NCRP Report 184 – A Radiation Exposure Census
Evan Boote, PhD

This year, the United States will conduct a decennial census of the population as mandated by the U.S. Constitution. These data will subsequently be used to apportion the House of Representatives. Various media reports have emphasized the criticality of the census to inform other functions of government including taxation and allocation of various types of federal funding and grants.

At the end of last year, the National Council on Radiation Protection published a "census" of their own, a review of the collective effective radiation dose of the U.S. population. While not constitutionally bound to perform every ten years, the motivation to produce another review ten years after the prior (NCRP Report #160, 2009) was due to the rapid growth of diagnostic and interventional procedures between the first report (NCRP #92, 1987). This is reflected in the modification of the titles of these three reports; from "Ionizing Radiation Exposure of the Population of the United States" (# 93 and #160) to "Medical Radiation Exposure of Patients in the United States" (#184). The principle reason that the effective radiation dose per individual increased between 1987 and 2009 was the increased use of diagnostic imaging, which many in the radiology community are aware, resulted in imaging being responsible for approximately half of the U.S. population radiation dose. The increase per individual was almost six-fold between the early 1980's to 2006. Hence, the focus on the most recent report is on medical exposures.

The good news is given first in this report, in fact, the first sentence of the executive summary states "Analysis and estimation of patient doses from diagnostic and interventional medical procedures indicates there was a substantial reduction (~15 to 20%) in nontherapeutic medical radiation dose to the U.S. population in the decade between 2006 and 2016." The report concludes that these numbers are real as the same methodology and the same data sources were used in 2006 and 2016 (there is a three-year delay from data acquisition to publication in both cases).

Another important part of this report which may be overlooked is a new section that addresses the medical ionizing radiation exposure of the pediatric population of the United States. This was not reviewed in prior NCRP reports, however this inclusion reflects the attention that the Image Gently program has given to this matter. It is reported that pediatric medical imaging accounts for 9% of combined medical and background radiation for individuals under the age of 18 (in contrast to medical imaging contributing roughly 50% of the total for adults). Unquestionably, computed tomography is the main source of radiation dose to the pediatric population. Of that 9% (about 0.3 mSv per individual to the U.S. pediatric population of 74 million in 2016), computed tomography accounts for 84% and radiography 6% with fluoroscopy, nuclear medicine and interventional splitting the remainder roughly equally. It is very likely that Image Gently and size-specific protocols have reduced that contribution, but the degree of reduction is impossible to assess in this report.

In reporting and interpreting these data, it is important to understand that the medical procedure dose is provided as the effective dose per individual. Firstly, effective dose is the sum of weighted equivalent doses for radiosensitive tissues and organs. The weighting is based on the fraction of the total radiation detriment to the body when the whole body is irradiated uniformly. In 2009, a different set of weightings was in use – the current report applies both sets and allows for comparison. For the most part, this has not changed the overall results (the report estimates possibly by 5%), however, for some studies like mammography, the change in weightings resulted in more than a two-fold change in the collective effective dose because the weightings in the later group was larger for breast tissue (ICRP No. 103). By the way, the most accurate volume and dose data is for mammography because of the 100%

data collection mandated by MQSA. The volume of mammography was reported in 2006 at 34.4 million mammograms with a population of women (45 yr and older) of 58.2 million. Also included here are data regarding the use of digital breast tomosynthesis.

For Computed Tomography, the American College of Radiology Dose Index Registry (DIR) has been of value to the authors of this report. The compilation of computed tomography dose indices and dose-length product values along with the anatomical sites provides a rich set of data with narrowing error bars. This is important because CT is still the highest medical source of radiation and was essentially unchanged from 2006 to 2016.

At this point, the patient reader will know that we are just getting to the good part – the rest of you are asking “Why did the numbers decrease? Please tell!”

The answer is a combination of technology and practice patterns, with the latter being the larger part of the decrease. While the number of CT studies increased by 25% (and population only increased by about 8%), the use of dose reduction methods kept the annual individual effective dose at 1.5 mSv (1.4 mSv in 2006). For other modalities, there were substantial decreases in the number of procedures – this included general and cardiovascular nuclear medicine – which resulted in a 68% decrease in the per individual dose. As the second largest contributor to collective effective dose, this was a significant effect. However, decreases in the number of chest, abdomen, pelvis and urologic exams resulted in a decrease of about 25%.

Lastly, it is important to recognize that the principle value identified in this report (Effective Dose per individual in the U.S. Population) is obtained by dividing the collective effective dose by the U.S. population, whether exposed or not. Since many people do not get any x-ray, CT or nuclear studies in the course of a year and many get multiple studies. Therefore, this number should not be used in a general epidemiological application, for example, how many cancers will result from medical imaging this year? The value of this data point is the historical comparison and trends. As such, it helps us to understand the effect of an aging population, Medicare reimbursement, technology and medical practice patterns have on the use of imaging. It is also still useful as a way to review overall population health. As health care professionals, we can say (informed as we are) that the use of medical imaging contributes roughly the same radiation exposure to the U.S. population as radon, cosmic radiation, consumer products and nuclear power combined.

By the way, the National Council on Radiation Protection and Measurements was chartered by the U.S. Congress and seeks to formulate, disseminate guidance and recommendations on radiation protection and measurements. Your friendly neighborhood medical physicist relies on the activities and publications of this organization for a variety of matters – our peers are often quite involved in these. However, they are also offer guidance to government entities like NASA (spaceflight dosimetry and radiobiology) and federal and state regulatory agencies. The reports are collaborative engagements, often involving twenty or more experts in the field.