

HOW TO COMPARE X-RAY DOSES TO OTHER IMAGING TESTS AND OTHER RISKS

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To understand this, you must first read the article titled "X-ray Exposure" on this website

As mentioned in the previous article, here are some representative ESEs for plain films: (typical equipment, 400-speed film/screen imaging)

Cervical spine study (7v)	½ r
Thoracic spine study (2v)	½ r
Lumbar spine study (2v)	1-2r
Chest study (2v)	1/20r or less

Here are some other representative ESEs:

Routine G-I study with fluoroscopy	5 r
4v routine screening mammogram	1/4 - 1/3 r

Here are some reference values (RVs) now recommended by the AAPM (American Association of Physicists in Medicine) are based on levels achieved by 75% to 80% of U.S. facilities in a nationwide survey. The following are the levels set for various exams (1mGy = 100mr). Note that "reference values" generally indicate that these values should not be *exceeded*. In practice, actual exposure values are often lower.

PA chest (1v):	0.25 mGy (25mr = 1/40 r)
AP cervical spine:	1.25 mGy (125mr)
AP abdomen:	4.50 mGy (450mr)
AP lumbar spine:	5.0 mGy (500mr)
Head CT (measured at the center of a phantom):	60 mGy (6000 = 6r)
Body CT (measured at the periphery of a phantom, 1 cm beneath the surface):	40 mGy (4000mr = 4r)
Fluoroscopy	65 mGy/min (6500mr/min)

A routine bone scan (radioactive isotope study) might create about 1/10 rem dose

Doses to specific organs would, of course, be less than the skin entrance dose, because the organs are obviously deep to the skin. For example, while the skin entrance dose for a 2-view thoracic study is approximately 1/2 rad, the male gonad dose for that same study is only approximately 1/10 of one millirad!

Comparison to Dental X-rays

Watch out for dental exposures reported as "**effective doses.**" The regional skin dose is *extrapolated to the whole body*, therefore a localized exposure of 15 mR is equivalent to some very small number of microGray (millionths of Grays, or 100 millionths of rads)!

Intra-oral (bite-wings) (film) measured exposure at skin entrance: WA state average is 250 mr, depending on the kV and film speed being used. While still low figures, the reason that these values seem a bit high as compared to cervical spine x-rays is that they are direct exposures on film; that is, there are no intensifying screens. If skin doses are compared, many offices could produce all 7 cervical spine films in a comprehensive study for less skin dose radiation than one or two bite wings!

Intra-oral (digital) WA state average is around 70 mr, depending on whether it is CR (phosphor plate technology requiring "processing") or DR (direct digital, like the Schick system).

Cephalometric (film) skin entrance is usually just 15 mr, coincidentally same as chest. Panoramic is more difficult to measure because it is a slit beam moving around. In units using film, we have measured around 1500 mR right where the beam, after exiting the patient's head, enters the slit of the image receptor, so obviously much more at skin entrance.

Literature says that "effective dose" is 0.3 to 1 mr!

Comparison to routine G-I studies

Routine G-I contrast studies involve x-ray doses that are approximately three to four times greater than that required even for one of our biggest plain film studies, a 5-view lumbar study. These studies have been utilized for decades and there is no data to show any transient or long-term symptoms or measurable functional defects associated with these studies. This places our routine diagnostic skeletal studies into a very safe range.

BACKGROUND RADIATION

People often make the mistake of thinking that x-rays are their only source of radiation! In fact, we are all routinely exposed to “background radiation,” simply because we exist in the world. We all receive whole body radiation dose from cosmic rays, from terrestrial sources (land, rocks, etc), and our food, water, and air.

The average total background radiation of about 1/3 rem per year roughly compares to having 7 2v chest x-rays! (Another example of how low the exposures are for diagnostic x-rays!)

If one lives in Denver, he receives more background radiation, because of the elevation, than if one lives at sea level in Seattle.

The term “rem” is used for measuring background radiation, in order to cover the other forms of ionizing radiation which we routinely encounter, which are not x-ray, but which can have biologic effect on living tissue.)

Here are some representative values for background radiation, obtained from the American Nuclear Society website www.ans.org:

Average background exposure for Americans	360 mrem / year (1/3 rem)
Cosmic radiation at sea level (higher w/ elevation)	26 mrem / year
Terrestrial (from the ground)	30 mrem / year
Living or working in stone, brick, concrete building	7 mrem / year
Food	40 mrem / year
Air (largely radon)	200 mrem / year
Jet flight	½-1 mrem / hour in air
Luggage inspection	0.002 mrem

People often also make the mistake of disregarding the **other life risks** that they routinely encounter: Estimated loss of life expectancy in days due to various causes (Health Physics 1979;36:707)

Cigarette smoking (males)	2250
Dangerous job	800
Motor vehicle accidents	207
Alcohol (US average)	130
Accidents at home	95
Average job	74
Safest job	30
Natural radiation	8
Medical x-rays	6

These statistics suggest that it is more dangerous to drive to the doctor’s office than to have the x-rays once you are there!

Consideration of impact to the body - comparison of stressors

There is no dosage of ionizing radiation which is low enough so that it causes *no* ionization, so there is always theoretic damage at the atomic level. We know, however, that a vast number of atoms can be altered without any effect being discernible by any known testing method, including our most detailed chromosomal analysis.

We have roughly 75 trillion cells, each composed of uncounted atoms. An astronomical number of whole *cells* die normally every day, and the body is designed to maintain itself and replace cells that are damaged or live their full life span. Just for your general amazement:

- 300 million cells in our bodies die *every minute* and are immediately replaced so that the number remains relatively constant throughout adulthood.
- 28 billion skin cells are lost every day; $\frac{1}{2}$ million *every 30 seconds!*

If we were to look at a skinned knee on the atomic – and even cellular – level, it would look catastrophic!

Benefit-Risk Ratio

This balancing act is what the doctor considers when he/she orders a radiologic study. We know that a well-produced diagnostic radiologic study, utilizing optimum radiation protection techniques, is a negligible health risk, at most - more theoretical than real - and that it is well justified in the proper investigation of health complaints because its potential benefits far outweigh the infinitesimal negative effects on the body.

How Do You Know YOUR Office Exposures?

As previously stated, there are tables available which provide averages for every standard type of diagnostic x-ray study. This is only an average, however, because individual x-ray tubes emit varying amounts of energy; and patient size, varying screen/film/grid combinations, etc, can bring figures out of the “average” range. The values derived from tables are perfectly adequate for general purposes, however, and are usually the only information which is available in any given case.

It is possible for an individual x-ray facility to be checked so that you will know what the output of your specific machine is. This test is performed by radiation control specialists, and it involves the use of a professional dosimetry unit. This cannot be accomplished in a brief routine inspection, but requires an extended period of time on the part of the radiation control examiner. Even so, you would still only obtain a few representative values.

When tube output is measured by the radiation control examiner, the results are given in units of mR/mAs. This indicates how many milliroentgens (mR) of exposure are actually produced for every mAs selected at the control unit. For example, if you set your machine utilizing the 200 mA station and the 1-second time setting, you know that you would end up with 200 mAs. The question is, how many mR of exposure does your machine produce for this 200 mAs? To make matters more complicated, the mR/mAs varies depending on the kV setting!

It is not really necessary for practical purposes to have a dosimetry test simply for the purpose of checking tube output (everyone just depends on the average doses published in charts), but it may be of interest in determining the adequacy of lead shielding in the walls and operator’s booth.

Remember: there is no comparison between **constant TOTAL BODY** radiation that radiation workers may be exposed to - and the **occasional REGIONAL** radiation that patients may require.