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ORIGINAL RESEARCH • SPECIAL REPORT

U.S. PET/CT and Gamma Camera Diagnostic Reference Levels and Achievable Administered Activities for Noncardiac Nuclear Medicine Studies

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Conflicts of interest are listed at the end of this article.

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Existing surveys of radiopharmaceutical doses for U.S. nuclear medicine laboratories are of limited scope and size. Dose data are important because they can be used to benchmark individual laboratories, understand geographic variations in practice, and provide source data for societal guidelines and appropriateness criteria. Diagnostic reference levels (DRLs) and achievable administered activities (AAAs) for 13 noncardiac adult gamma camera and PET/CT examinations were derived retrospectively from American College of Radiology accreditation data (January 1, 2015, to December 31, 2017). The calculated DRL and AAA are consistent with previously published surveys. The distributions of radiopharmaceutical doses across facilities are in general consistent but show variation within a particular examination. Analysis of dose distribution suggests this variation results from differences in clinical protocols, educational gaps, and/or equipment factors. The AAA for the surveyed facilities exceeds dose ranges proposed in societal practice guidelines for several common nuclear medicine studies. Compared with similar surveys from Europe and Japan, geographic variation is observed, with some doses greater and others lower than used in the United States. Overall, radiopharmaceutical dose variation within the United States and internationally, and deviation from societal guidelines, imply that these dose-related benchmarks may be used to further standardize and improve clinical practice.

The favorable impact of radionuclide imaging on medical diagnosis and patient care has led to a large increase in the number of diagnostic examinations performed since the 1950s (1). Patient radiation exposure has concomitantly increased, which has caused public health concerns and prompted organized medicine to pursue strategies to lower ionizing radiation exposure (2–5).

For diagnostic imaging using radionuclides, patient radiation exposure is proportional to the route and administered activity (ie, dose) of the specific radiopharmaceutical. Optimization of scintigraphic examinations depends on the use of the lowest radiopharmaceutical dose that allows for images of acceptable diagnostic quality. Two benchmarks that help facilities achieve that optimization are diagnostic reference level (DRL) and achievable administered activity (AAA), also known as achievable dose. DRL and AAA are expressed in megabecquerels and millicuries.

The DRL was introduced by the International Commission on Radiological Protection in 1990 and is defined as the 75th percentile of administered doses from a regional or national survey of imaging facilities (6–8). Imaging facilities should use DRLs to determine if they are administering radiopharmaceuticals in unusually high activities and, if so, should perform a local review to assess if protocols and equipment are appropriately optimized. Because this type of local review will occur in a minority of imaging facilities (the 25% whose radiopharmaceutical doses exceed the DRL), the AAA, which is defined as the median (50th percentile) radiopharmaceutical dose derived from a similar survey, has been advanced as a more effective guideline that represents doses realistically achievable by standard techniques and commonly available equipment (9).

Surveys of administered activities from U.S. nuclear medicine facilities have, by necessity, been limited in scope with respect to the types of examinations and number of sites surveyed (9,10). Unlike CT, where data can be compiled by using a computer-automated dose registry, surveys of scintigraphic examinations require manual data input. As a result, radiopharmaceutical dose source data used in societal practice guidelines and appropriateness criteria is limited.

In this article, we drew on the administered activities reported by imaging facilities in their applications to the American College of Radiology (ACR) nuclear medicine and PET/CT accreditation programs to derive adult DRLs and AAAs for a variety of adult gamma camera and PET/CT examinations. In addition to providing quality benchmarks, we assessed the results for consistency across practice facilities and compared them with similar surveys from the United States, Europe, and Japan. Finally, we used the AAA metric to identify differences between current clinical practice and societal practice guidelines.

Data Set

The queried source database and the results of the query do not contain patient-identifying data. There are no

Abbreviations

AAA = achievable administered activity, ACR = American College of Radiology, DRL = diagnostic reference level, FDG = fluorodeoxyglucose, HDP = hydroxydiphosphonate, MDP = methyldiphosphonate

Summary

On the basis of American College of Radiology survey data from 2015 to 2017, diagnostic reference level and achievable administered activity benchmarks are presented for gamma camera and PET/CT examinations. These data may be used to optimize radiotracer dose in nuclear medicine facilities and potentially reduce radiation dose.

Key Results

- Accreditation data bridge the gap caused by a lack of large-scale surveys of radiopharmaceutical doses used by U.S. nuclear medicine facilities.
- Although generally consistent, U.S. nuclear medicine facilities show variation in radiopharmaceutical dosing for individual examination types.
- For certain examinations, radiopharmaceutical doses used in clinical practice differ from societal practice guideline recommendations.

conflicts of interest. The current data set or parts thereof have not been included in previous publications.

The methods used to obtain the data and results were previously described (11). Briefly, the ACR requires a site to submit two clinical patient studies for every examination type that is assessed for accreditation. For each clinical study, the facility submits the type of radiopharmaceutical used, administered activity, gamma camera acquisition parameters, final physician report, medical physics data, site demographic data, and the facility's relevant written policies and procedures. The quantitative parameters from each accreditation application are entered into a structured query language database (Microsoft, Redmond, Wash). The following data fields were queried for our study: radiopharmaceutical type, administered activity, and examination type (data query, data tabulation, and statistical analysis performed by P.F.B., M.S., and D.A.G., with 43 years of experience in medical physics, 8 years of experience in data analysis, and 14 years of experience in data analysis, respectively). The extracted clinical study data spanned a single 3-year accreditation cycle from January 1, 2015, to December 31, 2017. We captured data from each accredited facility once and included successful initial and renewal applications. Data from submissions that either did not receive accreditation or were appealing a "fail" accreditation decision were excluded. Redundant examinations (eg, same examination was submitted for both planar gamma camera and SPECT accreditation) were excluded. The results of the database query were transferred to a spreadsheet (Excel; Microsoft) to tabulate and analyze the data.

Table 1: Radiopharmaceutical Doses, Achievable Administered Activities, and Diagnostic Reference Levels in Adults Derived from American College of Radiology Nuclear Medicine Accreditation Data

Radiopharmaceutical and Examination Type*	No. of Clinical Studies	Administered Dose		
		Mean	AAA	DRL
^{99m}Tc-HDP/MDP whole-body bone	4415	910 ± 130 (24.6 ± 3.5)	929 (25.1)	988 (26.7)
^{99m}Tc-IDA analog hepatobiliary	2264	218 ± 56 (5.9 ± 1.5)	204 (5.5)	241 (6.5)
^{99m}Tc-MAA perfusion lung	473	189 ± 48 (5.1 ± 1.3)	185 (5.0)	215 (5.8)
^{99m}Tc-sulfur colloid liver/spleen	52	229 ± 85 (6.2 ± 2.3)	222 (6.0)	255 (6.9)
^{99m}Tc-tagged RBC liver	14	862 ± 118 (23.3 ± 3.2)	840 (22.7)	925 (25.0)
^{111}In-pentetreotide neuroendocrine	303	226 ± 19 (6.1 ± 0.5)	226 (6.1)	237 (6.4)
^{99m}Tc-pertechnetate thyroid	48	389 ± 126 (10.5 ± 3.4)	370 (10.0)	407 (11.0)
^{123}I-NaI thyroid	182	10 ± 4 (0.270 ± 0.100)	9 (0.255)	11 (0.300)
^{131}I-NaI whole-body thyroid cancer	36	144 ± 48 (3.9 ± 1.3)	148 (4.0)	185 (5.0)
^{18}F-FDG oncology PET/CT	3459	485 ± 100 (13.1 ± 2.7)	485 (13.1)	555 (15.0)
^{18}F-FDG brain PET/CT	1257	366 ± 104 (9.9 ± 2.8)	370 (10.0)	414 (11.2)
^{18}F-florbetaben brain PET/CT	33	340 ± 78 (9.2 ± 2.1)	363 (9.8)	377 (10.2)
^{18}F-florbetapir brain PET/CT	109	381 ± 96 (10.3 ± 2.6)	374 (10.1)	411 (11.1)

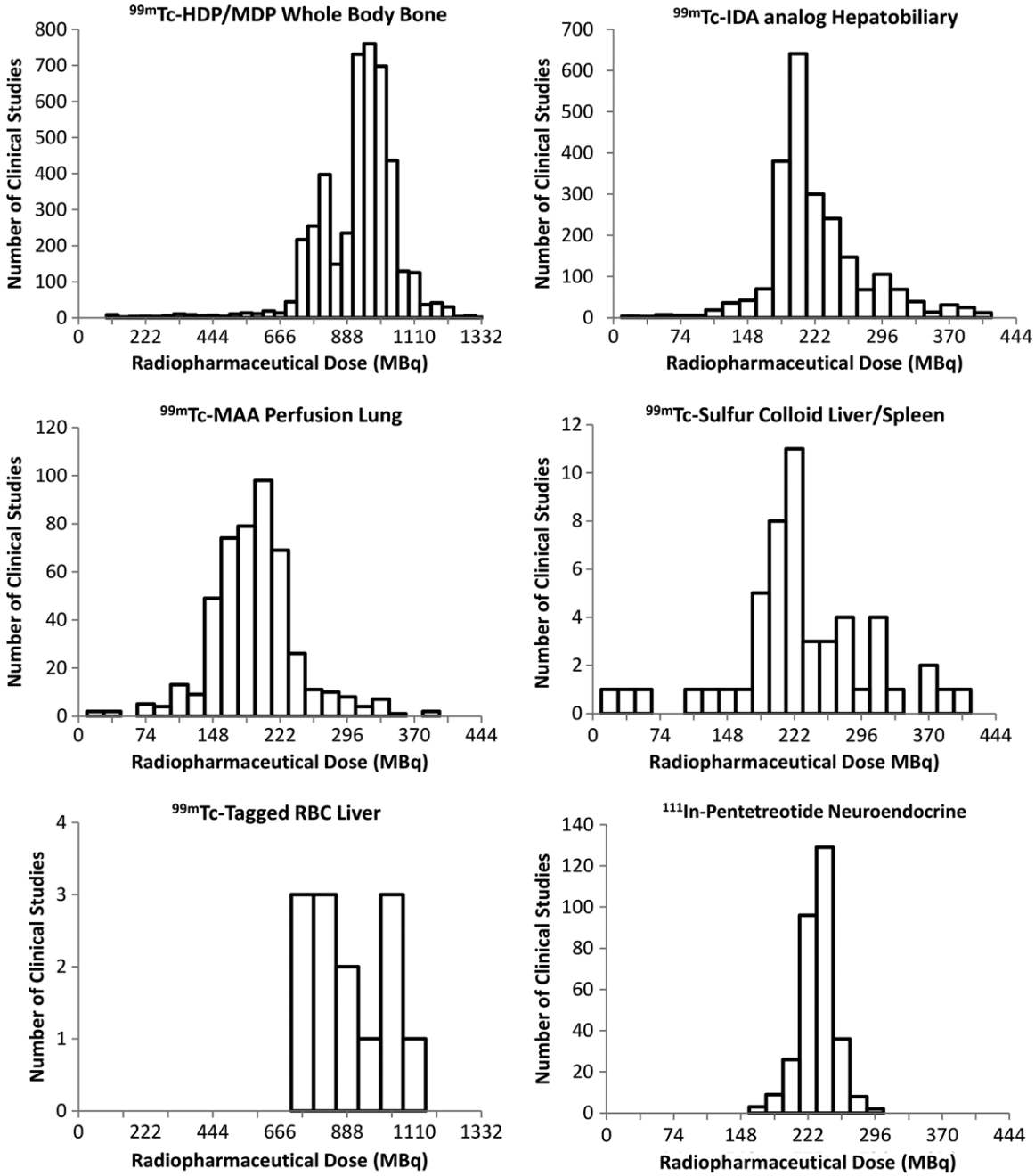
Note.—Data are in megabecquerels; millicuries are in parentheses. Mean data are ± standard deviation. AAA = achievable administered activities, DRL = diagnostic reference level, FDG = fluorodeoxyglucose, HDP/MDP = hydroxydiphosphonate/methyldiphosphonate, IDA = iminodiacetic acid, MAA = macroaggregrated albumin, RBC = red blood cell.

* Radiopharmaceutical agent listed with examination name.

Statistical Analysis

For each examination type dose data set, a spreadsheet (Excel; Microsoft) was used to calculate mean, standard deviation, median (50th percentile), and 75th percentile values, and to perform statistical comparisons. As previously described (11), DRLs were assigned to 75th percentile values and AAAs to 50th percentile values. The dose data sets were also used to create frequency distribution histograms.

Finally, the data for technetium 99m (^{99m}Tc)–methyldiphosphonate (MDP) whole-body bone (n = 3913) and ^{99m}Tc-hydroxydiphosphonate (HDP) whole-body bone (n = 502) were combined because these radiopharmaceutical agents



a.

Figure: Radiopharmaceutical dose frequency histograms. **(a)** Gamma camera nonthyroid examinations *(Figure continues)*.

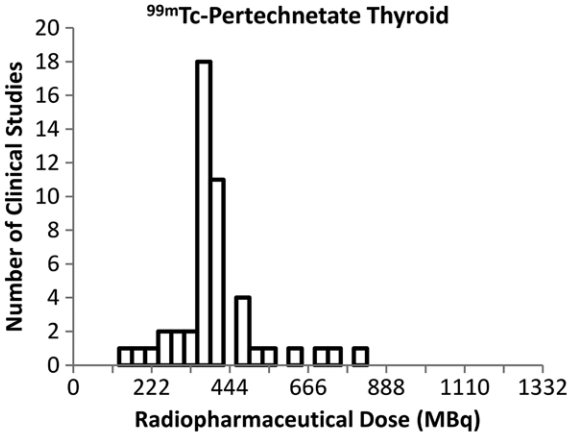
are often used interchangeably due to of the modest difference in skeletal uptake and no difference in lesion detectability (12). In the current data set, the individual frequency distributions for these radiopharmaceuticals are visually similar and the means are not statistically different (P = .88; Student two-tailed t test); however, statistical calculation is limited by the distribution's deviation from normalcy.

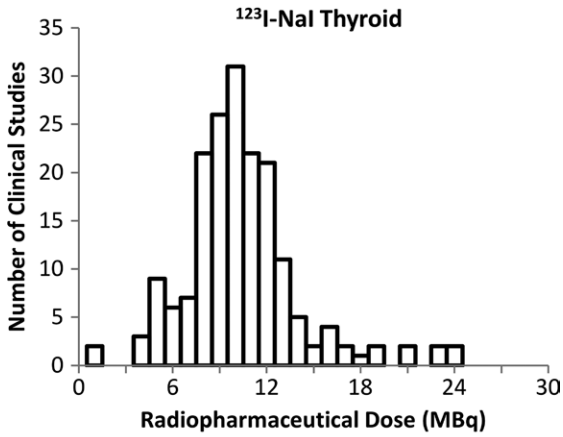
Results

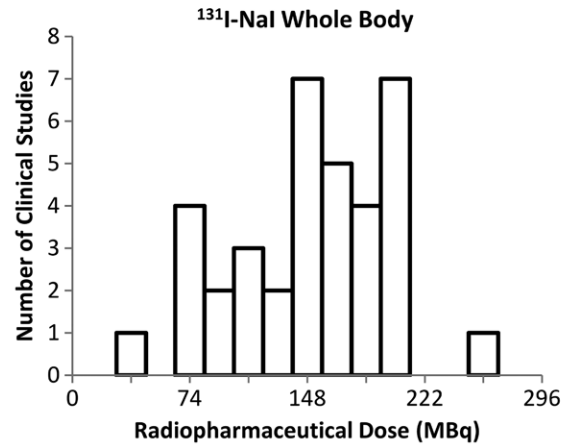
The tabulated survey results (number of examinations, mean dose and standard deviation, AAA, and DRL) collected from a total of 3135 unique facilities for 13 different diagnostic examination–and-radiopharmaceutical combinations are in Table 1. The administered doses are presented as frequency distribution histograms in the Figure. Comparisons with previous DRL surveys and societal practice guidelines are in Table 2.

Survey Findings

In general, the frequency distributions are bell-shaped curves in which the 50th percentile (ie, AAA) and 75% percentile (ie, DRL) are within 10%–20% of each other (Figure; Table 1). The survey findings showed that whereas variation in the ad-







b.

Figure *(continued).* **(b)** Gamma camera thyroid examinations *(Figure continues).*

ministered dose exists across the population of facilities seeking ACR accreditation, a relatively consistent approach is used to choose individual patient radiopharmaceutical doses. However, there were notable exceptions.

First, the frequency distribution for ^{99m}Tc-HDP/MDP whole-body bone shows two distinct superimposed bell-shaped curves, the lower centered at approximately 777 MBq (21 mCi) and the higher at approximately 962 MBq (26 mCi). Similarly, the frequency distribution for 131 iodine (^{131}I)-NaI whole-body thyroid cancer also show heterogeneity that may represent a lower dose group at 74–148 MBq (2–4 mCi) and a higher dose group at 148–222 MBq (4–6 mCi); the conclusion is limited by small sample size (n = 36). Second, ^{99m}Tc–tagged red blood cell liver shows a somewhat random distribution constrained to the range of 740–1147 MBq (20–31 mCi); this may simply reflect the small sample size (n = 14) of this uncommon examination rather than methodologic variations across facilities. Third, the frequency distribution for fluorine 18(^{18}F) fluorodeoxyglucose (FDG) oncology PET/CT shows a relatively broad peak across the range of 370–629 MBq (10–17 mCi). Fourth, the frequency histograms of multiple examinations show a right-sided so-called tail (^{99m}Tc–iminodiacetic acid analog hepatobiliary, ^{99m}Tc-sulfur colloid liver and spleen, ^{99m}Tc-pertechnetate thyroid, and iodine 123 [^{123}I]–NaI thyroid) (Figure).

Comparison with Previously Published Results

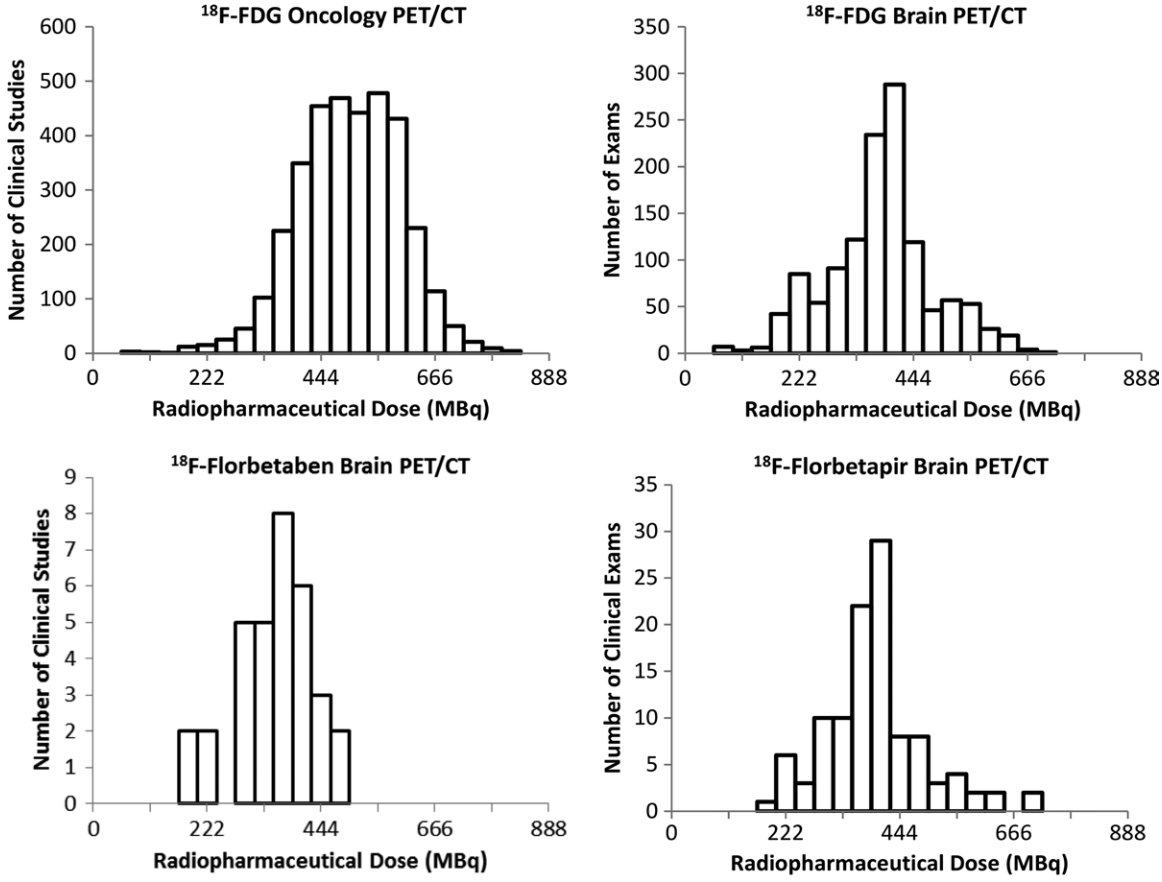
We compared our results with previously published AAA and DRL results from National Council on Radiation Protection and Measurements Report 172, Intersocietal Accreditation Commission, Japanese surveys, and European surveys (Table 2) (9,10,13,14). Our results are similar to previous surveys based in the United States from National Council on Radiation Protection and Measurements Report 172 and Intersocietal Accreditation Commission, although our study included more types of examinations (13 vs six and two, respectively). Our results are similar to the Japanese survey results (within 20%), with the exception of higher DRL with ^{99m}Tc–macroaggegated albumin perfusion lung and a lower DRL with ^{18}F-FDG brain PET/CT and ^{18}F-FDG oncology PET/CT in Japan compared with the United States. In general, the European data show lower DRL than ACR data for ^{99m}Tc-HDP/MDP whole-body bone (40% lower) and ^{99m}Tc-pertechnetate thyroid (80% lower), and a higher DLR for ^{123}I-NaI thyroid (77% higher).

Comparison with Societal Practice Guidelines

We compared our results with practice guidelines from the ACR (15–24), the Society of Nuclear Medicine and Molecular Imaging (25–30), and the European Association of Nuclear Medicine (25,31,32) (Table 2). The AAA, which represents median dose used in practice, is the metric most suited for assessing whether most facilities practice in accordance with practice guidelines. The AAA in our study is at the top or exceeds dose ranges recommended in practice guidelines for ^{99m}Tc–iminodiacetic acid analog hepatobiliary, ^{99m}Tc–macroaggregrated albumin perfusion lung, ^{99m}Tc–sulfur colloid liver and spleen, ^{99m}Tc-pertechnetate thyroid, and indium 111 (^{111}In)–pentetreotide neuroendocrine. The AAAs for the remaining radiopharmaceutical are within the dose ranges of the guidelines.

Discussion

The data set provides benchmarks that practices may use to optimize imaging protocols. Comparison with previous similar



c.

Figure *(continued).* **(c)** PET/CT examinations. FDG = fluorodeoxyglucose, HDP = hydroxydiphosphonate, IDA = iminodiacetic acid, MAA = macroaggregrated albumin, MDP = methyldiphosphonate, RBC = red blood cells.

surveys and with societal practice guidelines show heterogeneity in practice, both nationally and internationally, that can be used to further standardize clinical practice. Finally, analysis of the distribution of administered activities for a specific examination types suggests underlying causes for the observed variation in clinical practice.

In its most fundamental and perhaps most valuable form, our data provided AAA and DRL values that facilities may use to benchmark and optimize imaging protocols. The strength of our data set is its breadth (13 distinct examinations) and depth (number of cases and number of facilities). On the basis of 2015 estimates of the number of nuclear medicine and PET/CT facilities in the United States (33,34) and the number of sites applying for accreditation at the end of our data collection period, approximately 50% of nuclear medicine and 65% of PET/CT facilities were included. Thus, these data encompass a substantial fraction of U.S. facilities.

In our study, four radiopharmaceuticals have fewer than 50 clinical patient examinations, which makes the applicability of their AAA and DRL values questionable; however, to our knowledge, large U.S. data sets for these radiopharmaceuticals do not exist. The European data are a compendium of multiple surveys in which only the most representative data were selected for inclusion. The Japanese data are a true survey of a large number of facilities and contain many distinct examination types. Thus, our data augments these previously published data sets, increasing the breadth and scope of available data.

The AAA for two common examinations (^{99m}Tc–macroaggregrated albumin perfusion lung and ^{99m}Tc–iminodiacetic acid analog hepatobiliary) and for three less common examinations (^{99m}Tc–sulfur colloid liver and spleen, ^{99m}Tc-pertechnetate thyroid, and ^{111}In–pentetreotide neuroendocrine) is at the top or exceeds the practice guideline ranges. There is a variety of explanations for these discrepancies. First, facilities may not be able to achieve acceptable diagnostic performance at the practice guideline dose ranges because of equipment and/or patient factors. Second, there may be an educational gap whereby facilities may be unaware that they can use lower doses to obtain diagnostic quality images. It seems possible that both factors, and perhaps others that are unidentified, are at play.

The ability of a gamma camera to record a diagnostic image at a given administered activity depends on the technical capabilities of the gamma camera and on patient factors such as body habitus. Over time, the U.S. population has tended toward a higher body mass index (35), which can make higher doses advantageous with respect to image quality. On the other hand, many radiopharmaceuticals have been in use for decades, and whereas gamma camera and PET/CT physics and quality control methods are well understood and standardized (20,36,37), to our knowledge the literature does not contain rigorous studies

Table 2: Comparison of Current Results with Prior Surveys and Societal Guidelines

Radiopharmaceutical and Examination Type	DRL Survey					Societal Guidelines		
	Current ACR Data	NCRP Report 172 (9)	IAC (10)	Europe (14)	Japan (13)	SNMMI (25–30)	ACR-SPR-ASNR (15–24)	EANM (25,31,32)
^{99m}Tc-HDP/MDP whole-body bone								
AAA	929 (25.1)	833 (23)	925 (25)	...	...	740–1110 (20–30)	555–1110 (15–30)	296–740 (8–20)
DRL	988 (26.7)	925 (32)	999 (27)	600 (16.2)	950 (25.6)			
^{99m}Tc-IDA analog hepatobiliary								
AAA	218 (5.9)	186 (5.00)	…	…	…	111–185 (3–5)	111–185 (3–5)	…
DRL	241 (6.5)	282 (7.62)	…	…	…			…
^{99m}Tc-MAA perfusion lung								
AAA	185 (5.0)	148 (4.00)	…	…	…	37–148 (1–4)	111–185 (3–5)	…
DRL	215 (5.8)	226 (6.12)	…	150 (4.0)	260 (7.00)	…	…	…
^{99m}Tc-sulfur colloid liver and/or spleen								
AAA	222 (6.0)	186 (5.00)	…	…	…	111–222 (3–6)	111–222 (3–6)	…
DRL	255 (6.9)	293 (7.92)	…	…	4.9 (180)	…	…	…
^{99m}Tc-tagged RBC liver								
AAA	840 (22.7)	…	…	…	…	740–925* (20–25)	740–925* (20–25)	…
DRL	928 (25.0)	…	…	750 (20.2)	1000 (26.95)			…
^{111}In-pentetreotide neuroendocrine								
AAA	226 (6.1)	…	…	…	…	222 (6)	148–222 (4–6)	200 (5.4)
DRL	237 (6.4)	…	…	…	…	…	…	…
^{99m}Tc-pertechnetate thyroid								
AAA	370 (10.0)	…	…	…	…	74–370* (2–10)	74–370* (2–10)	…
DRL	410 (11.0)	…	…	80 (2.2)	300 (8.1)	…	…	…
^{131}I-NaI whole-body thyroid cancer								
AAA	148 (4.0)	…	…	…	…	37–185 (1–5)	37–185 (1–5)	…
DRL	185 (5.0)	…	…	…	…	…	…	…
^{123}I-NaI thyroid								
AAA	9.4 (0.255)	7.68 (0.21)	…	…	…	7.4–14.8* (0.2–0.4)	…	…
DRL	11.2 (0.300)	26.0 (0.71)	…	20 (0.53)	10.00 (0.27)	…	7.4–14.8* (0.2–0.4)	…
^{18}F-FDG oncology PET/CT								
AAA	485 (13.1)	555 (15)	518 (14)	…	…	370–740 (10–20)	185–740 (5–20)	…
DRL	555 (15.0)	710 (19)	592 (16)	…	240† (6.46)	…	…	…
^{8}F-FDG brain PET/CT								
AAA	370 (10.0)	…	…	…	…	185–740 (5–20)	185–444 (5–12)	150–370 (4.1–10.0)
DRL	414 (11.2)	…	…	…	240† (6.46)	…	…	…

Table 2 *(continues)*

Table 2 (*continued*): Comparison of Current Results with Prior Surveys and Societal Guidelines

Radiopharmaceutical and Examination Type	DRL Survey					Societal Guidelines		
	Current ACR Data	NCRP Report 172 (9)	IAC (10)	Europe (14)	Japan (13)	SNMMI (25–30)	ACR-SPR-ASNR (15–24)	EANM (25,31,32)
^{18}F-florbetaben brain PET/CT								
AAA	363 (9.8)	…	…	…	…	296* (8)	185–444 (5–12)	296* (8)
DRL	377 (10.2)	…	…	…	…	…	…	…
^{18}F-florbetapir brain PET/CT								
AAA	374 (10.1)	…	…	…	…	370* (10)	185–444 (5–12)	370* (10)
DRL	411 (11.1)	…	…	…	…	…	…	…

Note.—Data are presented in megabecquerels with millicuries in parentheses. AAA = achievable administered activities, ACR = American College of Radiology, ASNR = American Society of Neuroradiology, DRL = diagnostic reference level, EANM = European Association of Nuclear Medicine, FDG = fluorodeoxyglucose, HDP/MDP = hydroxydiphosphonate/methyldiphosphonate, IAC = Intrasocietal Accreditation Commission, IDA = iminodiacetic acid, MAA = macroaggregrated albumin, NCRP = National Council on Radiation Protection and Measurements, RBC = red blood cell, SNMMI = Society of Nuclear Medicine and Molecular Imaging, SPR = Society Pediatric Radiology.

* Collaborative guidelines from multiple societies.

† Not specified fluorine 18 (^{18}F)-FDG brain PET/CT or ^{18}F-FDG oncology PET/CT.

of how radiopharmaceutical dose specifically impacts clinical outcome measures such as mortality. Because of this lack of experimentally derived reference data, individual facilities may choose doses and imaging societies may choose guideline ranges that are partially on the basis of historical precedent or anecdotal practices. Thus, many factors may work synergistically and result in a mismatch between societal recommendations and current clinical practice.

Our data suggest three distinct patterns of radiopharmaceutical dosing: facilities specifically choosing a higher or lower dose, outliers in which a facility uses a relatively higher dose without a clear rationale, and doses driven by equipment and/or patient factors.

Examples of the first pattern are observed in the bimodal frequency distributions for ^{99m}Tc-HDP/MDP whole-body bone and ^{131}I-NaI whole-body thyroid cancer. Because the evolution of gamma camera technology is relatively mature, it does not seem likely that differences in camera capabilities explain this pattern. Weight-based dose could affect the data, but such protocols are distinctly uncommon on the basis of the policies and procedures submitted to ACR accreditation. Therefore, it seems more likely that the bimodal distribution for bone scintigraphy simply reflects different approaches in clinical practice, possibly historical precedent. Similarly, although it is a limited data set, the bimodal distribution for ^{131}I-NaI whole-body thyroid cancer may be from different approaches that consider thyroid tissue stunning (38).

Examples of the second pattern are observed in ^{99m}Tc–iminodiacetic acid analog hepatobiliary, ^{99m}Tc–sulfur colloid liver and spleen, ^{99m}Tc-pertechnetate thyroid, and ^{123}I-NaI thyroid, where the frequency distributions show right-sided so-called tails of higher doses. In these cases, a minority of facilities use higher doses than the overall population of facilities. In this case, the use of DRL to limit outliers seems most applicable because these outliers likely reflect an educational gap.

An example of the third pattern may be observed in the ^{18}F-FDG oncology PET/CT frequency distribution wherein there is a symmetrical bell-shaped curve, but the range of doses seems broader than for other radiopharmaceuticals. This may reflect differences in PET/CT system capabilities. For example, factors such as scan mode (two-dimensional, three-dimensional, time of flight), axial field of view, duration per bed position, and amount of bed overlap affect image quality and may affect the dosage chosen by a facility (39,40). This pattern raises the larger issue that, beyond radiopharmaceutical dose surveys and practice guidelines, advances in hardware (eg, calcium-zinc-telluride SPECT CT and position-sensitive photomultiplier PET/CT) and software (eg, ordered subset expectation maximization reconstruction) may offer perhaps the most efficacious means to lower dose (41–43).

Practice guideline dosage ranges are recommendations, not mandates, and the radiopharmaceutical doses used in diagnostic radionuclide examinations unequivocally result in small and low radiation exposures. The risk of an appropriately chosen scintigraphic examination rests not in the radiation exposure but in the fact that not performing the examination could negatively impact the diagnosis and management of the patient. Nonetheless, lowering radiation exposure without compromising diagnostic efficacy is clearly advantageous.

Our study had limitations. These data are not on the basis of a formal survey of radiopharmaceutical doses but rather are derived from cases submitted to an accreditation program. However, there is precedent for the use of such data for both radionuclide imaging and CT (10,11,44). Because facilities choose the cases submitted, there could be selection bias. For example, if a facility used weight-based doses and

submitted images from patients with small body habitus who have more favorable imaging characteristics, then the AAA and DRL would be underestimated. This type of bias is not believed to be significant because weight-based dosing is not common in adults. Another potential limitation can be the integrity of the data, which are self-reported and inputted into the ACR database manually. One can see outliers, with some doses that are unrealistically low for adult patients (eg, ^{99m}Tc-MDP/HDP whole-body bone). In the spirit of transparency and consistency, these data points were included in the calculations and graphs so as to not arbitrarily select and discard data points. We note that these outliers occur at a low frequency that we did not feel materially affected the calculated AAAs and DRLs. Finally, it must be noted that conclusions derived from the shape of the frequency distributions are extrapolated and not on the basis of direct evidence. For example, the range of doses used for ^{131}I-NaI whole-body thyroid cancer may be related to considerations regarding thyroid tissue stunning, but facilities were not directly questioned regarding how or why they choose their doses. Nonetheless, we believe the conclusions drawn are valid starting points for further investigation.

In conclusion, we present American College of Radiology accreditation data to derive diagnostic reference levels and achievable administered activities for 13 radiopharmaceutical imaging examinations, which extend and enhance existing data sets. The doses used in daily practice are not always consistent with practice recommendations. Furthermore, nonuniformities in the data raise the issue of historical factors, equipment factors, and/or patient factors that affect dosage choice. Our data provide benchmarks and a point-in-time assessment of radiopharmaceutical doses in the United States that can be used to refine and improve practice.

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