Fukushima, Goiania and the danger from internal radioactivity 4 May 2013

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Radiation and radioactivity are considered to be dangerous. As well as external radiation that may shine on the body from the outside, people worry in particular about activity that gets ingested by breathing, eating or through the skin, and that then irradiate the body from the inside. Should they concern themselves about this as much as they have in Japan? Culturally, it may be worse to have contamination inside than outside where you can wash it off, shield it or move away. But the question, whether radiation from internal radioactivity is in fact more harmful, should be answered with evidence -- strong evidence, simply understood and without the use of complicated statistics.

In the two years since Fukushima no death from radiation (or even a significant injury) has been reported, although there have been many casualties caused by fear, evacuation of elderly and terminal patients, and deep social distress (with serious economic and environmental consequences) [1,2,3]. In a billion years or so life has had the opportunity to evolve multiple defences against all but the most intense acute attacks by radiation and other agents, but are they effective against internal radiation? For over a century high intensity radiation has been used, both internally and externally, to kill cancer cells or to slow their progression, but at lower intensities life is well protected [4] and no radiation casualties, at the time or later, should have been expected at Fukushima [5]. But how about radioactivity that is specifically internal?

In Goiania, a provincial centre in Brazil, on 13 September 1987 an intense cancer therapy source was removed from an abandoned clinic – as it happened, a caesium-137 source, the same isotope of concern in Japan today [6,7]. Remnants of the radiotherapy unit were sold to a scrapyard and fragments of the source fell into the hands of people, including a 6-year old girl. They were intrigued by its blue light and the caesium got onto their skin, clothes and living space. The unfortunate girl ate a sandwich with bare hands while caesium fragments were dispersed on the kitchen table she used. Many individuals became ill and 16 days later what had happened became clear. By 28 October four people were dead from Acute Radiation Syndrome (by cell death) and altogether 249 people were contaminated, of whom 28 suffered skin burns requiring surgery in some cases. In addition to the internal activity shown in the Table below, many received large external radiation doses.

In the 25 years since 1987 [8] there has been no case of cancer due to radiation among those contaminated – none at all. This observation is compared with measurements from Fukushima and elsewhere in the Table below. As shown in the third column the lowest measured internal radioactivity for any casualty at Goiania was far more than 1000 times greater than the largest internal radioactivity measurement for any resident in a large survey of those affected in Japan [9]. For children this ratio was even larger [9]. At Goiania one woman, already four months pregnant, got a significant dose and gave birth normally; and another who had received one of the highest internal doses gave birth to a healthy child four years on [8].

Whole body internal radioactivity, kBq			Number of people	Dose mGy **per month**	Mortality
Goiania	Cs-137	above 1,000,000 kBq	1	above 6,500	ARS
Litvinenko [10]	Po-210	100,000-300,000 kBq	1		ARS
Goiania	Cs-137	100,000-1,000,000 kBq	7	650-6,500	50% ARS
Dial painters [11]	Ra-226	3,700 kBq threshold	191 above threshold	more than 120	0, cancer threshold
Goiania	Cs-137	10,000-100,000 kBq	20	65-650	nil
Goiania	Cs-137	1,000-10,000 kBq	23	6.5-65	nil
Goiania	Cs-137	100-1,000 kBq	15	0.65-6.5	nil
Goiania	Cs-137	10-100 kBq	11	0.065-0.65	nil
Fukushima adults [9]	Cs-137	all below 12 kBq	32,811	all below 0.07	
Normal body [12]	K-40	4.4 kBq	all	0.025	
Fukushima children [9]	Cs-137	all below 1.4 kBq Nov 2011- Feb 2012	1,494	all below 0.01	

Table comparing measured values of whole-body internal radioactivity for those affected at Goiania [6,7] *to other internal exposures, ordered in descending activity. The internal doses in red were fatal; those in pale yellow were marginal; those in green harmless; those lower in the Table safe by factors of many thousand. Cs-137 and K-40 may be compared directly, but Polonium (Litvinenko) and Radium (the Dial Painters) are alpha emitters and somewhat different and more damaging. However the difference is much smaller than the factor of 1000 that characterises the safety margin for Fukushima residents.*

The safety factor of 1000 for Fukushima residents is roughly in line with other relevant data on internal doses. Like at Chernobyl and Fukushima the main health effect at Goiania was psychological – 42.5% of those contaminated are reported to have suffered from depression, compared with 3 to 11% in the general population [8].

Publicly, nuclear radiation is seen as more threatening than the same ionising radiation in other contexts like clinical radiotherapy or UV in sunshine [4], but that is a matter of history and politics, not science [13]. The Cold War gave a premium to nuclear angst with its threat of a holocaust. But, only the blast and fire of a nuclear weapon live up to such a reputation, not the radiation whose main influence is psychological. In the past 60 years authorities, national and international, have chosen to appease public fear of radiation by ignoring the scientific facts. Safety regulations have been set to require that radiation levels are kept “As Low As Reasonably Achievable” (ALARA), just to reassure – but that is nothing to do with

safety. In fact these regulations themselves cause serious industrial risks and unwarranted costs [14]. Worldwide, a safety industry clings to a discredited policy of caution that is in denial of modern science.

Gratuitously restrictive regulations are as unaffordable in a nuclear power station as in the design of a bridge or dam. With a more reasoned approach to real safety and proper explanatory education, regulations could be relaxed by a factor of up to a thousand without risk and with costs reduced very substantially. Meanwhile, vital economic expansion opportunities that the world desperately needs are artificially debarred. But what if another accident like Fukushima should happen in the next few years? Well, it would be another local accident probably without serious casualties -- unless everybody panics and sees it through a lens of ignorance and mistrust, as they have at Fukushima. In March 2012 Yukiya Amano, the Director General of IAEA, described Goiania as the best illustration of the effect of a terrorist dirty bomb [15]. Indeed, like a single fatal car smash with four dead, followed by a totally unjustified panic. Neither the Goiania accident nor a terrorist dirty bomb present a global threat, and the Fukushima accident even less so. Regrettably, that may not be what Dr Amano intended to say; the IAEA should re-consider its own evidence and provide help by educating the public accordingly. A society riven by mutual recrimination and distrust of science cannot be stable and free. What is needed then? Education, mutual trust and personal confidence of the kind so admirably shown by the Japanese people when faced by the real dangers of the earthquake and tsunami.

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