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Eidgenössische Kommission für Strahlenschutz
Commission fédérale de radioprotection
Commissione federale della radioprotezione
Federal Commission on radiological protection

Approved on 15.3.2022

KSR Recommendation
Risk Communication for Ionizing Radiation

1 Introduction and goal of this document

Communicating about risk related to ionizing radiation is not limited to incidents in nuclear power plants or to radioactive waste management. Current examples in Switzerland include radon in dwellings, past use of radium painting, the application of contact shielding in medical diagnostic imaging using x-rays, or simply the consequences to be drawn from the annual report of the Federal Office of Public Health (FOPH) on the annual dose to the population (see Figure 1 [1]). As the covid-19 pandemics reminds us every day, the way risk is communicated has an important influence on the behavior of the population and the degree of trust in the advice and instructions from the authorities.

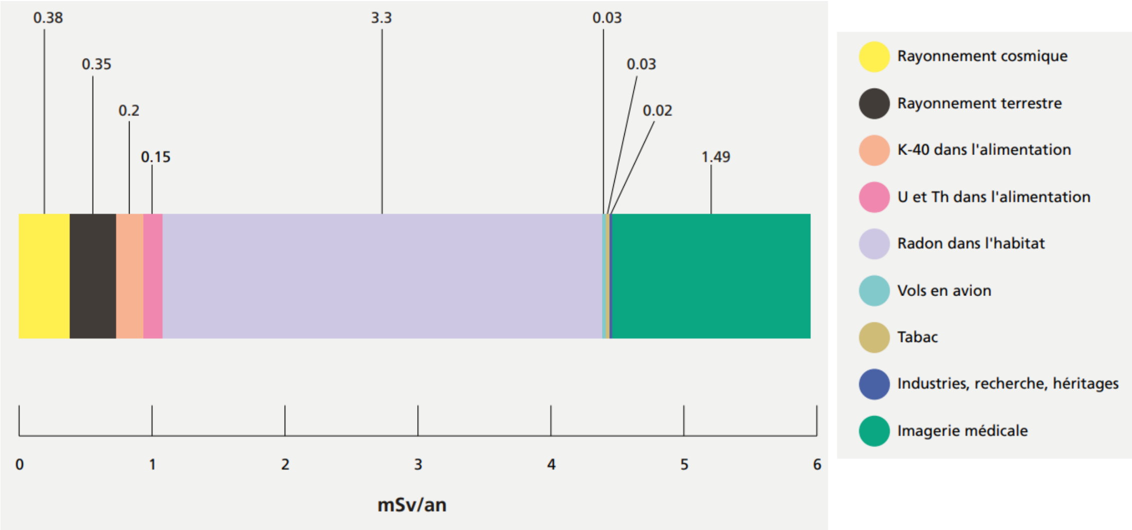

Figure 1: Annual average effective dose to the Swiss population [1]. The total value is approximately equal to 6 mSv/year.

The question of how best to deal with the form of the communication is present each time the Commission for Radiation Protection (KSR) publishes a recommendation or writes a position statement. This is not new. In the wake of the Fukushima accident, the KSR organized a seminar on perception and communication of radiological risk during an incident [2]. This led to the following recommendations:

- *In future, the basic and advanced radiation protection training that is recognized by the supervisory authorities (FOPH; Swiss National Accident Insurance Fund, SUVA; Swiss Federal Safety Inspectorate, ENSI) should also encompass the psychological aspects of hazard perception and communication.*

- *The supervisory authorities should actively prepare for communication during a radiological incident by preparing answers in all the national languages. Questions that have been rephrased in connection with the Fukushima incident should also be considered.*
- *Those facilities, businesses and hospitals overseen by the supervisory authorities should, for their part, prepare a list of Q&As to answer any questions raised by a possible radiological incident.*
- *An involvement of the news media in practice runs should increasingly be considered.*

Recently, several documents on risk communication were made available in the fields of radiological protection in general [3], medical imaging [4] and preparedness and response for a radiological emergency [5], as well as a special issue of the journal *Risk Analysis*, in the context of the 40th anniversary of the *Society for Risk Analysis* (SRA) [6]. This led the KSR to decide that time was ripe to write a general position statement on risk communication related to ionizing radiation.

The goals of this document are the following:

- To summarize the present knowledge on risk communication in general with emphasis on radiological protection.
- To propose a set of recommendations to the federal and cantonal authorities (regulators, federal and cantonal offices) and the professionals (radiation protection experts, heads of institutions, spokespersons) regarding risk communication, with practical examples relevant to Switzerland.

2 Definition of risk

2.1 General definition of risk

According to ISO, risk is broadly defined as *the effect of uncertainty on objectives* [7]. An effect can be positive, negative, or both, and results in opportunities and threats. A risk is generally expressed in terms of sources of risk (e.g. a medical examination), potential events (e.g. a genetic mutation induced by ionizing radiation) with their consequences (induction of cancer) and their likelihood (i.e. probability to induce a cancer).

The SRA [8] proposes a variety of definitions that can be very general, like "*the risk is the possibility of an unfortunate occurrence*", to something closer to the ISO definition like "*the risk is the occurrences of some specified consequences of the activity and associated uncertainties*". It is worth mentioning that for the SRA the consequences often focus on negative, undesirable consequences. There is always at least one outcome that is considered as negative or undesirable. Several metrics can be used to quantify the risk. For instance:

- The combination of probability and magnitude/severity of consequences:

  For example, the annual probability that a water dam will break and the number of expected deaths.
- The expected consequences:

  For example, the expected number of fatalities in a period of one year (Potential Loss of Life, PLL)

2.2 Definition and quantification of risk in radiological protection

There are numerous ways of quantifying a risk in radiological protection. Although they usually contain the word “risk”, they can have very different meanings and if the precise term is not well defined, it can lead to misunderstandings. The National Council on Radiation Protection and Measurements (NCRP) report N°185 [4] proposes the following definitions (with the exception of LBR):

- **Absolute risk** (AR) refers to the rate of disease in a population. It is the incidence rate or mortality rate of disease in an exposed or unexposed population. Absolute risks vary according to many factors, including baseline variables (such as age and sex) or by dose level when doses are heterogeneous among an exposed population.
- **Relative risk** (RR) is the rate of disease in an exposed population divided by the rate of disease in an unexposed population. It is also termed rate ratio. An RR of 1.10 indicates a 10 % increase in disease from radiation, compared with the “normal” occurrence. A RR compares the probability of an adverse event or disease in different groups, such as a group enrolled in a treatment or screening program versus a comparison group that does not receive treatment or screening.
- **Excess absolute risk** (EAR) is the difference in the rate of disease between an exposed group and an unexposed group. It is usually expressed as the arithmetic difference between the incidence or mortality rate of disease among those exposed (or those exposed to specific exposure levels) and those not exposed.
- **Excess relative risk** (ERR) is the rate of disease in an exposed population divided by the rate of disease in an unexposed population minus 1.0 (i.e., ERR = RR – 1). ERR is an expression of excess incidence or mortality rates among the exposed relative to the underlying (baseline) rates.
- **Lifetime attributable risk** (LAR) is the excess risk of an adverse event or disease that is attributable to an agent, such as radiation, expressed throughout the lifetime of the exposed population.
- **Lifetime Baseline Risk** (LBR) is the cumulative risk over lifetime of an adverse event or disease that is applicable to an unexposed population any normal circumstance.

All these definitions of risk compute the expected consequences of an exposure. They do not compute combination of probability of an event and the magnitude/severity of its consequences. This contrasts with article 123 of the Swiss Radiological Protection Ordinance (RPO) [9], which deals with the acceptable risk in terms of expected frequency per year of an event and a maximum effective dose for members of the public.

3 State of the art in risk communication

3.1 Definition of risk communication

Risk communication can be broadly understood as an iterative exchange or sharing of information related to the characterization, assessment and management of risk between and among different groups, including regulators, stakeholders, consumers, media and general public [10]. Risk communication is multi-directional between these groups and includes both formal and informal messages. In today's fast online media environment, risk communication brought new challenges. Risk professionals must recognize that any message they seek to communicate is likely to compete with multiple, conflicting messages from unofficial sources amplified by social media.

Successful risk communication requires an understanding of the target audience, as well as a credible or trusted source. It should be unambiguous and convey only intended and purposeful messages. However it is important to acknowledge that any message is open to potential misinterpretations.

3.2 Recent developments in risk communication in general

A recent research article on risk communication [11] analyzed how the field has been shaped during the last ten years. This article concentrates on the evolving conceptualizations of "risk" in society and how risk communication practice could and should be constituted, as well as a review of a selection of articles by prominent risk communication scholars. The main points of this publication are summarized in the next two sections.

3.2.1. Evolution of risk communication

The conceptual understanding of "risk" has constantly evolved. Until the 1980's, risk was mainly treated as the outcome of "expert" assessment processes, whereas "lay" perspectives were considered subjective and irrational. The field was largely defined by attempts to align "lay" perspectives with those of "the experts" with the expectation that this would change their behavior (the so-called "deficit model"). The recognition that risk encompasses both objective and subjective elements led the "multiway approach" (between experts and lay people) to gradually replace the deficit model. The last decade saw the developments of what constitutes effective risk communication, where "effective" refers to the degree to which a desired result is achieved. The arguments for engaging in multiway risk communication fall into three categories: normative, instrumental, and substantive.

The **normative arguments** do not fix any particular result. The practice is understood to have intrinsic value as the right thing to do in a democratic society. In this context, governments, businesses and scientists have an obligation to inform honestly and precisely, taking into account the relevance of the audience and specifying the uncertainties about the conclusions. Individuals are often seen as the best judges of their own interests. In radiological protection, examples of communications performed under normative arguments are scientific publications from academia, annual reports from the state regulators, surveillance measurements accessible online in real time [12] and, to be very general, the radiological protection legislation itself.

The **instrumental arguments** center on effective multi-channel risk communication as a resource to achieve specific results, namely to share information, change beliefs and change behaviors. In the field of radiological protection, these goals could include fostering trusting behaviors among practitioners so that they comply with legal obligations. A typical example is the National Radiological Protection Day, organized by the FOPH.

Substantive arguments have emphasized the ability of effective multiway risk communication to generate new perspectives of substantively engaging “outsiders” in order to reflect useful noninstitutionalized knowledge and experience. In radiological protection, this kind of arguments may have been applied by the Swiss National Cooperative for the Disposal of Radioactive Waste (NAGRA) with its discussions with the population before the selection of a location for the deep geological disposal of radioactive waste. Another example is the approach recently initiated by the International Commission on Radiological Protection (ICRP) to interact with a wide range of partners before starting to draft its new General Recommendations.

Risk communication could include normative, instrumental, and substantive arguments. There will never be a single, generic version of how risk communication could and should be constituted.

3.2.2. Messenger, message framing and audience

Trust plays a central role for **messengers** in virtually all risk communication contexts. This is particularly true for ionizing radiation where the audience often has little knowledge and seeks credible sources of information. Although all messengers desire to gain or maintain the trust of the public, the scientific literature suggests no simple and universal solution. The proposed approaches include developing long-term relationships of trust with key actors, such as journalists, local leaders and other influential messengers. Important trust determination factors are [13]:

- listening, caring, empathy, and compassion;
- competence, expertise, and knowledge;
- honesty, openness, and transparency.

Transparency is now indeed seen as essential element to build trust because it results in better informed audiences, who will judge the messengers in a positive way. Transparency does not mean, however, that everything has to be communicated. Several studies performed in many different fields have indeed shown that when huge volumes are put online, it can cause the public to become less informed and more confused [14]. Transparency should therefore be more focused on quality than quantity. Improving the quality of risk communication therefore involves helping messengers go beyond simply discussing communication tactics (e.g. speaking clearly, using short sentences), and thinking more about effectiveness, in terms of objectives that go beyond the simple transmission of scientific knowledge (e.g. changing behavior, learning from stakeholders).

The **framing** of the message (e.g., humans versus environment, gains versus losses) is crucial. Framing consists in the way the messenger highlights the meaning for the audience, for instance by using metaphor, telling stories or showing contrast. In radiological protection, framing could consist in expressing the risk of radio-induced cancer in a positive or negative way. For example, it can be positively framed as: "in 99.9% of cases, radiation has no deleterious effect". Negatively framed, this could lead to: "in 1,000 people who benefit from this examination, 1 could die from radiation-induced cancer ". Another aspect of framing is the proximity of the audience and the risk. For instance, the impact of communicating about a radioactive contamination in the surrounding rivers may be very different than focusing on radioactivity present in the drinking water.

Risk communicators need to address the affective and emotional components of messages. As Slovic argues, “people look to their positive and negative feelings to guide their assessment of the risks and benefits of an activity” and “feelings serve as an important indicator for judgments and decisions about benefits / risks” [15]. Communicating uncertain risk information is part of framing and is particularly critical. Uncertainty in communication can help to build public confidence, by improving transparency while opening up the possibility of multiway communication, and help in defining the limits of our current state of knowledge. It can also increase the legitimacy and credibility of the decision-making process. However, when not done well, communication of uncertainty can do more harm than good by eroding public trust, harming decision-making or the central message, or providing new opportunities for communicating malicious use of information. The proposed solution consists of a rigorous pre-publication evaluation of messages (the so-called "pretest") for which guidelines exist [16,17]. Whatever the framing, the decision to communicate about uncertainties should be decided in terms of the impact they may have on the public's understanding of the phenomena, as well as the importance that the messenger gives to the ethical principle of honesty.

Any risk communication message is filtered by the target **audience**. It has been shown in particular that personal experience of hazards such as floods or earthquakes, as well as preexisting trust in authorities and experts, had the greatest impact on public risk perceptions. Numerous studies have attempted to explain public disagreements on important risk issues ranging from energy to nanotechnology or vaccines. For example, one study [18] found a strong correlation between the cultural values of the respondents and their perceptions of the scientific consensus regarding climate change, nuclear-waste and handguns. Individuals with hierarchical and individualistic "cultural perspectives" disagreed significantly with those with egalitarian and communal perspectives. One way to address this problem is to interact directly with the public through consultations. However, meaningful engagement remains fraught with challenges, such as participants feeling they have little meaningful influence. In order to minimize these pitfalls, Pidgeon [19] recommends that the public engagement process should seek to:

- provide participants with balanced information and policy framings;
- open and maintain deliberative spaces that enable different forms of engagement and reflection;
- avoid naïve audience sampling strategies;
- use varied methods to elicit broader values.

Engaging with the public, even if well-intentioned and accompanied by objective scientists, has its limits. For example, a Swiss study [20] involving leading scientists and laypeople that had to prioritize a series of 28 risks related to food and everyday life activities showed that deliberation had very little influence on laypeople's hazard rankings. On the other hand, trust and confidence had a great importance.

4 Risk communication for ionizing radiations

4.1 Strong prior opinion and risk aversion regarding ionizing radiation

Most people, whether they are expert or laypeople, tend to have an opinion about the risk of ionizing radiation. This state of prior knowledge is generally associated with a minimization of the risk perception when the benefit is direct and personal or the source is seen as natural (e.g. medical examination, radon in homes) or an amplification of the risk when the benefit is more diffuse or non-natural (e.g. nuclear industry in general). Although this amplification of the risk may seem irrational, the social sciences teach us that at least some part can be explained by the notion of *risk aversion*, which is the tendency to prefer outcomes with low uncertainty to those outcomes with high uncertainty, even if the average outcome of the latter is equal to or higher than the more certain outcome.

The notion of risk aversion is commonly explained by the following example (Figure 2). Suppose you have the choice between receiving for sure the sum of 750 francs, or the sum of 1,000 francs with a probability of 80%. A risk-averse person will choose the first alternative, while a risk-neutral or a risk-lover person will take the second. At first glance, risk aversion may seem irrational, because the second alternative allows us to earn an average of 800 francs (1,000 x 0.8). However, this behavior becomes rational if we consider the utility of the sum received. Typically a gain of 50 francs brings a certain utility (e.g. pleasure, possibility of acquiring an object, etc.). The utility of an additional 50 francs is generally lower. In the extreme, the utility of an additional 50 francs after having already received 1 million francs becomes irrelevant. In the example, the utility of 750 francs is equal to 9, whereas the utility of the alternative is only 8.

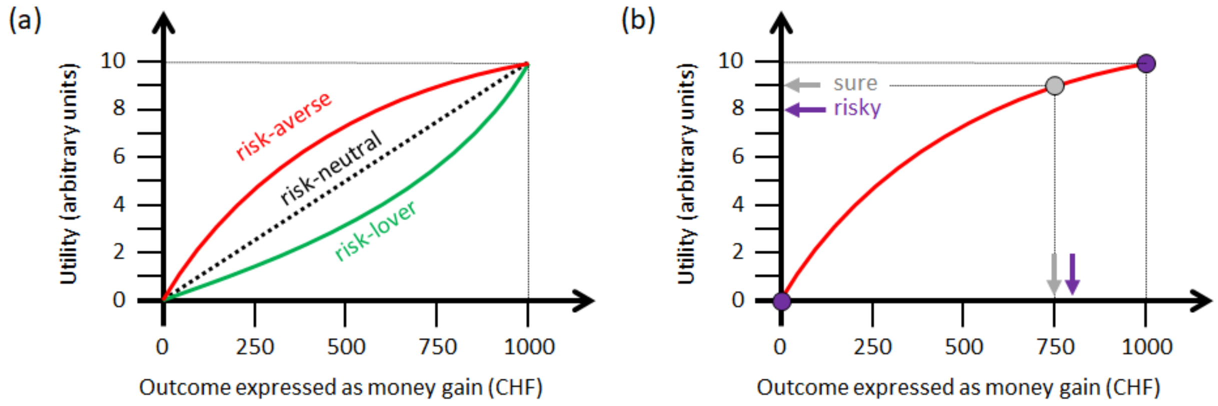

Figure 2: Example of the relationship between outcome and utility in the example of receiving for sure 750 francs, or 1,000 francs with a probability of 80%. (a) Typical relationship for risk-averse, risk-neutral, and risk-lover persons. (b) For a risk-averse person, the utility of 750 francs for sure is 9 (arbitrary units). For the alternative, the utility of winning 1,000 francs is 10, whereas the utility of nothing is 0. On average, the utility is therefore 8 (10 x 0.8 + 0 x 0)

This example does not apply specifically to ionizing radiation, but it illustrates two important points in terms of risk communication. The first is that because the audience is diverse, it will evaluate a risk according to a wide range of utility criteria, which are likely to be very different from those of the messenger. Furthermore, given the intrinsic scientific and technical difficulty of ionizing radiation, this leaves the door open to a large number of irrational factors. This confirms the usefulness of multi-way communication to better understand how the audience will interpret the message. The second point relates more directly to message framing. If a situation is to be accepted by a population, the chances of success are greater if the message is framed with little uncertainties. But this approach should not obscure the fact that the audience's long-term trust in the messenger is also an important parameter.

One might think that experts in the field of ionizing radiation are not (or not very) sensitive to risk aversion. In fact, this is not the case, as it has been shown that even the supervisory authorities in the nuclear industry are subject to risk aversion [21].

Despite (or rather because of) these difficulties to influence the perception of the audience, the International Radiation Protection Association (IRPA) enjoins "radiation protection professionals (...) to engage with the public and to put their expertise at the service of the public good". In this chapter, we recall some facts specific to ionizing radiation, which are useful to have in mind when communicating with people with limited scientific knowledge in this field [3].

4.2 What we know and what we do not know about radiological risk

4.2.1 Uncertainty

The low-dose effects of ionizing radiation involve a large part of uncertainty, which is not easy to communicate to non-specialists. Uncertainty is not, however, synonymous with lack of knowledge. The degree of consensus of the scientific community can be summarized as follows [22]:

- There is a high degree of consensus on how radiation induces tissue damage.
- There is some understanding of repair mechanisms with time.
- Our knowledge is much less certain for stochastic effects.
- There is a good degree of consensus on the role of DNA mutation, but not for cancer development, which is believed to proceed in a multistep fashion where other factors such as adaptive response, impact on the immune system, genomic instability, and bystander effects may also modify development.
- The role of these latter factors at low and very low doses are the subject of scientific debate, with some authors doubting that any effect at all may be present [23].
- At total radiation doses below around 100 mSv, the ICRP assumes that the increase in the incidence of stochastic effects occurs with a small probability and in proportion to the increase in radiation dose. This so-called linear non-threshold (LNT) model is not a proven scientific fact, but "it is considered to be a prudent judgement for public policy aimed at avoiding unnecessary risk from exposure" [24].
- For heritable effects in humans, the scientific consensus is that they are plausible, but at a much lower frequency than the induction of cancer.

This only deals with the uncertainty associated with the dose-effect relationship, which essentially interests the radiological protection specialists. But other actors are faced with different types of uncertainties [25]. The uncertainty of the decision-makers is related to the likely consequences of decision options and public reactions, whereas the uncertainty of the laypeople tend to be related to the trustworthiness of experts or the emotional potential of specific risk exposures.

Collin Powell (US secretary of states between 2001 and 2005) went on to say that he holds intelligence officers responsible for what they knew or did not know, but that he was responsible if he took action based on what they thought. This led to the so-called "Powell principle" [26]: "Tell me what you know. Tell me what you don’t know. Tell me what you think [, and make the distinction between the three objects]".

This type of humble approach could be useful for experts who communicate with decision-makers or medical professionals engaged in shared decision-making with patients.

4.2.2. What we know can be prepared in advance

During an acute event such as a nuclear accident or a dirty bomb, authorities should expect to receive a large number of questions from the media and the public. As indicated in the report of the 2013 KSR seminar following Fukushima [2], most of the questions are already known and the answers can be formulated in advance. Although some documents have been collected, this has not yet materialized.

4.3 Plain language

Because there is a potential imbalance between the messenger and the audience, the choice of language has a decisive effect on the impact of risk communication. This imbalance of literacy – as well as comprehension and confidence – is often underestimated [27]. In Switzerland, around 800,000 people between 16 and 65 years old have extreme difficulties in reading. They are not able to filter and relate the main information of a short text to each other and draw simple conclusions [28].

More generally, studies show that a significant part of adults in Western societies find their skills inadequate to meet the demands of today's society. The recent NCRP report [4] addresses this problem and proposes many recommendations regarding evaluating and communicating radiological risk for studies involving human subjects in medicine. The report emphasizes the need to avoid expert jargon and promote effective risk communication through "plain language". A message communicated in plain language is designed to ensure that the reader understands a message as quickly, easily, and completely as possible [29]. Two examples from medical radiology are presented in Table 1.

Table 1: Examples of plain language in the medical field (from [4], Table 1).

Original language	Plain language	Strategy involved
A chest radiograph will be performed to rule out tuberculosis.	You will have a chest x ray to make sure you do not have tuberculosis.	Use active voice and avoid technical terms
A fluoroscopy-guided placement of the novel cardiac pacemaker will be performed for all subjects who participate in this protocol. There is a risk of transient erythema consequential to this procedure.	If you take part in this research, you will have a new kind of heart pacemaker placed in your chest. The doctor will use x rays to place the pacemaker. You may have temporary reddening of your skin by the x-ray beam (like sunburn).	Speak to participants using “you” and the active voice; avoid technical terms where feasible; use shorter words and sentences.

4.4 Type of possible quantification

Apart from the risk quantities presented in Section 2.2, several methods of qualifying / quantifying the radiological risk have been proposed or are commonly used in practice.

4.4.1. Approximate indicator of possible risk

Although the ICRP recommendations advise against the use of the effective dose to estimate individual risks, it has been widely used in practice, and especially in medicine.

Very recently, the ICRP [30] clarified how the effective dose could be used for an individual. The Commission defines the *approximate indicator of possible risk* as the product of the effective dose E (in Sv) times 5×10^{-2}. This quantity roughly estimates the probability of fatal cancer for an individual in the working age population. For younger individual, this value can be multiplied by a factor 2. For older individual, it can be divided by a factor 2. The terminology used underlines the uncertainties in the estimation of risk at low doses (approximate indicator) and recognizes that these doses are very often below levels at which excess cancer rates have been demonstrated in epidemiological studies (possible risk). This quantity will generally be used at doses below 100 mSv, but its use at acute doses in the range up to approximately 1 Sv is reasonable. It shall not be used when a single organ receives most of the absorbed dose. In any case, the best estimates of risk to individuals will use organ/tissue doses and specific risk to dose response models.

4.4.2. Qualitative categorization

In the same publication [30], the ICRP proposes risk bands that can be used to communicate about risk to patients and subjects willing to participate in research. Table 2 reports this scale, together with similar qualitative indicators from the NCRP and American Nuclear Regulatory Commission (NRC). The second column of Table 2 informs on which basis the risk of cancer has been deduced. We can see that below E = 10 mSv, the lifetime risk of cancer is entirely based on the precautionary principle and the LNT model. Above 100 mSv, the risk is solidly backed by epidemiological studies, while there is a transition in-between.

Table 2: Qualitative indicators of radiation detriment proposed by ICRP in medicine (from [30], Table 5.2), by NCRP (from [4], Table 8.1), and by the NRC (BEIR VII Report [31]) in general.

Effective dose E (mSv)	**Evidence of lifetime risk of cancer**	**Qualitative indicators**		
		ICRP in medicine	**NCRP in general**	**BEIR VII in general**
< 0.1	Inferred < 10^{-5} on LNT model	Negligible	Negligible	Low
0.1–1	Inferred 10^{-5} – 10^{-4} on LNT model	Minimal	Minimal	
1–10	Inferred 10^{-4} – 10^{-3} on LNT model	Very low	Minor	
10–100	Risk 10^{-3} – 10^{-2} based on LNT model and epidemiology	Low	Low	
100s	>10^{-2} based on epidemiology	Moderate	Acceptable	Medium

4.4.3. Probabilities and micromort

As mentioned in Table 2, the risk is expressed as a power of ten. While the value associated with a moderate dose level is easily understandable (higher than 1 %), this is less the case for lower dose levels.

In order to make these very low numbers more understandable, Howard [32] proposed the *micromort* as a unit of risk defined as one-in-a-million chance of death. A risk of one micromort is roughly equal to the risk of dying of an accident during one day in developed countries. The advantage of this unit is that it brings the affected person closer to a palpable risk that they generally agree to take in their everyday life.

With the approximate indicator of possible risk, a probability of 5 10^{-2} Sv^{-1} of fatal cancer corresponds to 50 micromort per mSv. In other words, an effective dose of 1 mSv roughly corresponds to the risk of dying of an accident for a person living 50 days in a Western country. Again, as mentioned in Table 2, below 10 mSv, the assumed risk is entirely based on the precautionary principle and the LNT model.

Due to the quality of the most recent epidemiological studies, it is now advisable to present the risk in terms of incidence rather than in terms of mortality. This is what was done by the WHO following the Fukushima disaster [33]

4.4.4. Comparisons

According to Covello [13], the most effective comparisons appear to be:

- Comparisons of the same risk at two different times.

- Comparisons with a regulatory standard (such as a public health or food safety standard).
- Comparisons of the risk of doing something versus not doing something.
- Comparisons of alternative solutions to the same problem.
- Comparisons with the same risk as experienced in other places.

4.4.4.1 Comparison with natural radioactive background or other risks

As mentioned in Figure 1, the mean annual effective dose associated to natural radioactive background is equal to 4.38 mSv (radon 3.3 mSv, cosmic 0.38 mSv, food 0.35 mSv, and terrestrial 0.35 mSv). This "unit" is widely used in medicine to explain the risk to a patient. For instance a CT exam of 20 mSv corresponds to a risk of approximately 5 years of natural radioactive background. Although this makes possible to compare two radiological risks of similar amplitudes, it is not without flaws:

- Many people are often unaware that they are constantly subjected to naturally occurring ionizing radiation. Asking for acceptance of a similar risk on the basis of a previously unknown risk poses significant ethical questions.
- The effective annual dose from all natural radiation sources of 4.4 mSv is an average value for the Swiss population and the fluctuations amongst different people and different geographical areas are large. Since few people know their own doses, the comparison is not trivial.
- It is not because we accept the risk associated with background radiation that we necessarily accept the same risk associated with another source of radiation exposure.
- Implicitly, if the radiation source when compared with background radiation fluctuations both have risks of the same order of magnitude, the audience of the communication process may feel that their hand is being forced.
- The messenger may be tempted to make such a comparison in order to minimize the risk to which he/she subjects the audience.

4.4.4.2 Comparison with other accepted activities

In order to avoid comparing with a risk that is unknown to the audience, one can resolve to compare the radiological risk with other day-to-day risks. A typical example is that the annual dose limit for workers of 20 mSv approximately corresponds to a risk of a fatal traffic accident in Switzerland for 500,000 km driven by car.

4.4.4.3 Comparison with not using ionizing radiation

In certain situations, the risk associated with not resorting to ionizing radiation is more telling than the distant and hypothetical risk of radiation-induced cancer. This is the case, for example, in medicine, where minimally invasive fluoroscopy-guided interventions advantageously replace more risky operations.

4.4.4.4 Distance to an atomic bomb

The American National Academy of Science (NAS) discussed the possibility to compare the effective dose with the distance from the epicenter of the atomic bombs used in the cities of Hiroshima and Nagasaki [34]. For instance, a 20 mSv effective dose would correspond to a distance of 2 km. This type of comparison can be useful in training professionals when it comes to understand how well the exposures of atomic bomb survivors can be compared with current exposures. For example, in terms of dose and dose rate, diagnostic medical exposures are very comparable, and therefore the risk estimated by Japanese epidemiological studies is relevant for estimating that of patients. However, it is obvious that this type of comparison cannot be used to inform a patient who worries about the possible consequences of an X-ray examination.

4.4.4.5 Banana equivalent dose

The banana equivalent dose (BED) is an informal description of ionizing radiation exposure. Because bananas contain naturally occurring radioactive isotopes, particularly ^{40}K, one BED is often associated to 10^{-7} Sv. Apart from its educational role aimed at making the public aware of the ubiquity of radioactivity, this comparison may appear condescending or as an attempt to distract the audience from the risk in question. It may even appear dishonest when we consider that potassium contained in food is in homeostatic equilibrium. In other words, ingested ^{40}K is usually eliminated through the stool and urine.

4.4.5. Traffic light model

Three members of the Fachverband für Strahlenschutz recently published a letter in which they describe a two-stage concept to plan and communicate protective actions in the case of an exposure to hazardous substances, which they call the "trafic light model" [35] (see Figure 3). In the red area, there is an intolerable hazard that requires action. In the yellow area, a risk management is required by applying the ALARA[1] principle. In the green area, there is no relevant or avoidable risk to health, and therefore, no precautions beyond the usual duty of care need to be taken. The tolerance threshold separates the red (upper) from the yellow (middle) area. The acceptance threshold divides the yellow (middle) area from the green (lower) one.

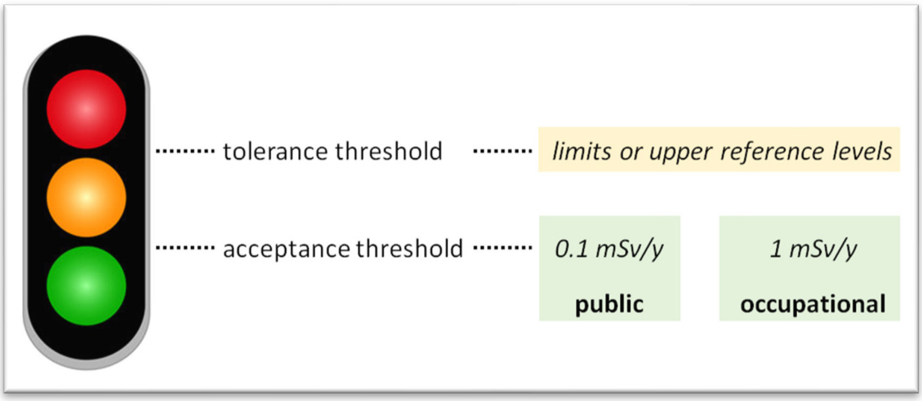

Figure 3: Traffic light model [35].

For the application of the model to radiological protection, the authors suggest an acceptance threshold at 0.1 mSv per year for that of the public, which corresponds to a tenth of the lower end of the typical range of the unavoidable natural radiation exposure. For occupational exposure, they propose a threshold at

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[1] ALARA: As low as reasonably achievable, economic and societal factors being taken into account

1 mSv per year, and justify their choice as being "in the range of occupational risks from professional activities considered safe". For both categories of exposure, they propose the annual dose limit as an acceptance threshold for planned exposure situations and the upper reference level for emergency and existing exposure situation.

4.4.6. Quantification is not sufficient

Regardless of how risk is quantified, it is clear that this only covers one aspect of how it will be perceived. More subjective (but equally rational) aspects are such as trustworthiness, fairness, benefits, alternatives, control, dread, catastrophic potential, and familiarity.

This is especially the case when the risk is compared with the background radiation, which tends to be perceived as being "good" (since it is natural) and inevitable (because we have little influence on its level).

5 Findings and Recommendations

5.1 Findings

The time when the authorities, the industrialists or the academics were the only repositories of knowledge, and could content themselves with explaining, has definitely given way to multiway communication where the public has to be engaged. Large institutions have communication specialists who are essential in the event of a crisis or during specific actions. But to interact well with these professionals, radiation protection experts must know the basics of communication and the specifics associated with ionizing radiation, as described in this document.

The Commission considers, however, that this is not sufficient and that radiological risk communication should be addressed more in radiation protection education. This is particularly the case in continuing education and training, when professionals have acquired practical experience.

The Commission has already drawn the attention of the authorities to the need to prepare in advance the questions which will undoubtedly be asked in the event of a radiological event. We reiterate our recommendation in this document.

Finally, to be trusted and listened to, experts must pay daily attention to the three components of communication, which are the messenger, the framing of the message and the audience. The three sections below summarize the aspects that we think are the most important. So that this does not remain entirely theoretical, this document presents in the appendix three examples taken from emergency, existing and planned exposure situations respectively.

Messenger

The greatest quality of a messenger is the trust he/she inspires in his/her audience. Trust, together with credibility, can never be taken for granted and need to be cultivated on the long term by developing relationships with key actors, such as physicians, journalists, local leaders and other influential messengers.

Transparency is a way to obtain trust from the public. It should focus on improving the quality of communication, rather than on the quantity of information presented.

Independence of the messenger is often presented as a factor that promotes public trust. However, the example of the (reputedly independent) covid-19 task-force recently showed that "independence" can be perceived in very different ways. Additionally, over-emphasizing independence per se can be counterproductive: a person who is too independent can easily become incompetent.

Instead of independence, the messenger would benefit from cultivating his/her impartiality. This probably explains why the ISO standard 17025 [36] does not require accredited laboratories to be independent, but to be *impartial*. In order to explain this notion the standard mentions that other terms used to convey impartiality include "absence of any conflict of interest", "probity", "non-discrimination", "neutrality", "justice", "openness", "fairness", "disinterestedness" and "balance". One of the main differences between independence and impartiality stems from the fact that it is possible to justify one's impartiality by applying strict rules. For example, a new employee of the FOPH who has previously worked in a hospital as a medical physicist may apply behaviors ensuring his impartiality. But his/her personal relationships and skills will remain dependent on his previous career.

The covid-19 crisis also showed that the population struggles to grasp complex concepts. But the most important lesson for the messenger undoubtedly resides more in the need to remain modest in terms of the explanatory and above all predictive quality of the skills of the experts. For that, the "Powell principle" mentioned above could be a useful tool.

Framing of the message

The framing of the message should be based on the goal of the communication and the targeted audience. The message should usually be short and written in plain language. Mentioning sources and levels of uncertainties is part of being transparent, and also promotes trust for the messenger. However, the way this is addressed must be carefully considered in order to minimize unintended consequences. A good way to reach this end consists in challenging the message internally in order to detect any interpretations that would go against the desired goal. In other words, the message should be *pretested*.

Finally, when authorities are communicating, it is essential that different levels (national, cantonal and local) display a coherent message.

Audience

Engaging with the public is important, but that must be done early enough to avoid being wrongly interpreted as wanting to minimize the consequences of a situation.

When this is not possible, the messenger should at least assess the confidence shown (or not) by the audience. It is important to take the feelings and knowledge of the audience, as well as the general range of opinions into account, without discrediting such opinions on the grounds of "subjectivity" or "lack of common sense".

5.2 Recommendations

- Radiation protection specialists must know the basics of communication and the special features associated with ionizing radiation. Communication about radiological risks and situations should therefore be given greater consideration during basic training and, in particular, during the periodic continuing education and training of radiation protection specialists.
- A large part of the answers to questions asked in the event of a radiological incident can and should be formulated in advance (prepared question and answer catalogs).
- Radiation protection specialists should pay attention to the three elements of the communication process "sender", "framing of the message" and "target audience" in their daily work and especially during a radiological event.

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7 Appendix - Examples of exposure situations in Switzerland in which good communication is required

Depending on the exposure situation, specific aspects should be taken into account. Concrete examples are presented below.

7.1. Emergency exposure situation: EU-CONFIDENCE project

7.1.1. Description of the situation

In the event of a nuclear power station accident, good communication is required because the public may have concerns about potential detrimental health effects related to the radiation releases from such an accident. After the Fukushima nuclear power station accident in 2011, the World Health Organization (WHO) put a major effort into quantifying the excess cancer risks related to the radiation exposure from the accident and communicating these risks to non-specialists [33]. Since then, the EU project - CONFIDENCE (COping with uNcertainties For Improved modelling and Decision making in Nuclear emergenCies), [37] extended the WHO methodology to include uncertainties and expand on risk communication aspects. More recently, in Switzerland, a working group with representatives of the competent federal authorities developed text modules that can serve as a common basis for communication in the event of an incident. For specific topics, frequently asked questions (FAQ) are prepared (e.g. the list of FAQ for the information of the affected population at the “consultation point radioactivity”).

7.1.2. Messenger

The lead messenger for communicating the health effects of a nuclear power station accident on the population in Switzerland is the FOPH. However, it is important that all relevant professional actors be involved in early stages of communication to ensure that clear and coherent messages are validated by the authorities and the nuclear power plant, before being made available to the public.

7.1.3. Framing of the message

For communication, it was decided by WHO and in the EU-CONFIDENCE project to represent the excess lifetime total cancer incidence risk from the accidental radiation exposure (LAR) in relation to the lifetime cancer risk applicable in any normal circumstance (LBR). An appropriate form for presenting and communicating such risks was considered to be bar charts that show these two types of risks, in relation to each other, calculated based on Swiss population data. If the risks in such bar charts are given in terms of numbers of lifetime cancer cases per 10,000 persons – then it is very clear to communicate to the general public, how many cancers occurring over the lifetimes of 10,000 persons would normally be expected and how many could be related to radiation exposures. Furthermore, the bar charts may illustrate how these cancer numbers vary between sex (females are more sensitive to detrimental health effects from radiation exposures than men) and the age at which the radiation exposure occurs (younger people being more sensitive to radiation related detrimental health effects than older persons).

Figure 4 shows these two types of risks, in relation to each other, calculated based on Swiss population data for a hypothetical situation after a nuclear accident in which the mean effective dose to a population-subgroup was 20 mSv. Excess risk models that come from fitting the cohort data on the atomic-bomb survivors of Hiroshima and Nagasaki were used in these calculations of LAR. The risks are given in terms of numbers of lifetime cancer incidence cases per 10,000 persons. Since both types of risks depend on age at exposure, the figures show the lifetime risks for age at exposure 1, 10 and 20 years of age. The black confidence intervals (error bars) on the central estimate of the radiological risk (yellow in the figure) shows the range in uncertainty in the risk such that 95% of the uncertainty in risk lies between the two limits in the error bars.

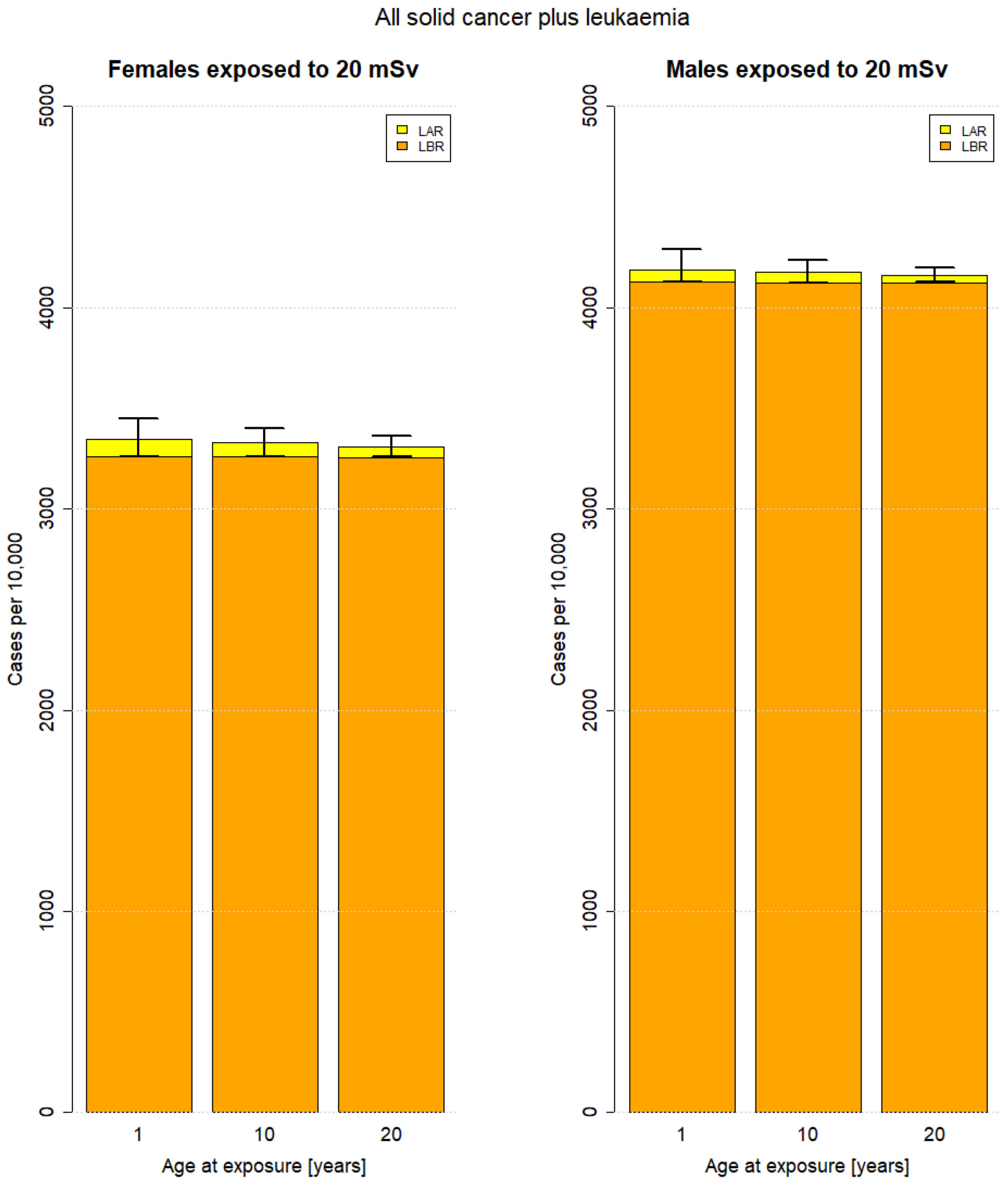

Figure 4: (graphics courtesy of Luana Hafner, ENSI). Lifetime Attributable Risk (LAR) from a mean effective dose of 20 mSv in relation to the Lifetime Baseline Risk (LBR) for men and women and for three different ages at exposure. The risks are given in terms of cancer incidence cases per 10,000 exposed persons. The confidence intervals (error bars) on the central estimate of the radiological risk (yellow in the figure) shows the range in uncertainty in the risk such that 95% of the uncertainty in risk lies between the two limits in the risk. Here it was assumed that the uncertainties in these doses to the affected sub-population were such that 68% of the doses lie between 10 and 30 mSv (i.e., a standard deviation of 10 mSv in a normal distribution of the doses).

7.1.4. Audience

The audience will be all the members of the public with a special emphasis on those who are likely to have received a radiation exposure from the accident above a certain level of exposure.

7.1.5. How communication could be done

The FOPH could put information on their website and organize public information sessions in the affected areas. Local general practitioners (GPs) could also be included, as trustworthy members of the local community, to communicate information to concerned members of the public. Such information on potential detrimental health effects from radiation could be made available to GPs directly by FOPH.

7.2. Existing exposure situation: Radon

7.2.1. Description of the situation[2]

Radon is responsible for 200 to 300 deaths a year in Switzerland and is second only to smoking as a leading cause of lung cancer. It is the main source of radiation in the general population, more than 10 % of the buildings already measured in Switzerland show an exceedance of the reference value of 300 Bq/m^3 in at least one room where people are present. Radon is an element in the decay chain of uranium, which is ubiquitous in the ground. The natural decay of uranium gives rise to products including radium and radon. Radon gas atoms can in turn disintegrate, producing polonium, bismuth and lead. These decay products, which are also radioactive, attach themselves to airborne particles and tend to accumulate in enclosed spaces. When inhaled, they can be deposited in the lungs and irradiate lung tissue, possibly leading to lung cancer. The more permeable the ground, the more readily radon gas can rise to the surface. High permeability is found with the smallest (pores) or larger cavities (cracks, fissures, masses of debris or fallen rocks) and in karstic zones and cave systems. Layers of dense clay are scarcely permeable to radon. Local differences, therefore, are highly marked. In Switzerland, areas with elevated radon concentrations are mainly found in the Alps and the Jura. In some cases, however, high concentrations have also been found in buildings on the Central Plateau. Thus, radon may be found anywhere.

The risk of lung cancer increases as airborne radon concentrations and the length of exposure rise. Years or even decades may elapse between the irradiation of lung tissue and the onset of lung cancer.

About 8 million people live in Switzerland. Every year, there are about 64,000 deaths, including 17,000 from cancer. Lung cancer is responsible for around 3,200 deaths a year, with 200 to 300 cases being attributable to radon.

7.2.2. Messenger

The cantons are in charge of the implementation of the radon regulations in buildings according to the RPO. The cantonal authorities – and if delegated to the municipalities – should contribute to the delivery of correct information to the population on their territory.

The Suva is the authority in charge of radon exposed workplaces in the field of industry and should communicate with the concerned companies.

The FOPH is in charge of communication for the scientific justification and the national strategy; It also responds to requests from the media, e.g. for the provision of radon measurement results in accordance with the Freedom of Information Act (FoIA).

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[2] This part comes from the website www.ch-radon.ch

7.2.3. Framing of the message

Communication in radon issues has been an extensive activity during the Radon action plan 2012-2020, many messages targeting different stakeholders have already been framed in a variety of communication modes. To be successful in transporting the message, indirect measures of communication such as through legal regulations, are valuable strategies. Local authorities (canton and municipalities) are e.g. in charge to communicate about radon risk to the builder as part of the building permission process according to the RPO. Cantonal authorities also communicate in the framework of measuring campaigns in schools and kindergarten.

The FOPH is providing tools for the general public in order to assess the individual radon risk and increasing risk awareness in general (e.g. the national radon map and the radon check tool).

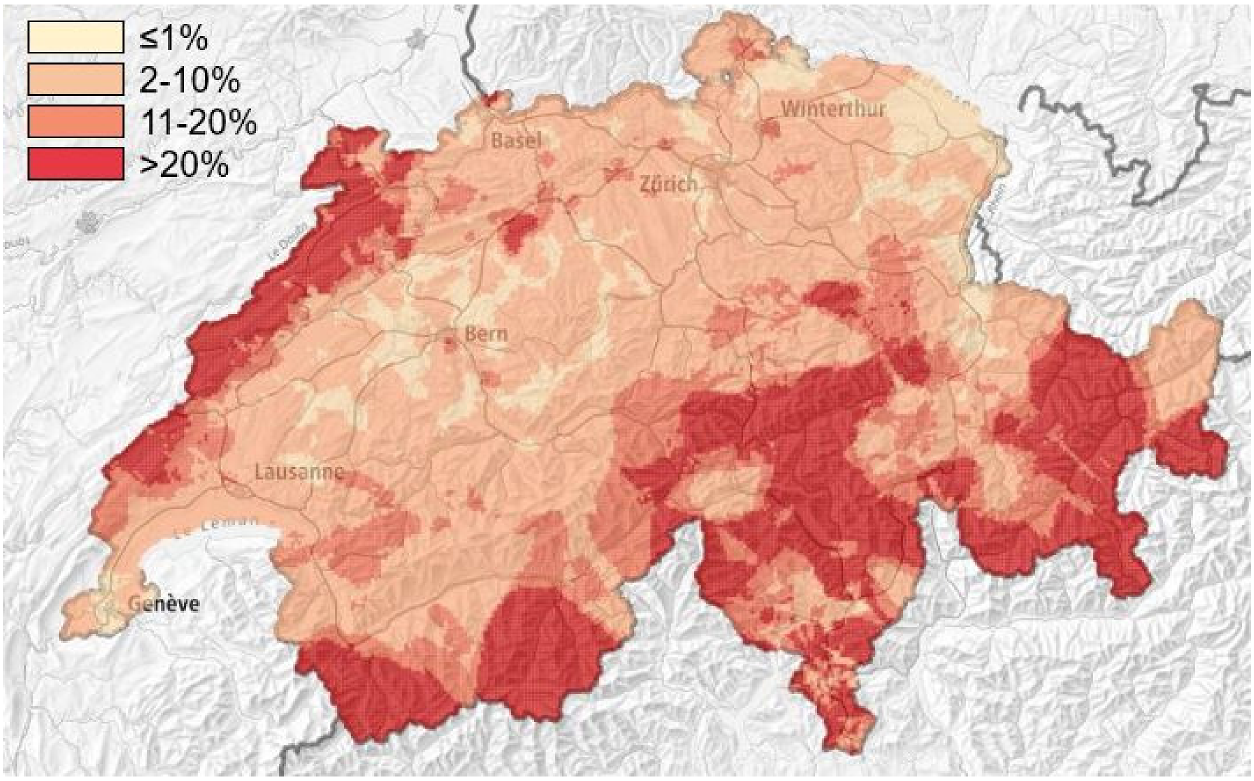

Figure 5: Probability (5) of exceeding the reference value (www.radonkarte.ch). Source: FOPH, 2018.

7.2.4. Audience

The audience should be the public, the general population, and more precisely: home owners, builders, construction experts and professionals in the building sector.

7.2.5. How it could be done

Delivering radon dosimeters at low cost and provide cost-effective radon mitigation methods would implement the efficacy of the message and the awareness to the radon issue. In this context, it is also necessary to simplify procedures to make them more attractive e.g. by developing a short measurement protocol. Information should be targeted to specific groups in situation where radon issues are relevant (e.g. by building transaction or during the implementation of energy saving measures). Furthermore, renters should be aware of their right to live in a radon safe environment. For this issue, the FOPH should create multipliers, e.g. through umbrella associations, such as the landowners' association or the association of notaries.

7.3. Planned exposure situation: Use of contact shielding for patients in radiology

7.3.1. Description of the situation

Until now, the FOPH recommends using contact shielding to protect radiosensitive organs of patients when using x-rays in medical imaging. The technological advances and research results of recent years clearly revealed that these garment protections no longer provide any significant gain. On the contrary, in certain situations, involving automatic dose delivery adjustments, shielding garments may even increase the dose to the organs they are supposed to protect. Several developed countries have, thus, recently changed their policy and stopped recommending garment shielding for patients. At the beginning of 2021, based on a report of the Swiss Society of Radiobiology and Medical Physics, the KSR recommended to adopt this policy also in Switzerland [38].

7.3.2. Messenger

In this case, the lead messenger is the FOPH, but it is important that all professional actors will be involved from the beginning in the process of paradigm change to ensure a coherent message.

7.3.3. Framing of the message

The message will have to be framed in very rational terms, based on scientific knowledge, but not only. It is indeed of the utmost importance to integrate the social dimension (and the values associated with it) when explaining why the policy has changed. Patients, like professionals, will need to be supported in this paradigm shift. This will require skill, since it is important to avoid losing public trust, as was the case in the spring of 2020 with the Covid pandemic, where protective masks were first presented as unnecessary, before being considered mandatory.

The difference of cultural mentality across the different parts of the country needs to be considered.

7.3.4. Audience

The ultimate audience will be the public (or rather the patients). However, the first steps of communication should be initiated by the medical societies involved in this problematic. Face to face discussions will be necessary.

7.3.5. How communication could be done

The FOPH should set up a working group in which at least one member of the concerned medical societies will be involved. This group should then work out an exact strategy for communication individually adapted to each stakeholder. The modes of communication should include articles published in scientific journals, newsletters sent by e-mail, live sessions organized at the annual congresses, teaching courses, and videos. The learning objectives for radiographers and radiologists should be adapted. Even the x-ray industry must be informed about the paradigm change.