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Special Contribution

# Issues and Challenges of Radiation Risk Communication to the Public

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This article focuses on issues and associated challenges in radiation risk communication to the public. All of the issues start with very simple questions and the challenges are to answer them in a way that can be easily understood by the public. Two of the most commonly asked questions are addressed, "what is radiation?" and "are we safe?". The discussion is based mostly on information available on the internet to the public. Collectively, more is known and understood about the biological effects of radiation than any other toxin or carcinogen. As health physicists, we are confident that current radiation dose limits protect workers and the public. It is our duty to engage the public, address their concerns, translate our knowledge to their language, and eventually build trust among us. From the discussion given here, one can see that radiation risk communication to the public is a science-based art. Depending on how it is designed, the communication can be a beauty to people when it makes their life easier, or it can turn into a beast when it makes people even more scared of radiation.

*Key words:* radiation, health risk, risk communication

## 1. Introduction

Risk communication is an area that has been studied and practiced for many decades. Among various risks, communicating radiation risk to the public is unique in large part because of the public's intense fear of radiation, particularly in a nuclear emergency. In my professional life as a health physicist, there is no more fascinating area of work that I have encountered than the topic of radiation risk communication to the public. The public includes almost everyone not specialised in radiological sciences, even including general medicine professionals and scientists other than health physicists. When talking about radiation, people often recall the atomic bombings of Hiroshima and Nagasaki in August 1945 and the high-profile accidents like Chernobyl in Ukraine in April 1986 and the more recent Fukushima power plant disaster that followed the earthquake and tsunami affecting Japan in March 2011. In this article, I will not touch the controversial area about radiation and nuclear energy where everyone seems to have his/her own personal expert opinion. I will rather focus on issues and associated challenges in radiation health risk communication to the public. All of the issues start with very simple questions and the challenges are to answer them in a way that can be easily understood by the public. Here, I will try to address two of the most commonly asked questions, "what is radiation?" and "are we safe?". The discussion is based mostly on information currently available on the internet to the public.

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## 2. What is radiation?

Radiation is everywhere around us. There are many types of radiation that we come across frequently in everyday life, such as heat, light, radio-waves, microwaves and x-rays used in dental offices. Here we are concerned with one type of radiation, ionizing radiation from atomic processes or nuclear decays, which is produced by sources such as naturally occurring radioactive radon gas and radioactive lead in drinking water, as well as x-rays commonly used in the medical services. In plain language, the term "radiation" commonly refers to ionizing radiation.

Even though radiation is all around us, most people are not familiar with the basics of radiation. In the literature and on the internet, there are many articles and books, even international guidance documents on risk communication. When dealing with risk communication related to radiation, there are always introductions or primers on basic sciences of radiation, sometimes in the form of answers to frequently asked questions. For the question, "what is radiation?", one can easily google and find many answers. When you google "what is radiation", the first result listed on the web page is the Health Physics Society's definition[1]:

> *Radiation is energy that comes from a source and travels through space and may be able to penetrate various materials. Light, radio, and microwaves are types of radiation that are called nonionizing. The kind of radiation discussed in this document is called ionizing radiation because it can produce charged particles (ions) in matter.*
>
> *Ionizing radiation is produced by unstable atoms. Unstable atoms differ from stable atoms because unstable atoms have an excess of energy or mass or both. Radiation can also be produced by high-voltage devices (e.g., x-ray machines).*

This was followed by the World Nuclear Association's definition[2]:

> *Radiation is energy travelling through space.*
>
> *Sunshine is one of the most familiar forms of radiation. It delivers light, heat and suntans. While enjoying and depending on it, we control our exposure to it.*
>
> *Beyond ultraviolet radiation from the sun are higher-energy kinds of radiation which are used in medicine and which we all get in low doses from space, from the air, and from the earth and rocks.*
>
> *Collectively we can refer to these kinds of radiation as ionising radiation. It can cause damage to matter, particularly living tissue. At high levels it is therefore dangerous, so it is necessary to control our exposure.*

In the International Atomic Energy Agency (IAEA)'s document entitled "Communication with the Public in a Nuclear or Radiological Emergency"[3], radiation is defined as:

> *Radiation is a phenomenon in which particles with some energy travel through air or material (skin, glass, water, etc.). Radiation can have an impact on the material through which it is travelling depending on its energy. Radiation is produced by matter and this matter is generally called a source. This source can be natural or artificial (person-made).*

The World Health Organization (WHO) tried to provide information on the basics of ionizing radiation for the general public[4]. The WHO stated

> *Energy emitted from a source is generally referred to as radiation. Examples include heat or light from the sun, microwaves from an oven, X rays from an X-ray tube, and gamma rays from radioactive elements.*
>
> *Ionizing radiation is radiation with enough energy so that during an interaction with an atom, it can remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized.*
>
> *Here we are concerned with only one type of radiation, ionizing radiation, which occurs in two forms - waves or particles.*

This is supposed to be the basic information for everyone. However, I am not sure everyone will have the ability or patience to really digest the information provided even for people with high-school and university educations.

The Radiation Effects Research Foundation (RERF), a cooperative Japan-US research organization established to conduct extensive health studies on A-bomb survivors, has ongoing radiation risk communication to the public. On the RERF's website[5], one can also find answers to the basic question "what is radiation?":

> *Radiation can be defined as small (subatomic) particles with kinetic energy that are radiated or transmitted through space.*
>
> *One form of radiation possesses properties of light, with most of the radiation around us having this quality. E.g.: x rays and gamma rays, which are used in medicine.*
>
> *Other radiation possesses particle-like properties (so small, these particles cannot be seen with microscope). E.g.: alpha rays, beta rays (from radioactive materials), heavy particle radiation (used in treating cancer).*

Many of the answers to this basic question may be written by radiation specialists who are familiar with the definitions for atoms, waves, charged particles, kinetic energy, energy transfer and ionization. When talking to the general public, we should try to avoid using terminology found in physics textbooks. We should also try to not give examples that use radiation with negative connotations or can scare people, such as heavy particles used to treat certain types of rare cancers.

When we are trying to find a better way for the public to understand what radiation is, there is really no need to explain what ionizing means. Mubeen *et al*.[6] found severe misconceptions about ionizing and non-ionizing radiation among 217 medical students who had completed their 25 days posting in the radiological department during their fourth or final years of medical professional training. Many of those future medical doctors were unaware of the fact that MRI and ultrasound examinations do not emit ionizing radiation. A survey conducted by Hafele[7] among high school students showed clear learning difficulties associated with understanding ionization, because students, just like most of the public, tend to have incomplete and non-functional images of atoms and radiation.

On the U. S. Department of Energy's website[8], the answer to the question "what is radiation?" may be easier to understand than the examples given above:

> *Radiation is a form of energy that is a part of our everyday lives. All of us receive a "dose" of radiation each day. Most of the dose comes from naturally occurring radioactive materials such as uranium, thorium, radon, and certain forms of potassium and carbon. The air we breathe contains radon, the food we eat contains uranium and thorium from the soil, and our bodies contain radioactive forms of potassium and carbon. Cosmic radiation from the sun also contributes to our natural radiation dose.*
>
> *We also receive radiation doses from man-made sources such as X-rays, nuclear medical procedures, power plants, smoke detectors and older television sets. Some people, such as nuclear plant operators, flight crews, and nuclear medicine staff may also receive an occupational radiation dose.*

The example starts by telling people the basic fact that radiation is a natural process, nothing strange at all. In recent years, when talking about radiation risks associated with the Fukushima accident, many of us tend to make comparisons between background radiation dose and dose resulted from exposure to radiation released from the Fukushima accident. To make the communication easier during nuclear emergencies, we should work hard in non-emergency situations to help people understand the very basics of radiation and increase public awareness of background radiation and the fact that radiation exposure is a part of our everyday lives and around us everywhere at all time. I would like to propose the following answer to the basic question for further discussion:

> *Radiation is a natural phenomenon that is a part of our everyday lives. Radioactivity exists everywhere and in all materials naturally around us in varying concentrations. Cosmic radiation from the sun and outer space bombards our body all the time. The Earth contains uranium, thorium and many other natural radioactive materials. These earth materials (rocks and soils) release invisible radiation all the time. All living beings on Earth are exposed to natural radiation. This natural radiation is always present and is easily measured. In fact, natural background radiation is always measured by radiation monitors. You will always detect it, even when there are very little or practically no man-made sources around.*
>
> *In addition to external exposure to radiation, radiation can also be taken into our body. The air we breathe contains radioactive radon. The food we eat and the water we drink contain naturally occurring radioactive substances originating from radioactive materials in the ground. Therefore, every one of us receives a small radiation dose each day from inside and outside of our bodies. The radiation dose to our bodies is measured in units called millisieverts (mSv). The natural background radiation doses to people vary widely because the levels of natural radiation differ significantly from one location to the other. For example cosmic radiation from the sun is much stronger on mountains than in coastal areas and the soil and rock in some areas have much more radioactive materials than other areas. On average the annual background radiation dose for people living on the Earth can vary from 1 millisievert to 10 millisievert. The worldwide average dose from background radiation is 2.4 millisievert.*
>
> *In addition to natural background radiation exposure we are exposed to radiation from man-made sources such as X-rays and CT scans. Nuclear power plants are often a radiation source that the public is most worried about. While they do routinely release very small amounts of radioactive materials into the environment, they are heavily regulated and contribute a tiny amount of radiation doses to people's overall lifetime radiation exposure.*

## 3. Are we safe?

With very little knowledge about the basics of radiation, most people have unreasonable fears of radiation and intense worry about the associated health risk. During a nuclear emergency, one of the most asked questions is, am I safe? or is my family safe? Unlike the first commonly asked question given above, it is very hard to find clear answers on the internet that explain to people whether a situation is safe or not safe.

Health physics is concerned with protecting people from the harmful effects of ionizing radiation while allowing its beneficial use in medicine, science, and industry. It is important to realize that most of the effects observed in human populations have occurred at high radiation doses, much higher than the background radiation doses discussed above, such as the health effects observed among atomic bomb survivors in Japan and people living in areas affected by the Chernobyl accident. The information gathered from those populations must be scaled down to low or very low doses comparable to the background radiation in order to effectively estimate the risks that may occur in most situations. As health physicists, we know that current radiation protection standards embody the extensive knowledge on radiation effects gained through radiobiological and epidemiological research of the last century. At low doses (for example, several times background radiation dose), the main health effect from exposure to radiation is a slightly increased risk of developing cancer later in life. As scientists, we use the linear non-threshold model to assess risks at low doses. This model assumes that there is a risk at any level of radiation. Even for exposure to background level of radiation, there is an increased risk of developing cancer. We understand that no radiation exposure is the ideal. However, risk exists everywhere in our natural environment. In this universe, we can't find a risk free or radiation free place to live. We have to accept a certain level of risk, below which we consider something 'safe'.

In the literature or on the internet, it's hard to find clear and direct answers to the question, is my family safe? Scientists like to express a risk in the term of so called incidence ratio, such as a risk of 1 in 100,000 or 1 in 1,000,000. However, the public won't understand or appreciate this type of answer, they simply want to know, am I safe or not?

Let's google on the internet and see what answers we can get, even though it is very hard to find answers to such a general inquiry. The closest answer found on the internet was from the US EPA's question, is any amount of radiation safe?[9]

> *There is no firm basis for setting a "safe" level of exposure above background for stochastic effects. Many sources emit radiation that is well below natural background levels. This makes it extremely difficult to isolate its stochastic effects. In setting limits, EPA makes the conservative (cautious) assumption that any increase in radiation exposure is accompanied by an increased risk of stochastic effects.*

This is not a clear answer at all. In addition, the scientific term "stochastic effects" could confuse many people, and cause even more fear of radiation and its effects due to people making assumptions of what this unfamiliar term means if is not well explained in advance. I would prefer using the term "cancer risk" instead of "stochastic effects", because the main health concern of stochastic effects is an increased risk of developing cancer in most situations. In addition, people understand cancers, and an increased risk of developing cancer is already scary enough for many people, especially for parents when they worry about the safety of their children.

Collectively, more is known and understood about the health effects of radiation than any other toxin or carcinogen. We are confident that current radiation dose limits protect workers and the public. As health physicists, it's our duty to engage the public, address their concerns, translate our knowledge into a language they understand, and find a way to tell them how safe they are when exposed to low levels of radiation. If we as experts in radiation protection have no health concerns with regards to exposure at low and very low levels of radiation we need to find a way to communicate this because often the public is very concerned when they don't need to be.

During a nuclear emergency, the question (am I safe?) can be asked by people from almost everywhere, either living in affected area or thousands of kilometers away from the accident location. People living in affected areas, such as those who lived within 100 km of the Fukushima nuclear power plant, should follow the guidance issued by the local government. All guidelines for nuclear emergency responses that I am aware of are very conservative with regards to radiation protection. Early protective actions are based on the worst case prediction and in many cases even before any radiation releases actually occur. Those early protective actions, such as evacuation orders, are done to ensure that the public are not likely to receive a radiation dose more than the dose limit for radiation workers in a normal operation situation. Occupational dose limits of 20 mSv or maximum 50 mSv in a year for radiation workers in normal situations are set well below radiation levels where any health effects have been observed. Therefore, it should be considered safe as long as guidelines of protective actions are followed. Take the Fukushima accident for example, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR)[10] estimated that the districts with the highest average doses for members of the public were within the 20-km evacuation zone and the deliberate evacuation area (farther to the north-west of the plant). For adults, the radiation dose estimated to have been received before and during the evacuation was, on average, less than 10 mSv and less than 5 mSv for those evacuated early on 12 March 2011. Adults living in the city of Fukushima were estimated to have received, on average, a radiation dose of about 4 mSv in the first year following the accident; the estimated doses for 1-year-old infants were about 8 mSv in the first year following the accident. In later years, the radiation doses due to the Fukushima accident became lower and lower. The UNSCEAR concluded that the doses to the general public, both those incurred during the first year and estimated for their lifetimes, are generally low or very low. No discernible increased incidence of radiation-related health effects are expected among exposed members of the public or their descendants. The most significant health effect is on mental and social well-being, related to the enormous impact of the earthquake, tsunami and nuclear accident, and the fear and stigma related to the perceived risk of exposure to ionizing radiation.

Because Fukushima-related radiation doses are low or very low, and no increased incidence of radiation related health effects could be observed among the public, the key message to the public could be very simple and direct; that is: we are safe with regard to radiation released from the Fukushima nuclear power plant.

During and after the Fukushima accident, radiation fear does not only exist in Japan, but also around the globe. Releases of radioactive contaminants, especially the long-lived radioactive caesium-137 ($^{137}Cs$), into the Pacific Ocean following the Fukushima-Daiichi nuclear accident in 2011 have raised public concerns about seafood safety. It is well known that many fish species can migrate long distances in the ocean. Therefore, public concerns about the safety of consuming seafood have extended to seafood caught off the west coast of Canada, far away from the east coast of Japan. To date, none of the marine fish samples analyzed in Canadian studies contained any elevated levels of radioactive caesium. In many cases, levels of radioactive caesium are below the detection limits. As scientists, we know that fish from the Canadian west coast are of absolutely no health concern for radiation contaminants from the Fukushima accident. It is then our duty to provide a simple and clear answer to the public: we are safe to consume fish harvested in the Pacific.

In addition to the draft answer to the basic question “what is radiation?”, I would like to draft following answer to the basic question “are we safe?”:

> *To put levels of exposure to man-made radiation sources in perspective, we can always make comparisons to background radiation levels around us at all time. If the radiation dose we received from a nuclear emergency is in the range of background radiation levels (1 to 10 mSv in a year), we are safe and no radiation related health effects are expected. This is also true for radiation doses somewhat higher than background radiation levels, for example up to 20 or even 50 mSv in a year.*

## 4. Conclusions

Radiation risk communication to the public is a science-based art. Depending on how you design it, the communication can be a beauty to people when it makes their life easier, or it can turn into a beast when it makes people even more scared of radiation. As health physicists, we don’t have to demonstrate in front of the public how deeply we understand radiation physics and the complex ways various waves and particles interact with the human body. When communicating to the public, we must use plain language at grade 6 level of primary school or even lower. During a nuclear emergency, many people trust scientists more than the government. However, scientists can only be respected when people understand what scientists communicate to them. In conclusion, the famous quote from Maria Curie[11] explained it best

> *Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.*

This is so true for many things in our life, especially for radiation and the potential risks associated with radiation exposure.

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