Radiation Risks at Doses Less Than 100 mSv

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The Proceedings of the 12th Prefectural Oversight Committee Meeting for Fukushima Health Management Survey in October 2013 states:

"*The latest effective radiation dose estimates showed similar trends to those observed so far. Since previous epidemiological studies indicate no significant health effects at doses <100 mSv), we concluded that radiation doses estimated so far are unlikely to cause adverse effects on health, although this conclusion is based on effective doses estimated only for the first four months following the accident.*"

The question I want to address is, does this statement carry any scientific credibility?

The report of the United Nations scientific committee on the effects of atomic radiations (UNSCEAR) of 2008 is cited in support of this assertion. It says as follows:

"*So far, neither the most informative LSS study nor any other studies have provided* ***conclusive*** *evidence of carcinogenic effects of radiation at smaller* [than 100 mSv] *doses*".

The issue here is what is meant by the term "conclusive", because in fact epidemiology is incapable of returning a conclusive (meaning a 100% true) result except in the most rare circumstances. The results of epidemiological studies are judged by their "statistical" significance.

What do we mean by the term statistical significance?

As an example let us say I have a coin that I suspect is biased to land heads up more often than it should if it were unbiased. So I toss the coin and record the results as follows:

Number of tosses	Number of heads-up
1	1
2	2
10	7
50	30
100	61

For one and two tosses we cannot say much about the bias of the coin – we could easily get that result by chance alone. However, for 10 tosses we can definitely suspect that the coin is biased and for 50 and 100 tosses we can be even more certain but not CONCLUSIVLEY certain.

To determine the significance of these results we calculate what is called a p-value. Below are the p-values for each of the experiments we performed:

N	heads up fraction	p-value
2	2	0.25
10	7	0.117
50	30	0.042
100	61	0.007

One toss tells us nothing, 10 tosses makes us suspicious that the coin is biased, but 50 tosses tells us that we can be 95% certain (p< 5%) that the coin is biased and the 100 tosses tells us that we can be 99% (p < 1%) certain that the coin is biased.

For epidemiological studies to determine radiation risk, we generally accept the 95% confidence level as the benchmark for statistical significance:

Since the UNSCEAR term “conclusive” cannot imply 100% confidence, their statement only makes sense if we interpret “conclusive” as meaning 95% confidence.

UNSCEAR admits that above 100 mSv there are conclusively determined radiation risks (>95% confidence), so if there are studies demonstrating a risk above the 95% confidence level at doses of less than 100 mSv, then UNSCEAR’s statement is WRONG and so is that of the Fukushima Health Management Survey Oversight Committee.

But there is an important point to note:

As we saw from the coin tossing experiment, the number of tosses strongly influenced the result. For small numbers of tosses it was much more difficult to reach the 95% confidence level. The same is true of epidemiological studies in terms of the number of people being studied. If the study is small a genuine effect, that is, a real risk, may not be detected because of the inherent insensitivity of the technique. Therefore, when numbers are small, real risks may be undetectable, especially at low doses. As numbers of participants increases and as the dose increases, the easier it is to detect radiation risk.

Therefore, studies with significance over 95% at doses of less than 100 mSv are at least as reliable as those with doses above the 100 mSv level:

The idea that 100 mSv has special significance in terms of risks above and below it is FALSE and misleading (deliberately on the part of UNSCEAR).

In a study in the UK in the 1950s to1960s of pregnant women given diagnostic x-rays, an increase in the risk of leukaemia in the children born to such women was detected by the Oxford Survey of Childhood Cancers (OSCC).

The x-ray history of 8513 cases of leukaemia were compared with that of a similar number of controls revealing an overall relative risk of 1.47 (significant at the 95% confidence level) which increased with the increased number of films exposed, that is, was dose dependent.

Determination of the dose delivered per film indicated that the risk applied to doses of the order of 10 mGy (10 mSv) and that the transit of a single electron through a single cell was sufficient to cause leukaemia.

These results caused considerable controversy at the time they were published and the principle author, Dr Alice Stewart was subject to considerable criticism. Consequently, this work has been extensively discussed and re-analyzed.

It is interesting to note that in Germany (and confirmed elsewhere) there is solid evidence of very large (120%) increased incidence of childhood leukaemia in children under 5 years of age living around (within 5 km) nuclear power plants which is so far unexplained. It has been suggested by Ian Fairlie that at routine maintenance sessions such reactors can release radioactivity to the air and that the fetuses of pregnant women downwind of the site are at a special risk.

It seems most unlikely that the doses received are above a few mSv.

The evidence of significant risk below 100 mSv is NOT confined to children, although they are definitely more sensitive than adults.

A study of more than 400,000 radiation workers (preeminently male) in 15 countries yielded a relative risk for all cancers excluding leukaemia of 1.97, significant at the 95% confidence level. The average cumulative dose received by these workers was about 20 mSv.

The central estimate of this risk is larger than that determined by the atomic bomb survivor study (>86,000 individuals) of 1.42 for both sexes combined in the latest (2012) analysis. Furthermore, from this analysis there is no evidence of a threshold, the assumption of linearity from zero dose provides the best fit to the data.

Finally, there is a growing body of evidence from studies of people treated with diagnostic x-rays, for example, CT scans, showing excess risks at the 95% confidence level with doses well below 100 mSv.

The evidence recounted here is far from comprehensive and is given in full detail in a paper at present in the process of publication. I have provided here sufficient evidence to show that there is NO case to assume that the risk per 100 mSv for doses less than 100 mSv is any different from that above 100 mSv.

This is not new! In 2003 a paper published in the prestigious US Journal, Proceedings of the National Academy of Sciences, made the same case.

Cancer risks attributable to low doses of ionizing radiation: Assessing what we really know

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Contributed by Richard Doll, August 29, 2003

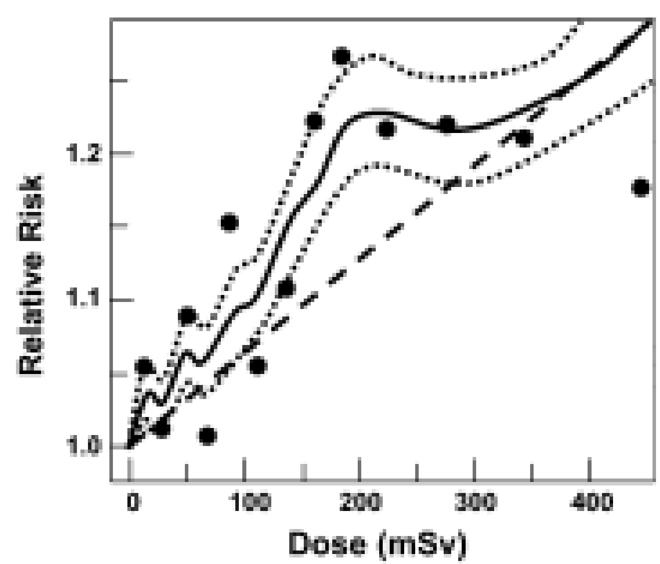


Fig. 4. Estimated risks (relative to an unexposed individual) of solid cancer in atomic bomb survivors exposed to low radiation doses (12). Data points are placed at the mean of each dose category. The solid curve represents a weighted moving average of the points shown (dotted curves: ±1 SE), and the dashed straight line is a linear risk estimate computed from all the data in the dose range from 0 to 2,000 mSv. Age-specific cancer rates from 1958 to 1994 are used, averaged over follow-up and gender.

An important benchmark is 20 mSv/year as that is the external dose rate that is considered suitable for re-habitation of areas previously considered too contaminated for occupation.

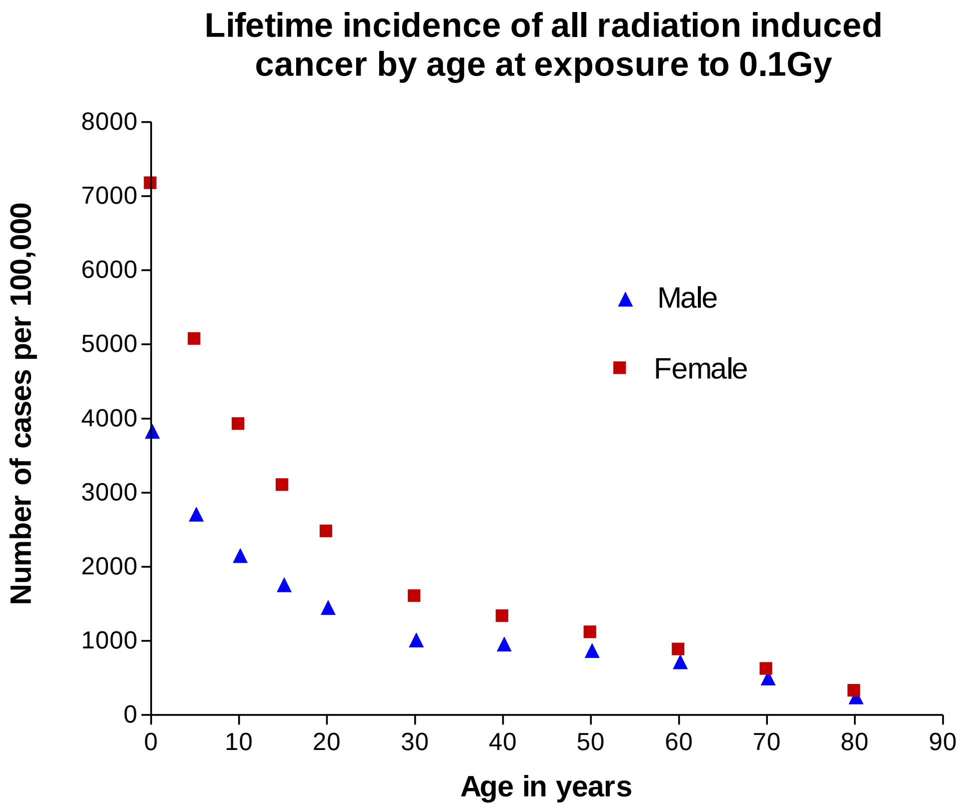
What does this mean in terms of radiation risk for the those returning to their homes in those regions?

Firstly, we need to consider the dose rate in subsequent years and then the risks of disease associated with those dose rates.

The external dose from freshly deposited fallout radioactivity drops quickly in subsequent years due to the decay of the short-lived isotopes. That is why the dose received over 10 years is about twice that received in the first year. This is the case even a few years after fallout deposition as the short-lived radioactivity has already decayed.

It maybe that the dose rate will fall by only a factor of 2 over 10 years, so the dose averaged over 10 years will be 15 mSv/year, a total of 150 mSv in 10 years.

The risk from radiation exposure varies with age and gender, being the highest for the youngest and under the age of 20 years, and girls are twice as sensitive as boys



Figures taken from BEIR 2007 with DDREF = 1

I will take the worst case scenario as I understand this is not ruled out by the proposed legislation:

a girl of 1 year of age living in the environment giving 20 mSv/ year at year 1 and dropping to 10 mSv/year after 10 years (average dose rate 15 mSv/year).

Her accumulated dose over the 10 years will be 150 mSv.

Her life-time cancer risk will be 4,500/100,000 per 100 mSv = 6.75% for the accumulated dose of 150 mSv.

In addition there could well be a further risk of non-cancer disease, the magnitude of which is difficult to estimate but could well be of a similar magnitude.

Thus, within the first 11 years of her life she could have incurred a risk of serious disease within her lifetime of some 10 to15% due solely to her exposure to radiation.

Let us compare that to the lifetime risk to a male radiation worker working between the ages of 20 and 60 years and receiving the maximum allowable annual dose rate (according to ICRP dose limits) of 5 mSv, giving a lifetime dose of 200 mSv.

This is a possible scenario for a Fukushima Daiichi worker in the next few decades.

From the previous graph we see that his risk accrued over 40 years of his working life would on average for cancer be:

1,000/100,000 per 100 mSv = 2% per 200 mSv.

To allow for other non-cancer disease we can roughly double this to: 4% per 200 mSv.

Of course, a girl living in a non-contaminated region would also have a radiation related risk from natural background radiation and the public dose limit of up to 1 mSv/year, let us say equal to 3 mSv per year or 30 mSv in 10 years.

Her lifetime serious disease risk on the same basis as above would be 2 to 3%.

That risk would apply almost anywhere in the world.

We saw from the review of the available epidemiological data that the lowest dose at which an effect (childhood leukaemia as a result of fetal irradiation) was observed was ~ 10 mSv.

Could this be a threshold?

Yes it could, but that would mean that in just a few years after birth, unavoidable exposure to natural background radiation would exceed that threshold and risk would then increase.

Now let us explore what would be the effect of assuming that the risk below 100 mSv could be ignored in the three cases we have considered:

The girl living from ages 1 to 11 years in an area with annual dose rate of 20 mSv in the first year:	2 to 3%
The radiation worker:	2%
The girl living from ages 1 to 11 years in an area with no fallout contamination:	0%

Up to this point I have assumed that the only source of exposure will be external radiation from fallout.

It seems to be the case that controls on foodstuffs have considerably reduced internal doses. These will need to be maintained over the foreseeable future. There will also be a risk over perhaps several decades of uncontrolled internal irradiation from, for example, mushrooms collected in the forest. Recently in Norway increased levels of radioactive Cs were detected in reindeer. This was due to an unusually prolific mushroom season which increased the amount of Cs from Chernobyl fallout nearly 30 years ago.

The risks estimated above do not take account of doses already received and particularly those received in the early days of the accident from the radioactive plumes, both externally through immersion and through inhalation. A recent publication gives important data that may allow these to be estimated.

What does UNSCEAR 2013 have to say about risks entailed from the accident?

"*although a disease risk in the longer term can be theoretically inferred on the basis of existing risk models, an increased incidence of effects is unlikely in practice to be observed in future disease statistics using currently available methods, because of the combination of the limited size of population exposed and low exposures, i.e. consequences that are small relative to the baseline risk and their uncertainties*" (Paragraph E23)

UNSCEAR are of course correct here on the basis of their dose estimates – the limitation is epidemiology. In other, more prominent, parts of the report they say there will be "*no discernable increase in risks*" without further qualification. This can be taken by the lay reader as a highly reassuring statement concerning the impact on public health, but what it in fact is - is statement concerning the sensitivity of the "detector" of the effect, i.e., epidemiology.

If all potentially toxic releases to the environment were permitted to be released up to the point at which their effects were demonstrable by epidemiological studies, life expectancy would be declining dramatically.

This is in fact what UNSCEAR would be suggesting – if the risk is "not discernable then it is safe to ignore it", taken together with "there being no conclusive evidence of risk below 100 mSv". But the risk to young girls of being exposed to 100 mSv is 4% for cancer and perhaps the same again for other diseases. These are not risks to be ignored.

If the risk of exposure to 100 mSv was set as a risk that could be ignored for ALL environmental pollutants life expectancy would be drastically reduced.

Conclusion

There is no scientifically sustainable case for the assumption that the risk per 100 mSv for doses below the 100 mSv level is quantitatively or qualititively different from that above it.

In all probability, risk is linearly dependent on dose from zero dose upwards – that is – a linear no threshold (LNT) relationship applies, and in the estimation of risks for public health policy purposes, it is essential to include all doses to which the population may be exposed however small.

Now, three and a half years after the accident, a detailed picture of the risks entailed by the civilian population, are still not completely understood.