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## ● *Forum*

# CONCEPT OF A "LIFETIME DOSE" OF 350 mSv

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*Abstract*—**After the Chernobyl accident, a number of radiation protection criteria for the early and intermediate phases of the accident were set up by the authorities to protect the public in affected areas. For the late phase, an intervention level of 350 mSv over a lifetime, the so-called 350-mSv concept, has been recommended by the National Council on Radiation Protection and Measurements (NCRP) in the USSR. This concept has been strongly criticized by opponents in the affected republics as being far too high and therefore inhumane. However, a lifetime dose of 350 mSv would impose on an individual an average annual risk of the order of $10^{-4}$ $y^{-1}$, which is lower than the annual individual risk due to nonradiation causes prevailing in many areas in the USSR. The basic radiation protection principles for nuclear accidents as recommended by the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) are at present very difficult to apply in the USSR because the concepts of risk and acceptable risk are rejected categorically. If, however, principles of justification and optimization had been used, the result might have shown that the present lifetime dose limit of 350 mSv, as an intervention level, is actually too low.**

## INTRODUCTION

BEFORE the Chernobyl accident there had been no nuclear accident in the world that had resulted in heavy, long-term contamination of rural areas populated with hundreds of thousands of people. Not surprisingly, there was no available international guidance on radiation protection criteria for dealing with such a long-term situation. Therefore, the National Council on Radiation Protection and Measurements (NCRP) of the USSR recommended a lifetime dose limit (LDL) of 350 mSv as an intervention criterion for countermeasures such as relocation of people from contaminated areas. The projected lifetime doses to comply with the limit would include doses to which the population had been exposed since 26 April 1986 and were to be considered the sum of internal and external doses accumulated during 70 y of life. If projected doses were expected to exceed this limit, countermeasures would be introduced.

The proposal of the 350-mSv lifetime dose limit created a heated discussion in those republics of the USSR affected by the fallout. The numerical value of LDL/70 = 5 mSv/y was compared to the International Commission on Radiological Protection (ICRP) dose limit of 1 mSv/y for the population, and on this ground the lifetime dose limit was claimed to be far too high and even inhumane.

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The discussion of 350 mSv as a lifetime dose, however, is questionable, at least as long as its adherents continue to hold outmoded views regarding our public hygiene. Exactly which principles of our approach to hygiene as an element in our public health arrangements have become out of date and make the whole system unacceptable as a justification for a lifetime dose will hopefully soon be apparent from what is discussed below. However, one thing should be noted: The criticism of the 350-mSv value that has recently been heard has not been accompanied by any well-substantiated proposal (i.e., of an alternative value) by its opponents that would seem valid and more acceptable. This is understandable too, however, since the same principles that have made our public hygiene of questionable value are, for that very reason, also a powerful tool in the hands of those who would categorically reject any dose as acceptable that is not equal to zero.

Under the terms that are typical of the USSR's approach to hygiene, no established dose limit could be regarded as anything other than safe. The 350-mSv limit does not fall in this category, if only because no such limit really exists: The effects of radiation have no threshold according to the concepts of modern radiobiology. Thus, we can only try to justify some level of exposure that is not "safe" in the currently accepted sense but that might nevertheless be acceptable in accordance with specific criteria.

A level exceeding what is "safe" (according to those arbitrary criteria) would be unacceptable and would accordingly call for intervention. One of the intervention measures designed to prevent violation of the acceptable limit (but certainly not assuring any unattainable "absolute" safety) is evacuation of the population from the affected region. Indeed, any proposed limit should be regarded only as an intervention level, and the 350-mSv lifetime dose is no exception. This concept may seem vague or undefined, but only from the standpoint of the approach to hygiene by scientists in the USSR, which, unlike the rest of the world, does not recognize such concepts. This lack of recognition makes it impossible to justify any lifetime dose limit in terms of knowledge accessible to us at present.

## RADIATION PROTECTION PRINCIPLES

Where our own radiation protection principles fail, it becomes acceptable to fall back on the experience of the rest of the world. In 1977, the ICRP espoused these goals (ICRP 1978): "The purpose of radiation protection must be to prevent harmful nonstochastic effects (purpose 1) and to limit the probability of occurrence of stochastic effects to levels which can be considered acceptable (purpose 2)."

The world community accepts these purposes generally in the same way, regardless of the group of people exposed to radiation effects and regardless of the source of the radiation.

Nonstochastic effects have a threshold. With regard to the aim of preventing such effects, the validity of the 350-mSv lifetime dose limit should not raise any doubts after the international study carried out by the ICRP (1987) reporting the consequences of medical exposure to radiation. From this work it is clear that at an annual dose limit of 5 mSv, nonstochastic effects do not occur, even with a lifetime exposure at this rate—and even assuming a number of violations of the dose limit. We can be quite confident in saying that justification of the above "concept" has not, in fact, gone far beyond the limits set by multiplying 5 mSv $y^{-1}$ by 70 y. The author points out that a "concept" should normally imply more than simply multiplying two familiar figures together; in other words, the concept of "lifetime dose" is merely an alternative way of stating that the average annual dose limit will not exceed 5 mSv $y^{-1}$.

Attaining the second of the two goals mentioned above for radiation protection does not yet have solid roots within the framework of the "concept." But then, it would be impossible to achieve this goal if we insisted on adhering to our domestic approach to public hygiene, which still takes into account neither objective scientific knowledge nor the abominable realities of the present state of our environment. The first of these, objective scientific knowledge, has long recognized the thresholdless action of radiation, which can induce, even at the lowest possible doses, late effects—mutagenic and cancer-inducing. It is important to remember that these effects constitute the only source of damage to individuals exposed to low radiation levels (UNSCEAR 1977, 1986).

The second element on which radiation protection (of any and all groups of people) is based consists of limiting the risk (probability) that such effects will occur to the lowest possible level achievable by modern technical and social means. This is the ALARA (as low as reasonably achievable) principle, and it was instituted in a place where the economic mechanisms and infrastructure of society (including public health) are indeed placed at the service of individuals.

## RADIATION PROTECTION PRINCIPLES IN THE USSR

The principles underlying hygiene in the USSR have always been based, and continue to be based, on unconditional recognition of a threshold for inducing all types of effects and an equally categorical rejection of the existence of any risk from low levels of exposure. This principle is intended to apply to all harmful agents present in the environment: "Any departure from the threshold principle inevitably leads to adopting the concept of 'acceptable risk'. . . notions about 'socially acceptable risk' stand in contradiction to evolutionary theory and to the principles of public health in a socialist society" (Izmerov et al. 1984).

From a scientific viewpoint, the above quotation, like other similar ones, is a piece of nonsense. We demonstrated this repeatedly in previous publications (Filyushkin 1983; Filyushkin and Petoyan 1988). However, that does nothing to diminish the administrative weight these ideas have brought to bear: Any public health worker in a socialist society has only to look at the list of authors in Izmerov et al. (1984) to realize that the principles they stated up to 1984 would be put into effect without questioning.

The rejection by those in charge of administering public hygiene in our country of any effects (or risk) due to low levels of harmful agents will clearly not have done anything to reduce the actual effects of such agents on healthy people. Moreover, this approach has made it impossible to apply categories such as "risk" due to low levels of radiation, "risk control," and "socially acceptable risk," which are the only categories that offer a realistic basis for a rational limitation of risk, rather than simply ignoring it. Another unfortunate effect of this policy of ignoring the true harm to health resulting from our long-ruined environment has been a sort of ecological illiteracy among the USSR population.

All this has made it impossible to provide a convincing justification not only for the lifetime dose but for any other radiation protection rules following nuclear accidents; such rules are objectively aimed at limiting risk, and this criterion simply did not exist among the principles of "socialist" hygiene enshrined in law. Further, if a justification cannot be made convincing, it is perceived as invalid. This is, in fact, the source of many of the misunderstandings that still persist in connection with the radiation protection standards applied after the Chernobyl accident, and the 350-mSv lifetime dose is no exception.

To apply in the USSR the ALARA principle developed in the West is not easy. For example, it would surely prove unacceptable to apply the logic of a benefit-harm (cost-benefit) analysis (ICRP 1985). This type of analysis compares the benefit obtained by applying measures to protect a group of people—for example, resettlement—with the costs required to implement those measures. If the level of the risk to be avoided is too low (e.g., a low intervention level), then the indirect harm accruing from excessive expenditure of resources outweighs (even for the group to be protected) the immediate benefits of resettlement. From here we arrive at what is called the "optimal" intervention level, where benefit and harm balance each other perfectly.

This logic requires a thorough knowledge of the country's economic mechanisms, and this is something even our leaders cannot boast of. It also assumes that due allowance will be made for benefit accruing indirectly to all people (including those requiring protection) from savings realized on radiological protection measures. At this point we need confidence in the social institutions of the country, but what person who has suffered from a nuclear accident is likely to believe that economic resources allotted for his protection will be spent in his interest and not get lost in an inflated budget.

## THE RISK COMPARISON APPROACH

Also possible, however, is an approach based on comparing the risk among the group requiring protection with a risk already in existence among some comparable group. This is, for example, the basis on which ICRP Publication 26 (1978) justified the dose limit of 50 mSv $y^{-1}$ for occupationally exposed persons. The calculated radiation risk derived from this dose limit proved to be 1 in 10,000 $y^{-1}$, which corresponds to the traumatic risk prevailing in the safest branches of industry.

The selection of a group comparable to those who have suffered from the Chernobyl accident turns out to be simpler than it might seem at first. We have only to recall that the Chernobyl catastrophe, for all its unique scale and consequences, did not create but merely enlarged the ecological disaster zone that has been encompassing our territory for a long time.

In the period 1981–1985, mortality from malignant tumors was reported as 150 cases per 100,000 population per year (Dvojrin et al. 1988). If we accept figures that indicate that, in our ecologically damaged cities, cancer mortality is at least 30% higher than this (Buldakov 1991), we realize that the technogenic cancer risk alone in these places will be at least $0.3 \times 150 = 45$ cases per 100,000 per year. All people living in such ecological conditions (and there are tens of millions of them) need an improved environment. And what benefit would be due those who fell victim to the accident if the lifetime dose limit of 350 mSv were, in fact, accepted and implemented? Where would they be ranked in the three categories so familiar to us: the general population, those who warrant special consideration, and those who are singled out for special treatment even among this last group?

The approach proposed appears unscientific or, at the very least, unsuitable from a medical point of view. This is perfectly natural; after all, an "acceptable" radiation risk can be justified only in terms of social categories that must not only consider the production potential and resources of the country but must also be consciously perceived as meaningful within the framework of the country's economy and its political system. In our present situation, this last factor is obviously very important. Who among us has not been placed in some socially advantaged category conferring, for example, the right to a house or a hospital bed simply because of the situation in which we find ourselves. It would be inhumane to set a lifetime dose so high that it placed the victims of the accident at the bottom of the ecological rank and file. Evaluations of other kinds are perhaps rather less obvious, but where would they be, in fact, if the 350-mSv lifetime dose were adopted?

The coefficient of radiogenic cancer risk resulting from the exposure of the population to large radiation doses at Hiroshima and Nagasaki has been assessed at about 0.042 deaths per Sv according to the "absolute" risk model (UNSCEAR 1988). Extrapolation of this factor to low radiation levels requires a correction (NCRP 1989), the so-called dose rate effectiveness factor (DREF), to reflect the decrease in the risk coefficient for low dose rates of low-level radiation. This dose rate effectiveness factor has been assessed variously at 2–10 (UNSCEAR 1988), 3 (NCRP 1989), or not less than 5 (Filyushkin et al. 1988). Consider, for example, a DREF = 4. The action of other harmful factors that can exercise a synergistic effect along with radiation is considered by applying the so-called "relative" risk model (UNSCEAR 1988). The upper boundary will be a doubling of the risk coefficient compared to the one derived from the "absolute" risk model.

The risk coefficient applicable to a situation in which the normally accepted principles in the USSR apply will thus be $0.042 \times 2/4 \simeq 0.02$ per Sv. For a group-averaged dose of 350 mSv over 70 y (or, on average, 5 mSv per year), the excess mortality rate due to radiation-induced cancer would be no more than 10 cases per 100,000 population per year. However, 350 mSv is not an average lifetime dose but a dose limit. If the limit were observed, the actual average dose would be several times less. Accordingly, anticipated mortality from radiation-induced cancer would not be 10 cases per $10^5$ per year but much lower, corresponding to the actual average dose.

This means that the 45 deaths per $10^5$ population per year characteristic of our ecologically (or, to be more precise, chemically) damaged towns would be comparable, according to this criterion, to a lifetime radiation dose of 1.5–2 Sv or higher. Similarly, residents in the merely "gassed" regions and towns (let us say Moscow) would correspond to at least 0.6–1 Sv, but needless to say, there are no plans to "relocate" towns with a ruined environment. The most we can hope for is some improvement in the situation, and even that is obviously not going to come about in the near future. Hence, all that our customary social criteria would seem to suggest is that 350 mSv as a lifetime dose limit would mean weighting the population very definitely toward the socially privileged in regard to improvements in ecological conditions.

As shown, we have used a single indicator—technogenic cancer risk—as our measure of ecological misfortune. However, a complete evaluation would need to consider other no less important indices of medical risk such as mutagenesis and teratogenesis. But if radiation or chemical exposure results in equal carcinogenic risk, there are weighty reasons to believe that genetic and teratogenic harm from the latter would be far more considerable: Contrary to popular belief, radiation is a comparatively "weak" mutagen. Accordingly, if these indices were also considered in our evaluation, the results would shift even more definitely toward "chemical" damage to the environment.

Finally, comprehensive assessments of ecological conditions, whether good or bad, require reliable registration, analysis, summarization, and publication of epidemiological data on the indices of congenital pathology in children—data at least as thorough and complete as those collected for cancer statistics. But this is still something for the future. Until quite recently, our common and communal approach to public hygiene treated this material as "confidential"—in much the same spirit as the blind principles that rejected the thresholdless nature of radiation effects, i.e., the existence of effects from harmful factors operating at "low" levels that have plagued our environment for a long time and that, in a sense, have brought about our present lamentable public health situation.

## CONCLUSION

Based on the analysis of the public health situation prevailing in the USSR as well as on international recommendations in radiation protection, the following conclusions on setting intervention levels for protecting the public after the Chernobyl accident have been drawn:

1. Radiation regulations, including intervention levels, have the purpose of limiting radiation risk to a level considered acceptable in light of "social" criteria.
2. One way of establishing and justifying an acceptable level of radiation risk is to compare it with more general ecological conditions in the country, for example, levels of regional medical risk due to environmental chemical contamination.
3. Taking these considerations into account, we conclude that the lifetime dose limit of 350 mSv, as an intervention level, actually may be far too low, in contrast to the notion that has gained credence among the public that it is far too high and therefore "inhumane."

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