COMMUNICATING BASICS OF RADIATION

1.0 BACKGROUND

Communicating with the public about radiation is challenging. It is important to remember at all times to communicate in plain language. This section provides explanations using plain language terminology about the basics of radiation so that they can be communicated to the public in an understandable way whether during the preparedness or emergency phase.

2.0 Radiation is energy that comes from a source and travels through some material or through space. Light and heat are types of radiation. The said radiation discussed is called ionizing radiation because it has enough energy to remove an electron from an atom, making that atom an ion.

In order to reach stability, these atoms give off, or emit, the excess energy or mass in the form of radiation. The two types of radiation are electromagnetic (like light) and particulate (i.e., mass given off with the energy of motion). Gamma radiation and X-rays are examples of electromagnetic radiation. Beta and alpha radiation are examples of particulate radiation. Ionizing radiation can also be produced by devices such as X-ray machines.

Radiation is naturally present in the environment. This is called natural background radiation. People are exposed to natural radiation from outer space, the air, food and drinks. People may also be exposed to artificial radiation from medical treatment, consumer products and occupational exposure. Often, medical exposures from diagnosis and in treatment account for the largest dose from artificial sources.

2.1 Types of radiation

Radiation is energy, in the form of particles or electromagnetic rays, released from radioactive atoms. The three most common types of radiation are alpha particles, beta particles, and gamma rays.

2.2 Alpha radiation:

This radiation can be hazardous if it enters the body by inhalation or ingestion because large exposures can result in nearby tissues.

- Alpha radiation is not able to penetrate skin.
- Alpha-emitting materials can be harmful to humans if the materials are inhaled, swallowed, or absorbed through open wounds.

- A variety of instruments have been designed to measure alpha radiation. Special training in use of these instruments is essential for making accurate measurements.
- Instruments cannot detect alpha radiation through even a thin layer of water, blood, dust, paper, or other material, because alpha radiation is minimally penetrating.
- Alpha radiation travels a very short distance through air.
- Alpha radiation is not able to penetrate turnout gear, clothing, or a cover on a probe. Turnout gear and clothing can keep alpha emitters off of the skin. Personal protective equipment should be worn to protect clothing and otherwise uncovered skin from contamination of all types.

2.3 Beta radiation:

This radiation does not normally penetrate beyond the top layer of skin but large exposures can cause skin burns and is also hazardous if it enters the body.

- Beta radiation may travel meters in air and is moderately penetrating.
- Beta radiation can penetrate human skin to the innermost layer of the epidermis where new skin cells are produced. If beta-emitting contaminants are allowed to remain on the skin for a prolonged period of time, they may cause skin injury.
- Beta-emitting contaminants may be harmful if deposited internally.
- Most beta emitters can be detected with a survey instrument. Some beta emitters, however, produce very low energy, poorly penetrating radiation that may be difficult or impossible to detect. Examples of these are carbon-14, tritium, and sulfur-35.
- Clothing and turnout gear provide some protection against most beta radiation.Personal protective equipment should be worn to protect clothing and otherwise uncovered skin from contamination of all types.

2.4 Gamma radiation:

It can deliver significant doses to internal organs without needing to be taken into the body.

- Gamma radiation and X-rays are electromagnetic radiation like visible light, radio waves, and ultraviolet light. These electromagnetic radiations differ only in the amount of energy they have. Gamma rays and X-rays are the most energetic of these.
- Gamma radiation is able to travel many meters in air and many centimeters in human tissue. It readily penetrates most materials.
- X-rays are like gamma rays. They can also travel over long distances in both air and human tissue.
- Radioactive materials that emit gamma radiation and X-rays constitute both an external and internal hazard to humans.
- Dense materials are needed for shielding from gamma radiation. Clothing and turnout gear provide little shielding from penetrating radiation but will prevent contamination of the skin by radioactive materials.
- Gamma radiation is detected with survey instruments, including civil defense instruments. Low levels can be measured with a standard Geiger counter.
- Gamma radiation or X-rays frequently accompany the emission of alpha and beta radiation.
- Instruments designed solely for alpha detection will not detect gamma radiation.
- Pocket chamber (pencil) dosimeters, film badges, thermoluminescent, and other types of dosimeters can be used to measure accumulated exposure to gamma radiation.

Each of these types of radiation represents a different hazard. The nature of this hazard depends, in part, on how much material these different types of radiation can penetrate or how far they can pass through material.

Alpha particles can be stopped by a sheet of paper or the outer skin. Beta particles can be stopped by thin layers of metal, plastic or the skin. However, gamma and X rays can pass through the body and even in some cases thick layers of lead or concrete. Neutrons can also pass through thick layers of lead or concrete.

3.0 Exposure pathways

The appropriate plain language for communicating the exposure pathways to the public can be done in a simple way.

There are two main ways of radiation exposure: external exposure from radiation sources outside the body and internal exposure from radioactive material taken into the body. The ways in which people can be exposed to radiation are referred to as exposure pathways and include:

a) External exposure from contact with or being in proximity to a source of radiation (e.g. an item, material or device that can cause radiation exposure, a plume containing radioactive material or ground contamination);

b) Internal exposure from ingestion (e.g. of contaminated food, fluid, inadvertent ingestion of contamination on hands); inhalation (e.g. from a plume or deposited radioactive material); or absorption (e.g. through skin or open wounds).

3.1 Common exposure pathways for a small radioactive source

The most common ways people are exposed by a small radioactive source.

- Carrying a source in the hand or pocket for only a matter of minutes can result in severe burns or lethal exposure
- These sources have been brought to homes or workplaces resulting in deaths from exposures that occurred over a period of up to several months
- These sources may contain radioactive powder and, if damaged, this powder can be released, get on someone's hands and be inadvertently ingested. This has also resulted in deaths.

4.0 Quantities and units

Radiation cannot be detected by the senses but it can be measured in other ways.

Quantities and units should be used very carefully, and when possible they should not be used when communicating with the public. This is because quantities and units of radiation are not commonly used or easily understood by the public. They are very different from units to measure speed and weight for example, which are used in everyday life. Radiation cannot be detected by the senses (smell, vision, taste, touch) but it can be measured in other ways.

5.0 Effects of radiation

Radiation can have two different types of effect on the body:

- Deterministic (short term, occurring early after exposure) and
- Stochastic (long term, occurring years later).

It is essential to describe these effects in simple terms and avoid using the words “deterministic” or “stochastic” when communicating with the public. Instead, the following terminology can be used:

5.1 Deterministic effects: Exposure to high levels of radiation above a certain threshold (100mSv) can harm the body. Such radiation effects can be clinically diagnosed in the exposed individual. Once a radiation dose above the relevant threshold has been received, symptoms will develop. The severity of those symptoms will depend on the dose received.

5.2 Stochastic effects: Exposure to radiation can also lead to the development of cancer several years later and possibly, of hereditary effects. Effects such as these cannot usually be confirmed in any particular exposed individual, but can be inferred from statistical studies of large populations. They appear to occur at random in the irradiated population. At no time, however, even for high doses, is it certain that cancer or genetic damage will result. Similarly, there is no threshold dose below which it can be ascertained that an adverse effect cannot occur. It can never be determined for certain that an occurrence of cancer or genetic damage was due to a specific exposure.

6.0 Recognizing a radiation source

Two internationally recognized symbols exist as warnings for radiation sources.

- The traditional trefoil radiation warning symbol
- A recent standard ionizing radiation warning supplementary symbol has also been developed and is in use.

7.0 Radiation protection

The basics of protection from radiation are time, distance and shielding.

I. Time allows us to minimize or at least limit the amount of radiation exposure we receive. The longer the exposure time, the higher the radiation dose. The relationship between time and exposure is linear. If we double the time, we double the exposure. If we triple the time, we triple the exposure. Ten times as much time, ten times as much exposure, etc. Typically, time is used in the opposite direction to lower or minimize the exposure. The shorter the exposure time, the lower the dose.

II. Distance from a radiation source is a very effective way to lower the radiation dose received. The decrease of exposure with distance is not linear. For example, if the exposure rate at 1 meter from a source is 100 then, at 2 meters it will be 25. At 10 meters, it will be 1

III. Radiation can penetrate further into materials or tissue, but can be stopped by some materials. The appropriate shielding can be used to decrease or minimize the radiation exposure.

8.0 Potential health effects

8.1 Deaths: These are projected deaths resulting from external exposure that occur within hours to weeks. These deaths are not the result of cancer induced by the radiation. Deaths from radiation are ultimately the result of multi-organ failure and depend on factors such as medical treatment, age and health of the exposed individual, and the received dose rates.

8.2 Severe health effects (severe deterministic effects): These are health effects, which result in a reduction in the quality of life. They include:

- Severe burns (localized necrosis –death of tissue) from carrying an unshielded source in the hand or pocket. Local necrosis is usually not life threatening.
- Other non-fatal effects from exposure of the whole body (e.g. Cataract, Hypothyroidism (h), permanently suppressed ovulation, permanently suppressed sperm counts, Necrosis). The thresholds are conservative and fatalities would not be expected to occur at these values in the majority of cases.

8.3 Heath effects to foetus: The foetus, depending on the stage of development can be the most sensitive, with severe health effects occurring at lower doses than for any other member of the population. The impact of exposure on fertility and the probability of bearing healthy children are unchanged for doses below 100 mSv. The termination of a pregnancy at foetal doses of less than 100 mSv is NOT justified due to the risk from radiation exposure. A foetal dose above 100 mSv does not mean that the foetus will be injured. The effects to the foetus from doses above 100 mSv depend on many factors, such as the stage of development and these health effects can only be assessed fully by experts in diagnoses and treatment of the effects radiation exposure.

8.4 Cancer risk: Projecting the potential for radiation exposure to result in an increase in the incidence of cancer is a complicated and controversial issue. In part, this is because a cancer in a particular person cannot be definitely attributed to the exposure. Therefore cancer risk is discussed in terms of an increase in the cancer incidents (rate), above what would normally be expected, in the group that was exposed. An increase in cancer incidents would only be expected if large numbers of people were exposed high dose that approach those that can result in severe health effects. An increase in the cancer rate has not been detected in any group of people who received a whole body dose from external exposure below about 100 mSv.

9.0 Health effects from being near an unshielded radioactive source

9.1 Quantity: Effective dose to the whole body from external gamma radiation received over a relatively short period (within weeks). External radiation exposure comes from radioactive material that is outside the body.

9.2 Scenario: The person has been near a source of external gamma radiation resulting in external exposure to their whole body. This could be the result of being in a room with an unshielded source (object) or from carrying an unshielded source (object). It is also assumed that the person has not ingested any radioactive material (contamination). If ingestion is suspected (e.g. from inadvertent ingestion from dirty hands) then the potential for health effects should be assessed by experts in diagnosing and treating the health effects of radiation exposure. Ingestion could cause severe health effects including death.

10.0 Plain language explanation:

10.1 1000 mSv: A dose to the whole body of more than 1000 mSv could result in severe health effects. Therefore doses above 1000 mSv would require immediate medical evaluation by experts in diagnosing and treating the health effects of radiation exposure.

10.2 100 mSv: At doses above 100 mSv to a fetus, expert medical evaluation is warranted to determine the possible effects and to provide counselling to allow informed decisions. The effects to the fetus from doses above 100 mSv depend on many factors, such as the stage of development. Furthermore, these health effects can only be assessed fully by experts in diagnosing and treating the health effects of radiation exposure. Others, such as local physicians, probably will not always have the expertise needed to make such assessments. At levels of effective dose towards 100 mSv, there is a small subsequent additional cancer risk of less than 1%.

10.3 Below 100 mSv: At doses below 100 mSv there would not be any detectable cancers or other severe health effects even to the fetus. The termination of a pregnancy at fetal doses of less than 100 mSv is NOT justified based upon the radiation risk. An increase in the cancer rate has not been detected in any group of people who received a whole body dose from external exposure below about 100 mSv.

Average annual dose to the public from natural sources of radiation exposure is shown for perspective.

10.4 General comments*:* These doses at which the health effects are shown to occur (thresholds) are the dose values at which the effect may be seen — though unlikely — in a few people, only if large numbers of people have been exposed at these levels. The actual dose value at which an effect would be seen strongly depends upon the dose rate; the dose values in the figures are for brief exposure at a high dose rate (e.g. > 10 mSv/h). The dose value at which the health effect would be expected to be seen would be higher for lower dose rates.

11.0 Health effects from carrying an unshielded radioactive source

11.1 Quantity: The dose rate (mSv/h) measured by a dose rate instrument at 1 m from the radioactive source (object) that was carried (ambient dose equivalent).

11.2 Scenario: The person was carrying the source (object) for the time indicated. The source is not leaking any radioactive material and therefore the person has not ingested any radioactive material. If the source is leaking, then the potential for health effects from inadvertent ingestion (e.g. from dirty hands) should be assessed. Ingestion could cause severe health effects including death.

Dangerous sources may become lost or stolen. There have been several cases in which prompt public announcements, by alerting the public of a hazard following the loss or theft of dangerous sources, resulted in the prompt recovery of the source, and thus the prevention of serious consequences. Physicians recognizing radiation-induced health effects have been the first to alert the authorities of many, if not most, emergencies involving lost or stolen sources.

12.0 Plain language explanation:

12.1 100 mSv/h: Carrying or holding a source (object) with a dose rate more than 100 mSv/h for minutes could be fatal or result in severe burns and other severe health effects.

12.3 10 mSv/h: Carrying or holding a source (object) with a dose rate more than 10 mSv/h [5] for hours could be fatal or result in other severe health effects.

12.4 1 mSv/h: Carrying or holding a source (object) with a dose greater than 1 mSv/h [5] for hours could result in severe burns.

12.5 0.1 mSv/h: If a pregnant woman carries a source for hours with a dose greater than 0.1 mSv/h [5] it could result in doses to the fetus that require an expert medical evaluation. The health effects can only be assessed fully by an expert in diagnosing and treating the health effects of radiation exposure. Others, such as local physicians, probably will not always have the expertise needed to make such assessments.

12.6 Below 0.1 mSv/h: At doses below 0.1 mSv/h it is highly unlikely that there would be any severe health effects, even to the fetus, from carrying or holding the source.

12.7 General comments: Carrying or holding a radioactive source can result in severe health effects (e.g. severe burns requiring surgery) to the hand, skin and tissue next to a pocket holding the source. These burns may not appear for weeks and require specialized treatment (they are not the same as a burn from intense heat). Carrying a source will also result in exposure to the whole body and to the fetus of a pregnant woman.

Exposures possibly resulting in severe health effects require an immediate medical evaluation by experts in diagnosing and treating the health effects of radiation exposure.

Dose rate measured at 1m from the source (object). The dose to the hand or tissue is calculated assuming the source is at 2 cm and the dose from carrying a source to the whole body and fetus was calculated assuming the source is at 10 cm.

13.0 CONCLUSION

Carrying or being near a radioactive source when the only source of exposure is from a small (in size) source of external gamma radiation. It must not be used for emergencies involving possible intake or significant contamination (e.g. from a reactor release). Only external exposure from being near or carrying a radioactive source is considered. Situations where significant radioactive contamination is present and internal exposure from ingesting or inhaling radioactive material is possible are not considered here

We only consider the effects of external exposure from gamma radiation (exposure from radioactive material outside the body) because this type of exposure is common and can be addressed in a general way since it does not depend on knowing the specific radionuclide (radioactive material) involved and can be based the dose rates measured by commonly available monitoring instruments. Estimating the health impact of ingestion or inhalation of radioactive materials requires a sophisticated analysis that can only be performed once actual radioactive material is known.