

Hot job. Technicians check radiation hourly in a gravel lot in Fukushima City. Exposure has dropped but remains 35 times above background.

tain organs—such as iodine-131 in the thyroid gland—the constant bombardment of surrounding tissue can overwhelm repair mechanisms and trigger cancer.

The clearest insights come from decades of follow up on survivors of the atomic bombings of Hiroshima and Nagasaki. These studies have linked an acute dose of 100 millisieverts (mSv) of radiation—16 times the amount that an individual receives on average from all sources over the course of a year—to a 1.05 times increase in the chance of developing some form of cancer. Children with similar exposures appeared to have a higher risk of developing cancer later. These risks scaled linearly as exposures increased.

But the health effects of chronic low-level radiation exposure over years or decades are far from clear. Several large cohort studies of medical x-ray technicians and nuclear industry workers suggest a slight increase in cancer risk at exposures below 100 mSv, Shore says. To err on the safe side, most radiation protection agencies follow the linear no-threshold model, which posits that risk diminishes with decreasing exposure but that any increase above background poses a cancer risk. Extrapolating from this model to estimate health effects in a population “is not wise because of the uncertainties,” Shore says.

Opportunities to narrow uncertainties have been missed. In the aftermath of the Soviet Union’s April 1986 Chernobyl nuclear accident, which spewed radionuclides over a swath of Europe, “there was no continuity, no overarching panel looking at how science should be done,” says Ronald Chesser, a radiation biologist at Texas Tech University in Lubbock. The subsequent Soviet collapse, scarce funding, imprecise dosimetry, and difficulties tracking people over the years have limited the number of studies and their reliability, he says. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) concluded in a 2008 report that over 6000 cases of thyroid cancer in young people could be linked to Chernobyl but that evidence for other cancers was inconclusive. To resolve outstanding questions, on 26 April the World Health Organization’s International Agency for Research on Cancer in Lyon, France, asked the international community to support a Chernobyl Health Effects Research Foundation to conduct life-span studies, similar to

those following A-bomb survivors in Japan.

Animal studies have yielded conflicting data. Laboratory experiments on animals indicate that as doses decrease, less and less damage escapes DNA-repair mechanisms, says Yoshihisa Matsumoto, a radiation biologist at the Tokyo Institute of Technology. “There must be some threshold below which the damage is completely repaired,” he says. Chesser says some of his group’s studies of mice exposed to radioactivity around Chernobyl hint at hormesis: Small exposures over 10 to 45 days, they found, appeared to temper damage from an acute radiation dose delivered in the lab later. He thinks the reaction to low doses could be quite complex. “There’s not going to be a uniform response of all biological functions to low levels of radiation,” Chesser predicts.

Patchy contamination

Japan’s experience tracking A-bomb survivors, an early start gathering data on environmental exposures in Fukushima, and a family registry system that tracks virtually all individuals all offer “great advantages” in devising more definitive low-dose studies, says Preston, who believes such a study would be well worth the cost. “I think we will learn something important,” he says.

The 800 or so workers who have helped bring the Fukushima reactors under control will be included in an ongoing study of nuclear industry workers by the Tokyo-based Radiation Effects Association. Many workers are getting higher doses in weeks than they would have received on the job over a year. Fukushima residents facing higher than background exposure can blame an unfortu-

Schoolyard Radiation Policy Brings a Backlash

TOKYO—The Japanese government has made a number of missteps during the 2-month-long Fukushima nuclear power plant crisis. But the most controversial may have been the release of guidelines from the education ministry on allowable radiological contamination in schoolyards. They seem to allow children to accumulate radiation exposures of 20 millisieverts (mSv) over the course of a year. By comparison, nuclear industry workers in Japan can absorb no more than 100 mSv per year; the limit for U.S. nuclear personnel is 50 mSv per year.

The 19 April announcement unleashed a torrent of criticism from civic groups and experts. “Setting [such radiation limits] for elementary schools is inexcusable,” Toshiso Kosako, a radiation health expert at the University of Tokyo, said on 30 April, when he resigned as an adviser to Prime Minister Naoto Kan on the nuclear crisis. Because children are known to be more susceptible than adults to risks of cancer from radiation, Physicians for Social Responsibility, a U.S. antinuclear proliferation group, condemned the exposure limit as “unconscionable.”

The ministry has backpedaled—but not fully retreated. On 11 May, it released suggestions for removing contaminated topsoil from schoolyards to reduce radiation exposures. But it did not change or retract the exposure guidelines.

In its “provisional idea” for acceptable levels of radiation in schoolyards, the education ministry cited a 2009 recommendation from the International Commission on Radiological Protection (ICRP), an Ottawa-based nongovernmental organization. During emergencies, ICRP Publication 109 states, populations can be exposed to 20 to 100 mSv per year. The education ministry calculated that children could spend 8 hours a day in a schoolyard exposed to as much as 3.8 microsieverts per hour, and 16 hours a day indoors exposed to 1.52 microsieverts per hour, and not exceed the 20-mSv limit. Civic groups contend that the education ministry should follow another ICRP recommendation, which states that exposure limits for long-term residence in contaminated areas after an accident should be kept “in the lower part of the 1-20 mSv/year” range.

In the past few weeks, several schools took matters into their own hands and stripped topsoil from their grounds. On 11 May, the ministry jumped on that bandwagon, announcing test results showing that swapping the top 10 centimeters of topsoil with dirt from deeper down cut surface radiation 90%. Stripping and burying the topsoil in a deep hole reduces surface radiation 99%. The ministry is leaving final decisions on what to do in the hands of local officials.

—D.N.



Dirty dirt. Fukushima schools are stripping contaminated topsoil from playgrounds.

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