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Nuclear Medicine Exposure in the United States, 2005-2007: Preliminary Results

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Medical radiation exposure of the U.S. population has not been systematically evaluated for almost 25 years. In 1982, the per-capita dose was estimated to be 0.54 mSv and the collective dose 124,000 person-Sv. The preliminary estimates of the National Council on Radiation Protection and Measurements Scientific Committee 6-2 medical subgroup are that, in 2006, the per-capita dose from all medical exposure (not including radiotherapy) had increased almost 600% to 3.0 mSv and the collective dose had increased more than 700% to approximately 900,000 person-Sv. >Nuclear medicine accounted for only about 2% of all procedures but 26% of the total collective dose from diagnostic studies in medicine. In 1982, the estimated number of nuclear medicine procedures was about 7.5 million. The per-capita effective dose from nuclear medicine was 0.14 mSv and the collective dose was 32,000 person Sv. By 2005, the estimated number of procedures had increased to about 19.6 million. The per-caput effective dose increased to about 0.75 mSv and the collective dose to about 220,000 person Sv. There also has been a marked shift in the type of procedures being performed with cardiac scanning accounting for about 70% of procedures.
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The last comprehensive report on ionizing radiation exposure of the U.S. population from all sources was published in by National Council on Radiation Protection and Measurements (NCRP) in 1987.[1] This was followed by another report in 1989[2] that included supporting data relative to medical exposure. Both of those reports included data only up through 1982. In the fall of 2006, the NCRP established a scientific committee (SC 6-2) to review the current state of knowledge and prepare a new report on the magnitude of all sources of radiation exposure to the U.S. population. A medical subgroup was included as part of the committee to specifically examine the changes that had occurred during the last 25 years.

Specific tasks of the medical subgroup included estimating the current number and types of medical procedures using ionizing radiation, evaluating the effective dose per procedure as well as the annual per-capita defective dose and annual collective effective dose. Additional tasks included evaluating past and potential future trends. Nuclear medicine was a modality specifically examined.

Materials and Methods

Frequency and Mix of Procedures

Data were derived from both primary and secondary data sets. The primary sources on national utilization included Medicare claims data for approximately 40 million subscribers during 2004 as well as commercially available benchmarking reports for various modalities from IMV.[3,4] The IMV reports cover both hospital and nonhospital sites and the surveys typically obtained responses from one-half to two-thirds of the universe of imaging sites. The data provided information on the total numbers of general categories of

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examinations. The primary source of the distribution of specific types of examinations within a category was primarily derived from Medicare payment data, because it supplied specific CPT billing codes. Secondary utilization sources included 2006 data from the U.S. Veterans Administration, claims data from a large national employer's insurance plan, and data from the Agency for Health Care Quality and Research. When data were only available for years before 2006, prior annual growth rate was used to estimate the 2006 frequency of procedures.

There was no single complete data source set on frequency, and various incomplete data sets were used and compared and crosschecked with each other to obtain a fairly complete picture of the situation. When crosschecking was not possible, the combination and interpolation of incomplete datasets was assumed to be a reasonable representation of the situation.

The primary data set used for the detailed estimation of specific procedure mix in nuclear medicine was the Medicare financial reports. The data are by category, description, and CPT code. These data must be carefully analyzed; use of the number of billed CPT codes would overestimate the number of actual examinations because some CPT codes are "add-on" codes for purposes of billing and do not represent additional administrations of radiopharmaceuticals.

On the basis of the 2004/2005 IMV National Survey report, the 2004 Medicare data source appears to only have approximately 25% to 33% of the national data. The Medicare data are "financial" and based on billing codes. In some instances, there is more than one CPT code for a given procedure. Thus, counting discrete CPT-based billing data as visits or procedures without excluding the "add-on" codes would result in an overestimate. This is a particularly important issue for estimation of nuclear medicine procedures and doses. The most common nuclear medicine examination (cardiac perfusion) has 3 CPT codes (78465 as the primary code and 78478 and 78480 as add on codes) for a single procedure. For this report, the "add-on" codes have been identified and have not been counted in total number of procedures or in calculating effective dose. The Medicare data set is complimented with more general data from IMV. Additional data also are available from the VA data and that from the large national employer. The IMV data set is judged to be the best-available estimate for the total number of studies. For purposes of dose estimation, the specific Medicare procedure counts were multiplied by a factor of 3.41, reflecting the ratio in total visits reported in the IMV surveys.

The number of patients cannot be approximated with much certainty from our data. One might analyze the procedures and determine which procedures are performed in conjunction. For example, most lung scans include both a ventilation and perfusion component. On billing records and financial data these may or may not be separate CPT codes and charges. More importantly, similar bundled codes are found in cardiac nuclear medicine which compromise over half of all nuclear medicine studies. Some data sets we have reviewed give reports of "visits" to nuclear medicine departments, but it is often not clear exactly what the respondent to the survey meant by this term. It appears that a "visit" equates to an examination, as defined by financial records or billing codes. This is substantiated to some extent when comparing the number of "visits" reported by IMV to have been paid by Medicare with the Medicare numbers by CPT code. On the basis of comparison of recent Medicare procedure numbers and IMV reported visits, it appears that there are about 1.14 procedures per visit. Finally, it is not known how many patients have repeat of additional procedures within the same year. The IMV 2005 report indicates that of the 17.2 million procedures, 11.5 million were done in hospital settings and 5.7 million in nonhospital sites. Overall, 23% of examinations were done on inpatients and 77% were performed on outpatients.

In our source data and review of surveys, there is some uncertainty in the distribution of the percentage of procedures for a category of studies (such as gastrointestinal). The main data source we have for this information was the 2004 Medicare billing data. The percentage distribution for specific procedures in the categories was assumed to be constant across the other more general surveys. There is a small amount of uncertainty in leaving out procedures with very small numbers such as those listed as "other" or "miscellaneous" categories in our source data. This would likely lead to an underestimation of only a few percent.

Therapeutic nuclear medicine procedures represent a small percentage of all examinations and by the nature of the high therapeutic doses cannot be evaluated with effective dose. As a result, the frequency of therapeutic procedures has been estimated but they have not been included in either per capita or collective effective dose estimations. NCRP Report 124[5] assumed that in 1991 treatment of hyperthyroidism and thyroid cancer were approximately 2% of the number of diagnostic procedures. The Medicare 2004 data indicates that less than 0.1% of all procedures were for unsealed radionuclide therapy however the age distribution of the Medicare population likely excludes most hyperthyroid and thyroid cancer patients. There are very few data on the use of nuclear medicine studies in medical research protocols. Our database is predominantly financial and many of these purely research procedures would not be paid by insurance companies.

Dosimetry

Absorbed organ doses in patients and effective doses are not measurable quantities. They are estimated by a variety of methods. Estimates of absorbed organ doses as well as effective doses from nuclear medicine procedures are available from a number of sources. Dose coefficients are expressed as dose per unit of administered activity. Previously, Medical Internal Radiation Dose modeling was used; however, now there are more sophisticated Monte Carlo models. The most common dose coefficients are derived from models of the International Commission on Radiological Protection (ICRP) and published in the *Annals of the ICRP*.[6] In addition, dose coefficients are available from the Food and Drug Administration-required inserts for approved radiopharmaceuticals, and a more limited amount of information is available in

textbooks and on the Society of Nuclear Medicine (SNM) website (www.snm.org [see practice guidelines]).

In addition to the dose coefficients, it is also necessary to know the amount of administered activity. Suggested ranges of administered activity are available both in textbooks and the SNM website (www.snm.org). Knowledge of the actual administered activity in the United States is one of the largest sources of uncertainty in estimation of dose to an individual. Most nuclear medicine departments have standing physician directed orders for the amount to be administered for different studies. There are no surveys available regarding the actual administered activity in the U.S. Typically, however, many departments use activities near or at the high end of suggested activity ranges to optimize patient throughput and image quality. If lower average amounts are actually administered the dose estimates could be 10% to 20% too high, but we think this is unlikely. For example, we have had discussions with large commercial radiopharmacies who indicate that the most common activity ordered for a bone scan is 1.11 GBq (with the suggested range in the literature being 740 MBq to 1.11 GBq). The activity chosen for cardiac myocardial perfusion studies has the greatest impact on the total dose estimates because this is the most common procedure and relatively high dose. The most common radionuclide used is technetium-99m. If a 1-day stress rest protocol is performed, the activity administered is usually 370 MBq at rest and an additional 1.11 GBq at rest for a total of 1.48 GBq. If a 2-day protocol is used, typically the administered activity is 1.11 GBq each day for a total of 2.22 GBq. There are also circumstances in which the standing orders for the administered activity are changed particularly with smaller administered activities for infants and children and larger administered activities being prescribed for large patients (usually in excess of 150 kg. Doses to individuals will vary a small amount based on patient size for the same amount of administered activity. Dose coefficients and assumed administered activities for each specific type of examination considered in this report as well as the effective dose per procedure are shown in Table 1.

Actual variation caused by calibration errors are not likely to be more than a percent or so. The activity to be administered is measured and usually calibrated for a specific administration time. The actual time may be either earlier or later than the calibrated time. It is unlikely that this would affect effective doses by more than 10%. Disease states will also affect the retention as well as distribution of the radiopharmaceutical.

Table 1 Representative Adult Effective Dose (mSv) for Various Nuclear Medicine Examinations

Examination	Administered Activity (MBq)*	mSv/MBq†	Effective Dose (mSv)
Brain (^{99m}Tc-HMPAO/exametazime)	740	0.0093	6.9
Brain (^{99m}Tc-ECD/neurolite)	740	0.0077	5.7
Brain (^{18}F-FDG)	740	0.019	14.1
Thyroid scan (^{123}I-Na)	25	0.075 (15% uptake)	1.9
Thyroid scan (^{99m}Tc-pertechnetate)	370	0.013	4.8
Parathyroid scan (^{99m}Tc-sestamibi)	740	0.009	6.7
Cardiac stress-rest (thallium)	185	0.22	40.7
Cardiac rest –stress (^{99m}Tc-sestamibi 1 day protocol)	1100	0.0085 (0.0079 stress, 0.0090 rest)	9.4
Cardiac rest –stress (^{99m}Tc-sestamibi 2 day protocol)	1500	0.0085 (0.0079 stress, 0.0090 rest)	12.8
Cardiac (rest-stress) (^{99m}Tc-tetrofosmin)	1500	0.0076	11.4
Cardiac ventriculogram (^{99m}Tc red blood cells)	1110	0.007	7.8
Cardiac (^{18}F-FDG)	740	0.019	14.1
Lung perfusion (^{99m}Tc-MAA)	185	0.011	2.0
Lung ventilation (^{133}Xe)	740	0.00074	0.5
Lung ventilation (^{99m}Tc-DTPA)	1300 (40 actually inhaled)	0.0049	
Lier-spleen (^{99m}Tc sulfur colloid)	222	0.0094	2.1
Biliary (^{99m}Tc-DISIDA)	185	0.017	3.1
Gastrointestinal bleeding (^{99m}Tc red blood cells)	1110	0.007	7.8
Gastrointestinal emptying (^{99m}Tc solids)	14.8	0.024	0.4
Renal (^{99m}Tc-DTPA)	370	0.0049	1.8
Renal (^{99m}Tc-MAG3)	370	0.007	2.6
Renal (^{99m}Tc-DMSA)	370	0.0088	3.3
Renal (^{99m}Tc-glucoheptonate)	370	0.0054	2.0
Bone (^{99m}Tc-MDP)	1110	0.0057	6.3
Gallium-67 citrate	150	0.100	15
Pentreotide (^{111}In)	222	0.054	12
White blood cells (^{99m}Tc)	740	0.011	8.1
White blood cells (^{111}In)	18.5	0.360	6.7
Tumor (^{18}F-FDG)	740	0.019	14.1

*Recommended ranges vary although most laboratories tend to use the upper end of suggested ranges.
†See ref. 6.

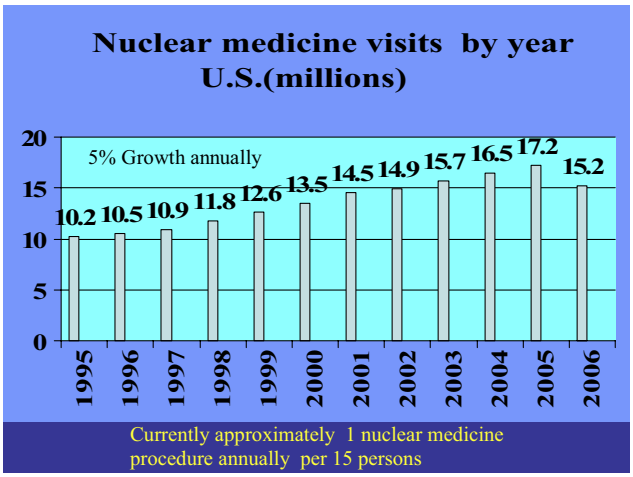

Figure 1 Nuclear medicine visits per year (data from IMV[3]). (There are approximately 1.14 procedures per visit.) (Color version of figure is available online.)

For example dehydration will reduce the elimination of a number of radiopharmaceuticals and increase both absorbed and effective dose. In extreme circumstances the actual dose to a very ill individual could be several-fold different from that projected for normal persons. Some uncertainty in dose is caused when more than one radiopharmaceutical can be used for the same procedure (eg, use of technetium-99m pertechnetate or iodine-123 for thyroid scanning). In these circumstances, the committee used its best estimate of current clinical practice. With the exception of cardiac nuclear medicine these assumptions would have little effect on total population exposure.

In evaluation of collective effective dose for medical examinations one assumes that the radiation weighting factor (W_R) used in calculation of the dose coefficients is correct. The value used is 1.0 for gamma rays; however, there is some indication that 2.0 might be more appropriate for x-rays or gamma rays with energies of less than 200 kV.[7] Because the most common nuclear medicine procedures and those contributing most to collective dose use technetium-99m (140 keV). The choice of this factor is important.

There is no uncertainty provided for the values used for detriment and the calculated tissue weighting factors (W_t) defined by the ICRP.[8,9] This however is a measure of detriment in a general population of all ages and the nuclear medicine population is usually assumed to be an older population. Exclusion of patient doses resulting from therapeutic procedures for in estimation of collective dose is necessary since effective doses are not applicable to deterministic or cell killing effects on the target tissues. The exclusion of doses to other tissues in the patient is judged to have a minimal impact on estimate of per capita or collective effective dose from nuclear medicine.

Exposure to the Public from Nuclear Medicine Patients

Collective dose to the U.S. population from nuclear medicine includes not only dose to the patient but also doses to members of the public from nuclear medicine patients. For most diagnostic studies, the dose rate at 1 m from the patient immediately after injection is about 2 to 20 μGy/hr and decreasing to approximately one-third of this at 3 hours. For cancer therapy administrations (particularly with iodine-131 [3.7 GBq]), the dose at 1 m after administration is 220 μGy/hr, decreasing to approximately 20 μGy/hr at 72 hours. This report has not attempted to quantify public exposures from released radioactive patients. In 1996, NCRP Report 124 indicated, based on data from Benedetto and coworkers,[10] that a conservative estimate of skin dose to family members would be approximately 20 μGy, about 7 μGy to coworkers, and an average skin dose to the public of 10 μGy per person per year. The estimate of public dose was based on a population of 250 million and 10 million patient procedures resulting in a collective skin dose of 2500 person Gy. Applying the same logic to the current 17.2 million procedures yields, a skin dose of 4300 person Gy spread over 296 million persons or a skin dose of 14.5 μGy per person annually. Because the majority of patients are injected with technetium-99m (140 keV) and much of the radiation emanating from the patient is Compton scatter with relatively low penetration, the effective dose is likely less than 10% of skin dose (reference?). This conservative set of assumptions would then yield a 2005 collective effective dose of about 430 person Sv and per capita annual effective dose of about 1 μSv. Exposure of the public then is about 1% or less of the estimated patient doses and for practical purposes can be neglected, given the magnitude of other sources of uncertainty in our overall estimates.

Results

Frequency, Mix of Procedures, and Collective Effective Dose

The frequency of procedures was derived by the methodology described previously. Growth of nuclear medicine visits (not procedures) by year is shown in Figure 1 and was derived from the IMV data. The collective dose for individual procedures has been estimated by using standard dose coefficients, using an upper level of administered activity and multiplying by the estimated numbers of that specific proce-

Table 2 In Vivo Diagnostic Nuclear Medicine Visits, Year 2005

	Number (Millions)	%	Collective Dose (Person-Sv)	%
Brain	<0.1	<1	250	0.1
Thyroid	<0.1	<1	400	0.2
Lung	0.74	4	2000	0.9
Cardiac	9.80	57	188,000	85.2
Gastrointestinal	1.21	7	3500	1.6
Renal	0.47	3	650	0.3
Bone	3.45	20	20,500	9.3
Infection	0.38	2	1300	0.6
Tumor	0.34	2	4000	1.8
Misc	0.83	5	–	<1
Total	17.2	100	220,000	100

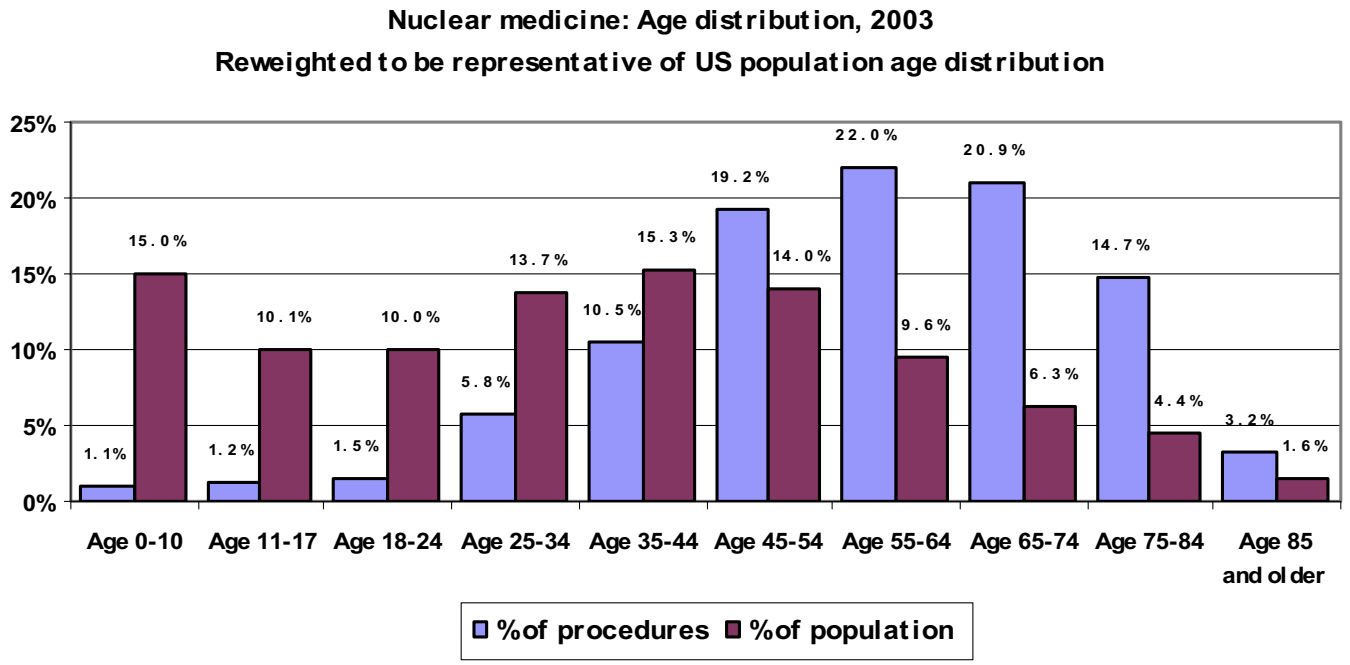

Figure 2 Age distribution for patients having nuclear medicine examinations compared with the general U.S. population. (Color version of figure is available online.)

dure. The collective doses for each procedure were then totaled and divided by the population of the U.S. (an estimate of 300 million was used). The results are shown in Table 2.

Age Distribution

The age distribution of all diagnostic nuclear medicine examinations derived from a large insurance plan and adjusted for the age distribution of the U.S. population is shown in Fig. 2 and that for cardiac nuclear medicine procedures is shown in Fig. 3.

The age distribution shown in Fig. 2 is virtually identical to the age distribution found for all NM in 1980. At that time, 37.8% of procedures were done on persons 45 to 64 years and 39.0% done on persons over the age of 64.[11] These can be compared with 41.2% and 38.8%, respectively, found for the same age groups in 2003.

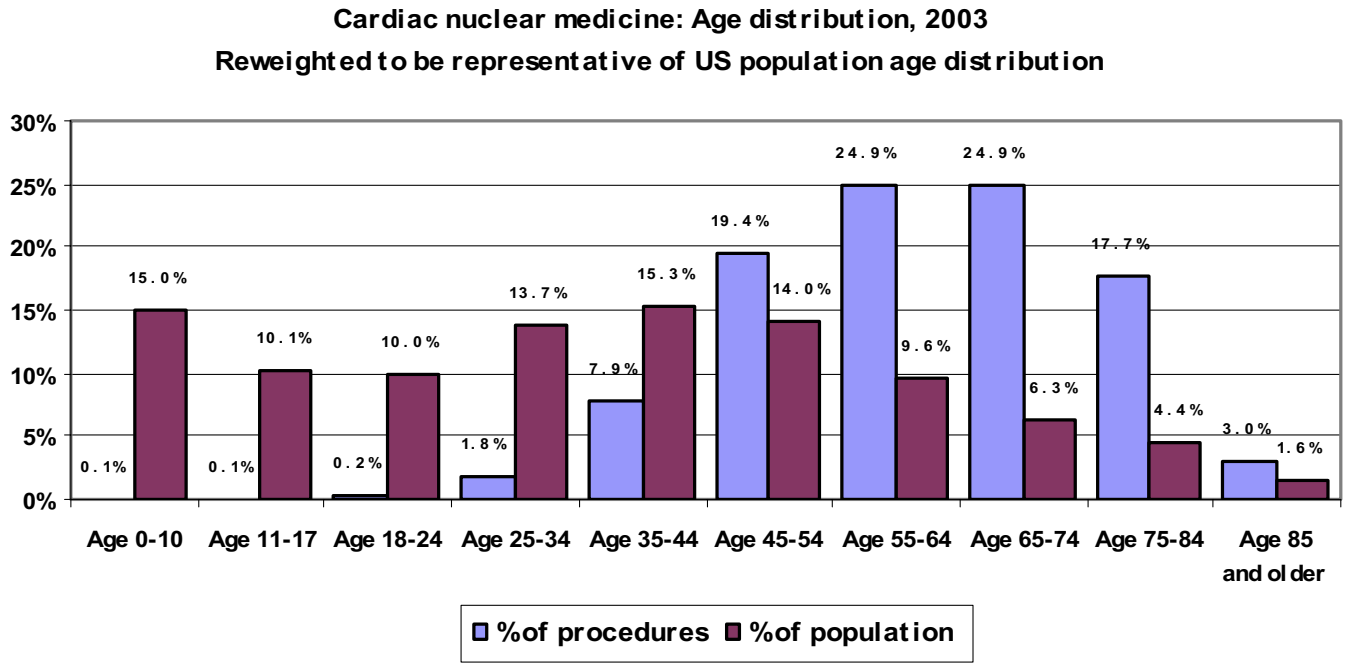

Figure 3 Age distribution for patients having cardiac nuclear medicine examinations compared with the general U.S. population. (Color version of figure is available online.)

Given that the major change since 1980 was a marked increase in cardiac scanning and the general aging of the population, it is not surprising that the average age of nuclear medicine patients has increased. In 1980 39% of procedures were done on persons over the age of 65 and this has increased to 46% in 2005. The number of nuclear medicine examinations done on younger patients has also decreased. In 1980 23% of procedures were done on patients younger than 45 years of age and this has decreased to 9.6% in 2005.

Discussion

Table 3 shows available data on the number of nuclear medicine examinations performed between 1972 through 2005. The table indicates that, during the last 25 years or so, diagnostic nuclear medicine procedures increased 5- to 6-fold whereas the U.S. population increased by approximately 50%. During the last decade, there was been 5% annual growth in the number of nuclear medicine procedures while the growth of the U.S. population has been less than 1% annually. Between 1982 and 2005, the estimated per capita effective dose from in vivo diagnostic nuclear medicine increased by 550% and the collective effective dose increased by 720%. In fact, the estimated 2005 per capita effective dose from diagnostic nuclear medicine (0.75 mSv) is greater than the total per capita dose from both diagnostic radiology and nuclear medicine examinations was in 1982 (0.14 and 0.40 mSv, respectively). As might also be suspected, the estimated 2005 collective effective dose from diagnostic nuclear medicine (220,000 person Sv) is greater than the total per capita dose from both diagnostic radiology and nuclear medicine examinations in 1982 (32,600 and 92,000 person Sv, respectively).

Table 4 shows a marked shift in the type of procedures with the studies of the brain and thyroid decreasing from a combined percentage of more than 56% of all procedures in

Table 3 Number of Nuclear Medicine Examinations Performed in the U.S. From 1972 Through 2005

Year	Procedures (Millions)	U.S. Population (Millions)	Exams per 1000 Population	Per-Capita Effective Dose (mSv)	Collective Effective Dose (Person-Sv)
1972	3.3	209.9	15.7		
1973	3.5	211.9	15.6		
1974		213.9			
1975	4.8	216.0	22.2		
1976		218.0			
1977		220.2			
1978	6.4	222.5	28.8		
1979		225.0			
1980	(5.8 to 6.4)	226.5			
1981	7.0	229.5	30.5		
1982	7.55 (7.4 to 7.7)	231.6	32.6	0.14	32,100
1983		233.0			
1984	6.3*	235.8	26.7		
1985	6.2*	237.9	26.2		
1986	6.7*	240.1	27.9		
1987	6.8*	242.3	28.1		
1988	7.1*	244.5	29.0		
1989	7.1*	246.8	28.9		
1990		249.7			
1991		252.1			
1992		255.0			
1993		257.7			
1994		260.3			
1995	10.2†	262.8	38.8		
1996	10.5†	260.3	40.3		
1997	10.9†	262.8	41.5		
1998	11.8†	265.2	44.5		
1999	12.6†	272.7	46.2		
2000	13.5†	282.1	47.9		
2001	14.5†	284.8	50.9		
2002	14.9†	287.9	51.8		
2003	15.7†	290.8	54.0		
2004	16.5†	294.7	56.0		
2005	(19) 17.2†	296.0	58.1	0.75	220,500

*FDA 1985 Radiation Experience Data 1980, Survey of U.S. Hospitals, DHEW Pub FDA 86-8253, National Technical Information Service, Springfield, VA.

†Data from IMV Inc Benchmark Report 2005 are patient visits, not procedures.

Table 4 Change (in Thousands) and Percentage of Total Exams Since 1972 for In Vivo Diagnostic Nuclear Medicine Examinations

	1973*		1982*		2005*	
Procedure	Number	(%)	Number	(%)	Number	(%)
Bone	125	(3.6)	1811	(24.5)	3450	(20)
Cardiac	33	(1.0)	950	(12.8)	9800	(57)
Lung	417	(11.9)	1191	(16.1)	740	(4)
Thyroid	460	(13.1)	677	(9.1)	—	(<2)
Renal	122	(3.5)	236	(3.2)	470	(3)
GI	535	(15.2)	1603	(21.7)	1210	(7)
Brain	1510	(43.0)	812	(11.0)	—	(<2)
Infection					380	(2)
Tumor	14	(0.4)	121	(1.6)	340	(2)
Other	294	(8.4)			—	(<2)
Total	3510	(100)	7400	(100)	17200	(100)

*National Council on Radiation Protection and Measurements.[2]
†IMV is for patient visits. Ratio of visits to procedures is about 1.14.

1973 to less than 4% in 2005. The most dramatic increase occurred in cardiac procedures increasing from 1% in 1973 to 57% in 2005. Cardiac studies are relatively high dose procedures and account for more than 85% of the effective dose to the patient population. Currently, more than 75% of all studies fall into 2 categories, cardiac and bone and these 2 types of examinations account for almost 95% of the collective effective dose.

There are a number of recent trends of which we are aware but which are new enough that their impact has not been evident in survey data from 2005. One of these is the marked shift from ventilation perfusion nuclear medicine scans to the use of multidetector computed tomography (CT) scans for evaluation of pulmonary embolism. Several years ago, most referring clinicians would have ordered a nuclear medicine examination. With the advent of the new faster CT scanners, the diagnosis is easier for the interpreting physician and provides more specificity. As a result, nuclear medicine lung scans have become very rare, and greater than 95% of studies ordered for pulmonary embolism evaluation are CT scans. This has almost certainly reduced the number of scans and reduced the dose in nuclear medicine but only by a percent or so. The dose to the patients for evaluation of pulmonary embolism, however has almost certainly gone up as CT scans of the chest have an effective dose of about 5 mSv (compared with about 2.5 mSv for a lung scan) and because the CT examination is easier to perform, many more examinations are being ordered.

Another trend that is occurring in cardiac myocardial perfusion studies is the gradual replacement of thallium-201 chloride with technetium-99m sestamibi or technetium-99m tetrofosmin. Depending on the activity injected, the effective dose per examination could be somewhat lower with technetium radiopharmaceuticals. For purposes of this report we assumed that only 25% of cardiac perfusion studies were performed with thallium-201 chloride but we believe that this may be as low as 5% to 10% at the present time. There is, however, little effect on the total dose since the lower effective dose per unit activity for technetium-99m sestamibi compared with thallium-201 chloride is offset by much higher administered activities of technetium-99m sestamibi. The potential impact of CT coronary artery screening and calcium scoring on cardiac nuclear medicine is uncertain.

Positron emission tomography (PET) scans have been available clinically for several years, but only with the recent availability of more cyclotrons and the increase of availability of fluorine-18 FDG, combined with the sales of PET/CT scanners has probably increased PET scans from the 1% or so of procedures listed in this report to about 5% of procedures currently. These will increase the radiation dose to the patients as the combined scans have an effective dose in the range of 20 to 40 mSv; however, the potential long-term detriment from these procedures is not likely to be great because the main use of the scans at the moment is to locate and stage cancers. The 2005/2006 IMV report on PET scanning indicated that there were approximately 1130,000 PET scans annually performed in 1725 hospital and nonhospital facilities. Of these, 93% were for oncologic purposes, 3% for cardiac, 4% for neurological, and <1% for other applications. The report also indicated that there were 248,000 PET scans in 2001, 447,000 in 2002, 706,000 in 2003, and 1,002,000 in 2004, with an annual growth rate ranging from 25% to 50%.

PET and PET/CT scans have increased rapidly since we collected our original data. Although future trends are hard to predict, it appears from informal surveys conducted at the end of 2007 that in many nuclear medicine departments PET/CT scans are additional workload and now represent about 10% of the total number of procedures. Thus, it is likely that the number of NM scans in 2007 (with the addition of 1.5 million PET scans) was about 19 million and that the per-caput dose was about 7.5 mSv and collective dose may have been almost 230,000 person Sv. The does not count the doses from the CT portion of the PET/CT scans.

The increasing size and, more importantly, the increasing mean age of the U.S. population will likely increase the demand for tumors scans (for localization and cancer staging) bone scans (looking for metastatic disease), and cardiac scans. The potential use of newer techniques in molecular

imaging, gene and antibody targeted cancer therapies remains largely uncertain.

Conclusion

There have been dramatic changes in the practice of nuclear medicine since the last comprehensive surveys and reports were made. The frequency of examinations has increased much faster than the U.S. population growth. Some, once common procedures have become almost extinct (predominantly as a result of CT scanning) whereas cardiac nuclear medicine has gown to become the major contributor to procedure number and to radiation dose. Both per-capita and collective effective doses from nuclear medicine are at least 5 and sevenfold higher than previously reported.

In 2005, it was estimated that there were 19.7 million procedures during 17.2 million patient visits. There has been extremely rapid growth of cardiac nuclear medicine procedures. In 2005, these represented 57% of all diagnostic nuclear medicine procedures and contribute more than 85% of the collective effective dose from nuclear medicine. In 2005, the annual per-capita effective dose was estimated to be about 0.75 mSv and the annual collective effective dose estimated to be about 220,000 person-Sv. IMV reported a decrease in nuclear visits in 2006 but an increase PET scanning likely resulting in no significant decrease to the per-caput or collective dose for 2006.

Acknowledgment

Marvin Rosenstein, PhD, served as the scientific secretary for the NCRP 6-2 medical subgroup.

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