

## People Exposed to More Radiation from Medical Exams

With its release of a new report, titled *Ionizing Radiation Exposure of the Population of the United States* (Report No. 160, 2009), the National Council on Radiation Protection and Measurements (NCRP) shares information about the increase in average medical radiation doses received by members of the public. Its information, collected and verified by experts across the United States, tells a story of our increasing use of technology to enhance our lives. “Based upon an evaluation of the peer-reviewed literature that details the improvements brought about by such technologies ... it is reasonable to conclude that millions of lives have been saved and millions more dramatically improved as a result of these imaging technologies (MITA 2007a).”

Technological advances and innovations in medicine have produced significant benefits for society, noted by healthier, longer lives (MITA 2007a). Early disease diagnosis and some disease treatments involve imaging exams that expose us to [radiation](#). With radiation, physicians have the capability to see inside the human body, to determine if any organ is not functioning properly, to determine if a growth is cancer, to treat disease, and to see if our disease is gone after treatment. Timely detection and treatment of disease is critical to improving outcomes.

As with any medical imaging procedure, individuals need to discuss with their physician the need for the procedure and the potential benefit of having it performed. Imaging procedures must be justified based on a need for information to improve the patient’s health condition. Self-referral for an imaging exam is discouraged and the use of some imaging modalities in healthy individuals is opposed ([http://hps.org/documents/ctscreening\\_ps018-0.pdf](http://hps.org/documents/ctscreening_ps018-0.pdf)).

The Health Physics Society, a professional society of radiation safety professionals including those who work in the medical field, applauds the NCRP on putting together such a comprehensive report of doses to the population of the United States. With this information sheet, the Society is offering additional clarifying information to help assure that portions of the NCRP report are easily understood.

### ***Some Numbers (if it is not noted otherwise, the numbers are from the NCRP report)***

Total number of medical procedures (diagnostic and therapeutic) performed in 2006 that involve ionizing radiation = ~435 million

- All Radiography = ~414 million
- Nuclear Medicine = ~20 million
- Therapy = ~1 million

Number of General Radiography procedures performed each year = ~324 million (top five below)

- Chest x ray = ~129 million
- Extremities (arms, legs, hands, feet) = ~56 million
- Mammography = ~34 million
- Spine (cervical, lumbar, and thoracic) = ~20 million
- Pelvis/Hips = ~19 million

Number of [CT scanning](#) procedures performed in 2006 = ~62 million

- Most (~32 percent) are some combination of abdomen/pelvis, next most common is head (28 percent)
- The combination exam of chest/abdomen/pelvis delivers highest dose (ave. 28 [mSv](#)) (Stern et al. 2001)
- The combination exam of abdomen/pelvis delivers second highest dose (ave. 10 mSv) (Stern et al. 2001)
- Abdomen or pelvis average CT dose is 8 mSv (Stern et al. 2001)

### [Questions and Answers](#)

Has the [collective radiation dose](#) from all medical imaging procedures increased?

Yes, from about 124,000 [person sievert](#) in 1990 to 900,000 person sievert in 2006. Half of that (about 440,000 person sievert) is from CT scans.

Can you compare this to something with which I'm familiar?

The estimated collective dose to the U.S. population from natural background radiation is 918,000 person sievert. The estimated collective dose to all who were exposed to radiation as a result of the Chernobyl nuclear accident is 400,000 person sievert.

Why is there more CT scanning?

Many of the newer procedures in radiology are used to determine if someone needs (or doesn't need) to go to surgery and, in several cases, procedures can be done in radiology instead of open surgery. We can now see things inside the body we could not see before unless we opened the body up in a surgical suite. Some CT exams have actually replaced other x-ray imaging exams because the CT is more accurate and is done with a lower [mortality](#).

There are also two issues that increase the number of CT scans. One is demand by the patient that the procedure be performed and the other is the ordering of exams that are not necessary. Again, you (the patient) are strongly encouraged to work collaboratively with your physician when it comes to your medical care – ask why an exam is being prescribed, what information will be gained, whether other tests could provide the same information without radiation exposure, etc.

How does that affect the average dose per person?

The average dose also went up, from 3.6 mSv in the early 1980's to 6.2 mSv in 2006. The average dose per person is an average over the population of the United States.

What medical exams contribute most to that collective dose in this report?

CT exams account for only 18 percent of the procedures performed, but over 50 percent of the collective dose. In nuclear medicine, cardiac studies (studies of the heart) are 5 percent of the procedures performed, but account for 85 percent of the collective dose. Those two types of procedures contribute the most to the total collective dose.

How does that affect the average dose per person?

The average dose also went up, from 0.54 mSv in 1990 to 6.3 mSv in 2006.

Can you compare this to something with which I'm familiar?

The estimated average annual effective dose per person in the United States is 6.3 mSv. The average effective dose per person for a two-view chest x ray is about 0.1 mSv and for one abdominal image is 0.7 mSv.

Can we decrease the per procedure dose?

Yes, we should be able to reduce the dose without significantly affecting image quality. Manufacturers continue to work on this and have been able to reduce radiation doses for many procedures by 20-75 percent over the last 20 years (MITA 2007b). The American Association of Physicists in Medicine (AAPM) issued a CT radiation dose management report in 2008, recommending standardized ways of reporting doses and educating users on the latest dose-reduction technology. The report is available on the AAPM Web site at [http://www.aapm.org/pubs/reports/RPT\\_96.pdf](http://www.aapm.org/pubs/reports/RPT_96.pdf).

Will the collective dose decrease then?

It is hard to tell. A larger percentage of the population is aging and with that comes more medical procedure, plus with advances in technology it is likely that more and more imaging procedures will minimize the need for surgery. Those two things combined suggest that collective dose will not decrease even with decreases in per-procedure doses. The number of CT exams has been increasing at a rate of about 10 percent per year over the last decade; we are unlikely to see that change in the next decade. Collective dose can be minimized by preventing the inappropriate use of such imaging and by optimizing studies that are performed to obtain the highest image quality with the lowest radiation dose (Amis et.al 2007).

Who is getting all these exams?

Over half of the CT exams are done on individuals over the age of 55. In fact, those aged 55-75 in our population make up just 20 percent of us, but they are having over 54 percent of the CT exams. About 8-10 percent of CT exams are performed on children under age 18. For nuclear medicine tests, nearly 80 percent are performed on persons over the age of 45; many of these are cardiac imaging exams.

What does this mean for me if I get very few or no imaging exams in my lifetime?

It doesn't impact you other than a benefit from the diagnosis. It will not change your risk of getting cancer.

What does this mean for me if I have a lot of imaging exams done in my lifetime?

Multiple CT exams can approach radiation doses known to increase the cancer risk (ICRP 2007). If you receive a lifetime radiation dose of 0.1 Sv or more, your chances of getting cancer increase from the normal incidence of 42 percent to 43 percent. If you receive a lifetime radiation dose of 1 Sv or more, your chances of getting cancer increase from 42 percent to 58 percent.

- For some information about general radiation doses and expected effects, [click here](#).
- To see a table of commonly encountered radiation doses, [click here](#).
- For a list of resources used to write this summary: [Resources](#)
- For a list of references used to write this summary: [References](#)

- For a Health Physics Society Information Sheet on the Benefits of Medical Radiation Exposure:  
[http://hps.org/physicians/documents/Radiation\\_Benefit\\_and\\_Risk\\_Assessment.pdf](http://hps.org/physicians/documents/Radiation_Benefit_and_Risk_Assessment.pdf)
- For more information on radiation sources, doses, and cancer risks:  
<http://www.radiationanswers.org/radiation-and-me/radiation-cancer/radiation-sources-doses-cancer.html>

## **THE REST OF THIS IS ALL LINKED INFORMATION FROM THE PRIMARY SUMMARY**

General radiation doses and expected effects (radiation doses are to the entire body):

- 0-0.05 Sv received in a short period or over a long period is safe—we don't expect observable health effects.
- 0.05-0.1 Sv received in a short time or over a long period is safe—we don't expect observable health effects. At this level, an effect is either nonexistent or too small to observe.
- 0.1-0.5 Sv received in a short time or over a long period—we don't expect observable health effects, although above 0.1 Sv your chances of getting cancer are slightly increased. We may also see short-term blood cell decreases for doses of about 0.5 Sv received in a matter of minutes.
- 0.5-1 Sv received in a short time will likely cause some observable health effects and received over a long period will increase your chances of getting cancer. Above 0.5 Sv we may see some changes in blood cells, but the blood system quickly recovers.
- 1-2 Sv received in a short time will cause nausea and fatigue. 1-2 Sv received over a long period will increase your chances of getting cancer.
- 2-3 Sv received in a short time will cause nausea and vomiting within 24-48 hours. Medical attention should be sought.
- 3-5 Sv received in a short time will cause nausea, vomiting, and diarrhea within hours. Loss of hair and appetite occurs within a week. Medical attention must be sought for survival; half of the people exposed to radiation at this high level will die if they receive no medical attention.
- 5-12 Sv in a short time will likely lead to death within a few days.
- >100 Sv in a short time will lead to death within a few hours.

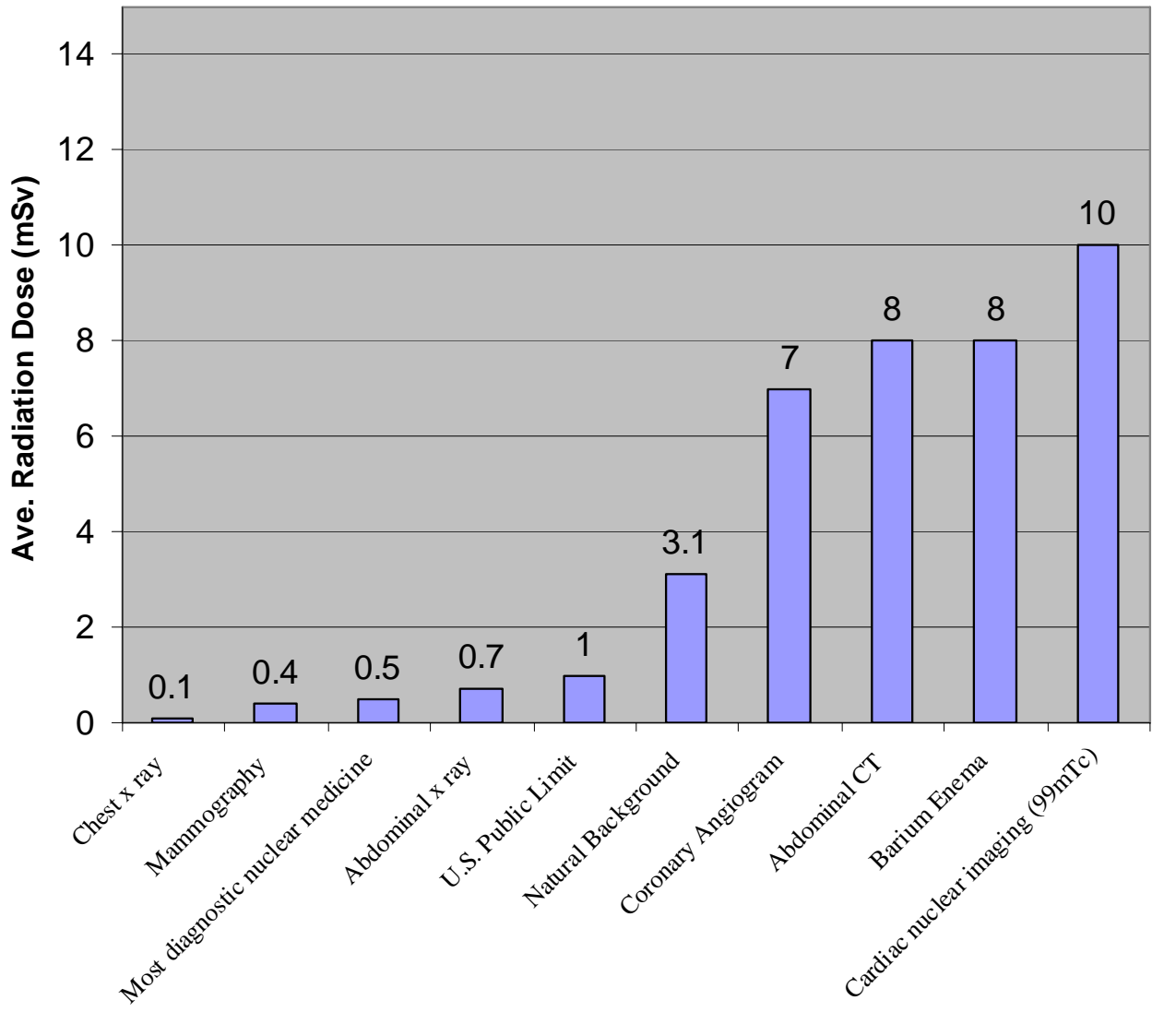
## Commonly encountered radiation doses:

Effective Dose	Radiation Source
Less than (<) or equal to (=) 0.1 mSv <sup>+</sup>	annual dose living at nuclear power plant perimeter bitewing, panoramic, or full-mouth dental x rays skull x ray chest x ray
<=1 mSv	single spine x ray abdominal x ray pelvic x ray hip x ray mammogram
<=5 mSv	kidney series of x rays most barium-related x rays head CT* any spine x-ray series annual <a href="#">natural background</a> radiation dose most nuclear medicine brain, liver, kidney, bone, or lung scans
<=10 mSv	barium enema (x rays of the large intestine) chest, abdomen, or pelvic CT*
<=50 mSv	cardiac catheterization (heart x rays) coronary angiogram (heart x rays) other heart x-ray studies most nuclear medicine heart scans

\*CT = computerized tomography; a specialized x-ray exam.

<sup>+</sup>mSv = 0.001 Sv or 1 Sv = 1,000 mSv; 1 mSv = 100 millirem

### Magnitude of Various Radiation Doses



## Resources Link

- [Health Physics Society Position Statement on Risk Assessment](#)
- [ICRP 60](#): ICRP Publication 60, Recommendations of the International Commission on Radiological Protection. Annals ICRP. 21(1-3):1-201, 1991. Pergamon Press.
- [ICRP 62](#): ICRP Publication 62, Radiological Protection in Biomedical Research. Annals ICRP. 22/3, 1991. Pergamon Press.
- [The University of Michigan's Radiation and Health Physics Page](#) – this link is the cover page for a book titled *What You Need to Know about Radiation to Protect Yourself, to Protect Your Family, to Make Reasonable Social and Political Choices*. On this cover page, you'll find titles and links to each section.
- An excellent review of radiation health effects can be found in the Executive Summary of "[Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2](#)" (2006).
- Beyond the visible: managing heart disease and cancer with nuclear science. <http://www.iaea.org/Publications/Booklets/HeartDisease/beyondvisible.pdf>

## References Link

- Amis SE, Butler PD, Applegate KE, Birnbaum SB, Brateman LF, Hevezi JM, Mettler FA, Morin RL, Pentecost MJ, Smith GG, Strauss KJ, Zeman RK. [American College of Radiology](#) white paper on radiation dose in medicine. J Am Coll Radiol 4:272-284; 2007.
- International Commission on Radiation Protection. Managing patient dose in multi-detector computed tomography (MDCT). Oxford: Elsevier; ICRP Publication 102, Volume 37, No. 1; 2007.
- Medical Imaging and Technology Alliance. How innovations in medical imaging have reduced radiation dosage. MITA; 2007a. Available at: [http://www.medicalimaging.org/news/fullreport\\_reduced\\_radiation\\_dose.pdf](http://www.medicalimaging.org/news/fullreport_reduced_radiation_dose.pdf).
- Medical Imaging and Technology Alliance. Radiation dosage and medical imaging: A statement from the Medical Imaging and Technology Alliance. MITA; 2007b. Available at: <http://medicalimaging.org/mita/radiationstatement071707.pdf>.
- Stern SH, Kaczmarek RV, Spelic DC, Suleiman OH. Nationwide evaluation of x-ray trends (NEXT) 2000-01 survey of patient radiation exposure from computed tomographic (CT) examinations in the United States. Presented at the 87<sup>th</sup> Scientific Assembly and Annual Meeting of the Radiological Society of North America, Chicago, November 25-30, 2001.



## Glossary

*absorbed dose:* Absorbed dose is used for purposes of radiation protection and assessing dose or risk to humans in general terms. Absorbed dose is the amount of radiation absorbed in an organ or tissue (i.e., the amount of radiation energy that has been left in cells, tissues, or organs). Absorbed dose is usually defined as energy deposited (joule) per unit of mass (kilogram). See gray and rad.

*collective dose:* Collective dose is the [effective dose](#) received by members of a population multiplied by the number of people exposed. At low individual effective doses ( $<0.1$  Sv), it is inappropriate to use collective dose to calculate cancer deaths since these low individual doses may or may not lead to disease. An example of collective dose with CT scans would be to say if 10,000 people each had one CT scan with a radiation dose of 0.01 Sv, the collective dose is  $10,000 \times 0.01$  or 100 person sievert.

*computerized tomography (CT scan):* a specialized x-ray that displays computerized cross-sectional images of the body, providing a noninvasive means of visualizing the brain, lungs, liver, spleen, and other soft tissue.

*diagnostic:* In medicine, diagnosis or diagnostics is the process of identifying a medical condition or disease by its signs and symptoms and from the results of various procedures. As used when referring to medical exams involving radiation, it is the use of x rays or radioactive materials to identify the medical condition.

*dose:* Dose is a general term used to express (quantify) how much radiation exposure something (a person or other material) has received. The exposure can subsequently be expressed in terms of the absorbed, equivalent, committed, and/or effective dose based on the amount of energy absorbed and in what tissues.

*effective dose:* Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. The health effects of one unit of dose to the entire body are more harmful than the same dose to only a portion of the body, e.g., the hand or the foot. To enable radiation-protection specialists to express partial-body exposures (and the accompanying doses) to portions of the body in terms of an equal dose to the whole body, the concept of effective dose was developed. Effective dose, then, is the dose to the whole body that carries with it the same risk as a



higher dose to a portion of the body. As an example, 8 rem (80 mSv) to the lungs is roughly the same potential detriment as 1 rem (10 mSv) to the whole body based on this idea.

*exposure*: Exposure is commonly used to refer to being around a radiation source, e.g., if you have a chest x ray, you are exposed to radiation. By definition, exposure is a measure of the amount of ionizations produced in air by photon radiation.

*high-level radiation*: High-level radiation refers to radiation doses  $>10$  rem to a human body.

*low-level radiation*: Low-level radiation refers to radiation doses  $\leq 10$  rem to a human body.

*mortality*: the relative frequency of deaths in a specific population; death rate.

*natural background*: Natural background includes radiation from cosmic sources, naturally occurring radioactive materials (including radon), and global fallout (from the testing of nuclear explosive devices). The typically quoted average individual exposure from background radiation is 0.30 rem per year.

*nuclear medicine*: diagnostic and therapeutic medical techniques using [radioactive materials](#).

*observable health effect*: An observable health effect is a change in physical health that can be detected medically. Observable health effects may include changes in blood cell counts, skin reddening, cataracts, etc. Whether or not it is an observable *harmful* health effect depends on whether damage to the body has occurred and whether that damage impairs how the body is able to function.

person sievert: a unit of collective dose where either the average dose to the individuals is multiplied by the total number of individuals exposed or the actual dose to the individuals is multiplied by the total number of individuals exposed. For instance, if 1,000 individuals were exposed to 0.1 Sv, the collective dose would be  $1,000 \times 0.1 = 100$  person sievert.

*radioactive material:* Radioactive material is material that contains radioactivity and thus emits ionizing radiation. It may be material that contains natural radioactivity from the environment or a material that has been made radioactive (see radioactivity).

*radiology:* the science dealing with radiation for medical uses to examine bones, organs, etc., with x rays and the interpreting of those x rays.

*rem:* Rem is the term used to describe equivalent or effective radiation dose. In the International System of Units, the sievert (Sv) describes equivalent or effective radiation dose. One sievert is equal to 100 rem.

*risk:* Risk is defined in most health-related fields as the probability or odds of incurring injury, disease, or death.

*safe:* Safe, as it is being used in the information here, is defined as an activity that is generally considered acceptable to us. This is not to say there is absolutely no risk with an activity that is considered safe; there may be a risk from the activity or the exposure to radiation, but it is the same or lower than the risks from everyday actions. At a level of radiation that is considered safe, an effect is either nonexistent or too small to observe.

*sievert:* The sievert (Sv) is the term used to describe equivalent or effective radiation dose. In the traditional system units, the rem describes equivalent or effective radiation dose. One sievert is equal to 100 rem. The millisievert (mSv) is one-one thousandth of a sievert ( $1,000 \text{ mSv} = 1 \text{ Sv}$ ).

*therapeutic:* Therapeutic describes the medical treatment of disease or disorders. With respect to radiation therapy, therapeutic doses (e.g., external beam treatments for tumors, radioiodine treatment for thyroid disorders) are significantly greater than those received from diagnostic procedures (e.g., chest x rays, CT scans, nuclear medicine procedures, etc.).

*x rays:* X rays are electromagnetic radiation (photons) that can be emitted from radionuclides or from certain types of devices. Generally, x rays have lower energies than gamma rays, but like gamma rays, x rays can penetrate into the body. Sometimes lead or concrete may be used as shielding for x rays.