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Evacuation in case of a nuclear power plant accident – Discussion of some ethical questions



Friedo Zölzer*

University of South Bohemia in České Budějovice, Faculty of Health and Social Studies, Department of Radiology, Toxicology and Civil Protection, České Budějovice, Czech Republic

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ABSTRACT

Although the probability of a nuclear power plant accident in the Czech Republic is considered to be extremely low, authorities and citizens have to be prepared. An important part of emergency preparedness is the provision of clear guidelines for the possible evacuation of people from areas of radioactive contamination. In this context, different types of questions need to be addressed: What are the health risks that people remaining in a contaminated area would have to face? When are people to be evacuated, i.e. which radiation levels warrant action? Who is to be evacuated first, i.e. which groups, if any, should take precedence? What are the ethical principles that determine the when and who? This latter question is addressed here. The paper looks at the guidance given by the relevant public documents and identifies a number of ambiguous and contradictory points. It recommends that decision-makers are provided with additional information and are made aware of the ethical aspects of their decisions. It suggests that classical ethical theories such as utilitarianism and deontology can be taken into consideration, but that in an age of globalization a cross-cultural approach may be more appropriate.

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Introduction

Nuclear power plant accidents are rare events. In about 50 years of civil nuclear power, there have been two events that have led to a major release of radioactive material and have necessitated large-scale evacuation of contaminated areas – Chernobyl in 1986 and Fukushima in 2011. These two have been categorized as “Level 7” accidents, i.e. accidents “with widespread health and environmental effects requiring

implementation of planned and extended countermeasures” [1]. That it was “only” two such events does not mean, of course, that there would be nothing to worry about, or that one major accident world-wide every two-and-a-half decades would be acceptable. It just shows that we have very little experience with such events and do not know everything we would need to know about their prevention and the prevention of health and environmental consequences.

* Correspondence to: University of South Bohemia in České Budějovice, Faculty of Health and Social Studies, Department of Radiology, Toxicology and Civil Protection, Emy Destinové 46, 370 05 České Budějovice, Czech Republic. Tel.: +420 389 037 590.

E-mail address: zoelzer@zsf.jcu.cz

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Chernobyl and Fukushima both involved a meltdown of the nuclear core, but in the course of the 50 years of nuclear power there have been at least nine other accidents with complete or partial meltdown [2]. This is an order of magnitude more than what used to be expected in the 1970s, when risk analyses suggested that there could be one accident with core damage in 10,000 [3] or 20,000 [4] reactor-years; the eleven accidents just mentioned occurred within 14,500 reactor-years worldwide. But considering the huge uncertainties in the calculations, perhaps one order of magnitude is not that far off after all. Anyway, with today's advanced reactor technology and the experience from a number of real accidents, the frequency of core damage events is now assumed to be in the order of 2–5 in 100,000 reactor years [5,6], if not even smaller than 1 in 1,000,000 reactor years [7]. For modern central European reactors such as those in the Czech Republic these estimates may indeed be reasonable, but it must also be noted that the assessments usually consider technical and natural risk sources, whereas they cannot really take account of things like terrorist assaults, internal sabotage, or cyberattacks. And there may be risk factors that we are not even thinking of. After all, the combined effects of technical shortcomings and human failure in Chernobyl, and of natural disaster and wilful negligence in Fukushima came as a surprise to most experts.

So, we cannot deny that there is some uncertainty about the uncertainties, even though the probability of another “Level 7” event would still seem to be extremely small. There is no other option than preparing for the day that will hopefully never come. National and regional authorities have to carry out emergency planning for the case of a major release of radioactivity from a nuclear power plant. This paper addresses ethical questions which arise in this context, especially with respect to evacuation from contaminated areas. It takes as a starting point a number of official documents of emergency preparedness in the Czech Republic, such as the Decree 307/2002 on Radiation protection [8] and the Evacuation plan within the External emergency plan for the Nuclear power plant Temelin [9].

Some notes on applied ethics

Ethics according to a standard Czech Dictionary is a philosophical discipline which analyses “views on morality, on the origin and nature of moral consciousness and behaviour”. Morality on the other hand means “a set of conventions and rules of conduct that are considered binding for the individual conscience” [10]. So while morality descriptively refers to what is acceptable behaviour in a society, ethics analyses the underlying principles, values and norms. It is therefore somewhat misleading to speak about ethics as if it was something that unambiguously and objectively tells us what to do and what not to do. There is no one “ethics” that must be reasonably accepted by everybody. There are rather a number of different schools of ethics or ethical theories which try to find one or at least no more than a few principles that in any given situation tell us what is right and what is wrong.

Just two of these theories will be mentioned here, because they are the most discussed when it comes to radiation risks. One of them is “utilitarianism”, which judges right and wrong on the basis of what is useful (Latin “utilis”). We should do

what leads to the best balance of pleasure over pain, or – in other words – “the greatest happiness for the greatest number of people”. Motives of people's actions are of no importance. What counts is only the outcome of our actions or of the rules that guide them. This theory was developed by Jeremy Bentham (1748–1832) and John Stuart Mill (1806–1873) in England and so it has been most influential in the Anglo-Saxon world. An alternative concept is “deontology”. It proceeds from the concept of “duty” (Greek “deon”). Our fundamental duty, according to the most common version of the theory, is to “treat humanity, whether in your own person or in the person of any other, never merely as a means to an end”. In other words, even if it would lead to more happiness overall, we should not exploit some individuals for the benefit of others and thus violate their individual rights. That was the advice of Immanuel Kant (1724–1804), and as he was German his theory has been of greatest influence in central Europe.

It is easy to see that the two theories can sometimes be at odds with each other. If, for instance, we asked a few individuals to remediate a radioactively contaminated site we might reduce the health risk of many others and so, by the logic of utilitarianism, should be ready to “sacrifice” those few. Deontological ethics would not find that acceptable and would rather recommend distributing the risk as fairly as possible, in which case however the health of many more people would be at risk. It has been argued that the principles constituting the recommendations of the International Commission of Radiological Protection [11] are based partly on one and partly on the other ethical theory outlined here, which may cause problems when a decision has to be taken in a concrete situation.

Apart from the incompatibility between utilitarian and deontological arguments, however, a more fundamental question needs to be asked: is it at all appropriate in a more and more globalized world to base the international system of radiation protection on ethical theories developed in Europe during the era of enlightenment? Less than 30% of the world's population is living in Europe and the Americas, but over 50% in Asia and another 20% in Africa and the Middle East. Can we really expect the majority of mankind to accept principles developed in a conceptual context largely alien to them?

I have argued elsewhere [12] that rather than basing our system of radiation protection exclusively on certain theories of “Western” ethics, we should work towards a “cross-cultural” concept, and I see a model of this in the “principles of biomedical ethics” developed by Beauchamp and Childress [13]. They propose four principles which in their view form the basis of all decision making in medical practise:

1. Respect for autonomy: Let people choose for themselves!¹
2. Non-maleficence: Do not harm!
3. Beneficence: Do good!
4. Justice: Be fair!

¹ Beauchamp and Childress relate “autonomy” mainly to “individual decision making”, but there is some debate as to whether this can be considered a cross-culturally agreed understanding [13], and “human dignity” has been proposed as a more widely accepted and broader concept [12,17].

These principles they assume to be rooted in a “common morality”, which is “not relative to cultures or individuals, because it transcends both” [14]. Initially, Beauchamp and Childress were not speaking about different cultures. They were just trying to find middle-level principles that the former as a utilitarian and the latter as a deontologist could agree to without referring to one single, more fundamental principle, such as usefulness or individual rights. It is not that the utilitarian and the deontologist each contributed one or more principles which the other had to accept in exchange of getting some of his own ideas through. Rather both could fully agree with all four principles, albeit for different reasons [14].

It can indeed be shown that the four principles of bioethics are respected in many different cultural, religious and philosophical contexts around the world [12]. And they have been applied in contexts other than biomedicine as well [15,16]. In particular, it has been argued that they can be used to back-up the recommendations proposed by the International Commission of Radiological Protection – as an alternative to the exclusively “Western” concepts outlined before [12]. The recently established Task Group 94 of the International Commission on Radiological Protection on “Ethics of Radiation Protection” is currently preparing a document in which this approach will feature prominently [17].

In the following I will therefore look at certain ethical aspects of the existing regulations for evacuation in case of a nuclear accident from the perspective of either the “classical” theories of European ethics or the proposed “cross-cultural” conceptual framework. In doing so, I hope to clarify, on the one hand, how the relevant documents address some fundamental ethical issues, and on the other hand, where they could be more explicit and helpful to decision makers in emergency situations.

When to evacuate

The Evacuation plan within the External emergency plan for the Nuclear power plant Temelin states at its very beginning that:

“Evacuation is an emergency measure that is introduced under the conditions specified in Decree SÚJB 307/2002, which lists values of intervention levels for evacuation. The aim of evacuation during a radiation accident is to avoid exposure to excess radiation doses and to permit an orderly relocation of people from the endangered zone.”

That sounds clear and straightforward, yet when we look into the relevant Decree SÚJB (State Office for Nuclear Safety) 307/2002 we find that things are less unambiguous. In ½ 99 it says that

(1) Urgent protective measures are always considered justified if the estimated exposure of any individual could lead to an immediate harm, and therefore urgent protective measures are always implemented if it is expected that the absorbed doses for any person could within two days exceed the levels specified in Table 1 in Annex 8.

(2) If urgent protective measures for a maximum of seven days could prevent or reduce exposure of a critical group in the range exceeding the lower constraints for the values of intervention levels specified in Table 2 of Annex 8, then the implementation of protective measures is considered in the light of the scope, feasibility and costliness of the measures and their possible consequences; if the upper constraints are exceeded, protective measures are usually introduced.

The first of these tables gives distinct dose values which should not be exceeded, and the decree even says why: the exposure of any individual should not “lead to an immediate harm”. Acute radiation sickness is known to occur only above a certain threshold dose, which for whole-body exposure of adults is around 1 Sv and that is exactly the dose value given for the maximal acceptable dose in this case.

The second table mentioned in the above quoted paragraph, however, is not as definite: it gives dose ranges in which the authorities should “consider” sheltering and iodine prophylaxis (5–50 mSv) or evacuation (50–500 mSv). Below the lower constraint these measures are not considered necessary, above the higher constraint they are obligatory. It may be interesting to note that the percentage of exposed individuals expected to die from a radiation induced tumour is about 5 among 10,000 exposed individuals for 5 mSv, 5 in 1000 exposed individuals for 50 mSv and 5 in 100 exposed individuals for 500 mSv.² In other words, only if more than 5% of the population must be expected to develop a fatal tumour as a result of radiation exposure is it considered absolutely necessary to evacuate.

That in itself is of course quite debatable, but it stems from the recommendations of the International Commission on Radiological Protection and thus the debate would have to be led on a different level. My concern here is with the authorities on the ground. The decision of whether to evacuate or not in the range of doses between the lower and the higher constraint is with the County governor. He will of course get advice from the Emergency task force, but in the end he will have to decide [internal documentation of the Fire and Rescue Service of the County of South Bohemia]. And the question is, how? The quoted ½ 99 of Decree 307/2002 gives an indication: “the implementation of protective measures is considered in the light of the scope, feasibility and costliness of the measures and their possible consequences”, but ½ 92 [similarly ½ 98 (2)] says it much clearer:

(2) The intervention is carried out if it is justified by an expected reduction in the health detriment that outweighs the costs, including social costs, and damages resulting from the intervention.

(3) The form, scope and duration of the intervention is to be optimized in such a way that the benefit from the reduction

² Strictly speaking this estimate applies for acute radiation exposure, whereas twice smaller values are considered appropriate for chronic irradiation by the International Commission on Radiological Protection. A number of studies, however, have recently cast doubt on the assumption that such “dose rate reduction factor” is applicable for the exposure of humans [18,19].

in the health detriment, after deduction of costs and damages associated with the intervention, is maximized.

To come back to our question of the ethical basis of decision making in case of evacuation, the wording of Decree 307/2002 clearly reflects utilitarianism: the benefit of an action has to be greater than the harm caused by it, and the balance of benefit over harm should be maximized. Here we see the two first principles of radiation protection at work, the principle of justification (“No practice should be adopted unless its introduction produces a positive net benefit”) and of optimization (“All exposures should be kept as low as reasonably achievable, taking into account economic and societal factors”). The problem with all this, of course, is that we do not know how to balance health detriment and death on the one hand, and economic and societal factors on the other. In the 1970s there were some attempts at cost-benefit analysis in the context of radiation protection, including suggestions of how to assess the “value of a statistical life”. But apart from the fact that this value proved hard to determine unambiguously for different situations (values between 1 and 20 million dollars are to be found in the literature [20]), it was realized that health and money are rather incommensurable and not much is heard about this approach any more.

If we abandon utilitarianism at least for the moment, and look at cross-cultural principles which might help us out, we realize that indeed the principles of non-maleficence and beneficence are of relevance here. “Do no harm!” would seem to be a valid advice not only to the physician treating a sick person, but also to the governor dealing with a nuclear accident. But in order to “Do good!” even the physician has to sometimes harm his patient, healing can sometimes only be achieved by some painful intervention (think of surgery or chemotherapy). This is what we call balancing of non-maleficence and beneficence. Admittedly, it does not seem to be very different from the utilitarian argument that the benefit of any action has to be greater than the harm caused by it, but thinking in terms of “Do no harm!” and then “Do good!” may focus the decision maker's attention more on people's needs than on financial and political arguments.

Summary and recommendation: The criteria for evacuation from radioactively contaminated areas are not unambiguously defined in the relevant official documents. Within a certain range of doses, the decision is with the governor. In order to decide responsibly, he needs to be provided with (1) scientific information about the health risks at the doses involved and (2) ethical principles which could be applied. Given the recent tendency in the ethics of radiation protection to look for globally accepted principles, the consideration of cross-cultural ethics, emphasizing non-maleficence and beneficence, should be recommended.

Whom to evacuate

The Evacuation plan stipulates under the heading “Extent of the evacuation” that “Evacuation applies to all persons in the hazardous area with the exception of persons who will participate in the implementation of rescue and relief work during evacuation or will engage in other emergency activities. Priority is given to the following groups:

- children under 15 years;
- patients in healthcare facilities;
- individuals living in social institutions;
- disabled persons;
- career of the aforementioned”.

Similarly, the Decree SUJB 307/2002 mentions that “By data specific to the determination of intervention levels (...) are also meant data characterizing the settlement (...) in the vicinity of the source of ionizing radiation and data having an influence on the expected collective effective doses (...) especially

- (a) the presence of specific groups in the population, particularly in hospitals, senior homes, nursing homes, and prisons”.

These provisions can be seen as a reflection of deontological ethics which, as outlined above, is mainly concerned with the rights of the individual. A modern version of deontological ethics is the “Theory of Justice” by John Rawls (1921–2002) who stated that “(1) Each person is to have an equal right to the most extensive basic liberty compatible with a similar liberty for others and (2) Social and economic inequalities are to be arranged so that they are to be of the greatest benefit to the least-advantaged members of society” [21]. Certainly, a strictly utilitarian approach would not attach much importance to the care for those who would be expected to contribute relatively less to the commonweal.

It is a point open to discussion whether the concern for the underprivileged is a necessary part of deontological ethics, but it certainly resonates with the principles of cross-cultural ethics. In the written and oral traditions of different cultures around the world there is a strong focus on the young, the old, the sick, the poor, and the down-trodden. This could be seen as striking a balance between justice on the one hand and human dignity on the other, which are both foundational components of “common morality”.

A problem in this context is the focus of the official documents on dose, as outlined in the section about “When to evacuate”. For children, the doses at which evacuation should be considered would need to be much smaller than those for adults, because to the best of our knowledge children under the age of 5 have an at least 5 times higher radiosensitivity than 50 year old adults [22]. As it would probably be unacceptable for most families if their children were evacuated separately, provisions would have to be made for whole families with children to take precedence.

For elderly people, however, dose may not be of primary concern, because the latent period between radiation exposure and the appearance of a tumour is 5–15 years in the case of leukaemia and more than 20 years in the case of most solid tumours [23]. At an advanced age, therefore, the exposed person may not have a life expectancy long enough for tumour induction to be a major concern. At the same time, evacuation itself may bring with it significant health risks for this group. After the Fukushima accident, for instance, dementia patients were evacuated from two facilities in the area, and 50 of the 436 evacuees died due to the emergency procedure itself, presumably because of stress and insufficient care [24]. Of course, the evacuation in this case seems to have been carried

out in a professionally insufficient way, but the fact remains that for this group of people it would have been better health wise to stay where they were. Another consideration, then, would be the risk from radiation exposure to the care personnel who cannot be expected to carry an undue extra burden of radiation exposure. A solution might be in a carefully planned and cautious evacuation not immediately, but in its own good time. In general, elderly people may have their own priorities. They may want to keep their home and heritage, and may not be concerned with a cancer-free life years ahead [25]. Certainly that means that “special attention to the elderly” does not necessarily translate into “the elderly have to be evacuated first”.

Summary and recommendations: The stipulation that certain groups within the population should have precedence when it comes to evacuation is in line with well-established Western as well as cross-culturally accepted ethical principles. Its application to a concrete situation, however, is not without problems. The focus on radiation doses instead of health risks can lead to undesirable results, especially for children and elderly people. The relevant documents should be amended to adequately address the differentiation of radiation risks within the population. Decision makers such as the governor need to be made aware that human dignity and justice may require attention to criteria other than dose.

Conclusion

Decision making in the case of a nuclear power plant accident is not an easy task. Even though radioactive contamination and radiation exposure can be quite reliably determined and the pertinent health risks are relatively well known, those that have to take action for the protection of the affected population will need more than scientific information and technological know-how. We have looked here at some ethical aspects of evacuation around a wrecked nuclear installation. The official documents relevant to such a case not only leave considerable space for the responsible country governor on the question of when to evacuate, they also fail to give clear guidance on how to balance health risks and other economic and societal factors. The question of whom to evacuate seems to be less ambiguous at first sight, but a more detailed discussion reveals that the principle of “precedence for the least advantaged” may have to be differentially applied for some of the groups mentioned. Certainly, these questions require a discussion of the principles, values and norms that could guide decision making.

The ethical guidelines themselves are not established once and for all. One or the other “classical” school of ethics – utilitarianism, deontology – may seem more acceptable for people from different backgrounds, and even the “common morality” way of thinking may not find universal approval. Principles, values and norms are a matter of choice, and there is no rational argument that can force the individual decision maker to follow a particular kind of ethics. And whatever principles, norms and values are chosen, their application to the particular situation at hand will have its own challenges.

I therefore venture to suggest that in a pluralistic society the only way around this problem is a participatory approach.

It seems anachronistic to me to leave such difficult decisions as the ones discussed above to one person, the county governor, even though he may receive advice from a group of advisors. A broader representation of stakeholders seems desirable. Participatory technology assessment has been discussed and in a number of cases practically applied for almost 50 years now [26]. The experience gained in this context, particularly with the assessment of nuclear technology, can and should be built upon [27]. Similarly, a participatory approach has found entrance into public health risk communication and decision making, where “best practice” is described by a leading expert as follows: “Demonstrate respect for persons affected by risk management decisions by involving them early, before important decisions are made”, “Let all parties with an interest or a stake in the issue be heard”, “Before taking action, find out what people know, think, and want done about risks. Use techniques such as interviews, facilitated discussion groups, information exchanges, availability sessions, advisory groups, toll-free numbers, and surveys” [28]. In my view, that must include an explicit discussion of ethical principles that can be applied, not just the sharing of information about the emergency situation. Experts on ethics are therefore as much needed as experts on the scientific and technological aspects of a nuclear accident.

Conflict of interest

The author has no conflict of interest to disclose.

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