Working with X-rays (Ionizing Radiation)

This sheet reviews working around ionizing radiation, particularly working with or near X-ray machines. This information is based on published research. It should not take the place of medical care and advice from your healthcare providers.

What is ionizing radiation?

Radiation waves are usually invisible (can't be seen) and have no weight nor odor. Radiation is grouped into 2 categories: 1) non-ionizing and 2) ionizing.

- Non-ionizing radiation has less energy than ionizing radiation. Non-ionizing radiation does not carry enough energy to produce ions (molecules or atoms that are charged). Sources of non-ionizing radiation include light bulbs, computers, Wi-Fi routers, cell phones, Bluetooth devices, FM radio, GPS, airport body scanning units, and broadcast television.
- Ionizing radiation refers to X-rays, gamma rays, and some of the higher ultraviolet electromagnetic spectrum. X-rays are used in diagnostic imaging and in therapeutics. Gamma radiation is used in therapeutics as well. Ionizing radiation can have enough energy to produce ions.

How is radiation measured?

The amount of radiation absorbed by the body is called the 'effective dose'. The international unit of measurement for effective dose is the milli-sievert (mSv), and in the United States you may also read or hear about milli-rem (mrem).

However, radiation is also measured in other ways, such roentgen, joule, gray, or rad. Therefore, the information below is included to help convert between different types of measurements, if needed. In general:

- 1 milli-sievert (mSv) is about the same as 0.1 rems. 1 sievert (Sv) is about 100 rems
- 1 rad is about the same as 1 rem
- 1 gray (Gy) is around the same as 100 rads. 1 Gy is around the same as 1 sievert (3,000 mSv)

It is also important to remember that we are surrounded by ionizing radiation every day. Ionizing radiation is in our soil, water, and air. These sources of radiation are called background radiation. Most people are exposed to about 3 milli-sieverts (mSv) of background radiation every year (300 mrem). This estimate can change based on where a person lives. During pregnancy, a fetus is exposed, on average, to around 1 mSv of background radiation (about 100 mrem).

What work settings might have ionizing radiation?

Ionizing radiation can be found in some work settings, such as healthcare facilities, research institutions, air travel (pilot, flight attendant), baggage X-ray screening, construction, nuclear reactors and nuclear support facilities, the transportation industry, and nuclear weapon production facilities, to name a few.

In a medical work setting, ionizing radiation can be produced by X-ray machines, CT machines, and radiation therapy machines (for example: assisting in fluoroscopy procedures and working in nuclear cath labs). Exposure to ionizing radiation could also occur with the use of radioactive isotopes (radionuclides). This fact sheet will focus on working around X-ray machines.

X-rays / X-ray Machines:

X-ray machines are not radioactive, which means they are not giving off radiation when not in use. X-ray machines are designed to make radiation, and the radiation is controlled by the person who runs the machine (turned on and off by the press of a button or the flip of a switch).

X-rays travel in straight lines. When X-rays hit an object, most of the energy waves will travel straight into the object. However, some of the energy waves will bounce off and can travel in any direction – this is called "scatter". X-rays will lose energy as they travel through an object. Since an X-ray is just energy, when the energy is gone, so is the X-ray. This is called "attenuation".

How do I know if I work in an area with radiation?

Areas with possible radiation are required to post a sign similar to what you see here.

The sign will distinguish between:



1) Radiation areas (area where the body could receive a dose of more than 5 millirems in an hour, or more than 100 millirem in 5 consecutive days);

2) High radiation areas (area where a body could be exposed to more than 100 millirems in one hour); or

3) An airborne radioactivity area (an area where a person can be exposed to higher than permissible amounts of airborne radioactive material).

In addition, areas that store certain amounts of radioactive materials must also display signs that will state: "Caution, Radioactive Materials".

How is workplace ionizing radiation measured?

To measure a person's workplace exposures, the employer should give workers personal monitoring equipment, which might include film badges, pocket chambers, pocket dosimeters, or film rings. The workplace Health and Safety officer or Radiation Safety officer tracks the results and reports as required.

What are the occupational limits for ionizing radiation in the workplace?

There are occupational limits for both non-pregnant and pregnant workers who could be exposed to ionizing radiation at their workplace. When a worker becomes pregnant and informs their employer, the ionizing radiation exposure limit is reduced for the protection of the embryo/fetus. The worker that tells their employer about the pregnancy is called a "declared worker".

Most workplaces will have a Radiation Safety Officer who can keep staff up to date on current workplace limits for their job. In general, the occupational limit for ionizing radiation exposure to the whole body is 5 rems (5 rads, 50 mSv) per year. There are also regulations for specific parts of the body, as measured over a calendar quarter (3 months).

Some regulation agencies have established limits for an embryo or fetus. Some of these agencies recommend that a fetus should not receive more than 500 millirems (500 millirads, 0.5 rads, 0.5 rem, 5 mSv) over the course of the entire pregnancy. Some agencies may have different guidelines. Looking at 1 gestational month (1 month during a pregnancy), the recommendation by some regulating agencies is that exposure should not be more than 0.5 mSv (50

millirem, 0.05 rem, 50 millirads, 0.05 rads) in any one month of the pregnancy.

If the worker belongs to a professional medical organization, union or other organization, it may be beneficial to consult with them also to learn about protections that might be in place for the pregnant worker.

I work around ionizing radiation. Can it make it harder for me to get pregnant?

Remaining within the occupational limit for ionizing radiation of 5 rems (5 rads, 50 mSv) per year is not expected to make it harder for a woman to become pregnant.

Does working around ionizing radiation increase the chance for miscarriage?

Miscarriage is common and can occur in any pregnancy for many different reasons. Remaining within the occupational limit for ionizing radiation of 50 mSv (5,000 mrem, 5 rad) per year would not be expected to increase the chance of miscarriage. Radiation doses greater than 50 mSv in the first 2 weeks of the pregnancy, before the egg implants into the uterus, might increase the chance for miscarriage.

Does working around ionizing radiation increase the chance of birth defects?

Birth defects can happen in any pregnancy for different reasons. Out of all babies born each year, about 3 out of 100 (3%) will have a birth defect. We look at research studies to try to understand if an exposure might increase the chance of birth defects in a pregnancy.

In most cases of radiation exposure, the actual dose received by the embryo/fetus is less than the dose received by the woman who is pregnant. This is because some of the dose is absorbed by the body before reaching the inside of the uterus (where the fetus is developing).

Ionizing radiation exposure of less than 50 mSv (5,000 mrem, 5 rad) has not been associated with an increased chance for birth defects over the background risk. It has been estimated that a woman would need about 125 unshielded pelvic X-rays for a fetus to be exposed to 50 mSv of radiation.

Does working around ionizing radiation increase the chance of other pregnancy problems?

Exposure to high doses (around 250 mSv or more (around 25,000 mrem or more) of radiation could be harmful to a pregnancy. These high dose exposures have been associated with small head size and poor growth. Some studies have looked at whether prenatal exposure to X-rays could increase the chance of cancer in children, but risks are unclear. If there is a cancer risk from prenatal X-ray exposure, it would be small. It is not known if working around ionizing radiation can cause other pregnancy problems, such as preterm delivery (birth before week 37).

Does working around ionizing radiation in pregnancy affect future behavior or learning for the child?

Remaining within the occupational limits for both pregnant and non-pregnant workers would not be expected to have long-term effects for a pregnancy. Exposure to high doses (more than 500 mSv or 50,000 mrem) of radiation could be harmful to a pregnancy and has been associated with learning difficulties and intellectual disabilities. In addition, exposure to more than 100 mSv (10,000 mrem) of radiation between the 8th week and the 15th week of pregnancy might be associated with learning difficulties and intellectual disability.

Breastfeeding while working with X-rays:

X-rays are present only during the time that an image is being taken and leave no radiation or radioactivity in the body or in milk. Diagnostic X-rays have no effect on the breastmilk at the time of a procedure and would not be expected to affect milk production. Be sure to talk to your healthcare provider about all your breastfeeding questions.

If a man works around ionizing radiation, can it affect fertility or increase the chance of birth defects?

Several studies have not found an association between low-level occupational radiation exposure to sperm and birth defects or childhood cancer in future children. It is possible that higher radiation exposure to the testes (more than 100 mSv or 10,000 mrems) could cause a temporary reduction in sperm count. As doses go higher, around 3,000 mSV or higher (around 300,000 mrems or higher), permanent male sterility could occur). It would be rare to be exposed to ionizing radiation at these doses.

In general, exposures that men have are less likely to increase risks to a pregnancy. For more general information, please see the MotherToBaby sheet Paternal Exposures at https://mothertobaby.org/fact-sheets/paternal-exposures-pregnancy/.

What can workers do to reduce exposure to ionizing radiation?

Follow the Safe Work Practices outlined for your job by your radiation safety officer or industrial hygienist.

Below are some general tips:

- Keep the time of exposure as short as possible.
- Maximize your distance from the source of exposure.
- Shield yourself from the source of exposure by:
- Using appropriate personal protective equipment (such as lead gloves and aprons);
- Standing the appropriate distance from the machine, or be out of the room or behind the appropriate shielding walls; and
- Not standing in a direct line from a machine's beam source.
- Wear the personal radiation monitoring badge (dosimeter) as supplied by your employer.
- Check to see if equipment is inspected as required; including machines and protective gear, such as lead aprons.
- Store lead aprons properly by hanging on an approved hanger (do not fold or crease).
- In extreme situations in which you cannot avoid being in the room while X-rays are being taken, use a mobile shield or wear a protective apron that has the appropriate thickness as outlined by your Radiation Safety Officer. Make sure the apron can wrap around the body and has full coverage of the abdomen. In addition, use lead goggles, gloves, and shields.

For other workplace exposures, MotherToBaby has a general fact sheet on ways to reduce potential exposures to chemicals at https://mothertobaby.org/fact-sheets/reproductive-hazards-workplace/. Your worksite is required to provide the proper personal protection for all parts of your job. Be certain to use them, even when not pregnant.

Where can I look for more information? / What agencies regulate radiation?

Listed below are some agencies involved in monitoring or regulating radiation.

- Canadian Nuclear Safety Commission
- The Centers for Disease Control and Prevention (CDC)

- Conference of Radiation Control Program Directors (CRCPD)
- Environmental Protection Agency (EPA)
- Federal Aviation Administration, Office of Aerospace Medicine, Civil Aerospace Medical Institute
- Health Physics Society
- International Commission of Radiological Protection (ICRP)
- International Commission on Radiation Units and Measurements (ICRU)
- National Council on Radiation Protection and Measurements (NCRP)
- National Institute for Occupational Safety and Health (NIOSH)
- Occupational Safety and Health Administration (OSHA)
- Radiation Safety Institute of Canada
- US Department of Energy (DOE)

Please click here for references.

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