no designation of gender/age).

¹² In 1990, the NRC stated that the average annual dose of radiation to a member of the public is in the range of 100 millirems a year. Before 2000 this number was reassessed to 360 millirems year to reflect exposure to radon in indoor air and some manmade sources. It has never been clear whether either of these estimates reflected radiation from atmospheric nuclear weapons tests, or Chernobyl and other nuclear accidents. Dr Bertell reports that manmade radiation ‘becomes’ part of background after it has been in the environment for a year. In an eerie coincidence, in January 2011, US NRC “upgraded” annual radiation, including medical doses and more of other sources and places background at 620 millirems a year, just as another catastrophic release of radioactivity is occurring.

millirems a year on average depending on elevation.¹³ For purposes of this discussion, where only low-LET radiation from external sources is considered, a millirem and a millirad are effectively interchangeable. "natural radiation" results in "natural cancer."

Everything on Earth gets exposed to radiation; this "background" exposure is not uniform--so averages are used, but are not necessarily accurate. When radiation hits living tissue there is **always** the *potential* for damage that may lead to disease. This "natural" ionizing radiation is from cosmic rays from deep space, from the sun, from meteors, from elements that are part of Earth's crust and core that are taken up in the food chain, dissolved by water or spewed by volcanoes and spread by dust storms. At 100 millirems a year over a lifetime, this natural background radiation exposure is comparable to the 100 mrad that the NAS looked at. Background radiation is however, ***an additional dose***. When doing research, it is assumed that the "control group" and the "study group" both get the same background radiation dose; therefore the "study group" who got the 100 mRad a year were in actuality receiving, on average, 200 mRad a year total radiation dose.

All radiation exposures from radioactivity that is released into our air and water from industrial energy production, military activities and all the accident sources are over and above the "naturally occurring background radiation" that comes with living on this planet. Thus, the NRC's legal dose of 100 mr/yr is on top of background, and constitutes a **doubling** (on average) of both the dose of radiation and risk of health consequences from radiation to the public.

Adding to the background dose does not change the rate of risk – but as dose goes up, so does harm. The dose/response (harm) relationship assumed by NAS (and NRC) is linear. When the dose doubles, so does the harm. Interpretation of the NAS data which reports both cancer incidence and cancer fatalities at two dose levels again opens the doors to many "apples vs oranges" vs "peaches and grapes" since it is not possible to completely factor the issues between a cancer which results in death and one which is survived. In addition, the linear model has been challenged by later, independent researchers who suggest, as the NAS data supports, a higher level of harm at the lower levels of radiation exposure.¹⁴

Assuming the additive nature of exposure and harm at low doses, adding the natural radiation and natural cancer to the NAS "study group" results in one in 50 women getting cancer from radiation exposure, and one in 100 dying as a result. This radiation dose (100 millirems/year "allowed" for industrial sources in addition to background) is precisely what the Nuclear Regulatory Commission sets as its overall regulatory goal for nuclear operations of its licensees.¹⁵ While there is a cancer epidemic in the U.S., this level of harm¹⁶ from legally "allowable" levels of radiation is stunning and worthy of our attention and action.

¹³ NRC currently states that about 15% of the 620 millirems – or 93 millirems – come from naturally occurring minerals on earth combined with cosmic rays. See: <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html>

¹⁴ See Gofman, John, 1990. *Low-Dose Radiation, an Independent Analysis*. CNR Books, Berkeley, CA

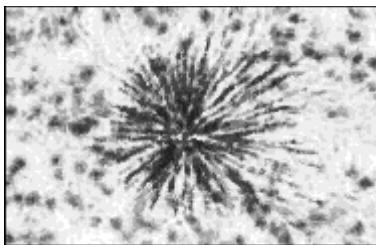
¹⁵ The NRC actually allows each license to expose the public (an adult male is assumed) up to 100 millirems a year in air, another 100 millirems/year in water, up to 500/year in sewage. Many nuclear power plants have two or three licenses per site.

¹⁶ Ionizing radiation regulation is demonstrably far less protective than the regulation of toxic chemicals where the allowable level of risk of fatal cancer is 1 in 100,000 or in some challenging SuperFund clean-ups, as high as 1 in 10,000. We have seen here that combined background, for which there is no option, plus only 100 mrad means that 1 in 50 women suffer cancer, and 1 in 100 die of it. That is a privilege by a factor of 1000.

Internal Exposure

Radiation from radioactivity taken inside the body via inhalation, absorption and ingestion is substantially different than external exposure. The NAS work explicitly does not consider any internal dose. The survivors of the Atomic bombings of Hiroshima and Nagasaki are often cited (incorrectly) as basis for 20th Century regulation of radioactivity, are also not representative of the type of radiation most people today suffer. This group was primarily exposed to an intense flash of external radiation. It is nuclear accidents like the meltdown of Three Mile Island,¹⁷ the explosion of Chernobyl¹⁸ and now the explosions and meltdowns of Fukushima where food, air and water have become substantially contaminated and internal exposures result.

Many radioactive elements emit particles (alpha, beta, neutrons) that are called high-LET because they are traveling with a force which, combined with its greater mass may inflict greater damage to living tissue than an X-ray. Lab studies show that an alpha particle may cause as much as 1000 times greater damage to a cell than an X-ray¹⁹. Internalized radiation also results in higher doses since every internal emission absorbed, at zero distance to the impacted tissues, will cause radiation impact for as long as it is in the body, and may concentrate in the most vulnerable areas, such as gonads or bone marrow.



The image (left) of tissue damaged by alpha particles originating from a plutonium particle embedded in the lung of an ape is from a photograph by Robert Del Tredici. (Photo used by permission)

When alpha and beta particle exposures from radioactive substances that have found their way inside the body are included the overall risk factors may or may not change,²⁰ but the assessment of the radiation dose itself does change. The European Committee on Radiation Risk report of 2003²¹ discusses this in detail. This explication is based on the NAS which explicitly does not include doses from internal sources.

History of Radiation Standard Setting²²

The first standards (in the 1920s) for exposure to ionizing radiation were developed to limit the exposure of physicians. A committee of the International Association of Radiologists dedicated

¹⁷ Wing, Steven, et al 1997. "A Reevaluation of Cancer Incidence Near Three Mile Island: The Collision of Evidence and Assumptions." *Environmental Health Perspectives*, page 52 - 57, Vol 105, No 1 January 1997. This study showed that people were harmed by radiation released during the core melt at Three Mile Island and that previous publications failed to have a strong scientific basis.

¹⁸ There is a large body of web-posted information about the Chernobyl accident, see for instance: <http://www.nirs.org/c20/c20us.htm>. Maps of the deposition of contamination have been produced by several sources. A recent animation of the cesium release is available (caution this is a LARGE file):

http://zerodegreeburn.com/chernobyl/film_nuage_web.swf

¹⁹ Many radiation research papers are cited in "No Such Thing as a Safe Dose of Radiation" posted: <http://www.nirs.org/factsheets/nosafedose.pdf>. See footnote 8 as well as additional reference section.

²⁰ Dr John Gofman did a meticulous reanalysis of the data from the survivors of Hiroshima and Nagasaki nuclear attacks. Gofman found that the assumption of a straight-line dose response may not be accurate at the low end of the graph--in other words, low doses per unit of exposure are MORE harmful than higher ones. In fact the NAS findings do not dispute this insofar as the higher dose group has a slightly lower risk of fatal cancer than the lower dose group. Gofman's work was published: *Radiation-Induced Cancer from Low-Dose Exposure: An Independent Analysis*. Committee for Nuclear Responsibility, Inc. 1990:18-16, 18-18. Isbn 0-932682-89-8.

²¹ The Executive Summary of the ECRR report is posted: <http://www.euradcom.org/2003/execsumm.htm>

²² Much of this section is text provided by Dr. Rosalie Bertell, who witnessed these events, It is effectively an oral history.

itself to setting standards and developing units for measurement of radiation. The U.S., Canadian and UK physicists of the Manhattan Project met, between 1945 and 1950, to set international recommendations for Radiation Protection Standards, in light of atmospheric nuclear testing which began in the Pacific by the U.S. in 1946, and the planned expansion of the nuclear industrial base. During this time, the physicists decided only cancer deaths caused by radiation were “of concern.” They also developed the Standard Man, 18-30 years old, Caucasian, healthy (the soldier or atomic worker). This Standard Man is to this day the body mass used to calculate a generic radiation “dose” when radiation measurements are taken. In 1950, the International Commission for Radiological Protection (ICRP) was formed from the Radiologist Committee and Manhattan Project physicists.

Membership in the ICRP is by recommendation of present members and approval of their Executive Committee which has resulted in physicists constituting more than half the membership of the Commission. This all took place, and the radiation exposure recommendations were set, before any analysis of the Hiroshima and Nagasaki atomic bomb data, contrary to myths. Indeed, the survivors had not even been identified in 1950 when the international standards, which stood unchallenged until 1990, were set. The ICRP as a self-appointed entity has functioned to provide the appearance of a scientific basis for standards designed to allow governments and private corporations to expose workers, and now by extension, the general public to amounts of radiation over and above natural terrestrial levels. In every case, these “legal” limits allow a doubling or more of the level of radiation that is “natural” and with which life evolved.

Government agencies worldwide have based their standards on recommendations from the ICRP and a corresponding “National” Committee for Radiological Protection (NCRP). These bodies have not explicitly made standards to protect either women or children, originally due to the historical focus on a relatively young male workforce. In the interim the public has become subject to the ongoing contamination of air, water and soil by atmospheric nuclear weapons tests, and from the growing number of catastrophic nuclear accidents including Windscale, Kyshtym, Fermi 1, Santa Suzanna, Brookhaven, Three Mile Island, Chernobyl, and Fukushima.

The Nuclear Regulatory Commission bases its levels of allowable radiation exposure to the public and workers²³ on the NCRP and ICRP recommendations. The NRC regulates the largest sources of radioactivity, the 104 operable nuclear reactors in the U.S. The radioactivity generated by a single 1000-megawatt nuclear reactor unit *per year* is on the scale of 1000 detonations of an atomic bomb like the one that destroyed Hiroshima. Reactors routinely release radioactivity to air, water and as solid waste, with ongoing potential for radiation exposure even without an accident.²⁴ The NRC does not regulate with respect to women or children, Using units that were developed expressly with the assumption that the individual receiving the dose is an adult male. Basing the national radiation limits on the “standard” or “reference” man is not protective of our species. The standard “reference man” cannot, of course, reproduce by himself.

October 2011. Prepared by Mary Olson, Director of the Southeast Office of Nuclear Information and Resource Service, maryo@nirs.org 828-252-8409 www.nirs.org CORRECTED 10/22/2011 page 5 (TYPO: 40% not 80%).

²³ Chapter 10 Part 20 of the U.S. Code of Federal Regulations

²⁴ See “Hidden Radioactive Releases from Nuclear Power Reactors in the United States” posted at: http://www.nirs.org/factsheets/drey_usa_pamphlet.pdf