# Global levels of radiation exposure: Latest international findings

*The 1993 UNSCEAR report reconfirms that peaceful nuclear activities account for a small fraction of total exposures*

by
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The radiation exposure of the world population has recently been reviewed by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). In its 1993 report to the UN General Assembly, UNSCEAR has reconfirmed that the normal operation of all peaceful nuclear installations contributes insignificantly to the global exposure to radiation. All peaceful nuclear activities taken together deliver a global exposure equivalent to just a few days of exposure to natural radiation sources. Even if all the nuclear accidents that have occurred to date are considered (Chernobyl included), the additional exposure would be equivalent to only around 20 days of natural exposure. *(See table below.)*

According to UNSCEAR, the military uses of nuclear energy have committed the world population to most of the radiation exposure caused by human activities. Exposure that has been and will continue to be delivered by all atmospheric explosions that have been carried out for the testing of nuclear weapons — not including other related activities such as the production of weapon materials or other military activities — is equivalent to 2.3 years of exposure to natural sources. In second place is exposure to natural sources itself. In a distant third place is medical exposures: one year of medical exposures to patients is responsible — on average — for the equivalent of 90 additional days of exposure of the world population to natural radiation. The annual occupational exposure to workers, averaged over the world population, is equivalent to few additional hours of exposure to natural radiation sources.

There are wide differences in the exposures incurred by particular individuals, but UNSCEAR is mainly concerned with the global picture of radiation exposures. *(See box.)* The committee's report can be construed to imply where the priorities should lie for the global protection of human beings against radiation. The peaceful uses of nuclear power are far down the list of concerns. Public perceptions are quite different, but this is frequently the case in relation to radiation exposure.

As is customary, UNSCEAR has also made a detailed compilation of world knowledge on the biological effects of radiation. It reconfirms deoxyribonucleic acid (DNA) as vulnerable to radiation. The report discusses the effects of changes in the cell genetic code, which are presumed to be induced by radiation exposure. Radiation exposure may either kill cells and produce the clinically detectable deterministic effects (sterility, opacities of the lens of the eye, depression of blood formation, erythema), which

***Exposure to man-made sources of radiation expressed as equivalent periods of exposure to natural sources of radiation***

| Source | Basis | Equivalent period of exposure to natural sources |
|---|---|---|
| Medical exposures | One year of practice at the current rate | 90 days |
| Nuclear weapons tests | Terminated practice | 2.3 years |
| Nuclear power (normal operation) | Total practice to date<br>One year of practice at the current rate | 10 days<br>1 day |
| Severe accidents | Events to date | 20 days |
| Occupational exposures | One year of practice at the current rate | 8 hours |
| Exposure to natural sources | Global average | (1 year) |

Dr González is Deputy Director of the IAEA Division of Nuclear Safety. The UNSCEAR report is called *Sources and Effects of Ionizing Radiation*, UNSCEAR 1993 Report to the General Assembly (48th Session, Suppl No. 46 (A/48/46)), UN Publication Sales No. E.94.IX.2, United Nations, New York (1993).

***Committed collective exposures to the public from nuclear power production (normalized per unit of energy produced and expressed as percentage)***

| Source | Percentage normalized per unit energy produced |
|---|---|
| *Local and regional component* | |
| Mining, milling and tailings | 0.7% |
| Fuel fabrication | nil |
| Reactor operation | 0.6% |
| Reprocessing | 0.1% |
| Transport | 0.05% |
| *Global component (including solid waste disposal)* | |
| Mining, milling and tailings (releases over 10 000 years) | 74.0 % |
| | — |
| Reactor operation | 0.25% |
| Globally dispersed radionuclides mainly from reprocessing and solid waste disposal | 24.3% |
| Total (rounded) | 100.0% |

***Collective exposure committed to the world population by a 50-year period of operation for continuing practices or by single events from 1945 to 1992 (as a percentage)***

| Source | Basis of commitment | Percentage |
|---|---|---|
| Natural sources | Current rate for 50 years | 76.58% |
| Medical exposure: | Current rate for 50 years | |
| Diagnosis | | 10.68% |
| Treatment | | 8.83% |
| Atmospheric nuclear weapons tests | Completed practice | 3.53% |
| Nuclear power | Total practice to date | 0.04% |
| | Current rate for 50 years | 0.20% |
| | *Total:* | 0.24% |
| Severe accidents | Events to date | 0.07% |
| Occupational exposure: | Current rate for 50 years | |
| Medical | | 0.005% |
| Nuclear power | | 0.01% |
| Industrial uses | | 0.003% |
| Defense activities | | 0.001% |
| Non-uranium mining | | 0.05% |
| *Sub-total (occupational exposures)* | | 0.07% |
| Total | | 100.0% |

***Annual exposures from natural sources***

| Source of exposure | Annual effective dose (mSv) | |
|---|---|---|
| | Typical | Elevated* |
| Cosmic rays | 0.39 | 2.0 |
| Terrestrial gamma rays | 0.46 | 4.3 |
| Radionuclides in the body (except radon) | 0.23 | 0.6 |
| Radon and its decay products | 1.30 | 10 |
| Total (rounded) | 2.40 | — |

* The elevated values are for large regions; even higher values occur more locally.

## Nuclear energy and radiation exposure

From the minute contribution of nuclear power to the committed (i.e. projected) exposure of the world population, the normal operation of nuclear power plants, in turn, accounts for just a fraction, the UNSCEAR report states.

The local and regional component of this exposure is a minor contribution to the total exposure, at around 1.5%. Of this, reactor operations account for less than half, and uranium mining, milling and tailings account for half. The major contributor is the so-called global component, which is dominated by the presumed effect of releases of long-lived radioactive materials. Radioactive releases due to mining and mill tailings — over the projected period of 10 000 years — are responsible for most of this global exposure, namely 75%. Radionuclides expected to be disposed of from reprocessing and solid waste disposal account for the other 25% globally. The global component from reactor operations is negligible in comparison.

It is important to note that the numbers in the tables shown here are derived from collective totals. They result from theoretical models that predict the summation of all individual exposures caused by an activity. However, individual exposures can vary widely. The fallout of radioactive materials due to nuclear weapon testing, for instance, has committed the world population to a roughly homogeneous exposure. The world average of occupational exposures, on the other hand, has little significance for the individual since only the relatively few workers exposed to radiation make up the sum. The individual exposures due to the normal operation of nuclear power also can be considered rather homogeneous because of the predominance of the global component; however, nuclear accidents have significantly delivered exposure to only a small fraction of the world population, and the global average should be treated with care. For the medical exposures, radiodiagnosis is relatively homogeneous throughout the world (most people have undergone radiographic analysis at some time in their lives). However, exposure to radiation for therapeutic purposes is incurred only by patients undergoing radiation treatment, who constitute a relatively small fraction of the population.

Even for natural exposures, the individual differences can be enormous — orders of magnitude between a person living in an uninsulated, unventilated house in a radon prone area having high levels of background radiation and a person living in a tropical area having low background levels of radioactivity.

***Note: In the table at left, exposures are expressed in millisievert (mSv), i.e. thousandths of the international unit of exposure, the Sievert. One mSv is the currently recommended annual dose limit for members of the public for exposures from practices under regulatory control.***

occurs only at high doses, or may transform cells and induce an increase of the epidemiologically-attributable stochastic effects (cancer induction or hereditary effects) to radiation. The biological annexes to the report concentrate on the mechanisms of radiation oncogenesis, the influence of dose and dose rate on stochastic effects, hereditary effects, radiation effects on the developing human brain and late deterministic effects in children.

All told, UNSCEAR reconfirms that:

- Clinically attributable deterministic effects occur only if a high threshold dose is exceeded. (These effects are easily preventable, since the threshold dose is much higher than the regulatory limits of radiation exposure.)
- The risk due to stochastic effects is extremely small. As a result, UNSCEAR states that radiation is a weak carcinogen, estimating that "about 4% of deaths due to cancer can be attributed to ionizing radiation, most of which comes from natural sources that are not susceptible to control by man".* The impact of radiation from peaceful nuclear activities is, as indicated, even substantially lower. ❐

*UNSCEAR recalls that even for the heavily exposed populations that survived the atomic bombing of Hiroshima and Nagasaki in 1945, "of 3350 cancer deaths, only about 350 could be attributed to radiation exposure from the atomic bombing".

**Forsmark nuclear power plant in Sweden.** ***(Credit: G. Hansson)***