Possible Impact of a Planned Nuclear Power Plant

on the Skagit Indian Population

A nuclear power plant is to be built in the Skagit area of Washington State and Skagit Indians have raised the argument that such a plant would be detrimental to their health for the following reasons. Skagit Indians have a higher inbreeding rate than the surrounding population. Nuclear radiation could produce an increased number of mutations. Recessive mutations in single dose have no deleterious effects but may produce various genetic diseases when two doses of an identical mutation occur in a human organism. Populations that have a higher inbreeding rate (i.e., a higher frequency of cousin matings and other marriages with relatives) incur a higher risk of recessive diseases since relatives are more likely to carry a deleterious gene inherited from a common ancestor. Therefore, it is argued that the effects of nuclear radiation would lead to a higher frequency of genetic diseases in Skagit Indians because of inbreeding.

The argument appears conceptually plausible. What would be the actual effects on the Skagit Indian population? The additional number of mutations caused by environmental radiation such as by nuclear power plants has been estimated as the relative mutation risk per 1 rem of radiation. The relative mutation risk gives the risk of induced mutation per rem (or 1000 millirem) expressed as a fraction of the current risk of spontaneous mutations. This relative risk has wide confidence limits and is considered to be 0.004 to 0.02 per 1000 mrem exposure. The effect of low level radiation particularly are poorly understood and the biologic effects may in fact be less than suggested by this figure. However, using this estimate there is an additional risk of an increase of 0.4 to 2% over the baseline mutation rate per 1000 millirem exposure. This relative risk is often expressed as the radiation dose which doubles the mutation rate and is the reciprocal of the relative risk, i.e., 50 - 250 r.

Actual additional radiation exposure to the population from a nuclear power plant is estimated to be around 1 millirem/yr or 25 mrem/generation of 25 years. The expected relative mutation risk added by nuclear power radiation therefore will be 1/40 (25 of 1000) of 0.02 to 0.004 or 0.0001 to 0.0005. (Table 1) A currently accepted mutation rate per locus is 1×10^{-5} locus/generation. This is a "worst case" assumption; the actual mutation rate is likely to be lower by an order of magnitude. The probability of a mutation caused by nuclear power would therefore be $1 \times 10^{-5} \times 0.0001$ to $1 \times 10^{-5} \times 0.0005$ or 1×10^{-9} to 5×10^{-9}. Assuming that there are 10,000 (10^4) genetic loci on the human chromosomes that could cause recessive disease (currently we know about 1000 recessive diseases) there is a 1×10^{-5} to 5×10^{-5} chance that any one of 10,000 mutations would be produced from nuclear power radiation. (Table 1) It would thus require a population of at least 20,000 - 100,000 individuals to find at least one mutation in single dose or in the heterozygote state that would have been induced by the additional radiation from a nuclear power plant. Thus, there may not be enough Skagit Indians for this additional radiation induced mutation to show up. Assuming that

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this Indian population would be exposed to higher background radiation than 25/mrem/ generation, calculations were also carried out for exposures of 100 mrem and 250 mrem per generation. (Table 1) Even with such higher exposure to nuclear power radiation, the actual number of recessive mutations produced would be relatively small. The full data are given in Table 1. A recessive mutation in single dose would not produce clinical effects. It would require the mating of two individuals each carrying an identical mutation for a given recessive disease for such a disease to manifest in their offspring. Even assuming very high inbreeding rate, the chances of such diseases actually occurring therefore would be very small.

Other possible hazards cannot be quantitated with current data. It is conceivable that inbred individuals would have a higher risk for cancer induction by radiation than those who are not inbred. Such effects would depend upon various models of carcinogenesis on which there is no current agreement. Dr. William J. Schull, an eminent expert in radiation genetics in humans and director of the Radiation Research Effects Foundation, Hiroshima, Japan, is working on this problem based on the inbred subsection of the Hiroshima/Nagasaki population that was exposed to atomic bomb radiation. As far as I know, no data have yet been published. Schull also might provide further information on possible ill effects of low level irradiation on children of inbred couples since he suggested that such children might be especially susceptible to the effects of any induced mutation that might manifest as higher spontaneous abortion rates and stillbirth rates. A relatively limited study involving inbred parents exposed to atomic radiation failed to show any such effects (Am J Pub Health 49:1621, 1959). However, in any consideration of ill-effects of ratiation in humans, biologic effects that produce birth defects, genetic diseases, and cancer should be clearly differentiated from fetal effects which may have less of a societal impact or may even be undetectable since they may only manifest as a delayed menstrual period.

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Table 1. Estimation of mutations produced by low level radiation (such as by exposure to radiation from nuclear plants)

	Most likely estimate	Higher estimate (worst case possibility)	
a) Possible exposure from nuclear plant radiation/ year	1 mrem	4 mrem	10 mrem
b) Possible exposure from nuclear plant radiation/ generation = 25 years	25 mrem	100 mrem	250 mrem
c) Human mutation rate/ locus/generation*	1×10^{-5}	1×10^{-5}	1×10^{-5}
d) Relative mutation risk with 1000 mrem (BEIR estimate)	2×10^{-2} to 4×10^{-3}**	2×10^{-2} to 4×10^{-3}**	2×10^{-2} to 4×10^{-3}**
e) Relative mutation risk per locus with actual nuclear plant radiation exposure	1×10^{-4} to 5×10^{-4}	2×10^{-3} to 4×10^{-4}	1×10^{-3} to 5×10^{-3}
f) Possibility of single mutation caused by added nuclear power radiation (c x e)	1×10^{-9} to 5×10^{-9}	4×10^{-9} to 2×10^{-8}	1×10^{-8} to 5×10^{-8}
g) Possibility of any one of 10,000*** mutations caused by nuclear power (f x 10^4)	1×10^{-5} to 5×10^{-5}	4×10^{-5} to 2×10^{-4}	1×10^{-4} to 5×10^{-4}
h) Population size required to manifest any one of 10,000 mutations in heterozygote state****	20,000 to 100,000	5000 to 25,000	2000 to 10,000

* Worst case - true human mutation rate probably lower.

** See text for explanation - corresponds to doubling dose of 50 - 250 r.

*** Assumed number of genetic loci that might produce recessive diseases.

**** Genetic recessive disease in offspring would require mating of two persons carrying an identical genetic mutation.

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