# X-Ray Imaging is Essential for Contemporary Chiropractic and Manual Therapy Spinal Rehabilitation: Radiography Increases Benefits and Reduces Risks

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**Abstract**

To remedy spine-related problems, assessments of X-ray images are essential to determine the spine and postural parameters. Chiropractic/manual therapy realignment of the structure of the spine can address a wide range of pain, muscle weakness, and functional impairments. Alternate methods to assess such spine problems are often indirect and do not reveal the root cause and could result in a significant misdiagnosis, leading to inappropriate treatment and harmful consequences for the patient. Radiography reveals the true condition and alignment of the spine; it eliminates guesswork. Contemporary approaches to spinal rehabilitation, guided by accurate imaging, have demonstrated superiority over primitive treatments. Unfortunately, there are well-meaning but misguided activists who advocate elimination or minimization of exposures in spine radiography. The radiation dose employed for a plain radiograph is very low, about 100 times below the threshold dose for harmful effects. Rather than increasing risk, such exposures would likely stimulate the patient's own protection systems and result in beneficial health effects. Spine care guidelines need to be revised to reflect the potential benefits of modern treatments and the lack of health risks from low X-ray doses. This would encourage routine use of radiography in manual spine therapy, which differs from common pharmacologic pain relief practice.

**Key words:** *spine rehabilitation, radiation exposure, X-ray, chiropractic, routine radiography*

## X-Ray Imaging Is Needed for Manual Therapy of the Spine

Chiropractic/manual therapy realignment of the structure of the spine can address a wide range of pain, muscle weakness, and functional impairments resulting from abnormal stresses and strains on the various spinal components including bone, muscles, ligaments, discs, and neural tissue. As shown in Figure 1, essential components in the pathoanatomical etiological mechanisms in human disease revolve around the spinal cord being housed in the spine, and the spinal nerves passing from the spinal cord through openings between the vertebrae to the regional nerves via the peripheral nervous system.[1] A spinal nerve is a mixed nerve, which carries motor, sensory, and autonomic signals between the central nervous system and the body. Thus, spinal deformities or "subluxations" resulting from various types of poor postures (eg, forward head translation, thoracic hyperkyphosis, etc) and spinal deformities (eg, scoliosis, cervical/lumbar kyphosis, etc) exert direct and indirect pressures onto the nerves and cord as well as onto the associated tissues including muscles, bone, ligaments, discs, and so on and thereby disrupt normal function to cause dysfunction or "dis-ease" and outright diagnosable pain and illness syndromes (eg, neck pain, low back pain, sciatica, tension headache, migraine, cervical myofascial pain syndrome, fibromyalgia, etc).

Classically, spinal nerve irritation typically involves radicular symptoms (eg, sciatica, cervical radiculopathy), however all of the involved tissues associated with spinal function including the muscles, ligaments, intervertebral discs, facet joints, and so on when irritated beyond some threshold will exert potential axial or localized symptoms (eg, muscle pains, facet syndrome, etc). Thus, spine and postural subluxation deformities may cause various ailments through various anatomical "pain generators," where the chiropractor and other manual therapists attempt to diagnose, treat, and manage these patients.

Imaging of the spine is an essential element of modern chiropractic and manual therapy.[2–10] Radiography of a standing patient provides important spine/posture data, such as segmental and total angles of curvature,[11–15] sagittal balance,[16] and degenerative processes.[17–23] Also shown are relative and absolute contraindications to manual therapy, such as the traditional "red flags" (ie, serious spinal pathology) including cauda equina syndrome, fracture, infection, inflammatory disorders, abdominal aortic aneurism, ligament instabilities, and malignancies, to name the most obvious (these are concerns for all health-care providers). Further, there are specific considerations for the chiropractor/manual therapist planning to apply external forces to a patient's spine, unrelated to red flags. These include initial postural presentation, such as sagittal balance, spinal contour, anatomical anomalies (cervical rib, lumbar sacralization, congenital fusions, pelvic morphology, etc), and spinal pathologies (osteoarthritic changes).[24–26]

In response to concerns about radiography-induced "health effects" such as cancer, we will demonstrate that the radiation doses in medical diagnostics, Figure 2, are more than 100 times lower than the measured threshold dose for radiation-induced cancer. A radiograph may in fact stimulate our protective systems, which is a beneficial health effect.

Alternative spine assessment methods, such as photogrammetry and skin contour measuring devices, give vague, unreliable, and invalid information. They do not represent true internal spine geometry.[28–30] Alternative imaging, such as by magnetic resonance imaging, is typically performed with the patient supine. This cannot reveal key anatomical features, including sagittal balance and spinal contour parameters.[16,31]

Only X-rays can detect the precise spinal coupling patterns present (ie, normal lordosis, hypolordosis, and kyphosis) in assessing craniovertebral syndromes,[11] such as forward head translation (Figure 3), lumbar spine disorders[12,13] (Figure 4), and to discriminate between true scoliosis and pseudo scoliosis[32] (Figure 5). The information obtained in these images is clearly very important for the assessment and treatment of spinal disorders by clinicians seeking to realign altered spine configurations in different patient populations.

Several clinical studies have demonstrated that spine rehabilitation programs, customized for the specific patient's spinal misalignment, provide better patient outcomes versus traditional standardized approaches of the past (and present).[2–10]

Recently, randomized clinical trials on patients having cervical hypolordosis (but not hyperlordosis) demonstrated that manual therapy methods, using extension-traction methods to increase the lordosis as part of a multimodal rehabilitation program, provide long-term relief in patients suffering from cervical spondylotic radiculopathy, neck pain, and dizziness.[2–5] However, patients in control groups who received traditional (standardized) rehabilitation methods were found to have temporary relief that regressed after cessation of treatment.

Similarly, randomized clinical studies, on patients with lumbar spine hypolordosis (but not hyperlordosis) using extension-traction methods to restore lordosis, have shown long-term relief from low back pain, disability, improved segmental rotation and translation motion, and discogenic lumbosacral radiculopathy (sciatica).[6–8] In contrast, control groups treated by conventional, standardized methods were observed to experience only short-term relief that regressed after the treatment ended.

Finally, in the treatment of scoliosis, trials have demonstrated that when comparing 2 matched groups, those receiving customized, scoliosis-specific exercise programs achieved significantly better outcomes (ie, higher quality of life scores, decreased vertebral and trunk rotation angles, and decreased spinal curve deformity angles). Comparison groups receiving conventional, nonspecific "core" exercise programs either had no improvements (ie, stabilization) or slight improvements but less than the customized treatment group.[9,10]

## Radiation Protection Advice Against Radiography

Radiation protection advice to minimize radiation exposures has spread to the chiropractic profession.[33–36] Acceptance of recommendations to eliminate, delay, or otherwise constrain radiography would be very detrimental to the quality of the treatment to patients who suffer from spine-related ailments. Radiographs are essential to accurately diagnose the causes of pain, muscle weakness, and impaired movement and to monitor the progression of the changes resulting from the manual therapy. It is very important to examine the basis for the radiation protection recommendation to restrict radiography. Is it based on evidence or ideology?

Immediately after the discoveries of X-rays in 1895 and radioactivity in 1896, X-ray devices and radioactive materials were applied in physics, chemistry, and medicine. Medical practitioners have employed ionizing radiation for imaging and treatment of patients. Low doses of ionizing radiation (LDIR) were used to treat many illnesses extensively until about the late 1950s when a radiation scare was created to stop testing, development, and production of atomic bombs.

Radiologists learned very early that low doses of radiation produced important beneficial health effects; however, they did not understand the mechanism behind the stimulation of the patient's protective systems. Many thousands of studies have been carried out over the past 120 years and much has been learned. In 1980, Lauriston Taylor, Past President, National Council on Radiation Protection and Measurements stated, "Collectively, there exists a vast array of facts and general knowledge about ionizing radiation effects on animal and man. It cannot be disputed that the depth and extent of this knowledge is unmatched by that for most of the myriads of other toxic agents known to man."[37] However, an intense controversy continues about LDIR health effects.

## Early Radiation Protection

In the very early days, the users of X-rays were unaware that a large radiation dose could cause serious harmful effects. They also had no instruments to measure the radiation. The calibration of X-ray tubes was based on the amount of skin reddening (erythema) produced when the operator placed a hand directly in the X-ray beam. The dose needed to produce erythema is high—if the skin is exposed to 200 kilovolt X-rays at a high dose rate of 300 mGy per minute, then erythema appears after about 20 minutes or 6 Gy of exposure. A third-degree burn occurs after about 110 minutes or about 20 Gy of exposure.38 (For X-rays, the equivalent dose, sieverts [Sv], equals the absorbed dose, gray (Gy). One gray equals 1 joule/kg of tissue.)

Ignorance of the hazards resulted in many injuries. A severe case of radiation burn was published in July 1896. The first dose limit, about 100 mGy per day, was recommended in 1902. It was based on the lowest dose that could be easily detected by a photographic plate. By 1903, animal studies had shown that X-rays could produce cancer. Most vulnerable were skin tissue and blood-forming bone marrow.[38]

In 1924, Arthur Mutscheller was the first to recommend (to American Roentgen Ray Society) a "tolerance" dose rate for radiation workers, a dose rate that could be tolerated indefinitely. He observed workers in shielded work areas and estimated that they had received about 1/10 of an erythema dose or 600 mSv per month. He also observed that none of them had shown any signs of injury. While concluding that this was acceptable, he applied a safety factor of 10, thus setting the limit at 1/100 of an erythema dose per month or 700 mSv per year. A tolerance dose was "assumed to be a radiation dose to which the body can be subjected without production of harmful effects." His paper, "Physical Standards of Protection Against Roentgen Ray Dangers," was published in 1925. Sievert's limit was about the same, using a similar approach.[38]

Subsequent concerns about potential genetic effects of ionizing radiation and risk of cancer resulted in a stepwise reduction in the recommended annual occupational dose limit from 700 to 10 mSv in 1993. A recommended annual public limit of 5 mSv was introduced in 1960 that was reduced in 1990 to 1 mSv. Figure 1 in Inkret et al shows the changes.[38]

**Genetic and Cancer Concerns**

Early geneticists began studying the effects of X-rays on organisms. Muller was a eugenicist who was impatient with the slow pace of natural evolution. In his 1927 seminal paper in Science, he lamented about "the extreme infrequency of mutation occurrence under ordinary conditions, and by the general unsuccessfullness of attempts to modify decidedly, and in a sure and detectable way, this sluggish natural mutation rate.…for more directly utilitarian purposes…" He irradiated fruit flies with very large doses of X-rays, at a very high dose rate, and measured high germ cell mutation rates.[39] The response was related to the square root of the X-ray energy absorbed. Further studies by geneticists and scientific analyses led to a linear dose–response model and concerns about the risk of low-dose radiogenic health effects in humans.

The use of atomic bombs in the Second World War followed by intensive testing, development, and production of nuclear weapons led to strong antinuclear political activity by many scientists. Without any evidence, they linked exposure to radioactive "fallout" or any ionizing radiation, no matter how small, to a risk of "health effects." Two articles by Calabrese give very detailed descriptions of why and how linearity at low doses became the basis for carcinogen risk assessment in 1956 and the origin of the linear no-threshold (LNT) dose–response concept.[40,41] Recently, Calabrese provided additional evidence about how scientific misconduct by the US National Academy of Sciences led to all governments adopting LNT for cancer risk assessment.[42] He also summarized the ideological history of cancer risk assessment.[43]

**Health Effects of Low Doses of X-Rays**

At high and LDIR, the detailed response mechanisms are complicated and involve all levels of biological organization. About 3/4 of the body is water, so an important effect of X-rays is the production of reactive oxygen species (ROS). While they cause damage by reacting with biomolecules, ROS also send signals to genes throughout the body. Independently of any radiation effects, it is very important to remember that the aerobic metabolism (breathing air) constantly produces a very large concentration of ROS.[44–47]

Damage of DNA molecules occurs at a very high rate due to natural, internal causes (eg, ROS). To survive in an environment of multiple toxic impacts, all organisms have powerful protective mechanisms that prevent, repair, or remove damage in and to cells. Surviving cells continue to accumulate internally- and externally induced DNA mutations and may become cancer cells. These may be destroyed by the immune system to prevent the growth and spread of cancer.[48,49]

A low dose of X-rays produces a burst of hits and ROS that damage biomolecules, but it also sends signals to upregulate many of the biological protection systems against aerobic ROS, other toxins, pathogens, and all damage events. Such stimulation produces a range of beneficial effects, including a lower risk of cancer.[45,48,49] However, exposures above known threshold dose levels will inhibit the protection systems resulting in harmful effects, including radiation illness.[49–51]

Since low doses of radiation stimulate many protective systems, including the immune system,[52] it is very unlikely that low-level radiation causes more damage than benefit. Indeed, damage to molecules and cells from low doses can hardly be observed, while protective mechanisms can be readily seen and quantified.[49–52]

**Is There a Risk of Radiogenic Cancer From Radiographs?**

Because of the high natural cancer mortality, about 1 in 4, epidemiology with LNT modeling is incapable of showing significantly increased radiogenic cancer mortality at doses below about 100 mGy. Rather, a prevention of cancer may be seen.[50] Figure 6 indicates a dose threshold of about 500 mSv for radiation-induced leukemia. Since blood-forming bone marrow cells are most sensitive to ionizing radiation, it is reasonable to expect that the dose thresholds for other types of cancer are higher than this level.[53] Concerns about the risk of cancer from chiropractic radiography are baseless because the dose of an X-ray normally does not exceed about 2 to 3 mGy (200-300 mrem) for a lumbar image,[27,54,55] which is more than 100 times lower than the dose threshold for radiogenic cancer.

## Conclusions

Chiropractic and manual therapy procedures aimed at the realignment of the structure of the spine can address a wide range of pain, muscle weakness, and functional impairments. Radiographic imaging is necessary to deliver acceptable patient care in the practice of contemporary manual therapy of the spine. Concerns about the risk of cancer are baseless because the dose of a chiropractic spinal X-ray is more than 100 times below the dose threshold for radiogenic leukemia. The threshold for other types of cancer is likely higher. Imaging guidelines need to be updated to reflect current radiobiology and scientific evidence.


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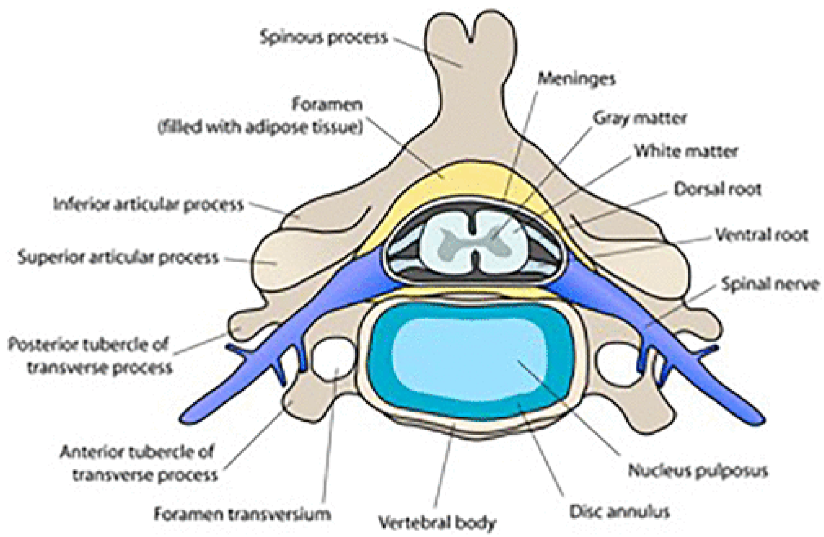


**Figure 1.** Spinal nerves, typical location (cervical spine).[1]

| **Medical Diagnostics** | **mGy** |
|---|---|
| (Estimated maximum organ dose) | |
| **X-ray films** | |
| **A – Chest (PA & Lat)** | **0.14** |
| **B – Dental Panoramic** | **0.7** |
| **C – Lumbar-Sacral Spine** | **2 – 3** |
| **D – Mammogram** | **2 – 4** |
| **Radiotracer Imaging** | |
| **E – Heart Stress (Tc-99m)** | **6 – 12** |
| **F – Bone (Tc-99m)** | **4 – 15** |
| **G – Dual Isotope Stress Test** | **40 – 45** |
| **H – PET: F-18 FDG (bladder)** | **55 – 80** |
| **CT Scans (X-ray)** | |
| (multiple scan average dose) | |
| **I – Chest CT** | **20 – 30** |
| **J – Head CT** | **30 – 50** |
| **K – Abdominal CT** | **22 – 60** |
| **L – Full Body CT** | **50 – 100** |
| **Fluoroscopy/Procedures** | |
| **M – Barium Contrast G.I.** | **10 – 22** |
| **N – Cardiac Catheterization** | **12 – 40** |
| **O – TIPS Procedure** | **400 – 1400** |

**Figure 2.** Doses in medical diagnostics.[27] A spinal radiograph delivers a maximum dose of 2-3 mGy.

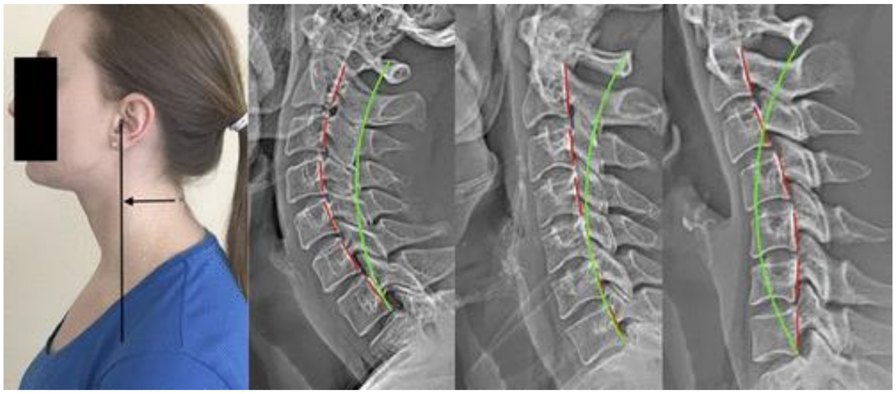

**Figure 3.** Forward head translation as shown in posture and in 3 unique lateral cervical radiographs. All 3 X-ray images have about 25 mm of forward head translation. Left: hyperlordosis; middle: hypolordosis; right: kyphosis. Green line is normal alignment;[11] red line highlights patient alignment.

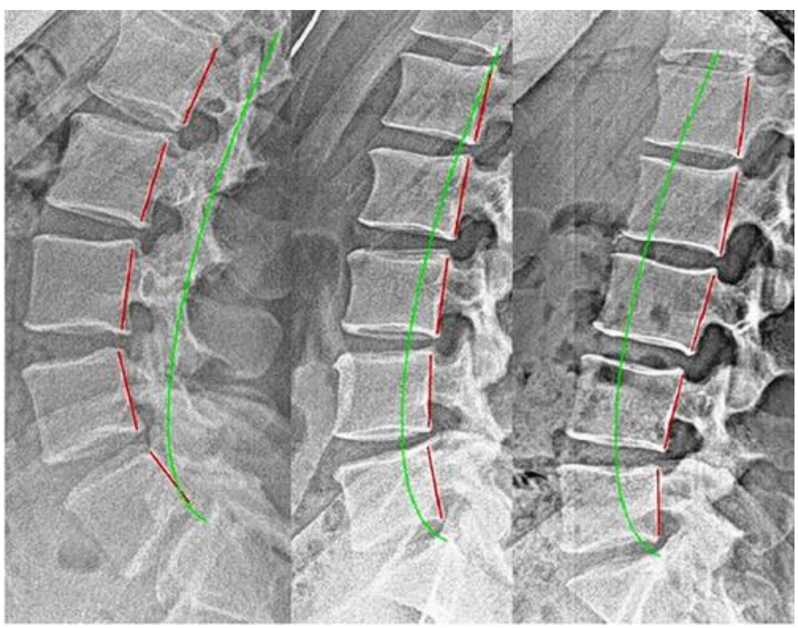

**Figure 4.** Lateral lumbar radiographs. Left: hyperlordosis; middle: hypolordosis; right: upper lumbar kyphosis. Green line is normal alignment;[13] red line highlights patient alignment.

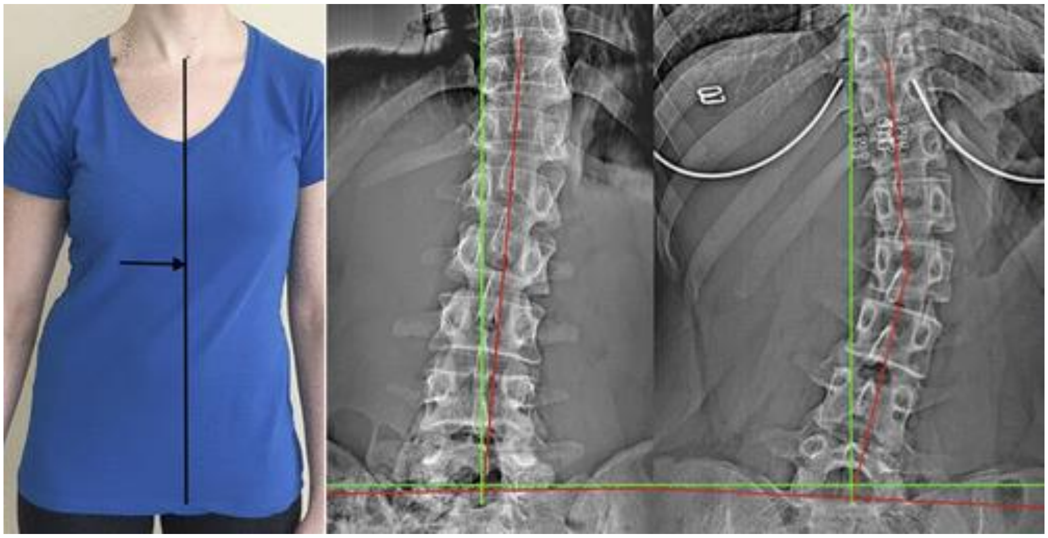

**Figure 5.** Posture image and anteroposterior lumbar radiographs depicting a left lateral thoracic translation (side shift). Both patients in the radiographs have a 20-mm left lateral shift of T10 off midline. Left patient has a pure left lateral thoracic translation posture, aka “pseudo scoliosis.” Right patient has a true left lumbar scoliosis (vertebral rotation). Green line is vertical; red line highlights patient alignment.

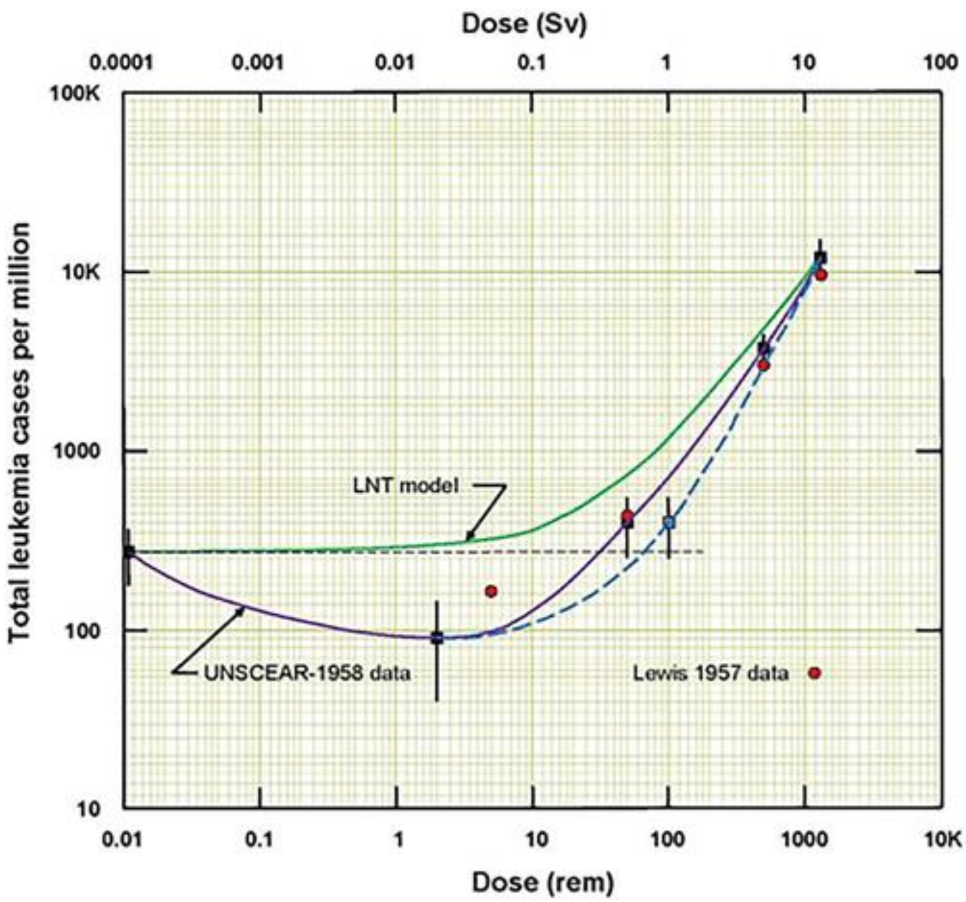


**Figure 6.** Leukemia incidence, from 1950 to 1957 among 97 000 Hiroshima atomic bomb survivors, reveals an apparent dose threshold at about 50 rem or 500 mSv.[53]