

NCRP REPORT NO. 160, IONIZING RADIATION EXPOSURE OF THE POPULATION OF THE UNITED STATES, MEDICAL EXPOSURE—ARE WE DOING LESS WITH MORE, AND IS THERE A ROLE FOR HEALTH PHYSICISTS?

In 2006, Americans were exposed to more than seven times as much ionizing radiation from medical procedures as was the case in the early 1980's, according to a new report on population exposure released March 3, 2009, by the National Council on Radiation Protection and Measurements (NCRP) at its annual meeting in Bethesda, Maryland. In 2006, medical exposure constituted nearly half of the total radiation exposure of the U.S. population from all sources.

The increase was primarily a result of the growth in the use of medical imaging procedures, explained Kenneth R. Kase, senior vice president of NCRP and chairman of the scientific committee that produced the report. "The increase was due mostly to the higher utilization of computed tomography (CT) and nuclear medicine. These two imaging modalities alone contributed 36 percent of the total radiation exposure and 75 percent of the medical radiation exposure of the U.S. population." The number of CT scans and nuclear medicine procedures performed in the United States during 2006 was estimated to be 67 million and 18 million, respectively.

NCRP Report No. 160, *Ionizing Radiation Exposure of the Population of the United States*, provides a complete review of all radiation exposures for 2006. The following Fig. 1 and Table 1 summarize the changes that have occurred from the 1980's to 2006.

Some causes and consequences of this significant increase in medical radiation exposure are the focus of this editorial.

According to James Thrall, chairman of the American College of Radiology's Board of Chancellors and Radiology at Massachusetts General Hospital, "Imaging has literally become the guiding hand of medical practice."

BENEFITS

Vivian Ho of Rice University wrote an editorial in *Medical Care* (Ho 2008) in which she asserted that, "An overall increase in advanced diagnostic imaging is likely



justified." She pointed out that non-invasive imaging has revolutionized medical practice by leading to early, more precise, and much less morbid diagnosis. She offered two examples: CT and magnetic resonance imaging (MRI) have replaced exploratory laparotomy for diagnosing abdominal problems, and CT angiograms are much less invasive than coronary angiography.

ISSUES TO BE CONSIDERED

Self-referral

Kouri et al. (2002) reported that 60 to 90% of non-hospital radiography is the result of self-referral. Self-referral originally consisted of physicians who are not imaging specialists (or a non-physician provider, such as a podiatrist or chiropractor) directing patients to their onsite imaging services. It now also includes physicians referring their patients to outside facilities in which the physicians have a financial interest. This "joint venture" type of self-referral has been targeted by federal legislation.

In an article titled *Turf Wars in Radiology: The Overutilization of Imaging Resulting from Self-Referral*, David Levin and Vijay Rao of Jefferson Medical College estimated that as much as \$16 billion per year is spent by our health care system to cover the cost of unnecessary (i.e., unjustified), self-referred, non-invasive diagnostic imaging, not including the costs of image-guided invasive procedures (Levin and Rao 2004).

In 2008, Jean Mitchell of Georgetown University reported findings that suggest that physician self-referral arrangements and independent diagnostic testing facilities seem to be contributing to a greater use of advanced imaging, especially for MRI and positron emission tomography (PET).

Mitchell concluded that, "Use of highly reimbursed advanced imaging, a major driver of higher health care costs, should be based on clear clinical practice guidelines to ensure appropriate use" (Mitchell 2008).

According to Mitchell, "For many cases use of an advanced imaging procedure *in lieu* of a less expensive diagnostic procedure results in higher revenues (profits)

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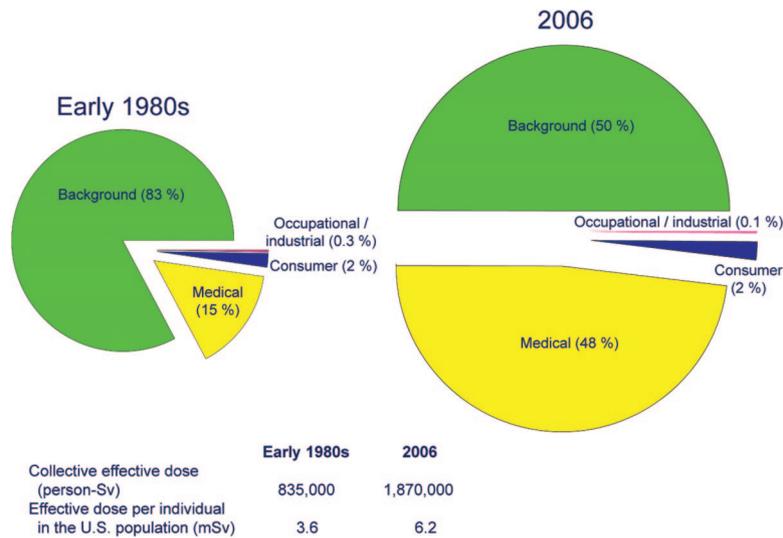


Fig. 1. Distribution of collective effective dose and effective dose per individual in the U.S. population in the early 1980's and 2006.

to the provider without any commensurate improvements in outcomes or quality. Use of highly reimbursed advanced imaging procedures should be based on clear clinical practice guidelines to ensure that advanced imaging is only used when warranted by the patient's clinical diagnosis."

Defensive medicine

In November 2008, the Massachusetts Medical Society issued a study in which the results showed that most of the physicians surveyed reported that they practiced defensive medicine. For example, approximately 33% of the CT scans ordered by obstetricians/gynecologists, emergency physicians, and family practitioners were *not* motivated by medical need. The estimated cost of defensively-motivated radiological imaging, laboratory testing, and consultations was \$281 million in 2006 dollars. The cost of hospital admissions was reported to

be \$1.1 billion, for a total estimate of nearly \$1.4 billion in Massachusetts alone.

WHAT IS BEING DONE TO REDUCE THE UNJUSTIFIED USES OF MEDICAL IMAGING?

American College of Radiology appropriateness criteria

The American College of Radiology (ACR) has published appropriateness criteria for medical imaging that address over 160 clinical conditions with over 700 variants. ACR's systematic process of criteria development with other disciplines provides credible guidelines for radiology decision-making based on scientific analysis and broad-based consensus techniques.

Hadley et al. (2006) of Eastern Virginia Medical School reported that use of the ACR appropriateness criteria at a level I trauma center was found to have the

Table 1. Magnitude of changes in collective effective dose and effective dose per individual in the U.S. population between the early 1980's (NCRP 1987) and 2006 (NCRP 2009).

Exposure category	Collective effective dose (person-Sv) ^a			Effective dose per individual in the U.S. population (mSv) ^a		
	(1) 2006	(2) Early 1980's	Ratio (1):(2)	(1) 2006	(2) Early 1980's	Ratio (1):(2)
Ubiquitous background	933,000	690,000	1.35	3.11	3.00	1.04
Medical	899,000	123,000	7.3	3.00	0.53	5.7
Consumer	39,000	12,000–29,000	— ^b	0.13	0.05–0.13	— ^b
Industrial, security, medical, educational and research	1,000	200	— ^b	0.003	0.001	— ^b
Occupational	1,400	2,000	— ^b	0.005	0.009	— ^b
Total	1,870,000	835,000	2.2	6.2	3.6	1.7

^a The quantities used in NCRP Report No. 93 (NCRP 1987) were expressed in effective dose equivalent.

^b Not listed; disparate aggregated sources.

potential to reduce imaging costs by 39% and the estimated radiation dose by 44%. The authors concluded that, “The ACR appropriateness criteria have the potential to have a strong positive impact on the overall cost of imaging and radiation dose received for patients in the setting of trauma. These criteria should be emphasized to clinicians to help guide their imaging decisions.”

Sistrom et al. (2009) evaluated the effect of appropriateness criteria, which were implemented in a computerized radiology order entry and decision support system, on the growth rates of outpatient CT exam volume over time. They reported a significant and substantial decrease in the growth rate of CT exam volume in a large urban academic health center. This result was achieved despite continued growth in outpatient visits.

American College of Cardiology appropriate use criteria

The American College of Cardiology (ACC) has worked with ACR and other specialty societies to ensure the quality and safety of these technologies by developing an array of quality-improvement tools that include the following:

- fellow training guidelines;
- clinical use guidelines;
- clinical competency statements;
- appropriate use criteria for each cardiac imaging modality;
- physician certification;
- laboratory accreditation; and
- national registries.

The ACC is currently piloting its appropriate use criteria in practices and has committed to reducing inappropriate imaging by 15%.

American Society of Radiologic Technologists

In 2007, experts in health policy, CT manufacturing, clinical practice and education met for a national, one-day consensus conference sponsored by the American Society of Radiologic Technologists and the American Registry of Radiologic Technologists. The purpose of the conference was to examine the evolution of CT and to achieve consensus on how it will affect the future of radiologic sciences education and practice. The following consensus statement on patient safety, regulations and reimbursement was issued:

- Medical imaging and radiation therapy professionals need more education in CT technology, including operation, application, and dose optimization, to ensure patient safety.

“Ultimately, when medical imaging and radiation therapy professionals thoroughly understand CT operation, techniques and protocols, they can optimize dose and perform safer examinations.”

World Health Organization

The World Health Organization has launched a Global Initiative on Radiation Safety in Health Care Settings. The Global Initiative is focused on public health aspects related to the risks and benefits of the use of radiation in medicine, including diagnostic radiology, interventional radiology, radiotherapy and nuclear medicine with special consideration for vulnerable groups (e.g., children and pregnant women), high dose procedures, and prevention of unintended medical exposures by clinical application of appropriateness criteria (U.S.) or referral guidelines (European Union).

American Board of Radiology Foundation Summit 2009, Medical Imaging: Addressing Overutilization

The American Board of Radiology Foundation and the National Institute of Biomedical Imaging and Bioengineering will host an invitational Summit August 6 to 7, 2009, to:

1. identify the root causes of overutilization of imaging procedures;
2. identify approaches to address these causes; and
3. develop a strategy to implement the approaches.

OTHER RELATED THOUGHTS

Diagnostic yield

The diagnostic yield (likelihood that a test or procedure will provide the information needed to establish a diagnosis) of CT scans has actually decreased over a 10-year period, according to a study conducted at Massachusetts General Hospital and presented at the 2008 annual meeting of the Radiological Society of North America (Dang et al. 2008).

The study set out to determine if growth in CT use from 1996 to 2005 resulted in changes in diagnostic yield and recommendations in radiology reports. The researchers reported a decrease in diagnostic yield and noted that children had lower findings (65.5%) than adults (77.6%). These data indicate that approximately 35% of CT scans performed on children had no impact on their diagnosis.

Dr. Thrall, one of the study’s coauthors, said imaging technology has created a financial incentive for some doctors to cash in by referring patients to get imaging tests on equipment in their own practices. This is one place the federal government and Congress can look in enacting healthcare reform, he added.

A study by the Government Accountability Office issued in June 2008 found Medicare spending on medical imaging doubled to about \$14 billion a year between 2000 and 2006, driven largely by increases in high-tech imaging (U.S. GAO 2008).

NCRP and the International Society of Radiology support the use of ACR's appropriateness criteria and ACC's appropriate use criteria as evidence-based clinical tools that will reduce the unjustified uses of medical imaging. Decisions to perform medical imaging procedures should be based on conclusive benefit to the patient that is greater than any actual or potential risk of the exposure to ionizing radiation.

IS THERE A ROLE FOR HEALTH PHYSICISTS?

From 1980 to 2006 there was a 35% decrease in collective effective dose from all occupational exposures in the United States. This decrease occurred despite the rapid growth of medical imaging during the same period. The medical category of occupational exposures had the largest number of exposed individuals (735,347) and the highest collective effective dose (549 person-Sv). According to NCRP Report No. 93 (1987), in 1980 the medical category consisted of 584,000 individuals and the collective effective dose equivalent was 410 person-Sv, or 21% of the occupational exposures. Medical exposures now account for nearly twice that amount.

The largest contributor to occupational exposures in 1980 was nuclear power at 27%. According to Report No. 160, the commercial nuclear power industry now accounts for ~8 percent of the occupational collective effective dose in the United States. The data for 2006 indicate that 58,788 individuals had a recordable dose and that the collective effective dose for that year was 110 person-Sv. The annual collective dose for nuclear power operation peaked in the early 1980's, reaching a maximum of 565 person-Sv. Since then, there has been a steady decline in both the number of individuals with recordable doses and the annual collective dose.

The decrease in annual collective effective dose for U.S. nuclear power workers occurred during a period in which the electricity generated by this industry increased. This can be accounted for because the efficiency of reactor operation increased with fewer and shorter outages, improved reactor coolant chemistries and materials, careful planning for outages, increased emphasis on the as low as reasonably achievable (ALARA) principle and radiation safety, improved tools and procedures, and a renewed emphasis on cleanliness of the work environment. Many of these contributions were made by health physicists at the 104 nuclear power plants in the United States [69 pressurized water reactors (PWRs) and 35

boiling waters reactors (BWRs)]. One could argue that the principles and practices developed and honed during the past 50 years of nuclear power plant operations could be more fully applied to radiation protection in medicine resulting in reduced exposures even in the face of rapidly escalating use of imaging procedures.

CONCLUSION

The 11th Report on Carcinogens (U.S. DHHS 2005) added x rays to the list of "known human carcinogens." It is this knowledge that forms the basis for the fundamental principles of radiation protection, *justification* and *optimization*.

A justified and optimized medical imaging procedure is one for which the ordering physician can demonstrate that the expected benefits to the patient exceed the overall costs. If the procedure does not meet the applicable appropriateness criterion, it should not be ordered. This approach will reduce the staggering costs to our healthcare system and avoid unnecessary dose to patients.

NCRP Report No. 160 is available from the NCRP Web site, <http://NCRPpublications.org>, in both soft- and hardcopy formats. For additional information contact David A. Schauer at schauer@NCRPonline.org, 301.657.2652 (x20) or 301.907.8768 (fax).

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Magnitude of Changes in Collective Effective Dose and Effective Dose per Individual in the U.S. Population Between the Early 1980s (NCRP Report No. 93) and 2006 (NCRP Report No. 160)

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