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Annex A: Health and Ionizing Radiation Exposure – women & children at greater risk

In the immediate aftermath of the Fukushima Daiichi disaster, the Japanese government raised the acceptable level of exposure for the general public to 20m/Sv per year as an emergency measure. It should be noted that the 20 mSv/year standard is the same level as nuclear workers' annual limit, averaged over a 5-year period, per the International Commission on Radiological Protection (ICRP) recommendations.[1] For children aged 16-18 that are in apprenticeships for radiation-related fields, the International Atomic Energy Agency (IAEA) stipulates that exposures should be no more than 6 mSv/year.

This low-dose, chronic exposure of nuclear workers has well-documented health consequences. For example, a 15-country collaborative research study of 400,000 nuclear workers, which encompassed 5.2 million person-years of follow-up, a significant association between radiation dose and all-cause mortality was found.[2] This was primarily due to dose-related increases in all-cancer mortality, excluding leukemia.

The increased mortality risks of long-term, low dose exposures for nuclear workers is obviously concerning. Yet, it is quite a different situation for employees to willingly accept these increased risks than it is for the public, including women and children, to be exposed in their daily lives to the same radiation risks as nuclear workers. In addition, the current resettlement limit of up to 20 mSv/year is 20 times higher than both international and Japanese standards (outside Fukushima-impacted areas) for "acceptable" exposures of the general public to human-made radiation, and also long-term decontamination targets for the contaminated region.

Epidemiological studies of atomic bomb survivors have also clearly shown a strong dose-response relationship, as well has the greater vulnerability of women and girls to radiation exposures. According to a report from the U.S. National Academy of Sciences (NAS), which examined an enormous body of research on atomic bomb survivors: "dose related increases in both cancer and non-cancer mortality imply that longevity is related to dose . . . there is a clear decrease in median life expectancy with increasing radiation dose . . .[3]

The NAS analysis noted that there were 10 cancers related to *in utero* radiation exposure, with a statistically significant dose-response correlation; the findings for fetuses were not significantly different from those exposed at 5 years or younger. However, ***9 of these 10 cancers occurred in females, and the significant difference between the sexes persisted even when female-specific cancers were excluded (breast, ovary, and uterus).***[4]

Further, the decrease in risk for developing leukemia with attained age was more rapid for men than for women.[5] The Excess Relative Risk (ERR, which quantifies the increased risk for persons with a given radiation dose compared to non-exposed persons) for all solid cancer mortality, excluding leukemia and other hematopoietic (i.e. blood) cancers, for females was double that of males.[6]

For site-specific cancers (stomach, colon, liver, lung, and female breast) the largest ERR per Sievert radiation dose (ERR/Sv) was for breast cancer.[7] Proliferative breast disease, both in general and atypical hyperplasia (i.e. precancerous accumulation of abnormal breast cells), was positively associated with radiation dose, with the strongest association in the 40-49 age-at-exposure cohort.[8] Researchers hypothesize that this is related to the age-at-exposure risk for radiation-induced breast cancer, and that potential cancers induced in this age group received too little hormonal exposure to progress to full-blown cancers.[9]

The ERR/Sv for females for stomach cancer was found to be about three times that of males.[10] The sex association for lung cancer is similarly strong, with female ERR/Sv at about 4 times that of males.[11]

It is also worth noting that, despite misleading information presented to Fukushima survivors – including pregnant women and children – regarding risks at doses below 100 mSv, the report highlights research that found evidence of a statistically significant dose-response ratio for solid cancers at low radiation dose levels (0 - 100 mSv).[12] Statistically significant dose-response was also found for nervous system cancers and schwannomas[13] (i.e. nerve sheath tumors) at low dose levels (less than 1 Sv).[14] Similarly, while non-cancer radiation-induced diseases were not found to differ significantly between the

sexes, researchers did note statistically significant dose-response relationships for heart disease, stroke, respiratory disease and digestive disease.[15]

The increased vulnerability of women to the impacts of radiation exposure is further corroborated by studies of diagnostic medical exposures. One study of CT scans found that though there was variance of exposure levels between hospitals and procedures, women – particularly young women – were at significantly greater risk than men for developing cancer from diagnostic procedures.[16] For example, for women who underwent a coronary angiography CT at the age of 40, their risk of developing cancer from the procedure was 1 in 270. For men, the risk was 1 in 600. For 20 year olds, the risk doubled.

Further, fetuses, infants and children are particularly vulnerable. One study analyzed the lifetime cancer mortality risks of individuals who had undergone pediatric (under 15 years at the time of the procedure) CT brain and/or abdominal scans.[17] It concluded that the lifetime cancer mortality rates attributable to the CT scans were an order of magnitude higher for pediatric patients than for individuals who were adults at the time of receiving the scan. Women were also at greater risk for developing cancer as a result of the pediatric CT scans, though this increased risk was primarily for abdominal examinations.

Other studies appear to show that fetal low dose exposures seem to confer greater health risk than for any other group, including infants and children. Studies have also shown that a single x-ray examination of the abdomen of a pregnant woman increased the likelihood of childhood cancers by 40-50%.[18] These studies also found that the risk for childhood cancers increased proportionately to the amount of in utero x-ray exposure.

The placenta can also transfer radionuclides that have been ingested or inhaled to the developing fetus.[19] Radionuclides that accumulate in the bladder can cause radiation exposure to the nearby fetus as well.[20] Depending on the stage of development and the dose received, such exposures can result in a wide range of impacts, such as pregnancy loss, malformations, neurobehavioral abnormalities, fetal growth retardation, and cancer.[21]

One study appears to show the effects of the Fukushima nuclear disaster on pregnant women less than a year after the disaster, albeit the researchers conclude the observed effects were likely a result of the impact on sperm and ovum, rather than on embryo and fetus.[22] The authors had noted that in the aftermath of the Chernobyl disaster, perinatal mortality rates increased after a 10-month time lag. In an effort to determine whether a similar uptick in perinatal deaths was evident after the Fukushima disaster, the researchers analyzed perinatal mortality data for the 47 prefectures of Japan from live births at 22 weeks of pregnancy to seven days after birth from 2001 - 2014. The data was solely sourced from the Japanese government's records. The study compared unaffected and less affected prefectures nationwide with the heavily contaminated (Fukushima, Gunma, Ibaraki, Iwate, Miyagi, and Tochigi) and moderately contaminated prefectures (Chiba, Saitama, and Tokyo).

To evaluate the impacts of the tsunami and earthquake, which might also influence perinatal mortality, the authors further divided the heavily contaminated prefectures into two groups based upon the number of dead and missing. Group 1 (Iwate and Miyagi) suffered the high rates of dead and missing due to the tsunami and earthquake. Group 2 (Fukushima, Ibaraki, Tochigi, and Gunma) were heavily impacted by the nuclear disaster, but suffered casualty and missing person rates 20 times lower than those of Group 1.

The results showed that for Group 1, there was a significant increase of more than 50% in perinatal mortality immediately following the earthquake and tsunami in March and April 2011, with no further increases the rest of the year. In Group 2, there was no significant increase in perinatal mortality in the immediate aftermath and for the remainder of 2011. However, all six of these heavily contaminated prefectures showed a long-term jump in infant mortality rates 10 months after the nuclear disaster, from January 2012 onwards, of approximately 15%. In the less contaminated prefectures of Chiba, Saitama, and Tokyo, perinatal mortality also increased 10 months after the disaster, albeit at the lower rate of 6.8%.

In these prefectures, perinatal mortality has steadily fallen, though at an elevated rate from previous trends.
No similar jump in perinatal rates was observed in prefectures unaffected by the disaster, where perinatal mortality continued to steadily fall with national trends over the time period studied. The authors conclude that these findings are consistent with those seen in Europe following the Chernobyl nuclear accident, though more study is needed. Given the 10-month time lag, the authors also note that this suggests an impact on ovum and sperm.

Further, children are at greater risk for developing thyroid cancer following exposures to radioactive iodine (^{131}I), as was seen in Chernobyl.[23] The risk can be greatly reduced if stable iodine pills are distributed immediately following an accident, which saturates the thyroid and inhibits the uptake of ^{131}I. In Fukushima, orders to distribute the iodine pills that were waiting in stock in the towns in the emergency planning zone were delayed until 5 days after the accident. By then, many residents had already fled the nuclear disaster area, and the window had passed for the pills to be effective in their preventative role.[24] This likely meant that many children were exposed to preventable high doses of radioactive iodine.

In June 2011, the Fukushima Prefectural People's Health Management Survey was launched to conduct thyroid screenings of people who were under the age of 18 at the time of the radioactive releases due to the triple reactor core meltdowns. The study was headed by Professor Yamashita Shunichi and Prof. Suzuki Shinichi, who stated that its purpose was, "to calm the anxiety of the population" and to convince the public that "the health impact of the nuclear accident of Fukushima can be assumed to be very minor."[25] The credibility of this research has been called into question by outside observers,[26] given that the head researchers began with the commitment to a stated outcome before the study even began – much less any results known.

But perhaps the worst aspect of this study is the difficulties for patients and their parents have faced in gaining access to their own medical files. While patients were given a poor-quality print of their ultrasound results (supposedly to prevent forgery), they have been forced to file Freedom of Information (FOI) requests to gain access to their own complete medical files.[27] This is not only wholly unfair, but is a gross violation of their right to health – including their right to information.

There is an ongoing contentious debate over the causes of the higher-than-expected thyroid abnormalities and cancers amongst Fukushima children. It is unclear whether this is a result of radiation exposure or of screening bias (i.e. more abnormalities and cancers are found due to widespread screening). As of December 2016, 145 children were found to have thyroid cancer.[28]

Numerous bodies and scientists have proposed that the increase in the detection of thyroid abnormalities in Fukushima children in the years immediately following the accident is due to screening bias and more sensitive ultrasonic testing.[29] The Fukushima prefectural review panel conclusion is that the results can be most likely explained through the screening effect and is unlikely to be due to radiation exposure.[30]

This is not the view of others, who contend that the incidence of thyroid cancer detected in Fukushima, when compared to national levels, cannot be explained solely based on screening. These experts assert that the high incidence can be explained, to a significant degree, by exposure to radiation.[31]

The French national nuclear research organization, Institute for Radiological Protection and Nuclear Safety (IRSN), analyzed studies of children from four prefectures not effected by the Fukushima Daiichi accident, as a control group. IRSN then concluded that it would appear the increases were due to screening bias due to similar results in nuclear disaster impacted areas and those prefectures that were not affected.[32] At the same time, the IRSN also holds that the screening program must continue and that, "a connection with the Fukushima accident may only be made if the annual incidence of thyroid cancer in children increases starting from the period 2016-2018."

This is recognition that thyroid cancer has a long latency period. In fact, significant increases in thyroid cancer incidence for those who were children and teenagers at the time of the 1986 Chernobyl nuclear disaster did not become evident in most regions until between 4-5 years after the disaster.[33]

As such, these next years will be critical for the continuation of the robust screening program for thyroid cancers in individuals who were children at the time of the disaster. Test results and complete medical files must be easily accessible to patients and/or the parents/legal guardians of dependent patients.

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[4] *Ibid.* pg. 151

[5] *Ibid.* pg. 144

[6] *Ibid.* pg. 145

[7] *Ibid.* pg. 148

[8] *Ibid.* pg. 151

[9] *Ibid.* pg. 151

[10] *Ibid.* pg. 150

[11] *Ibid.*

[12] *Ibid.* pg. 146

[13] Nerve Sheath Tumors. For further information on this type of tumor, see: http://www.webmd.com/cancer/neurofibrosarcoma-and-schwannoma

[14] National Academy of Sciences. *op. cit.* (2006). pg. 152

[15] *Ibid.* pg. 152

[16] Smith-Bindman, R., et al. (14 December 2009). "Radiation Dose Associated with Common Computed Tomography Examinations and the Associated Lifetime Attributable Risk of Cancer." *Arch Intern Med*.; 169(22): 2078–2086. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4635397/

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See also: Physicians for Social Responsibility, et al., *op. cit.* (2013).

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[21] *Ibid.*

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[26] *Ibid.*

[27] *Ibid*

See also, Kikuchi, K. (19 December 2013). 福島県県民健康管理調査の甲状腺検査から 2 年半 これまで、そして今、こんなことが起こっています レポート：菊池京子. http://311.yanesen.org/wp-content/uploads/2013/12/2f46387fbc23371adaba57ad8dd7b11b.pdf

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