2005

The Nuclear Medicine Workforce

Center for Health Workforce Studies

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The Nuclear Medicine Workforce in 2005

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PREFACE

This report was prepared as part of the initial fact-finding phase of a larger study of the nuclear medicine workforce in the U.S. This initial work was designed to help understand the coverage and quality of existing information systems related to the nuclear medicine workforce, and to inform the process of designing several surveys to gather up-to-date information about nuclear medicine technologists, scientists, physicians, educators, and students. The resulting information will inform nuclear medicine planners, policy makers, and practitioners about the current status and future prospects of the nuclear medicine workforce.

The report was prepared by the Center or Health Workforce Studies at the School of Public Health at the University at Albany in upstate New York, under a contract with the Society of Nuclear Medicine in Reston, Virginia. The authors were Margaret Langelier, Senior Research Associate, and Paul Wing, the Deputy Director at the Center.

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Executive Summary

Nuclear Medicine is a specialty in medicine based on basic and advanced principles from a variety of sciences including physics, biology, chemistry and pharmacology. Using radiopharmaceuticals ingested by, inhaled by, or injected into a patient, nuclear medicine professionals can identify and stage disease processes. Studies are also performed to check organ function and hormone levels. Radiopharmaceuticals, which are produced from radionuclides (unstable atoms that emit radiation), are given to patients in very small quantities. Using a variety of gamma cameras (with the choice determined by the kinds of images desired), the emissions from the radioactive materials in the body are traced, measured, and located and images are produced for evaluation and diagnosis.

Cellular processes in the body enable nuclear medicine professionals to make more accurate images and diagnoses of problem sites. Radiopharmaceuticals are metabolized at different rates by various kinds of cells in the body and in various organs. These tracers permit evaluation of the presence or absence of disease, the location of diseased tissue, and also provide insights about the efficacy of treatments that have been or might be initiated. Currently, there are over 100 nuclear medicine procedures with capability to image every major organ system.

Nuclear Medicine imaging differs from diagnostic radiology in that it documents physiologic function and not just anatomy. Nuclear medicine provides real time images of cellular processes and organ function permitting diagnosticians and treating physicians to understand patient disease.

The three main professions working in the field of nuclear medicine are nuclear medicine physicians, nuclear medicine technologists, and nuclear medicine scientists. This report summarizes basic information about these professionals, along with supplemental information about their professional environment.

The Nuclear Medicine Workforce Study

This report is the first of several to be produced as part of a larger three-year study of the nuclear medicine workforce in the U.S. The study, funded by the Society of Nuclear Medicine, began in late 2004 and is scheduled for completion in September of 2007. The goal of the study is to compile and collect data on the key aspects of the nuclear medicine field, and to help key nuclear medicine policy makers and stakeholders to use the data in decisions about the future of the specialty. Key elements of the larger study are:

- Surveys of nuclear medicine technologists, scientists, and physicians to learn more about their characteristics, education and training, licensure and certification, current employment, career paths, current work environment, and continuing education.
- Interviews and focus groups with nuclear medicine stakeholder to help understand the dynamics of the nuclear medicine field and the evolution of the professional and clinical aspects of the several professions.
- Case studies of a number of bellwether organizations that are leaders in the development and application of nuclear medicine tools, techniques, and applications.
- A series of reports and articles to disseminate study findings to appropriate stakeholders and policy makers.

Objectives of This Report

This preliminary report summarizes a great deal of information about nuclear medicine in the U.S. The authors hope it will be an important centralized source of information for planners and policy makers trying to take the measure of this ever-changing specialty. But the four key objectives of this report are related primarily to the larger nuclear medicine workforce study. The report:

- **Compiles and summarizes existing data on the nuclear medicine workforce.** These data will help planners and policy makers to understand the current size of the nuclear medicine workforce, the organizations involved in nuclear medicine, and related education and training programs.
- **Assesses the adequacy of existing data to support workforce planning.** In addition to summarizing the data available on different aspects of nuclear medicine, the report includes a general assessment of the adequacy of the data to support workforce planning.
- **Offers an up-to-date overview of the nuclear medicine field in the U.S.** Despite the limitation in some of the data presented below, this interim report does present and clarify many aspects of the nuclear medicine specialty and the related workforce.

- **Presents insights about future prospects of the nuclear medicine field.** While this report is not meant to be an exhaustive compendium of information about all aspects of nuclear medicine, it does present a wide range of insights about the field that create a context for other reports and study activities.

Key Strategic Findings

Despite gaps in the data about nuclear medicine and the nuclear medicine workforce, it is possible to identify a number of key strategic findings from the information presented in this report. Some of the conclusions are based entirely on the data presented in the report. Many, however, are based on the on-going interviews and discussions with different nuclear medicine stakeholders conducted as part of the larger study. The findings have been put into groups that seem relevant to different types of planning and policy issues.

General

- Nuclear medicine is a rapidly expanding and evolving medical specialty. Based on new scientific and technological paradigms that occur at the cellular level, the field is opening up new options for both diagnosis and treatment of disease and illness. Often referred to as molecular imaging, nuclear medicine is rapidly diffusing into other medical specialties, especially cardiology and oncology. This rapid evolution makes the specialty a moving target that is often difficult to focus on.

- Nuclear medicine is an unusually diverse field that brings together concepts, techniques, and technologies from a variety of scientific disciplines, including: chemistry, biology, physics, physiology, engineering, and computer science. Although some progress has been made in developing standard ways of bridging and synthesizing elements from these different disciplines, the field is so new that it seems likely that many new protocols will be discovered in the near future, some of which may transform the field even more than previous discoveries have transformed the field to date.

- The cameras and related equipment and pharmaceuticals used in nuclear medicine studies are the basis for an active international corporate enterprise. The vendors of this equipment, which include several major international corporations, are aggressively developing and marketing new products and services using entrepreneurial business models that are quite different from business models used by most non-for-profit organizations involved in health care. One of the spin-offs of this corporate model is a major expansion of the number of stand-alone imaging centers and nuclear medicine centers managed by entrepreneurial physicians and businessmen. The financial success of these enterprises has stimulated much interest in this business model across the country.

Data Issues

- Although considerable data on nuclear medicine workforce currently exist, these data are fragmented and contain gaps that make comprehensive analyses difficult. Perhaps even more important, the nuclear medicine field is evolving so rapidly that even the data that do exist are not always relevant to the clinical, scientific, and policy choices that must be made.

Nuclear Medicine Professions

- The formally recognized nuclear medicine professions are very small portions of the overall health care workforce. This limits the influence and political power of these professions as the use of nuclear medicine procedures and concepts spreads into other aspects and specialties of medicine. If these new diagnostic and treatment paradigms continue to grow in importance—as many experts believe will happen, then it will be increasingly difficult for existing nuclear medicine organizations to retain control over their own destiny.
- As is often true in new and developing professions, the number of professional associations serving nuclear medicine is very large, and most of the organizations are very small. The nuclear medicine field would probably be served well by a consolidation of these organizations into two or three primary groups. This would create opportunities for greater focus of the profession on critical issues and strategies to move nuclear medicine forward.

Education

- As is true in many professions that are in short supply, nuclear medicine technologist education programs are having difficulty recruiting faculty. This is true because faculty salaries in these programs are much lower than those attainable in clinical practice in the field. Without some sort of external subsidies, it is not clear how this faculty shortage can be overcome. Until the faculty shortage in nuclear medical technology programs is dealt with, shortages of nuclear medicine technologists are likely to continue.

Fusion Techniques and Protocols

- Imaging protocols based on the fusion of images prepared using multiple technologies seem poised to become the norm over the next decade and more. In practical terms this will create preferences in the workplace for professionals skilled in all of the technologies that are fused. This transformation of imaging professions and specialties has major implications for existing imaging professionals, including those in nuclear medicine. Many will have to update their education and training to become skilled in all the appropriate imaging technologies. It will also be necessary for many to learn new skills related to the joint interpretation of multiple images based on different technologies.

Government Regulation

- Nuclear medicine is a highly regulated medical specialty, with regulations imposed by the Food and Drug Administration (FDA) and the Nuclear Regulatory Commission (NRC), in addition to the Centers for Medicare and Medicaid Services (CMS) and others who are involved with all aspects of medicine. The regulatory push and pull between the desire to protect the safety of individual consumers and patients, and the desire to permit—even promote—rapid development and dissemination of new diagnostic and therapeutic tools and techniques is an important overlay on the policy making infrastructure of the nuclear medicine field.

- One aspect of government regulation that has not been as strict for some nuclear medicine procedures as it has in other aspects of medicine is application of the Stark Laws that restrict the extent to which physicians can make self-referrals or referrals to other affiliated physicians and organizations. At the moment these restrictions do not apply to newer technologies like PET, which creates a more favorable business environment for nuclear medicine procedures and equipment. If these laws were applied more restrictively, it could have significant negative impact on current users of these technologies.

Introduction

Nuclear medicine professionals provide diagnostic, evaluation, and therapeutic services to patients using knowledge of human anatomy and cellular biology. In 2002, 18.4 million nuclear medicine procedures were performed in 7,000 U.S. hospital and non-hospital provider sites, an increase from 16.8 million in 2001 [IMV, 2003]. Nuclear medicine imaging is a valuable tool for detecting pathology, for staging patient disease, and for selecting and evaluating treatment protocols. Nuclear Medicine is a synthesis field in medicine since the work requires understanding of basic and advanced principles of a variety of sciences including physics, biology, chemistry, and pharmacology.

Using radiopharmaceuticals ingested by, inhaled by, or injected in a patient, nuclear medicine professionals can identify and stage disease processes. Studies are also performed to check organ function and hormone levels. Radiopharmaceuticals, which are produced from radionuclides (unstable atoms that emit radiation), are given to patients in very small quantities. Using a variety of gamma cameras (the type is determined by the kinds of images desired), the light emissions from the radioactive materials in the body are traced, measured, and located and images are produced for evaluation and diagnosis. Cellular process in the body enables the nuclear medicine professional to make accurate diagnosis of problem sites. Radiopharmaceuticals are metabolized at different rates by various kinds of cells in the body and in various organs. These tracers permit evaluation of the presence or absence of disease, the location of diseased tissue, and also about the efficacy of treatments that have been or might be initiated. Currently, there are over 100 nuclear medicine procedures with capability to image every major organ system. [About the USA, 2004].

Many radiopharmaceuticals have been developed as specific tracers to understand a particular organ or organ system. For instance, cardiac perfusion testing is done with thallium, technetium, or rubidium because the properties of these radioactive substances interact with body process to permit excellent cardiac imaging. Although some radiopharmaceuticals like technetium are utilized to image a number of organs/body systems, some tracers are quite specific/ particular. As an example, Indium is a very specific radionuclide that works well in detecting soft-tissue infection in the body [Taylor et al, 2004]. Gallium whose properties are non-specific to tumor tissue or to inflammation is excellent for imaging in patients with AIDS [Taylor et al, 2004].

In some cases, multiple radiopharmaceuticals are used together to enhance or elaborate imaging in a patient. Dual isotope studies with Cardiolite and thallium measuring cardiac perfusion are an example of such applications. Nuclear medicine procedures may be performed almost immediately after ingestion/injection of the radiopharmaceutical or performed several days after depending on the half life and other properties of the radiopharmaceutical(s) being used.

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A Brief History of Nuclear Medicine

Although nuclear medicine traces its roots to the discovery of radioactive emissions from uranium by Henri Becquerel and the Curies [Morris, 2004], the technology that enables nuclear medicine applications has really developed most substantially over the last fifty years. Research in a variety of sciences including physics, engineering, computer science, and instrumentation, and chemistry has enabled nuclear medicine science to expand.

The discovery of technetium from leftover molybdenum by Emilio Segre in the 1930s and the associated work of Seaborg with other radionuclides provided the basic research to permit further development of radiopharmaceuticals [Morris, 2004]. The first uses of radioactive iodine and strontium for diagnostic purposes occurred in the late 1930s [Morris, 2004]. It was not until 1950, however, that commercial use of radiopharmaceuticals began in earnest.

In parallel to this research, during the early 1950s, Benedict Cassen and associates developed the rectilinear scanner. However, it was not until later in that decade that the scanner was available commercially Morris, 2004]. This machine permitted the user to scan the distribution of radioiodine in the thyroid gland [Morris, 2004]. The first gamma camera, also known as a scintillator, was developed by Anger in 1953 and was first marketed in 1958 [Morris, 2004].

These technologic developments were possible because of associated research in physics in photographic outputs, in intensity of detector signals, pulse amplification, crystal technology etc. that permitted improvement in image quality [Hughes, 2000]. A variety of engineering discoveries including transistors and integrated circuits that increased the capacity and speed of computing equipment and imaging machines further advanced the science [Hughes, 2000].

In 1961 the first cyclotron was installed at Washington University Medical Center. And two years later, Kuhl introduced emission reconstruction tomography, the precursor to SPECT and PET [Morris, 2004]. Advances in mathematics also occurred in the 1960's with Hounsfield developing image reconstruction algorithms that enabled improved imaging with SPECT technology [Hughes, 2000]. During these years, a number of new nuclear medicine studies were being introduced for the study of brain, thyroid, liver, pulmonary embolism, and cancer.

In 1971, the American Medical Association officially recognized nuclear medicine as a specialty [Morris, 2004]. Advances in SPECT occurred during the 70s with the introduction of the first dedicated head SPECT camera and rotating camera heads [Hughes, 2004]. During the 1970s, Michael Phelps also introduced the first PETT device (positron emission transaxial tomographic, lately known as PET) [Morris, 2004]. The microprocessor and personal computing devices were also being invented and implemented permitting much faster processing time and increased capacities within computing systems [Hughes, 2000]. By 1979, whole body SPECT was being performed [Morris, 2004].

The 1980s saw improvements in computer networking systems with enhanced image resolution [Hughes, 2000]. Rubidium was approved by the FDA for cardiac perfusion testing in the late 1980s [Morris, 2004]. Research was being conducted on the use of monoclonal antibodies for tumor imaging and the FDA approved the first monoclonal antibody radiopharmaceutical for tumor imaging in 1992 [Morris, 2004].

The 1990s was a decade in which the speed of the Internet was improved through optical cabling and satellite technology [Hughes, 2000]. New radiopharmaceuticals were introduced along with the use of FDG PET studies to assess patient response to chemotherapy treatments [Morris, 2004]. The PET/CT scanner was first used on human patients in 1998 and Medicare approved payment for PET studies for lung cancer [Morris, 2004]. Reimbursement was also approved for sentinel node studies for diagnosis and management of cancers. The first company to provide mobile PET services was also formed [Morris, 2004].

In recent years, progress in nuclear medicine has continued with the introduction of new applications for PET FDG for breast and gastric cancer diagnosis and with the approval of the radioimmunotherapy agent known as Zevalin.

Although change has been constant and progressive in nuclear medicine science and application, the rate of change has increased in recent years. Currently, advances in pure and applied science and in technological applications challenge the nuclear medicine professional to constantly educate and maintain professional currency. It is unlikely that this pace will abate as new discoveries advance the science of nuclear medicine over the coming decade.

Nuclear Medicine Professions

The availability of current data is a basic requirement for research. This is particularly true for health professions because the workforce is dynamic and fluctuations in the supply and demographics of nuclear medicine professionals impact the broader population by limiting, maintaining, or increasing the volume of services available to the public.

Data on the various nuclear medicine professionals is scattered among a number of current data sets. This chapter will describe the particular data sets that contain information about the nuclear medicine workforce or facilities providing nuclear medicine services.

National Data Sets

The Bureau of Labor Statistics (BLS) Standard occupational classification 29-2033 provides information about nuclear medicine technology (NMT) jobs at the metropolitan area, state, or national level and by industry. The Occupational Employment Survey of the BLS provides information about employment and wage estimates of NMTs. The Occupational Outlook Handbook of BLS provides projections to 2012 for the profession.

Nuclear medicine physicians are included in a conglomerated physician SOC code 29-1069, Physicians and Surgeons, All Other – making it impossible to learn specifically about nuclear medicine physicians.

Likewise, nuclear medicine scientists are most likely contained in the following SOC codes in the BLS data:

- 29-1051 Pharmacists
- 19-1021 Biochemists and Biophysicists
- 19-2012 Physicists
- 19-2031 Chemists
- 17-2030 Biomedical Engineers.

It is impossible to segregate nuclear medicine scientists from others in these broad categories.

The Current Population Survey (CPS. This survey of the Bureau of Labor Statistics does not separate information about nuclear medicine professionals. The Annual March Supplement of the CPS includes aggregated professional categories like physicians (261) and radiologic technicians (365) but does not provide sufficient detail to understand the nuclear medicine professions specifically.

The Public Use Microdata Sample of the U.S. Census (PUMS) Standard occupational categories in this data set are conglomerated making it impossible to isolate data on any of the nuclear medicine professions. The Census 2000 code 332 contains information about diagnostic related technologists and technicians including nuclear medicine technologists. Physicians and surgeons are also aggregated in census code 306. Nuclear medicine scientists are probably included in biological scientists (census code 161), medical scientists (census code 165), and chemists and materials scientists (census code172). It is not possible to separate out data about any of the nuclear medicine professions from this data.

The Area Resource File (ARF). The Area Resource File does contain some demographic information about nuclear medicine physicians, specifically age, practice setting, and professional practice type. This information however, is obtained from the American Medical Association which has much more comprehensive information on NM physicians than is detailed in ARF.

Professional Association Data Sets

The American Medical Association (AMA). The AMA Master File is very detailed. It is a comprehensive resource of physician data. Each year about one quarter of all physicians in the master file are surveyed. The master file contains data on all physicians beginning at entry into medical school or in the case of IMGs, at beginning of residency. The AMA file contains demographic information, professional activities, board certifications, and other physician characteristics. Since 1981 nuclear medicine physicians have been separated from other physicians making it possible to obtain both some current and some historical data on physicians from this file.

The Society of Nuclear Medicine (SNM). SNM conducted a Staff Utilization Survey in 2003. The survey was sent to facilities providing nuclear medicine services. The resulting report provides some data on professional activities of nuclear medicine technologists, on salaries of technologists, and on characteristics of facilities providing nuclear medicine services.

The American Society of Radiologic Technologists (ASRT). The ASRT regularly collects information on a variety of radiologic technologists including nuclear medicine technologists. The *ASRT Wage and Salary Survey Reports of 2004, 2001, 1997,* and *1992* contain information about wages and salaries, demographics and job characteristics of technologists with separate data about nuclear medicine technologists. The ASRT conducts a survey of educational program directors that includes directors of nuclear medicine technology education programs. The reports, *Enrollment Snapshots in Technology Programs for 2003, 2002, 2001*, contain some data on nuclear medicine technology education programs' enrollment trends.

Credentialing Organizations/Certifying Bodies

The American Registry of Radiologic Technologists (ARRT). The ARRT maintains an on-line census of radiologic technologists by state and modality. This census includes nuclear medicine technologists. This data is limited by the fact that not all nuclear medicine technologists are members of the ARRT.

The Nuclear Medicine Technology Certification Board (NMTCB). The NMTCB maintains a census of radiologic technologists containing some demographic information. Although the NMTCB is the major certifying organization for nuclear medicine technologists (NMTs), a large number of NMTs are also certified by ARRT. For this reason, the NMTCB database is not comprehensive.

The Joint Review Committee on Education Programs in Nuclear Medicine Technology (JRCNMT) The JRCNMT has a database that includes all currently accredited education programs in nuclear medicine technology. This database includes information about location of each program with contact information, program capacity, program length, program award, and program accreditation.

The Accreditation Council for Graduate Medical Education (ACGME) ACGME has a database of all graduate medical education programs in nuclear medicine that details enrollments, size of programs, characteristics of programs, and program accreditation.

The Commission on Accreditation of Medical Physics Educational Programs (CAMPEP) CAMPEP has a list of accredited programs in medical physics

Other Resources

We have accessed preliminary information from the following sources:

> ***The American Board of Nuclear Medicine (ABNM).*** The information provided to us contained the names of current diplomats and the year in which they were certified. The database lists date of decease. Other demographic data is apparently available but is not current. Recertification requirements were instituted in 1992 so the Board is only currently receiving updates to information.

> ***The American College of Nuclear Physicians (ACNP).*** This is a membership organization with over 300 members. We obtained a database that includes name, address and employer of each member. This database provides sufficient basic information to include it in a sample for our surveys.

> ***The Society of Radiopharmaceutical Sciences (SRS).*** The society is an international association of scientists. The membership is small, just over 200, and many of the members are international. The database could be used for the scientist survey once international members were eliminated.

Although we have not accessed any data from the following organizations, we suspect that each has information/data pertinent to the nuclear medicine workforce.

> ***The American Board of Radiology (ABR)***. This organization likely has information on nuclear radiologists.

> ***The Certification Board in Nuclear Cardiology (CBNC)***. This organization has data on over 3600 physicians who are certified in nuclear cardiology.

> ***The American Osteopathic Association and The American Osteopathic Board in Nuclear Medicine (AOA).*** These organizations likely collect data on osteopathic physicians certified in nuclear medicine.

> ***The American Board of Science in Nuclear Medicine (ABSNM).*** This organization likely has some data on scientists certified in nuclear medicine.

> ***The Health Physics Society (HPS).*** This organization may have data on both scientists and physicians working in nuclear medicine

The American Board of Health Physics (ABHP). This organization may have data on physicists certified in nuclear medicine.

The American Board of Medical Physics (ABMP). This board certifies scientists in MRI imaging and medical health physics and probably has information on the certified scientists.

Board of Pharmaceutical Sciences (BPS). The Pharmacy Specialty Certification Program in Nuclear Medicine. This organization may have information/data on pharmacists certified in nuclear/radiopharmacy.

The American Chemical Society (ACS). The Division of Nuclear Chemistry and Technology of the American Chemical Society may have some information on chemists working in nuclear medicine.

Sources of Data on Nuclear Medicine Facilities

The Information Means Value (IMV) Medical Information Division

The IMV survey has been conducted nine times since 1990, generally on an annual basis. This is a telephone survey of all nuclear medicine provider facilities in the United States. The survey is comprehensive and contains information on facilities, equipment, and workforce at the state level. The annual report is a significant resource of data on nuclear medicine.

The Intersocietal Commission for the Accreditation of Nuclear Medicine Laboratories (ICANL) ICANL provides lists of facilities that are accredited nuclear medicine laboratories. Accreditation is voluntary, however, so the lists are not inclusive of all laboratories providing nuclear medicine services.

Evaluation of Data Gaps

Although there is some data available on nuclear medicine professionals, the information is scattered and some of the statistics are not completely suitable to our research goals. For instance, BLS data does include a specific occupational category for nuclear medicine technologists. This data, however, counts jobs not professionals so there is an element of uncertainty in the numbers provided.

The data on nuclear medicine physicians from the American Medical Association is perhaps the most complete data set on this group. However, the data that is publicly available is not sufficiently detailed in certain aspects of interest to this study like employment settings, practice configurations, and salaries. Although the quality of this data is quite good, it describes a small subset of physicians who are actually performing nuclear medicine studies. Other physician specialists (cardiologists, radiologists, etc.) with competency in nuclear medicine are not included in these numbers.

Data on nuclear medicine scientists is woefully lacking. This group is difficult to identify or depict from any of the data sets that describe workforce characteristics because these scientists are subsumed in larger scientific categories like physicists, pharmacists, and engineers. During the course of this study, it will be particularly important to focus on obtaining and consolidating data on this widely divergent group of professionals working in nuclear medicine science.

Overall, an investigation of current data sets suggests that information on the various professions is scattered, somewhat superficial, and not always suitable for the purposes of this study. Research conducted on all three professional types would permit the creation of a centrally located, consolidated data set on the demographic and educational characteristics of the workforce, on current and future employment, and provide insight into the concerns of these professionals.

The following table presents known or suspected sources of information/data on the nuclear medicine workforce or nuclear medicine facilities.

Table 1. Data Sources for Nuclear Medicine Professionals and Facilities

Physicians				
Supply	IMV Survey 03	ARF 95, 00, 01		
by State	AMA 81 to 03	ARF 95, 00		
Demographics	AMA 81 to 03			
Education				
Residency	ACGME 05	AMA 03	ARF95, 00	
Certification	ABNM 03	AMA 81 to 03	ABR 05	CBNC 05
Continuing Education	AOA 05	ABNM 03	ABR 05	CBNC 05
Scientists				
Supply	PUMS (Medical Scientists) 00			
Physics				
Radiochemistry				
Engineering/Instrumentation				
Radiopharmacy				
Demographics				
Education				
Physics	CAMPEP 05			
Radiochemistry	ACS 05			
Engineering/Instrumentation	Whitaker 05			
Radiopharmacy	BPS 05			
Certification				
Physics	ABR 05	ABMP 05	ABHP 05	ABSNM 05
Radiochemistry	BPS 05			ABSNM 05
Engineering/Instrumentation				ABSNM 05
Radiopharmacy				ABSNM 05
Technologists				
Supply	PUMS (Diag Rel Techs) 00			
by State	IMV Survey 03	BLS OES 03		
by Setting	IMV Survey 03	BLS OES 03		
Demographics				
Education Programs	JRCNMT 05			
Enrollments	JRCNMT 05 (?)	ASRT 04		
Size of Programs		ASRT 04		
Licensure	SNMT 03, 04			
Certification	NMTCB 05	ARRT 05		
Employment Characteristics		ASRT 04		
Continuing Education	NMTCB 05	ARRT 05	SNM 2005	
Salary	BLS 03	SNM	ASRT 2004	
Procedures				
Types	IMV Survey 03			
Numbers	IMV Survey 03			
Facilities				
by Size	IMV Survey 03	ICANL 05	SNM 03	
by Type	IMV Survey 03		SNM 03	
Type of Equipment	IMV Survey 03			

Review of Available Data

A review of the data sets described in the previous chapter provides some background information to inform our study. This synopsis is necessary in order to understand what is currently known about each of the professions in nuclear medicine. Each profession is reviewed individually in this report to provide a picture of both the sufficiency and insufficiency in current data sets describing nuclear medicine workforce and workplaces.

This review elucidates areas of interest for data collection. This review will guide the content of surveys of nuclear medicine physicians, nuclear medicine scientists, nuclear medicine technologists, nuclear medicine educators, and nuclear medicine students. It will be especially important to address areas in which data are obviously deficient in the several survey instruments.

Nuclear Medicine Technologists

Tasks/Functions

Nuclear medicine technologists prepare and administer radiopharmaceuticals (prepared from radionuclides and isotopes) to patients and conduct therapeutic, diagnostic, and tracer-imaging studies using a variety of radiologic equipment using gamma ray cameras and other imaging technology. Some nuclear medicine technologists conduct laboratory tests including blood volume, red cell survival, and fat absorption studies [Occupational Employment and Wages, BLS, 2003]

Supply

Obtaining an accurate census of nuclear medicine technologists in the U.S. is difficult. Various sources describe the workforce in different terms and state/local regulations may permit other associated professionals, not necessarily certified in nuclear medicine technology, to provide nuclear medicine services. These technologists may be working in nuclear medicine though qualification as a radiologic technologist. As a result, obtaining a definitive number of nuclear medicine technologists is challenging.

During the design of a survey of nuclear medicine technologists, to be conducted in the fall of 2005, a comprehensive database of nuclear medicine technologists was compiled from lists obtained from the Nuclear Medicine Technology Certification Board (NMTCB) and the American Registry of Radiologic Technologists (ARRT). The NMTCB lists 18,127 certified nuclear medicine technologists (NMTs) while the ARRT lists 9,542 NMTs. After editing for duplications, the database includes 21,681 technologists certified in nuclear medicine by the NMTCB, by the ARRT or by both organizations as of June 2005. Of the 21,681 technologists on this list, 12,139 carry only NMTCB certification, 3,554 carry only ARRT certification and 5,988 carry both ARRT and NMTCB certification. This list does not include those who have certified in nuclear medicine technology since June 2005. Since recertification is only a recent requirement, this number does not also account for those on this list who may have left the profession. Most of the certified technologists on the list are located in the U.S. but some live and work internationally.

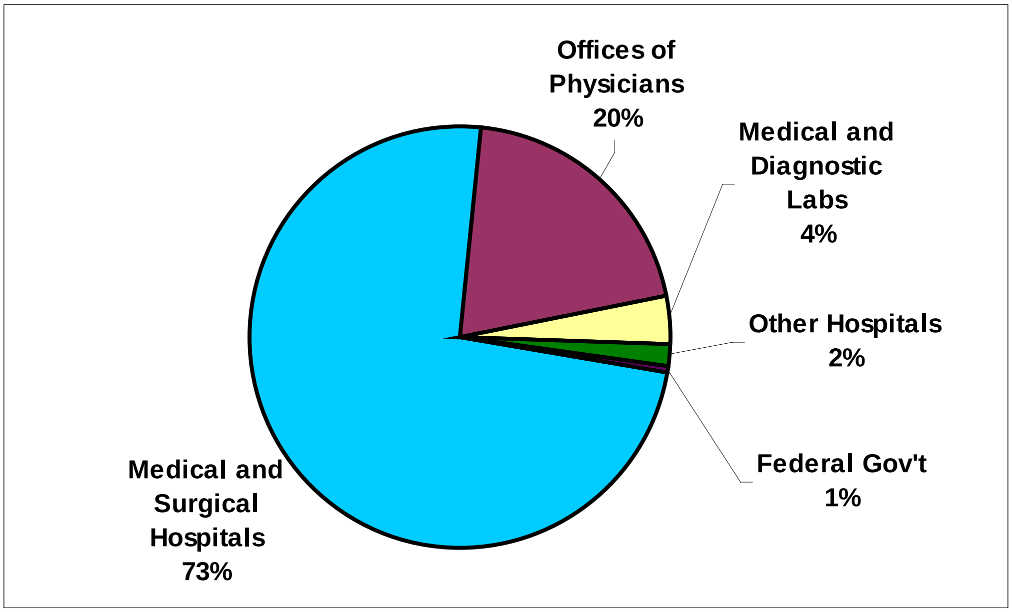
Perhaps the best public source of data is the (IMV), Medical Information Division Survey and Census which is a comprehensive summary of nuclear medicine practice in the U.S. (achieved through telephone/fax survey of all diagnostic nuclear imaging facilities). The 2003 IMV report estimated that in 2003, there were 18,120 FTE technologist working in nuclear imaging in the U.S., a 17% increase from 15,490 FTE technologists in 2002 [IMV, 2003]. Most of these technologists were working in hospital settings but increasingly technologists are employed in non-hospital sites. In 2003, there was a 47% increase in the number of FTE technologists working in non-hospital settings (an increase from 3,650 in 2002 to 5,370 in 2003)[IMV, 2003]. At the same time, FTE technologists working in nuclear medicine imaging in hospital settings increased only 8% from 11,840 FTE in 2002 to 12,750 FTE in 2003 [IMV, 2003].

While 98% of facilities responding to this IMV survey indicated that some or all technologists they had on staff were certified, 16% reported having some non-certified technologists on staff [IMV, 2003]. Hospitals with more than 400 beds responding to the survey were more likely to have certified staff than smaller hospitals. Just 16% of hospitals with greater than 400 beds employed some non-certified technologists while 22% of hospitals with less than 200 beds employed some non-certified technologists. Interestingly, only 11% of the non-hospital facilities reported having non-certified technology staff providing nuclear medicine services [IMV, 2003].

The average number of FTE technologists in sites providing nuclear medicine services increased from 2.9 to 3.0 in hospitals and from 1.7 to 1.9 in non-hospitals between 2002 and 2003. Overall, the average increased from 2.5 FTE technologists per site in 2002 to 2.6 FTE technologists per site in 2003 [IMV, 2003].

In November 2003, the Bureau of Labor Statistics reports national estimates of 17,400 nuclear medicine technologists [BLS, 2005]. Figure 1 shows that 73% of these technologists worked in hospital settings.

Figure 1. Percent of Nuclear Medicine Technologists Employed in Selected Settings, 2003



Source: BLS, 2005

Education Programs

The Joint Review Committee on Educational Programs in Nuclear Medicine Technology (JRCNMT) accredits education programs in nuclear medicine technology. This accrediting body is recognized by the United States Department of Education and by the Council for Higher Education Accreditation. JRCNMT began accrediting programs in 1970 but ceased that function in 1976 when the Committee on Allied Health Education and Accreditation (CAHEA) assumed that role. In 1994, JRCNMT again began accrediting nuclear medicine technology programs [JRCNMT, 2005]. The schools and colleges that are accredited are also accredited by one of the six recognized regional accrediting bodies.

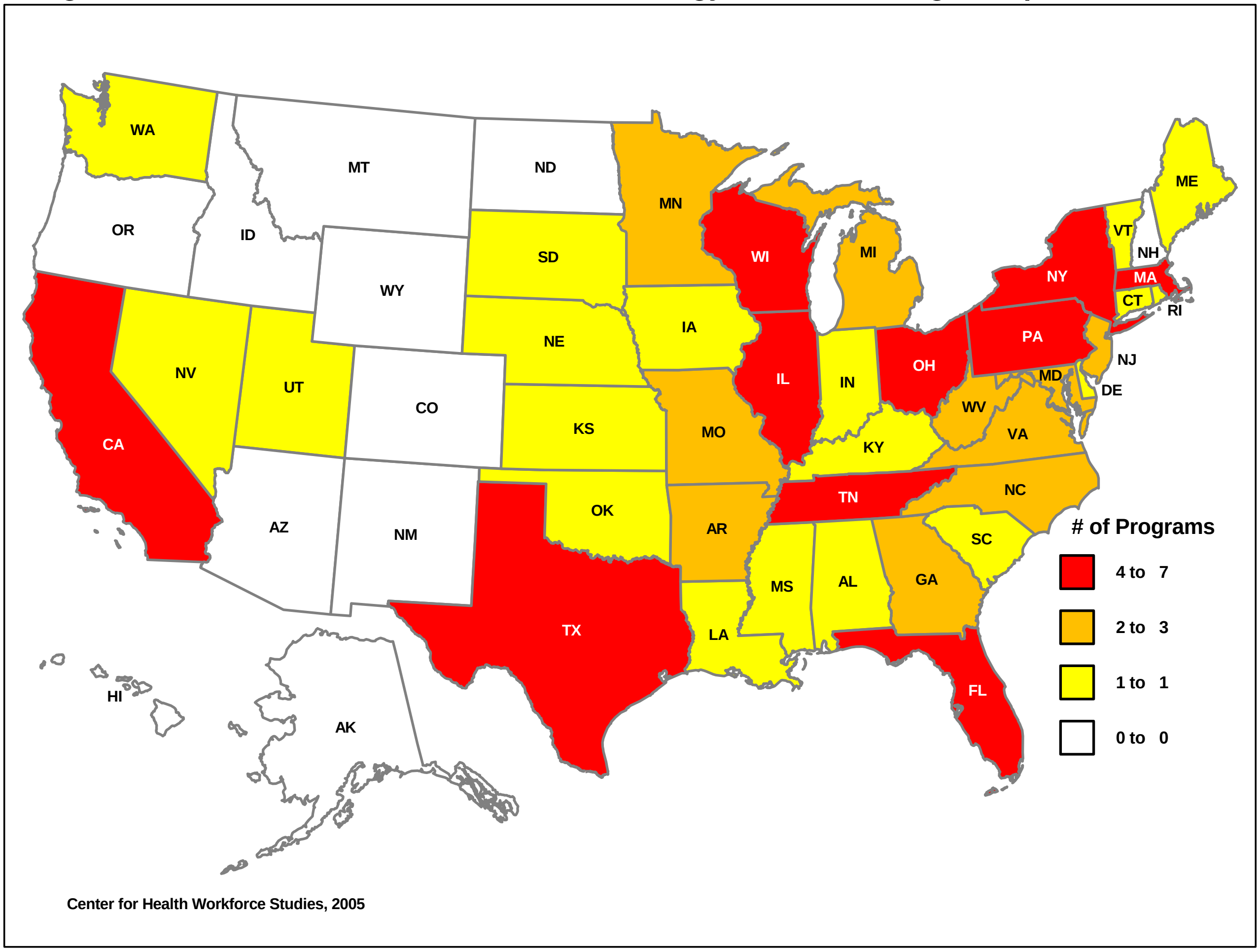
Nuclear Medicine Technology education programs include certificate level programs, associate degree programs, and bachelor degree programs. Although some certificate programs require only graduation from high school as an entrance requirement, other certificate programs require a background in radiologic technology or prerequisite education in certain science subjects. Some certificate programs, generally for professionals with experience and education in another health career (nurses, radiologic technologists, medical technologists, etc.) are one year in length while more comprehensive 2 year certificate or degree programs are available to prospective students without the requisite background.

In 2005, there are 98 institutions including hospitals, community colleges and four-year academic institutions accredited by JRCNMT [JRCNMT, 2005] up from 92 programs in 2002 [BLS, 2004]. Several of these programs include options for either a certificate or a degree program. Accredited programs currently have a capacity of 1,644 students [JRCNMT, 2005]. The American Society of Radiologic Technologists (ASRT) estimates that 1,454 students entered programs in 2002 [ASRT, 2002]. Since rates of graduation vary by length of program, the numbers of graduates vary each year.

The curriculum for nuclear medicine technologists includes prerequisite courses in mathematics, anatomy and physiology, and pathology, and coursework in health care delivery and patient care; nuclear medicine sciences including radiobiology, nuclear physics, radiopharmacy, equipment and instrumentation; courses in diagnostic procedures related to bone imaging, cardiovascular imaging, central nervous system studies, digestive system procedures, endocrine system procedures, genitourinary system procedures, hematology and in vitro procedures, oncology and inflammation imaging, respiratory systems procedures; courses in radionuclide therapy; and coursework in clinical education [JRCNMT, 2005].

There is significant regional variation in the location of nuclear medicine technology education programs. The map shows the location and number of education programs. Educational programs are noticeably deficient in the Mid Central, Southwest, and the West regions of the country while there is a concentration of programs in the Northeast and the Atlantic Coast regions.

Figure 2. Number of Nuclear Medicine Technology Education Programs per State, 2004

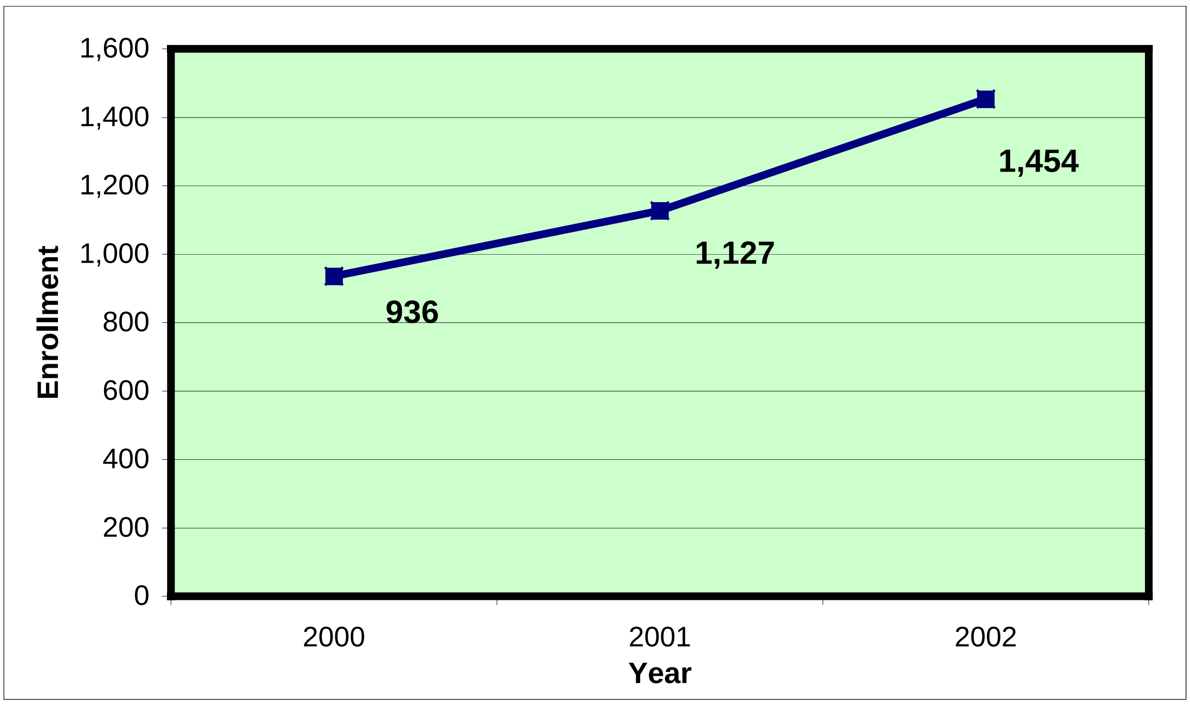


Enrollments

In 2002, ASRT surveyed education programs in nuclear medicine technology as well as those in radiography and radiation therapy. The response rate for program directors in nuclear medicine technology was 58%. Figure 3 shows estimated enrollments in nuclear medicine education programs from 2000 to 2002. Half of the respondent NM educators indicated an intention to increase enrollments in their programs at the time of the survey [ASRT, 2002].

Nuclear medicine programs had increased in size from a mean of 9 students per program in 2000 to 10.84 students per program in 2001 and up to 13.98 students per program in 2002. Estimates of total enrollment in nuclear medicine education programs developed by ASRT indicate an increase in enrollment from 2000 to 2002 [ASRT, 2002].

Figure 3. Estimated Enrollment in Nuclear Medicine Technology Education Programs, U.S., 2000 to 2002



Source: ASRT, 2002

Licensure

Nuclear medicine technologists are required to be licensed in 26 states (although 4 of those states limit the scope of practice). In 7 additional states, licensure for radiologic technologists is required but not for nuclear medicine technologists (NMTs). In 7 other states, licensure with limited scope is required depending on the kinds of imaging being performed (e.g., mammography, fluoroscopy). In 11 states and the District of Columbia, no licensure of any kind is required for imaging technologist professions [SNM, 2004].

Table 2. Regulation of Nuclear Medicine Technologists, 2003

Alabama	None		
Alaska	None		
Arizona	Licensure 01/01/04 (NM)(RT)	2 yrs	ARRT
Arkansas	Licensure (NM)(RT)	1 yr.	ARRT, NMTCB, ASCP (NM)
California	Licensure (NM)(RT)	5 yrs	NMTCB, ASCP (NM)
Colorado	*Licensure (RT) Limited Scope*		ARRT
Connecticut	*Licensure (RT)*	1 yr.	ARRT
Delaware	Licensure (NM)(RT)	4 yrs	ARRT, NMTCB
District of Columbia	None		
Florida	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB
Georgia	None		
Hawaii	Licensure (NM)(RT)	2 yrs	ARRT
Idaho	None		ARRT, NMTCB
Illinois	Licensure (NM)(RT)	2 yrs	
Indiana	*Licensure (RT)*		ARRT
Iowa	*Licensure (RT)*	1 yr.	ARRT, NMTCB
Kansas	None		
Kentucky	*Licensure (RT) Limited Scope, Certification*	2 yrs	ARRT
Louisiana	Licensure (NM)(RT)	2 yrs	NMTCB, ARRT, ASCP (NM)
Maine	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB
Maryland	Licensure (NM)(RT)	2 yrs	ARRT
Massachusetts	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB, ASCP (NM)
Michigan	*Licensure Limited Scope Mammography*		
Minnesota	Licensure (NM)(RT)	2 yrs	ARRT
Mississippi	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB
Missouri	None		
Montana	*Licensure (RT)*	1 yr.	ARRT
Nebraska	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB
Nevada	*Licensure Limited Scope Mammography*		
New Hampshire	None		
New Jersey	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB
New Mexico	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB
New York	*Licensure (NM)(RT) Limited Scope*		ARRT
North Carolina	None		
North Dakota	Advanced Practice Fluoroscopy		ARRT
Ohio	Licensure (NM)(RT)	2 yrs	ARRT, NMTCB
Oklahoma	None		
Oregon	*Licensure (RT)*	2 yrs	ARRT
Pennsylvania	*Licensure (RT)(NM) Limited Scope*		ARRT, NMTCB
Rhode Island	Licensure (RT)(NM)	2 yrs	ARRT, NMTCB
South Carolina	Certification, Licensure	1 yr.	
South Dakota	None		
Tennessee	*Licensure (RT)*	2 yrs	ARRT
Texas	Licensure (RT)(NM)	2 yrs	ARRT, NMTCB
Utah	Licensure (RT)(NM)	2 yrs	ARRT, NMTCB
Vermont	Licensure (RT)(NM)	2 yrs	ARRT, NMTCB
Virginia	*Licensure (RT) Limited Scope*		ARRT, ACRRT
Washington	Licensure (RT)(NM)	2 yrs	ARRT, NMTCB
West Virginia	*Licensure (RT)*	1 yr.	ARRT
Wisconsin	None		
Wyoming	*Licensure (RT)(NM)*	2 yrs	ARRT, NMTCB \

Source: SNM, 2004

Certification

The Society of Nuclear Medicine (SNM) Staff Utilization Report [SNM, 2003] found that 87% of the hospital facilities surveyed required certification or licensure of NMTs while 95% of non-hospital facility indicated a requirement for certification or licensure of the nuclear medicine technologists they hire [SNM, 2003]. Certification for nuclear medicine technologists is currently available from two certifying boards. Some overlap in census numbers of ARRT and NMTCB is likely since nuclear medicine technologists may be certified by both organizations:

- The American Registry of Radiologic Technologists (ARRT) certifies radiologic technologists in nuclear medicine with the credential RT(NM). Census data obtained from ARRT for this study lists 9,542 technologists certified in nuclear medicine technology.
- The Nuclear Medicine Technology Certification Board (NMTCB) also certifies nuclear medicine technologists with the credential CNMT. Census data obtained from NMTCB for this study lists 18,127 certified nuclear medicine technologists [NMTCB, 2005].
- At one time, The American Society of Clinical Pathologists also certified nuclear medicine technologists but that credential, ASCP (NM), is no longer offered. However, those with the certification are permitted to continue to use the credential. No recertification is necessary [e-mail communication ASCP, 2005].

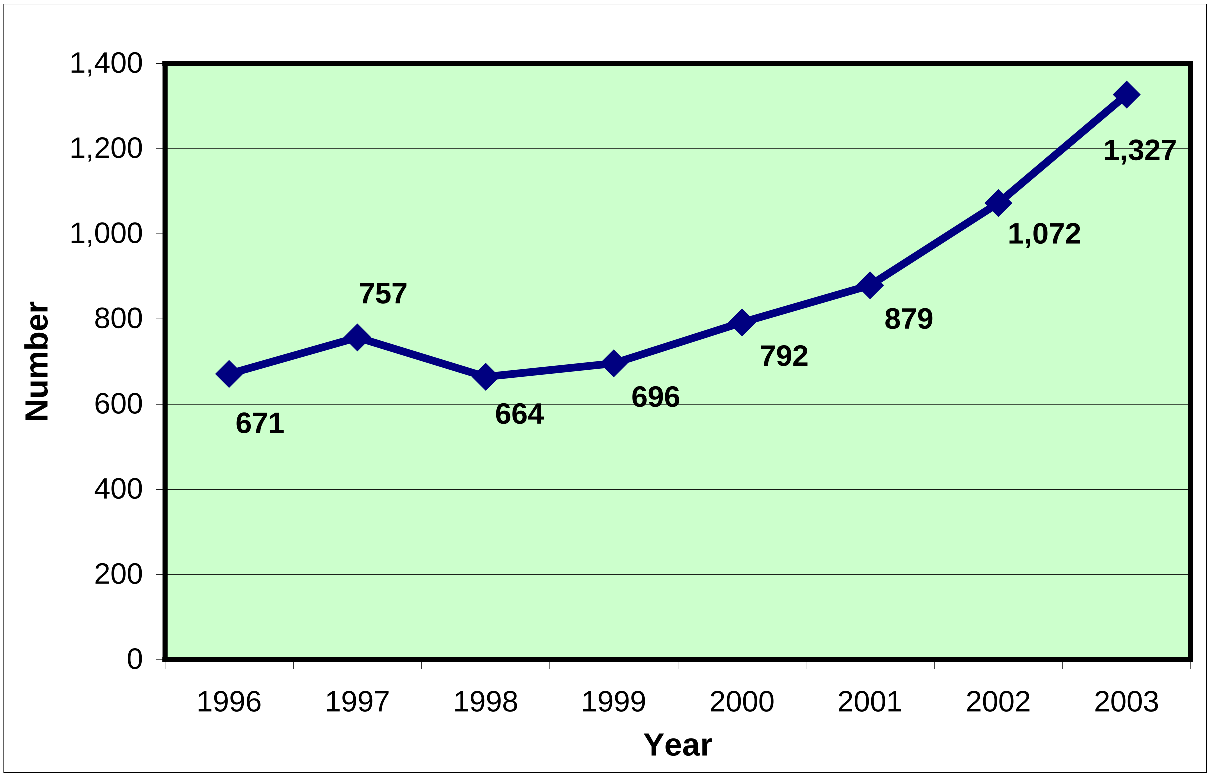
Data obtained from a variety of documents available from ARRT and the American Society of Radiologic Technology (ASRT) show that 10,024 members of ASRT indicate nuclear medicine technology is their primary sphere of employment [ASRT, 2004]. Another 2,314 ARRT members indicate that nuclear medicine is a secondary discipline. Some of these may not be certified in nuclear medicine technology.

The ASRT Wage and Salary Survey data from 2004 found that 85.1% of respondents credentialed in nuclear medicine were working in this specialty with 88.1% of credentialed NMTs indicating they work *primarily* in the specialty [ASRT, 2004].

Although there is no requirement that Nuclear Medicine Technologists be also licensed as radiologic technologists in most states, in 2002, about 5,000 nuclear medicine technologists are both registered/certified as radiologic technologists and certified as NM technologists by either the NMTCB or ARRT. Only 200 registered nuclear medicine technologists are also credentialed in CT [Fusion Imaging, PET-CT Consensus Conference, 2002].

Nuclear Medicine Technology Certification Board (NMTCB) Founded in 1997 to promote quality patient care and to serve the public, the Nuclear Medicine Technology Certification Board promotes standards for entry to and continuation in the profession of nuclear medicine technology. Requirements for certification include education (at a variety of levels), 8,000 hours (4 years) of clinical experience, didactic courses in nuclear medicine specific areas, and examination. The NMTCB primarily credentials nuclear medicine technologists but also certifies NMTs with specialization in Nuclear Cardiology or PET [NMTCB, 2004]. The number of NMTs taking the NMTC exam has generally been increasing over the past decade with 1, 327 NMTs taking the certification exam in 2003. In 1996, there were 671 NMTs seeking certification [NMTCB, 2004].

Figure 4. Number of NMTs Taking the NMTCB Certification Examination by Year



Source: NMTCB, 2004

The American Registry of Radiologic Technologists (ARRT) is also a certifying organization for NMTs. However, this organization more broadly addresses both primary and specialty certifications of radiologic technologists (RT). Certifications currently available from the organization include the four primary disciplines of radiography (RT(R)), nuclear medicine technology (RT(N)), radiation therapy (RT(T)), and effective in July 2005, sonography (RT(S)). Specialty certifications in cardiovascular –interventional radiography (RT(CV)), mammography (RT(M)), CT (RT(CT)), MRI (RT(MR)), quality management (RT(QM)), sonography (RT(S)), breast sonography (RT(BS)), and vascular sonography (RT(VS)), bone densitometry (RT(BD), cardiac – interventional technology (RT(CI)) and vascular – interventional radiography (RT(VI)) along with a new certification as a radiologist assistant are all available from this organization. There are currently more than 240,000 certified radiologic technologists in the U.S. [ARRT, 2005].

Continuing Education Requirements (CE)

Requirements for continuing education for nuclear medicine technologists vary depending on a variety of agency/board standards. Continuing education credits are required by:

- State licensing boards
- Facility certification boards
- Professional certification boards for nuclear medicine technologists

The requirements for continuing education vary depending on individual state licensure law. Typically, statutes permit licensed professionals certified/recertified by professional boards to use the CE requirements of those professional certifying boards to meet all or some of the CEUs needed for initial state licensure or for licensure renewal. State licensing requirements often dictate the acceptable medium for delivery of the CEs such as conferences, classroom instruction, video, self-study, etc., as well as the particular subject matter (nuclear medicine, pharmacy, patient care, etc.). State licensing law may also address permitted providers of CE credits such as professional associations, accredited institutions of higher learning, or approved private providers. The regulations governing licensure of radiographers, nuclear medicine technologists, and radiation therapists in Rhode Island are an example of typical requirements. A nuclear medicine technologist seeking biennial renewal of license in the state must have 24 hours of CE at least 2 of which are in radiation safety and 12 of which are obtained from formal, pre-approved programs. Continuing certification with ARRT is acceptable proof in the state of meeting CE requirements for the biennial renewal period [State of Rhode Island, 2005].

The Intersocietal Commission for the Accreditation of Nuclear Medicine Laboratories (ICANL) is a facility accreditation board that requires continuing education for technologists. Effective, January 1, 2004, nuclear medicine technology staff in ICANL accredited organizations must obtain 15 hours of continuing education every three years in specific categories including imaging, quality control/instrumentation, and radiopharmaceuticals. VOICE (SNM), ARRT, ASRT, or AMA must approve the CE. [ICANL, 2005].

Effective in January 2006, the Nuclear Medicine Technologist Certification Board will require 24 credits of continuing education on a biennial basis to renew certification. CE credits must be obtained from a list of approved CE providers. The approved list includes a number of professional associations as well as CE courses approved by 9 states [NMTCB, 2005].

Since 1994, continuing education is a mandatory requirement for renewal of registration/ certification with ARRT. ARRT requires that radiologic technologists complete 24 hours of continuing education credits biennially to maintain certification. ARRT has established both Category A and Category B continuing education activities with a requirement that at least 12 CEs be from Category A. Category A activities are courses approved by an established evaluation mechanism including formal academic courses, and those provided by certain professional associations. ARRT also recognizes CE courses approved by certain state regulatory boards [ARRT, 2005]. Both NMTCB and ARRT recognize passage of certification exams in other imaging specialties as sufficient to meet the CEU requirement for the renewal period.

Salaries

Table 3 presents the most recent data available from the BLS [2003] that shows that nuclear medicine technologists in the U.S. earned a mean hourly wage of $24.79, a median hourly wage of $26.57, and an annual mean salary of $55,260 [BLS, 2005]. ASRT data obtained from a 2004 wage survey showed a median annual salary of $72,410 for nuclear medicine technologists. The mean annual salary for nuclear medicine technologists was $67,429. Salary varied by years in the profession with the median salary being highest for those who had more recently entered the profession. However, the sample size was too small for meaningful comparison [ASRT, 2004].

Table 3. Hourly Pay and Annual Salary of Nuclear Medicine Technologists By State, 2003 and 2004

State	Bureau of Labor Statistics, 2003				ASRT Survey, 2004	
	# of NM Techs in State	Median Hourly Wage	Mean Hourly Wage	Mean Annual Salary	Mean Hourly Wage	Mean Annual Salary
Alabama	330	$20.83	$21.33	$44,360	$22.15	-
Alaska	N/A	-	-	-	$29.34	$120,000
Arizona	170	$25.45	$25.46	$52,950	$27.03	-
Arkansas	110	$23.04	$23.13	$42,100	$25.55	-
California	1,340	$27.35	$27.90	$58,030	$37.15	$79,283
Colorado	260	$24.27	$23.96	$49,830	$28.77	$75,000
Connecticut	240	$29.48	$29.51	$61,370	$31.55	$82,057
Delaware	40	$27.15	$26.82	$55,780	-	-
District of Columbia	130	$0.52	$1.28	$48,220	-	-
Florida	1,030	$25.47	$25.92	$53,910	$27.03	-
Georgia	400	$24.03	$23.98	$49,890	$20.50	-
Hawaii	60	$25.76	$25.42	$52,870	$31.24	$58,910
Idaho	40	$20.89	$21.40	$44,510	$26.27	-
Illinois	1,090	$28.54	$28.72	$59,740	$29.00	-
Indiana	330	$22.38	$22.91	$47,650	$30.75	-
Iowa	180	$22.16	$22.54	$46,880	$25.26	$58,000
Kansas	140	$22.89	$22.92	$47,670	$26.45	-
Kentucky	250	$20.52	$20.50	$42,530	$21.50	-
Louisiana	210	$23.73	$23.68	$49,250	$25.88	-
Maine	70	$22.67	$23.31	$48,490	$24.71	-
Maryland	320	$30.46	$30.16	$62,730	$34.33	$74,000
Massachusetts	480	$25.87	$25.81	$53,690	$33.28	-
Michigan	740	$24.49	$24.32	$50,580	$23.92	-
Minnesota	220	$26.18	$26.17	$54,440	$34.93	-
Mississippi	130	$22.74	$22.43	$46,660	-	$28,800
Missouri	310	$23.80	$23.51	$48,900	$29.01	$60,918
Montana	40	$22.80	$22.24	$46,250	$25.77	-
Nebraska	80	$22.60	$23.51	$48,900	-	-
Nevada	100	$23.53	$21.42	$44,560	$30.01	-
New Hampshire	60	$24.39	$24.45	$50,860	$30.00	-
New Jersey	640	$28.82	$29.12	$60,570	$37.00	-
New Mexico	50	$25.70	$26.02	$54,110	$28.24	-
New York	1,100	$25.24	$25.54	$53,120	$27.97	-
North Carolina	870	$22.18	$19.55	$40,660	$27.01	-
North Dakota	N/A	-	-	-	$22.96	$75,712
Ohio	1,040	$21.79	$21.19	$44,070	$27.23	$65,326
Oklahoma	200	$24.80	$25.11	$52,220	$25.75	$66,607
Oregon	140	$26.76	$26.52	$55,150	$28.70	-
Pennsylvania	930	$21.85	$22.95	$47,740	$31.16	$80,000
Rhode Island	N/A	$27.14	$27.81	$57,850	-	-
South Carolina	N/A	-	-	-	$25.35	$62,031
South Dakota	70	$20.53	$20.78	$43,230	$27.09	$100,000
Tennessee	480	$21.31	$21.22	$44,140	$26.32	-
Texas	1,110	$24.26	$24.85	$51,680	$40.07	$61,750
Utah	80	$22.54	$22.72	$47,260	$24.75	-
Vermont	N/A	-	-	-	$26.00	-
Virginia	280	$22.42	$22.77	$47,730	$29.79	$97,000
Washington	240	$28.00	$28.30	$58,870	$36.00	-
West Virginia	150	$19.85	$20.08	$41,770	$23.84	$61,303
Wisconsin	380	$24.34	$24.49	$50,930	$33.00	-
Wyoming	N/A	-	-	-	$24.42	$64,500

ASRT further analyzed salary data by type of position, by workplace, and by educational attainment (Table 4).

Table 4. Hourly Pay and Annual Salary of Nuclear Medicine Technologists in Selected Positions, 2004

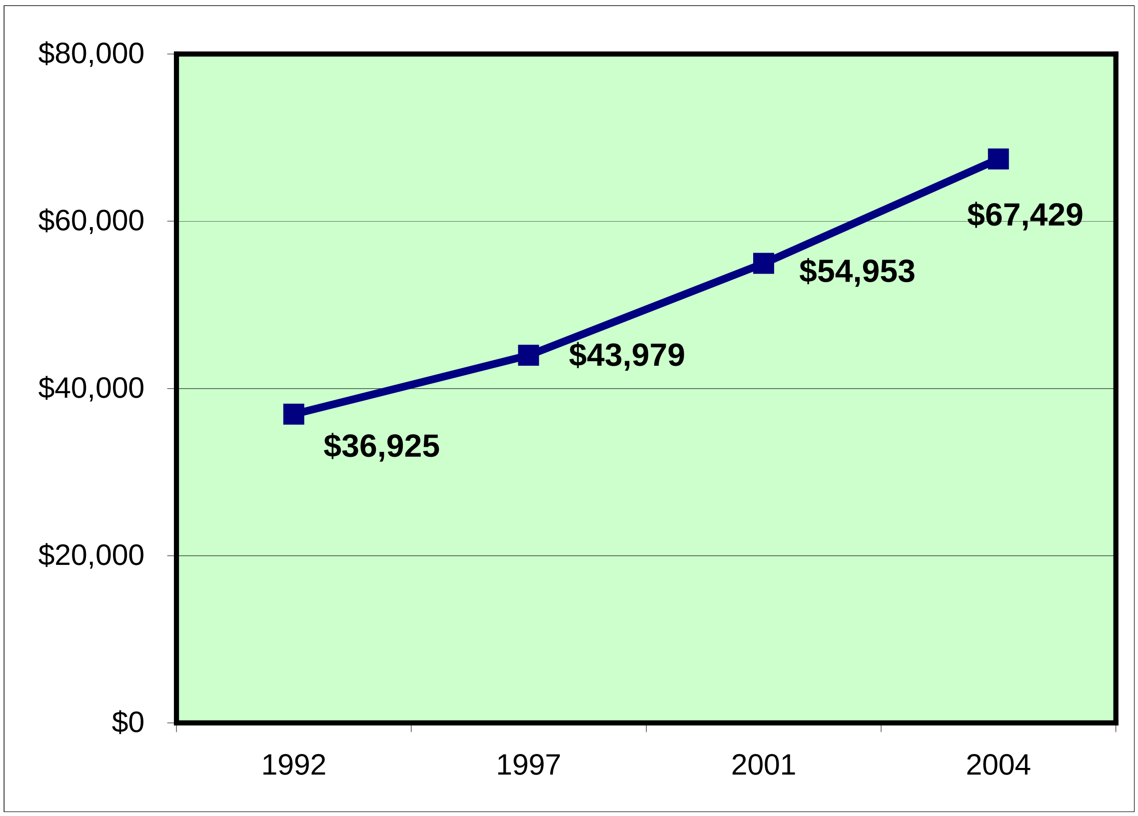
Category	Hourly Pay *	Annual Salary **
Overall	$29.53	$67,429
Position		
Staff Technologist	$27.39	$47,780
Chief Technologist	$32.44	$70,554
Senior/Lead Technologist	$28.54	$58,854
Instructor/Faculty	-	$59,274
Program Director	-	$61,432
Supervisor/Manager	$37.03	$71,353
Assistant Chief Technologist	-	-
Administrator	-	$60,633
Corporate Representative	-	-
Other	$38.86	-
Workplace		
Education	-	$60,455
Clinic/Physician's Office	$32.71	$63,400
Imaging Center/Outpatient Imaging	$37.40	$69,995
Corporate Representative	-	$58,727
Hospital (Not for Profit)	$27.92	$79,709
Government/VA	$26.66	-
Hospital (For Profit)	$28.55	-
Industrial	-	$72,500
Locum Tenens	$33.00	-
Mobile Unit	$27.34	-
Armed Forces	$23.00	-
Other	-	$72,650
Education		
High School Plus Certificate	$26.63	$60,024
Associate Degree	$29.13	$70,987
Bachelor's Degree	$30.29	$63,971
Master's Degree	$27.06	$75,455
Doctoral Degree	$54.47	-
Years in Profession		
0 to 2 Years	$25.95	-
3 to 5 Years	$27.77	$78,210
6 to 10 Years	$28.81	$68,733
11 to 20 Years	$31.73	$71,102
More than 20 Years	$30.72	$64,103
* Work at least 32 hours per week/ paid by hour/ not annualized/no overtime pay		
** Work at least 32 hours per week and paid an annual salary		

Source: American Society of Radiologic Technologist, Wage and Salary Survey, 2004

The June 2004 Staff Utilization Survey conducted by the Society of Nuclear Medicine and Anderson, Niebuhr Associates revealed a range in technologist salaries. New technologists with 1 to 5 years experience reported salaries between $13.00 per hour (annualized to $27,040) and $45.00 per hour (annualized to $93,600). Nuclear medicine technologist supervisors reported salaries in smaller hospitals at about $28.10 per hour ($58,448 annually) to $33.20 in large hospital departments ($69,056 annually). New graduates working in smaller hospitals reported a wage of about $20.20 per hour ($42,016 annually) to $23.80 per hour ($49,504 annually) [SNM, 2004].

Figure 5 summarizes average annual salaries of nuclear medicine technologists from 1992 to 2004. A historical evaluation of nuclear medicine technologist salaries indicates that salaries increased 16% between 1992 and 1997, 24% between 1997 and 2001, and 29% between 2001 and 2004.

Figure 5. Annual Salary of Nuclear Medicine Technologists, 1992 to 2004



Source: ASRT, 2004

Other Professional Societies for Nuclear Medicine Technologists

The American Society of Radiologic Technologists (ASRT) is located in Albuquerque, New Mexico. This is a professional membership association representing approximately 112,000 of the 240,000 currently certified radiologic technologists [ARRT, 2005] who work in a variety of specialty areas including MRI, CT, sonography, bone densitometry, nuclear medicine, quality management, mammography, medical dosimetry, radiation therapy and cardiovascular interventional technology [ASRT, 2005]. ASRT has organizational links with 54 state and local affiliate societies for radiologic technologists.

American Healthcare Radiology Administrators (AHRA) is a nonprofit membership association with a goal of encouraging professional leadership in imaging services [AHRA, 2005]. The membership includes health care imaging administrators and technologists interested in promoting a high level of administrative practice in imaging services. AHRA certifies radiology administrators through a combination of education, experience and examination. Once credentialed the Certified Radiology Administrator (CRA) is required to maintain the credential by taking 36 CEU credits every three years.

The Radiology Business Management Association (RBMA) is located in Irvine California. It is a non-profit professional association of radiology business managers with a current membership of approximately 1,600. The association began with the support of the American College of Radiology in 1968. It established offices and hired staff in the early 1980s [RBMA,2005].

Nuclear Medicine Physicians

Nuclear Medicine has been described by the Accreditation Council for Graduate Medical Education as a “clinical and laboratory medical specialty that employs the measured nuclear properties of radioactive and stable nuclides for diagnosis, therapy, and research to evaluate metabolic, physiologic, and pathologic conditions of the body” [ACGME, 2005].

Describing physicians who provide nuclear medicine services is quite difficult since these physicians are an amorphous group. Although there is a core specialty recognized by the ACGME and certified by the American Board of Nuclear Medicine, there are a number of other medical specialties that also provide nuclear medicine services. These other specialties are growing as developments in radiopharmacy and in imaging technology permit further specialization within a variety of medical fields. The growth in the use of nuclear medicine procedures for diagnosis and treatment has been accompanied by a concomitant growth in the number and kinds of medical professionals who provide nuclear medicine studies. For this reason, it is difficult to locate data that defines the wide range of physicians with interest/activity in the field.

A study done in 1993 by the Society of Nuclear Medicine found that only 7% of all physicians who practice nuclear medicine do so on a full time basis. Their workload, however, accounts for a large proportion of nuclear medicine studies [Lull et al, 1993]. The study found that 51% of nuclear medicine work is performed by radiologists certified by the American Board of Radiology with 42% of the work done by physicians certified by the American Board of Nuclear Medicine [Lull et al, 1993]. In 1993 only 4% of nuclear medicine was performed by cardiologists certified by the American Board of Internal Medicine with Cardiovascular Specialization [Lull et al, 1993]. This percentage has likely increased considerably since the introduction of SPECT and PET technology enabling expanded applications in cardiac imaging.

In the early years of the nuclear medicine specialty, physicians working in the field were often pathologists doing work that was largely in vitro, focused on tissue samples and testing. Pathologists understood the capabilities of nuclear medicine in helping to understand the progression of disease. As in vivo testing developed further, interest in the applications of nuclear medicine increased and the background and training of physicians working in nuclear medicine diversified. The current advanced level of the science and its applications to a number of areas of medicine has increased its appeal to various physician specialties including cardiology, neurology, endocrinology, and especially radiology. Interestingly, although in the early years of the specialty most nuclear medicine doctors were pathologists, currently most nuclear medicine doctors are not. Informants suggest that there are fewer than 50 physicians in the field presently who are dually certified in pathology and nuclear medicine.

As testament to the interest in nuclear medicine by other specialties, especially cardiology, market researchers cite strong demand for cardiology procedures with utilization of nuclear perfusion studies and stress tests driving the radiopharmaceutical market [Bio-Tech, 2005]. SPECT technology now plays an important role in functional cardiac imaging and accounts for as much as 85% of myocardial procedures [Market Research. Com, 2001]. Market researchers Frost and Sullivan cite increasing volumes of cardiac imaging procedures encouraged by cardiologists who realize the benefits of SPECT technology for patients and the economic benefits for practice [Forrest, 2005].

Pathways to Nuclear Medicine

The American Board of Nuclear Medicine (ABNM) was created in 1971 as the first conjoint board of the American Board of Medical Specialties by consensus of the American Board of Internal Medicine, The American Board of Pathology, the American Board of Radiology (ABR), and the Society of Nuclear Medicine (SNM). The American Board of Radiology had offered certification in diagnostic radiology with special competence in nuclear medicine between 1957 and 1966, at which point the board no longer offered the certification (ABR). At the time the ABNM was organized, the American Board of Radiology had little affinity for the NM specialty since it was not viewed as an imaging specialty. ABNM began awarding certification in nuclear medicine in 1972.

Early in the 1970s, with improvements in pharmaceuticals and, technology devices, the anatomy in the images produced in nuclear medicine studies became more discernible and therefore, more useful [Interviews, 2005]. In vivo nuclear medicine applications have increased substantially over the ensuing decades and as a result, nuclear medicine imaging is currently considered a valuable tool for measuring anatomic functions and physiology in non-invasive studies. As a result of renewed interest from imaging specialists, The American Board of Radiology now certifies radiologists in nuclear radiology. And more recently, because of cardiologist activity in nuclear medicine, a certification board in nuclear cardiology has emerged called the Certification Board of Nuclear Cardiology.

There are currently two established pathways to the nuclear medicine specialty. The American Board of Nuclear Medicine requires that physicians complete a one-year residency in a clinical specialty such as internal medicine, surgery or pediatrics followed by a two-year residency in nuclear medicine. Passage of an examination is required for certification in nuclear medicine.

The American Board of Radiology requires its residents to complete a four-year residency in diagnostic radiology followed by a one-year fellowship in nuclear medicine. An examination is required upon completion of the residency/fellowship for certification in nuclear radiology [ABR, 2005].

Dual certification in radiology and nuclear medicine is available through a combined training program sponsored by the American Board of Nuclear Medicine and the American Board of Radiology. The certification requires 6 years of training and passage of the certifying exams for each specialty [ABNM, 2005].

Dual certification in neurology and nuclear medicine is available through the corresponding boards after completion of a five-year residency with combined training in neurology and nuclear medicine. A candidate must pass the certifying exam of the American Board of Psychiatry and Neurology and of the American Board of Nuclear Medicine [ABNM, 2005].

Dual certification in Internal Medicine and Nuclear Medicine is available through the corresponding boards after 4 years of training and passage of the certifying exams from the American Board of Internal Medicine and ABNM [ABNM, 2005].

Physician residents who have completed an internal medicine cardiology training program that includes a residency in internal medicine, including invasive and noninvasive cardiology with an emphasis on nuclear medicine may also sit for the certifying examination of the American Board of Nuclear Medicine [ABNM, 2005].

It is apparent that those working in the field claim diverse primary specialties. As the diagnostic and treatment applications of nuclear medicine have expanded, the backgrounds of physicians working with nuclear medicine have diversified substantially.

The Effect of Technology on the Practice of Nuclear Medicine

The evolution of computers has revolutionized nuclear medicine. Advances in computing have made a significant difference in imaging technology including shorter procedure times and better quality outputs [Interviews, 2005]. The correlation of anatomy and function in three-dimensional fused images is possible because of the power of computing [Interviews, 2005].

Several factors influence nuclear medicine. Advances in technology permit better quality imaging and earlier diagnosis of disease. Additionally, the aging of the baby boom population with an anticipated increase in chronic illness is expected to support increased demand for imaging services over the next several decades. Market research firm Frost and Sullivan anticipate increased demand for imaging by the aging population stimulated by the development of less invasive diagnostic imaging procedures [Imaging Economics, 2004].

One effect of highly capable technology is increased interest in the new technologies by professional groups other than nuclear medicine and radiology. Frost and Sullivan cite increased interest among a number of medical specialties. This has resulted in internal competition for patients between radiology and nuclear medicine specialists as well as external competition from other professional specialties such as cardiology and oncology [Imaging Economics, 2004]. The revenue from attractive reimbursement for studies using the new PET and PET/CT technology is a major impetus to this market competition. Market researchers indicate that nuclear cardiology is clearly affecting the growth in demand for gamma cameras [Market Research, 2001]. Informants currently working in nuclear medicine indicate that this is having an impact on practice [Interviews, 2005] with other specialties currently providing NM services that were previously within the purview of the traditional imaging professions.

Frost and Sullivan also cite the development of new radiopharmaceuticals and other contrast agents as another stimulus to expansion in the nuclear medicine market [PACS Market, 2004]. Current research on nuclear medicine testing and neurological diseases such as Alzheimer's and attention deficit hyperactivity disorder are examples of important new biomedical applications that will drive continuing demand for services. [PACS Market, 2004]

A more educated public is also driving consumption of imaging services. The increased convenience of fusion imaging for patients (permitting two studies in one appointment consuming less time and with lower exposure to radiation) is a fact that is likely to also support both continuing and increased demand.

Another effect of technology is enhanced exchange of information. Images are now more readily available to referring primary and specialty care physicians through interoperable RIS and PACs systems. The availability of real time information is increasing as computing systems become more compliant with HIPPA regulations for standardization of electronic health records. This eased access to images may also contribute to increased demand for services as referring physicians begin to understand the content and the quality of the functional information provided by the various NM studies. The capabilities of these studies and their contribution to early diagnosis and effective treatment protocols are likely to support increased demand from both patients and referring physicians for the foreseeable future.

Technology developments have outpaced the ability of the system to effectively use what we have developed [Interviews, 2005]. Currently, rapid change in the imaging market is challenging health care providers and imaging specialists in a number of ways. There are professional challenges to competency and training and there are economic challenges to affordability of the technology and patient access to the new equipment.

Assuring a Competent, Well Trained Physician Workforce

The introduction of new technology, particularly fused hardware applications tests the standards for evaluation of competency to practice nuclear medicine by the various certifying agencies and by state and local regulators. The emerging popularity of hardware fusion technologies such as PET/CT and SPECT/CT also challenges both new and practicing professionals who either operate the machinery or interpret the images. The popularity of PET technology is documented in a number of market research reports that indicate that the PET market has been very active over recent years. At the same time, the number of PET/CT machines that are sold is increasing and represents close to half of the new equipment being sold in this class [Harvey, 2004]. Frost and Sullivan cite revenues of almost $500 million in 2004 in the PET and PET/CT market as an indication of this rising interest [Ward, 2004]. IMV Limited predicts that PET/CT scanners will constitute 90% of the PET market over the coming three years [Ward, 2004].

The evolution of computing is having an impact on all imaging professionals. However, it is of particular interest in this context since nuclear medicine physicians, scientists and technologists have traditionally been viewed as the “computer geeks of healthcare” [Interviews, 2005], as the most technically savvy of professionals in medical environments. NM professionals have typically been ahead of their medical peers in the use of computing equipment including digital imaging modalities, archiving systems, and other computing equipment. The impact of new technologies on the nuclear medicine professions is therefore, particularly remarkable. Nuclear medicine currently finds itself behind the curve or at least on the cusp of that curve as these new applications are introduced to the market. This is a profound change in position for the professions.

However, if we make several assumptions in an environmental context, we can better understand the depth and degree of the change. If we assume that NM professionals have typically been more technically savvy than most other medical professionals, we must assume that most other health professions are also challenged by the capability of the new technology. And we may also make the corollary assumption that nuclear medicine professionals are somewhat ahead of the curve in comparison to others using those new technologies simply because NM professionals have historically been more technologically capable. We conclude, therefore, that even if things are a bit muddled in the current healthcare environment, nuclear medicine professionals are certainly better positioned than many professional groups to react and adjust to the challenges of these new professional tools.

In this context, and in support of the supposition that nuclear medicine will adjust to these changes, a review of recent history suggests that these adjustments have previously occurred. Earlier, developments in cross sectional technology also affected the work of the nuclear medicine professions. When computed axial tomography (CAT) was introduced, for example, liver and spleen studies that were traditionally performed in nuclear medicine departments were moved to radiology for MRI and CAT scans. Currently, nuclear medicine studies for liver and spleen pathology are commonly reserved for more specialized gastrointestinal imaging like gastromas and gastrin-secreting tumors. The new PET/CT scanners may in fact, bring some imaging, like liver and spleen, back to nuclear medicine physicians.

The fused image outputs from this technology require co-competencies in nuclear medicine and cross sectional anatomy. A current pervasive concern in professional circles is who will be trained to interpret these studies that now integrate previously separately obtained information.

Nuclear medicine physicians are not generally trained in cross sectional anatomy and conversely, radiologists are not trained in nuclear medicine. The adequacy of either physician specialty to read outputs from fused hardware technology is questionable given the dual competencies required to provide a quality interpretation of PET/CT studies. As a result, physicians, health administrators, and radiology and NM professional associations are scrambling to determine standards for training currently practicing physicians. Data suggests that hardware fusion technology has been embraced by users and patients alike and interest in the applications is unlikely to abate. Therefore, the issue of competent personnel to interpret the studies will continue to be a major concern especially as the intricacy of CT technology increases from 2 slice to 16 slice and up to 64 slice capability (there is some indication that 256 slice technology is in development).

A further nuance of the issue of adequate supply of trained imaging specialists is that currently there are few specialists with training in both modalities. Those who are qualified in both radiology and nuclear medicine are likely found in academic or specialty centers where their high degree of specialization is in demand, rather than in group practices in outpatient settings where many of the studies are currently performed. Gamma cameras and fused hardware technology are being purchased at an increasing rate by large group practices from a number of specialties and are increasingly installed in outpatient environments [IMV, 2003].

The Effect of Technology on Prospective Students

The training and re-training of competent imaging specialists is a particularly difficult problem in a larger context since there are already insufficient numbers of physicians in either nuclear medicine or radiology. Demand for imaging specialists from all imaging modalities is high and is expected to intensify as the use of imaging in diagnosis and treatment protocols increases in many fields of medicine. A worldwide shortage of imaging professionals is also expected to hinder progression in the market for imaging services [Medical Technology Watch Canada].

Interviews with nuclear medicine physicians suggest that the introduction of fusion technologies has positively impacted the quality of recruited students in nuclear medicine residency and fellowship programs. Nuclear medicine has not typically been the most highly paid imaging profession. It is often viewed as more academic than radiology in its orientation. Potential NM residents struggle with opportunities for practice in competing radiology specialties that are more highly paid. Historically, the gravitation to private/group practice has been strong. [Interviews, 2005] This is likely changing a bit since payment for PET and PET/CT studies are among the highest for all imaging studies, helping to create some economic incentive for study in NM.

Directors of some residency programs comment on increased interest among the best and the brightest of medical students who are now more drawn to nuclear medicine. Some programs have relied on international medical graduates to fill their residency slots over the past few years but presently, they are finding more interest in nuclear medicine among U.S. graduates. Directors of programs also comment on increasing numbers of radiology residents and internal medicine physicians who are interested in a sub specialty/fellowship in nuclear medicine [Interviews, 2005].

The Economic Issues

There are very practical economic issues introduced to nuclear medicine practice along with new technologies. Market incentives that drive practice have affected many healthcare providers over recent decades. Although the business model was generally introduced to many areas of medicine with the advent of HMOs, it is only lately having a significant impact in imaging. Attractive reimbursement levels for NM studies and for radiopharmaceuticals have piqued the interest of providers. The approval of reimbursement for PET by the Centers for Medicare and Medicaid Services for applications in oncology has fueled this interest. The most common use of PET/CT is for diagnosis and treatment of cancer [Harvey, 2004]. Introduction of competition from other medical specialties is a recent phenomenon and may be a manifestation of these market forces. An example of this emerging competition is the current interest of some endocrinologists in thyroid diagnostic studies and NM treatment protocols [Interviews, 2005].

Nuclear medicine has often been viewed as an academic specialty and the members of the profession may not he as aggressive as other more entrepreneurial specialties [Interviews, 2005]. Informants cite cardiology as an example of a specialty that realized the potential from new technologies and seized the opportunity to incorporate the new cameras into their practice protocols. The cardiac imaging technical fees are appealing and myocardial perfusion studies currently constitute a large piece of the NM pie.

Although competition is introduced between and among a variety of medical specialties, there has also been competition introduced from within. Nuclear medicine was historically provided in inpatient hospitals and academic medical centers with some services provided in outpatient settings. Currently, more entrepreneurial providers in the nuclear medicine field are offering nuclear medicine studies in outpatient settings to a patient population that is typically well. There are currently for profit providers in some communities who are providing bone scans and other more routine studies to patients in an efficient and cost effective manner. This “skimming” of the more profitable studies is affecting more specialized institutions and could eventually affect the profitability of medical centers and academic institutions [Interviews, 2005]. This may have an effect on research since larger institutions must capture sufficient patient revenue to afford the cost of research.

One of the most fundamental economic issues introduced by fusion technology is which physician is to receive reimbursement for interpretation of a study that requires the competency of both a nuclear medicine physician and a radiologist. This is a practical question since reimbursement for the professional portion of an imaging study is limited. Ideally, only one physician would read a study and bill for professional services. Currently, the outputs from PET/CT and SPECT/CT may require interpretation from two different specialists. The use of PET increased by 35.6% in 2002 in the United States so the importance of this trend in utilization cannot be ignored [European Association for Nuclear Medicine]. Arriving at a solution as to who will provide quality interpretation of images from fused hardware technologies is imperative to payers and providers alike.

Frost and Sullivan forecast increased revenue from PET technology from $216 million in 2000 to $880 million in 2007 [Medical Imaging]. PET/CT is also gaining in popularity. According to Frost and Sullivan, in 2002, the sale of PET/CT scanners constituted 45% of the PET market and is predicted to outpace the sale of PET scanners in the near future [Harvey, 2004]. Although most of the applications for PET/CT are in oncology, in staging and managing disease, applications are expanding to cardiology and neurology. PET/CT in cardiology has advantages over SPECT since the study is considerably shorter in duration, the amount of radiation exposure to the patient is reduced, and there is no attenuation correction adjustment required [Harvey, 2004]. The promise of PET/CT in oncology is demonstrated by the $100 million in funding designated for molecular imaging research by the National Cancer Institute in 2004 [Medical Technology Watch Canada].

The current trend to outpatient services in all areas of health care is also affecting nuclear medicine. Overhead is high in hospitals, so many of the tests previously performed in inpatient settings are being performed on an outpatient basis where they are accomplished on a more cost effective basis. Additionally, most DRGs do not accommodate the extra expense of nuclear medicine studies; so only patients who are in serious need of those studies while inpatient receive them during a hospital stay. Cardiac stress tests are an excellent example of the trend to provision of services on an outpatient basis. As well, most PET scans are performed on an outpatient basis. This trend is evidenced in market research that describes noticeable increase in the amount of NM technology purchased for installation in physician office and other outpatient settings. This is especially true of PET technology. One incentive for using PET in these settings is that this technology is not currently regulated under Federal Stark requirements so the question of self-referral does not apply. Should this circumstance change, the health system would be required to adjust and some ensuing shift in provision of services would be required.

There is also an economic incentive for physicians who provide nuclear medicine services in their offices. Although hospital and other outpatient clinics are required to bill nuclear medicine tests under APCs, cardiologists, or other physicians providing office based testing can bill for the services rendered on a fee for service basis.

One challenge for all providers is the high cost of these new technologies [Medical Technology Watch Canada]. To justify the cost of equipment providers must maximize profit through utilization. Whereas hospital facilities must provide a wide range of imaging studies (some more profitable than others), outpatient centers may be specialized or more limited in the kinds of studies they select to provide. This permits these facilities to control their profit margin more effectively than hospital providers. In its survey of institutions, the Society of Nuclear Medicine found that 36% of non-hospital facilities offer cardiac only, 13% offer general NM only, 25% offer both cardiac and NM and 26% offered other specialties [SNM Utilization Survey, 2004].

The cost of radiopharmaceuticals is also an issue. Currently, hospitals receive almost full reimbursement from Medicare for the radioisotopes they use. Several of the cardiac drugs including Myoview and Cardiolite will soon be going generic and that will affect reimbursement rates and ultimately, the profit margin for Nuclear Medicine studies.

The purchasing of radiopharmaceuticals also affects profitability. Some providers including large outpatient clinics may have the opportunity to obtain premier pricing for radioisotopes that increases their profit margin. Those providers that have negotiated lower pricing are the best positioned in the market.

Description of Nuclear Medicine Physicians

As indicated in earlier paragraphs, describing nuclear medicine physician is quite difficult given the widespread use of nuclear medicine applications in a number of physician specialties. As the following data will indicate, we are able to characterize the core specialty of nuclear medicine as described by data from the American Medical Association. However, we are unable to describe or understand the larger workforce that may be supplying the portion of nuclear medicine studies that are useful to particular medical specialties.

This reinforces the need for a physician survey to collect reliable data about physicians from other primary specialties not characterized in the AMA data. The cardiologists and oncologists using nuclear medicine applications are of particular interest. Initial telephone interviews with some of the professional membership societies for these professions suggests that overall, data is lacking on physicians providing nuclear medicine services. This should provide added justification to conduct further study on the characteristics of the workforce.

An analysis of the nuclear medicine physicians who are members of the Society of Nuclear Medicine suggests that a number of members claim primary specialties other than nuclear medicine including radiology, cardiology, and internal medicine. The following chart, drawn from an SNM annual report, demonstrates the variety of specialties among professionals with membership in the association.

Table 5. Physicians with Membership in the Society of Nuclear Medicine, 2004, by Selected Specialties and Subspecialties

Society of Nuclear Medicine Physician Membership, 2004	Number in Sub-Specialty	Total in Specialty
Nuclear Medicine		
Total Nuclear Medicine		**2,259**
Cardiology		
Cardiology	166	
Nuclear Cardiology	1	
Total Cardiology		**167**
Radiology		
Radiology - CT	8	
Radiology - Mammo	4	
Radiology - MRI	8	
Radiology - Ultrasound	3	
Radiography	8	
Radiology	825	
PET	3	
Total Radiology		**859**
Other Medical Specialties		
Endocrinology	20	
Family Practice	1	
Gastroenterology	1	
General Practice	2	
Hematology	1	
Immunology	8	
Internal Medicine	65	
Nephrology	3	
Neurology	18	
Oncology	15	
Osteopathy	1	
Pathology	24	
Pediatrics	4	
Physiology	5	
Psychiatry	10	
Radiation Biology	6	
Radiation Therapy	17	
Surgery	2	
Total Other Medical Specialties		**203**
Grand Total		**3,488**

Source: Society of Nuclear Medicine, 2004

The following chart provides an illustration of the various resources for data on nuclear medicine physicians. Although, many of these boards and associations collect some data on their members, it is not generally available or the collected data may not contain sufficient fields to adequately describe the workforce. We assume that membership in a corresponding professional society or board certification in a specialty is a proxy for practice in the field. Of course, these counts may be duplicated as physicians may have multiple board certifications or have membership in a variety of professional associations. It is apparent from these numbers that the characteristics of physicians working in nuclear medicine are diverse. As an example, the number certified in nuclear cardiology is approximating the number certified in nuclear medicine.

Table 6.
Numbers of Physicians With Interest in Nuclear Medicine as Indicated by Board Certification or Affiliation with a Professional Association, 2005

Specialty/Affiliation	Board Certification	Professional Affiliation
Society of Nuclear Medicine		**3,488**
Nuclear Medicine	2,259	
Radiology	859	
Cardiology	167	
Other Specialties	203	
American Medical Association		**1,624**
Nuclear Medicine and Nuclear Radiology	1,481	
Nuclear Radiology	143	
American Board of Nuclear Medicine		**4,869**
American College of Nuclear Physicians		**364**
Certification Council in Nuclear Cardiology		**3,696**
(No total is provided since overlap in membership or certification is possible/likely)		

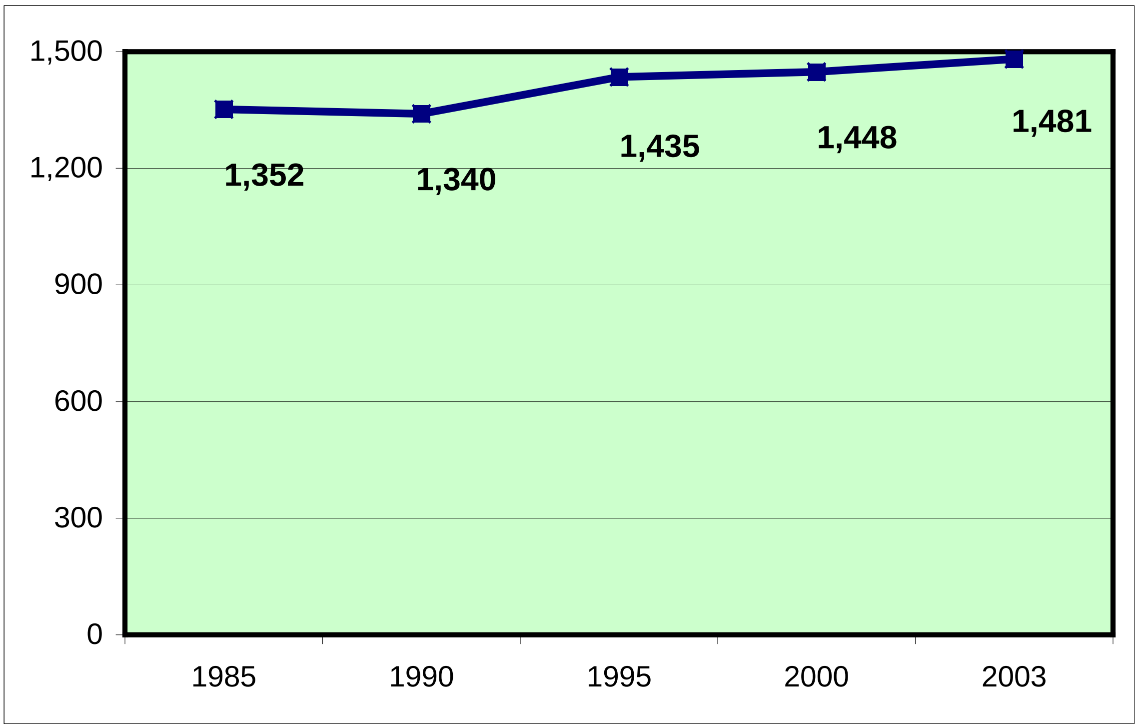
Source: Center for Health Workforce Studies, 2005

The American Medical Association collects data on physicians, one of which is a self-designated primary medical specialty selected by the physician from 40 specialties used by the AMA [AMA, 2005]. Since physicians may provide nuclear medicine services while practicing any of a number of primary specialties, the AMA data will only describe physicians primarily practicing in nuclear medicine. Although the AMA data definitely undercounts the physicians who are providing nuclear medicine services, it is the most accurate data available on the profession. Therefore, we have used it in the following pages of analysis to describe the members of the profession.

Supply

According to the American Medical Association, in 2003 there are 1,481 physicians who indicate that they are nuclear medicine physicians in the United States or its possessions [AMA, 2005]. 1,299 indicate that their major professional activity is patient care. This is a 9.5% increase since 1985, the first year in which the AMA data for nuclear medicine physicians is available [AMA, 2005]). Of the 1,481 nuclear medicine physicians, 485 are international medical graduates (32.7% of the profession) [AMA, 2005].

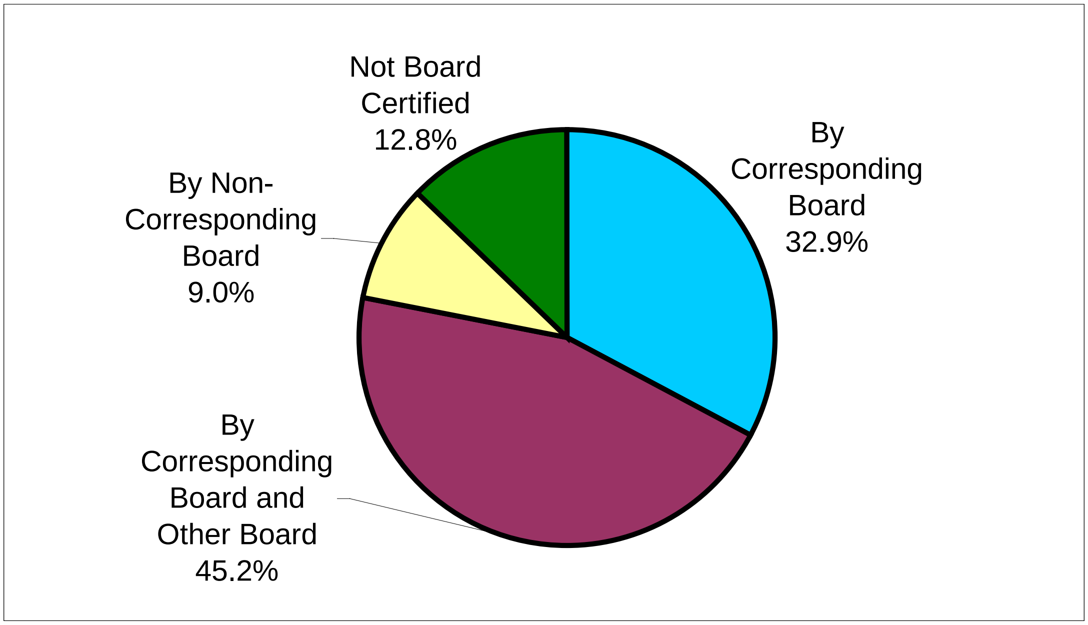
Figure 6. Number of Nuclear Medicine Physicians, U.S., 1985 to 2003



Source: AMA, 2005

Among all medical specialties, nuclear medicine is among the top ten specialties in percent of physicians who are board certified. Figure 7 shows that 87.2% of nuclear medicine physicians were certified in 2004 [AMA, 2005]. Certification may be by the corresponding board (nuclear medicine), by a non-corresponding board (e.g., cardiology, internal medicine, etc.), or by the corresponding board and another board.

Figure 7. Number of Nuclear Medicine Physicians by Type of Certification, 2004



Source: AMA, 2005

Demographics

Table 7 shows that nuclear medicine is fifth among medical specialties with the largest proportion of Asian physicians (12.4% of all NM physicians) [AMA, 2005]. Similarly, nuclear medicine ranked fifth among specialties in the proportion of Hispanic physicians (4.5% of all NM physicians). [AMA, 2005] These findings are consistent with the fact that a high percentage of NM physicians are international medical graduates.

Table 7. Gender and Racial-Ethnic Mix of Nuclear Medicine Physicians in the U.S., 2003

Race-Ethnic Category	Male NM Physicians		Female NM Physicians		Total NM Physicians	
	Number	Percent	Number	Percent	Number	Percent
White	625	51.6%	100	37.0%	725	49.0%
Black	14	1.2%	6	2.2%	20	1.3%
Hispanic	53	4.4%	14	5.2%	67	4.5%
Asian	138	11.4%	45	16.7%	183	12.4%
Am Indian/ Alaska Native	-	-	-	-	-	-
Other	25	2.1%	10	3.7%	35	2.4%
Unknown	356	29.3%	95	35.2%	451	30.4%
Total	1211	100.0%	270	100.0%	1481	100.0%

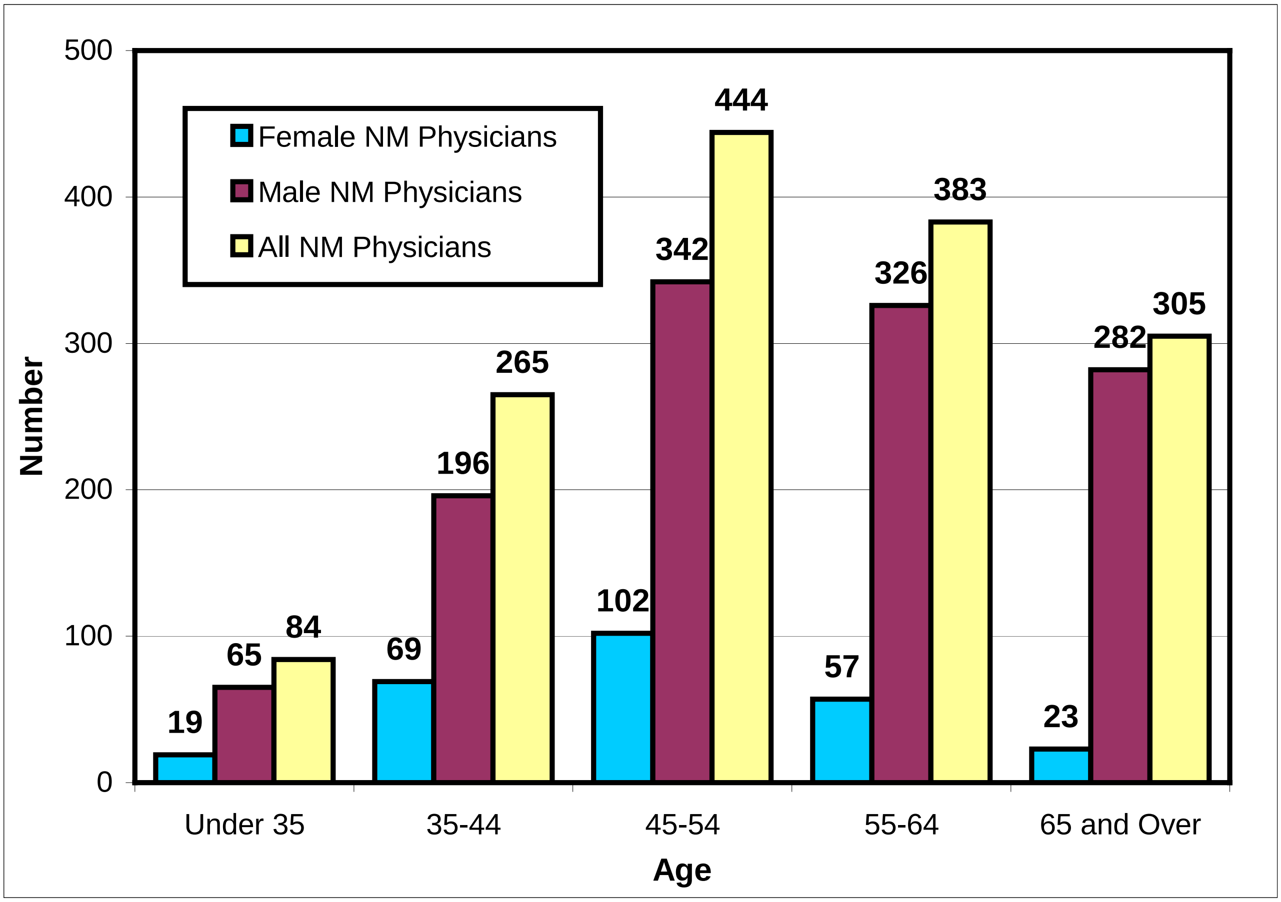
Source: AMA, 2005

Table 8 shows that fully 46.5% of nuclear medicine physicians were age 55 and over in 2003 [AMA, 2005]. While female nuclear medicine physicians represent only 18.2% of all nuclear medicine physicians, females in the profession are proportionately younger. 32.6% of the females listed in AMA data with a nuclear medicine specialty are 44 years of age or younger. Only 21.6% of the males in the profession are in that age group. Overall, only 23.6% of all nuclear medicine physicians are younger than 44 years of age [AMA.2005]. The age distributions are shown graphically in Figure 8.

Table 8. Age Distribution by Gender of Nuclear Medicine Physicians in the U.S., 2003

Gender	Under 35		35-44		45-54		55-64		65 and Over	
	#	%	#	%	#	%	#	%	#	%
Female	19	7.0%	69	25.6%	102	37.8%	57	21.1%	23	8.5%
Male	65	5.4%	196	16.2%	342	28.2%	326	26.9%	282	23.2%
Total	84	5.7%	265	17.9%	444	30.0%	383	25.9%	305	20.6%

Figure 8. Age of Nuclear Medicine Physicians, U.S., 2003



Source AMA, 2005

Education Programs

Nuclear Medicine physicians are educated in medical schools and upon graduation, must complete one-year in a preparatory clinical residency such as internal medicine and then complete a 2-year residency in nuclear medicine. Those residency programs are required to provide didactic instruction in physics, instrumentation, mathematics, statistics, computer science, radiation biology, and radiopharmaceuticals.

In 2005 there were 64 accredited residency programs in 27 states and the District of Columbia [AMA, 2005]. There were eight residency programs in California and 12 programs in New York. Selected characteristics of these programs are shown in Table 9. In 2003, there were 143 active residents/fellows in those programs, 26.8% of whom were female [AMA, 2005]. A high percent of nuclear medicine residents are international medical graduates (IMGs) with 45.5% listed as IMGs in 2003 [AMA, 2005].

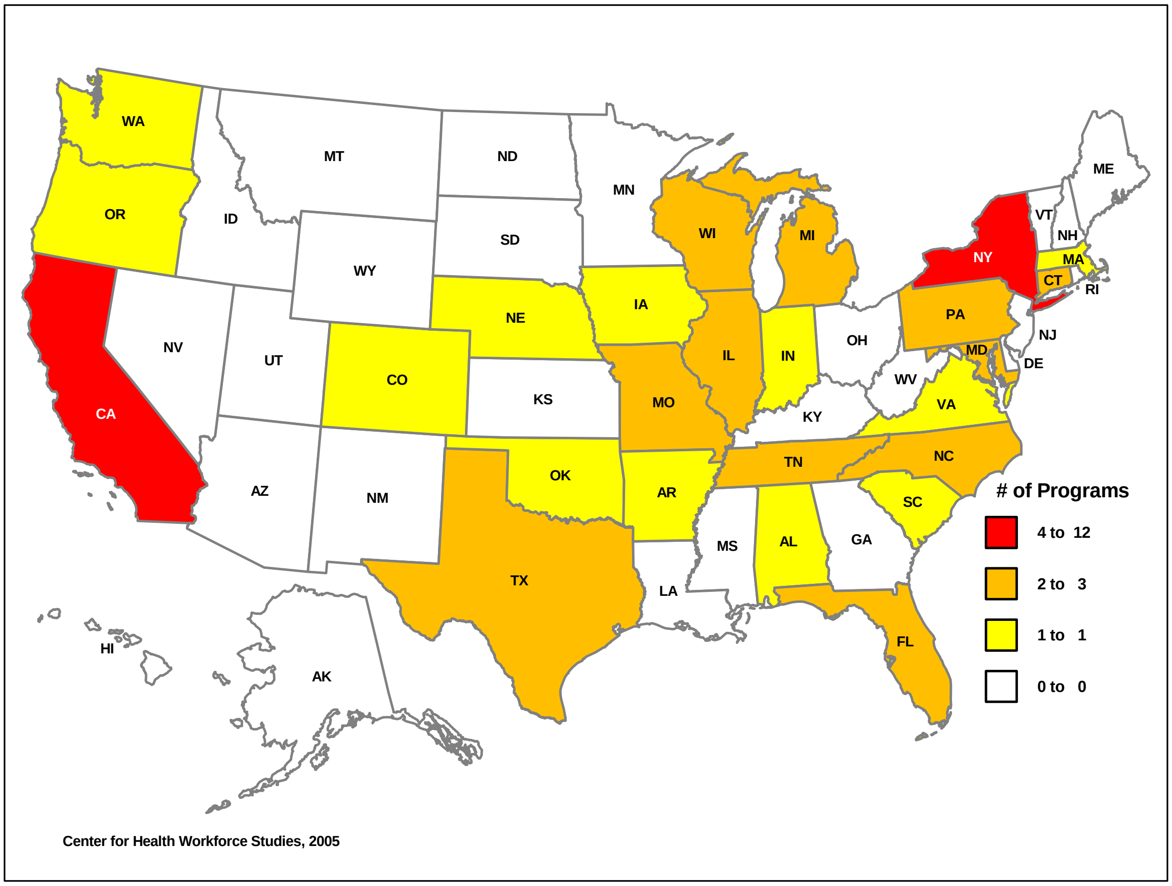
Table 9. Characteristics of Nuclear Medicine Residency Programs, 2003

Characteristic	Value
Number of Accredited Programs	64
Length of Accredited Training	2 years
Minimum number of Prior Years Training	1 year
Total Number of Active Residents, 2003	143
Average Number of Residents/Fellows	2.2
Average Percent Female	26.8%
Average Percent International Medical Graduate	45.5%
Average Number of Full Time Physician Faculty	4.9
Average Number of Part Time Physician Faculty	0.6
Average Percent Female of Full Time Physician Faculty	16.6%
Average Ratio Full Time Physician Faculty to Resident	2.3
Average Percent Training in Hospital Outpatient Clinics	37.8%
Average Percent Training in Non-Hospital Ambulatory Care Community Settings	0.20%

Source: AMA, FREIDA Online, 2005

A map of the residency programs available in nuclear medicine reveals some interesting variation (Figure 9). As with nuclear medicine technology programs, there are noticeable regional differences in the availability of nuclear medicine residency programs. There are fewer programs in the Mid-Central and Southwest regions of the country with more residency programs available in the West, the Northeast, the East Mid-Central and the Southeast regions. [ACGME, 2005]

Figure 9. Number of Nuclear Medicine Residency Programs per State, 2005



Employment of Nuclear Medicine Physicians

The IMV survey referenced earlier in this report examined employment of nuclear medicine physicians and found that only 39% of nuclear medicine provider organizations employ full time nuclear medicine physicians [IMV, 2003]. 70% of all nuclear medicine providers employ some physicians part-time for nuclear medicine studies [IMV, 2003]. Overall, the average number of nuclear medicine studies per physician providing NM services regardless of full or part time employment status is 525 studies per year [IMV, 2004]

The Society of Nuclear Medicine Utilization Survey supports these statistics. The survey found that 37% of hospitals have a Nuclear Medicine Medical Director while 63% of hospitals surveyed do not [SNM, 2004]. Among other non-hospital facilities, 41% have an NM director while 59% do not [SNM, 2004].

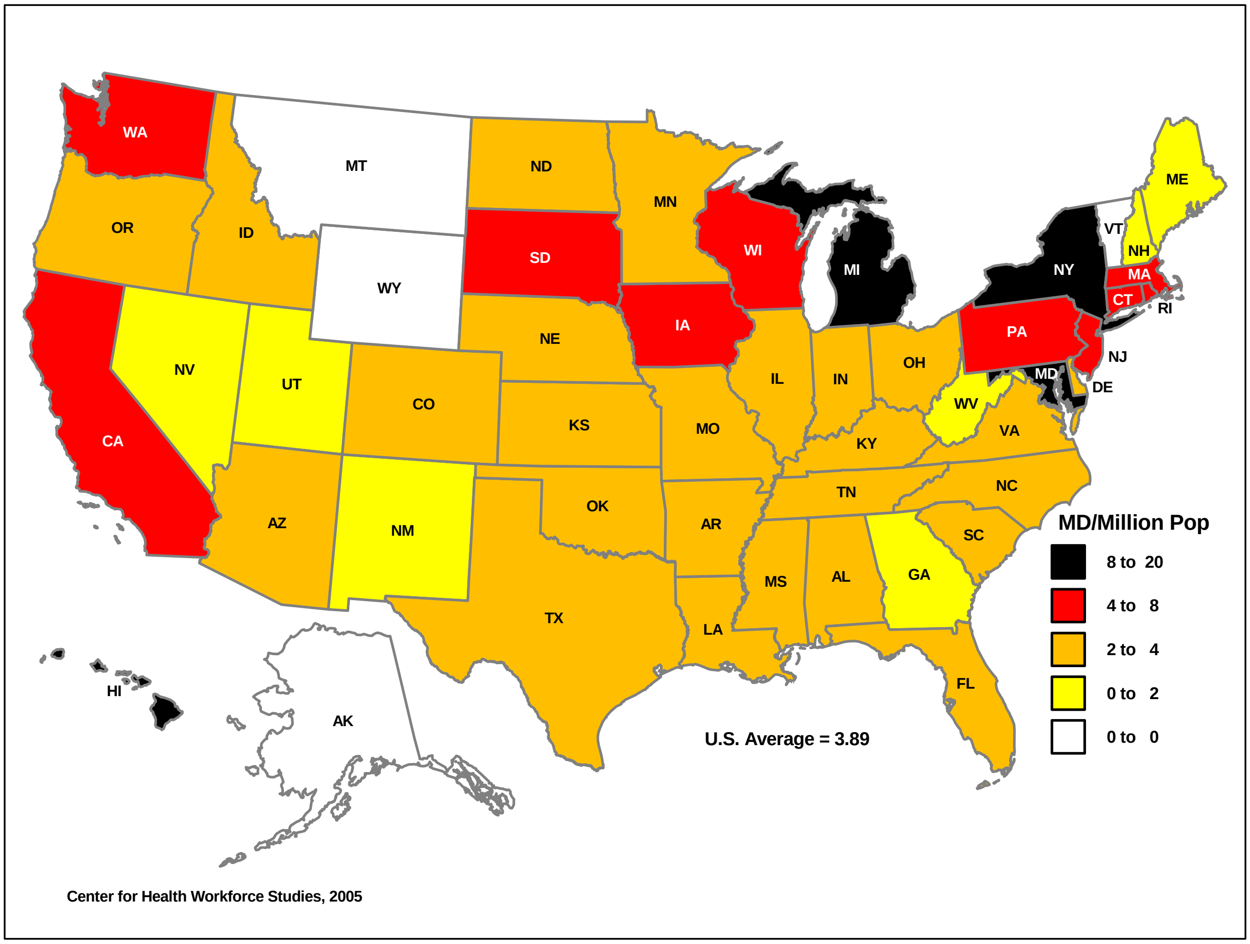
The SNM survey found that ABR certification is the most common certification (77%) for nuclear medicine professionals. In hospitals, 43% of physicians are ABNM certified, 77% are

ABR certified, 17% are ABR with CAQ certified and 14% are ASNC certified. 60% of physicians were certified in only one specialty area [SNM, 2004].

The SNM survey also found that there were not many vacancies for NM physicians. Only 6% of hospitals and 2% of non-hospitals reported vacancies for NM physicians [SNM, 2004]. Positions for nuclear medicine doctors in the current market appear to be somewhat limited by setting because of the very specialized nature of their work. Available positions may also be highly research intensive and may not appeal to more entrepreneurial physicians.

A map of the current distribution of nuclear medicine physicians in the AMA Master File in 2005 (representing 2003 data) suggests that distribution across the U.S. may be uneven. This may reflect the practice patterns of NM physicians. The tools for nuclear medicine practice are expensive gamma cameras that may not be accessible to all institutional health providers. In addition, nuclear medicine procedures require radiopharmaceuticals that are produced in specialized radiopharmacies. This suggests that NM physicians may often be found in medical centers with sufficient resources to purchase gamma cameras and that, additionally, they may be located in areas with relatively easy access to radiopharmacies. Since research is also an important component of nuclear medicine practice, NM physicians would also likely be found in academic medical institutions.

Figure 10. Nuclear Medicine Physicians per 100,000 Population by State, 2003



Certifying Boards

The American Board of Nuclear Medicine (ABNM) (Los Angeles, CA) was incorporated in 1971 at the recommendation of a number of American Medical Association Boards and Councils [ABNM, 2005]. It was the first co-joint board of the American Board of Medical Specialties (ABMS), which is an umbrella board of 24 approved medical specialty boards including the American Board of Nuclear Medicine [ABNM, 2005].

The American Board of Nuclear Medicine has certified 4,869 (this number includes deceased physicians) diplomats since 1972. As one of the boards of ABMS, certification must follow the uniform standards for all boards of the ABMS. Although there is some data collected by the ABNM on those who have been certified, that data is not publicly available and also not easily accessible. The ABNM database includes basic demographic information about the diplomates including name and address, gender, date of birth and decease, telephone number, and e-mail address, date, type and status of certification. However, the information contained in the files may not be current for those who are certified. Recertification on a ten-year renewal basis has only been required since 1992. Therefore, much of the data in ABNM files is not current. An Interviews with a member of the board suggests that some effort is currently underway to update records in a more useable format consistent with ABMS formats [Interviews, 2005].

A study conducted in 1989 examining the characteristics of physicians certified by the ABNM found that the board was certifying an average of 67.8 physicians yearly over the previous five years. The study found that in the initial six years of ABNM certification, 56.7% of radiology/nuclear medicine candidates were dually certified while only 26.4% of these same specialties were dually certified in the years from 1983 to 1989. The study concluded that there was a decreasing trend of dual certification and also that there was an uneven distribution of certified nuclear medicine physicians across the United States [Shah, 1992]. This uneven distribution continues to prevail (see map of NM physicians per 100,000 population by state).

An explanation for the early high number of dual certifications is probably that, in the absence of a certifying body in nuclear medicine, physicians had certified in other specialties. When the NM board began certification, these physicians then sought NM certification creating the high number of dual certificates. As the years progressed, subsequent graduates had ABNM available to seek a primary certification without having to certify in another specialty first.

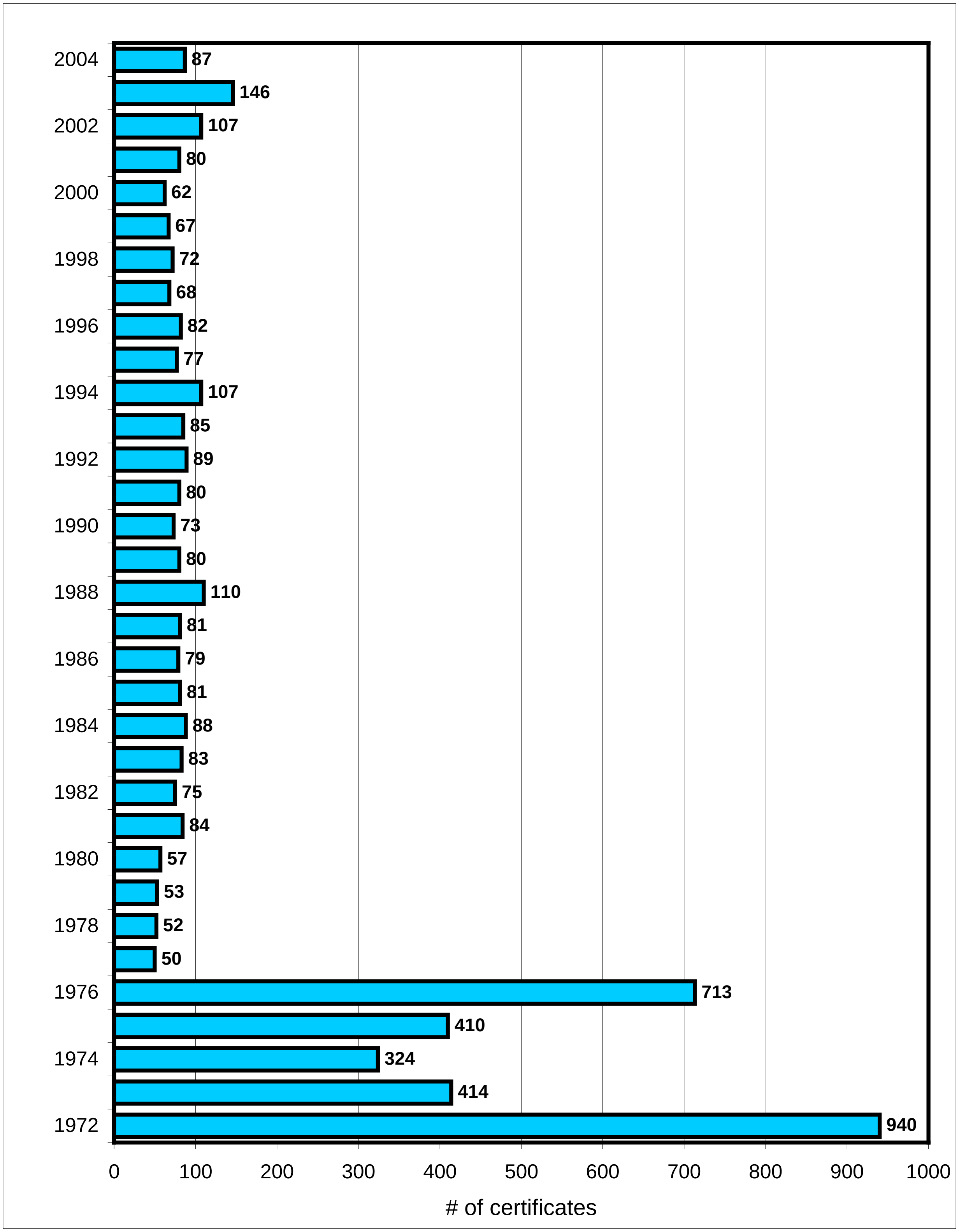
An examination of all certification data available from ABNM suggests that the number of certifications over the most recent five years exceeds the 67.8 average from 1984 to 1989. Since 2000, there appears to be an increase in the number of applicants passing the board with an unexplained decrease in 2004. Still the yearly number of physicians being currently certified represents an increase over most of the years in the decade of the nineties and certainly over those in the eighties. The increases are small however, and the trends in certification appear stable.

The following chart includes data obtained from the ABNM about yearly number of certifications by the board. This data includes currently deceased members of the profession so the count over represents the number of living ABNM certified physicians, The data does not account for activity in the profession and may include some who are currently retired from practice.

In the early years of ABNM certification (1972 to 1976), there was a high number of physicians who became board certified. This probably represents a backlog of physicians without a board from 1966 to 1972, the period in which ABR had abandoned certification and in which there was no corresponding board available to nuclear medicine physicians.

Although currently the only corresponding board certification available to nuclear medicine physicians is from the ABNM, there is a subspecialty radiology certificate in nuclear radiology available from **The American Board of Radiology**. This certification is obtained by completing one year of a fellowship in a nuclear program after residency in radiology. This certification is available to diplomats in radiology or diagnostic radiology but not to those in radiation oncology. It is obtained through an oral examination and is effective for ten years [ABR, 2005]. In 2003 the American Medical Association indicates there are 143 physicians in the United States who practice Nuclear Radiology as a primary specialty. This number does not account for those who may be certified in nuclear radiology but who consider themselves to have another primary specialty. Data from the ABR would likely indicate a much higher number of physicians certified in nuclear radiology. There are currently 19 programs in 14 states that train physicians in Nuclear Radiology [AMA, 2005]. Three of those programs are in New York State.

Figure 11. Annual Number of Board Certifications from the American Board of Nuclear Medicine, 1972 to 2005



Certification Board of Nuclear Cardiology (CBNC). This certification board was founded in 1996 by the American Society of Nuclear Cardiology to examine and certify as competent physicians working in nuclear cardiology. A requirement of the council is that all applicants must be board certified or board eligible in cardiology, nuclear medicine, or radiology with experience or training at a specified level in nuclear cardiology. [CBNC, 1996]. Currently there are 3,696 physicians certified in nuclear cardiology [CBNC, 2005]. Some states such as New York, Connecticut, and Wisconsin require that physicians practicing nuclear cardiology be CBNC certified [Interviews, 2005].

The American Osteopathic Board of Nuclear Medicine in Chicago, Illinois is one of 18 osteopathic specialty boards. The board certifies osteopaths who have completed a one-year residency in internal medicine, or pathology or radiology and a one-year residency in nuclear medicine or a two -year residency in nuclear medicine. Other training and experience may qualify an osteopathic physician for certification in nuclear medicine. Certification is valid for ten years [AOA, 2005]. Osteopathic physicians are required to complete 150 hours of continuing medical education every three years. Specialty certifications may require more or specific CME for continuing certification. [AOA, 2005].

Professional Associations For Nuclear Medicine Physicians

The American College of Nuclear Physicians (ACNP) (Reston, VA). The American College of Nuclear Physicians has both physician members and others "dedicated to enhancing the practice of nuclear medicine through the study, education, and improvement of clinical practice" [ACNP, 2005]. This is a trade association that began in 1974 with the stated purpose of directly representing the interests of nuclear medicine physicians in public forums such as legislative and regulatory bodies, other professional associations, with the media and the public [ACNP, 2005].

Full membership in the organization is available to physicians who are board certified by the ABMS or an equivalent body and are working in nuclear medicine or to nuclear scientists working in the field with an advanced degree. Bachelor's prepared scientists with ten years of experience in the nuclear medicine field may qualify for membership. Different categories of membership are available including emeritus, associate, corresponding, affiliate, and honorary. There are currently 364 members of the American College.

American College of Nuclear Medicine (ACNM) Hazelton, PA. The American College of Nuclear Medicine was founded in 1972 to advance the science of nuclear medicine [ACNM, 2005]. There are currently 500 members. Membership is limited to physicians with a residency and 10 yrs experience in nuclear medicine or residency training in internal medicine, pathology or radiology and five years experience in nuclear medicine, or certification by an American Medical Specialty Board and 3 yrs experience in nuclear medicine or certification in nuclear medicine by ABNM. Scientists with advanced degrees and certification by ABNM (or equivalent certification) are also eligible for full membership [ACNM, 2005]. Other classes of membership include associate, fellow and honorary membership.

American Society of Nuclear Cardiology (ASNC) Bethesda, Maryland, is a professional association with a stated purpose of fostering professional education and the establishment of standards for practice of nuclear cardiology [ASNC, 2005]. The society currently has approximately 4500 members [Interviews, 2005]. Although many of the members have an interest in nuclear medicine applications in the practice of cardiology, members do not generally use nuclear medicine applications full time. Those practicing nuclear cardiology do many other things in cardiology and may read perfusion studies on an intermittent basis as required by their practice protocols [Interviews, 2005] . Membership in the organization is available to physicians, technologists, and scientists. The society publishes the Journal of Nuclear Cardiology.

Nuclear Medicine Scientists

The science of nuclear medicine is the foundation for practice by the physicians and technologists providing nuclear medicine services. Developments in physics, chemistry, engineering, computer science, and pharmacy contribute to the progress of nuclear medicine and to new and improved products to permit better diagnostic and treatment applications.

As new developments in applied technology have permitted faster and more patient friendly applications in nuclear medicine; advancements in a number of pure sciences are also required to move nuclear medicine forward. Many of the scientists working in nuclear medicine are doing research in a variety of fields. Some also work in nuclear medicine centers or for nuclear medicine provider organizations in quality control, radiation safety monitoring and education, applications monitoring, and other supportive technical services.

Scientists working in nuclear medicine may have academic credentials from a number of scientific areas. Generally scientists in NM come from computer science and instrumentation backgrounds, or from study in physics, biology, chemistry, or pharmacy. NM is highly academic and requires rigorous intellectual science. It appears that scientists working in the field are interested in both the pure aspects of scientific research and the health and medical applications that represent the applied aspects of that research.

The previous discussions in this paper about the effects of hardware technology on the nuclear medicine professional suggest demand for scientific experts in physics, engineering and computer science for research, development, implementation, and maintenance of these highly capable devices. Commercial producers of these products would necessarily require scientists for all phases of the development process. Although NM represents a niche market, it is a growing market and one that promises continuing appeal at least in the near future.

The need for computer and information engineers and physicists in nuclear medicine is apparent when one considers the tools of nuclear medicine. Physicists are required in both development and application of the gamma cameras that are used. Cyclotrons and reactors are essential to production of the radiopharmaceuticals given to patients. In all areas of nuclear medicine, physicists are required for research, for radiation safety and monitoring, for calibration and maintenance of equipment, and for education and training of other nuclear medicine professionals. Since this equipment is computerized, often digital, and requiring many algorithms to produce quality outputs, the need for computer scientists is also quite evident. Continuing demand for these scientists is expected especially as cameras proliferate across a number of settings. However, it is difficult to link demand to numbers of cameras since one physicist may work with several providers in calibration and safety so the number of scientists required in provider settings may be a fraction of the number of cameras that are installed. Research centers and production facilities will generate demand for physicists but that demand is limited by funding and other economic factors.

The demand for radiochemists and radiopharmacists is also evident given the need for radionuclides in nuclear medicine studies. However, it is also difficult to project demand for these professionals from patient and provider demand for radiopharmaceuticals. If demand were linked solely to applications in nuclear medicine, the science would remain stagnant. Radiochemists must be able to perform research in order to advance nuclear medicine. This is a challenge since it requires economic resources and the interest of the government and foundations in supporting grants to advance the science. Since this interest changes over time, predicting the employment market for radiochemists is extremely difficult.

The radiochemistry and radiopharmaceutical research required to permit patients to be imaged safely and effectively in focused studies of particular organ or body systems is of interest to this current research examining workforce. The development of specific radioisotopes to accomplish targeted imaging is an especially important part of nuclear medicine science. Developments in radioisotopes permit expanded diagnostic and treatment applications. There are, however, several barriers to research in radioisotopes and to production of new and innovative applications.

Radiochemistry and Radiopharmacy in Nuclear Medicine

Perhaps the most significant barrier to production of radioisotopes is the lack of reactor facilities capable of producing the medical isotopes that are needed to further the science. “Medical isotopes are an indispensable and growing component of this nation’s health care system. The use of medical isotopes cuts the cost of health care and dramatically improves the level of patient care. The medical isotope market is expanding rapidly yet domestic sources have lost considerable market share to foreign supplier who are now dominating the industry" [Nuclear Medicine Research Council].

A recent analysis of the radiopharmaceuticals market anticipates growth in a number of areas including diagnostic imaging agents, nuclear cardiology products, and radiopharmaceuticals used in oncology and neurology [Bio-Tech]. There are 17 elemental groupings of radiopharmaceuticals currently in use in 51 different compounds with different biological affinities. From these 51 compounds, there are 117 radiopharmaceuticals approved for use in nuclear medicine in the U.S., the most common being technetium [Nuclear Medicine Research Council]. Technetium, which is the base compound in 53 of these radiopharmaceuticals, is used in over 65% of injections [Nuclear Medicine Research Council]. Technetium is a "daughter isotope"[Nuclear Medicine Research Council] product of molybdenum, which is produced outside of the United States.

Although the market for radiopharmaceuticals is expected to continue to grow over many years, growth is limited by the lack of availability of isotopes for research and subsequent clinical trials. Many promising compounds are simply not available in the United States or are too costly to obtain [Nuclear Medicine Research Council]. This is a particularly difficult issue since the cost of construction and maintenance of nuclear reactors is prohibitive for many private industries so government involvement in the market is essential.

Historically, isotopes were produced in reactors and accelerators located in facilities managed by the Atomic Energy Commission (AEC) and its successor agency, the Department of Energy (DOE) [Expert Panel, 1999]. The Manhattan District Project of the AEC made byproducts of nuclear reactors available to the medical community after World War II [Expert Panel, 1999]. Since that time, the largest supply of isotopes produced in the US was from government owned reactors. This dependence on government production of radionuclides is problematic since much of the Department of Energy infrastructure is old and some reactors are no longer operating. Although some commercial providers are willing to produce the more profitable isotopes, production is limited because of the high cost of capital investment in facilities to produce radionuclides [Expert Panel, 1999]. As government production has decreased, reliance on foreign sources for radioisotopes has increased.

Radioisotopes produced in large reactors are not as specific as those that are produced with charged particles in an accelerator that can produce neutrons in a carrier free state [Expert Panel, 1999] There are approximately 50 small cyclotrons in the U.S. presently producing some radionuclides [Expert Panel, 1999] that cannot be made in nuclear reactors including such radionuclides as carbon-11 and fluorine-18 [Expert Panel, 1999]. The supply of these radionuclides is limited mostly to tracers that are produced by regional suppliers such as academic medical centers and radiopharmacies. These supplies are not sufficient to meet demand [Expert Panel, 1999]. As an example, one author cited the use of some radionuclides, holmium-166, lutetium-177, and rhenium-186, for use in whole body imaging because of their short half lives and the characteristics of their energies [Tenforde, 2004]. However, these compounds are not widely available which significantly limits their use in clinical trials and therefore, limits approved applications [Tenforde, 2004].

Currently, 90% of radionuclides used in biomedical applications in the U.S. are produced in other countries [Expert Panel, 1999]. The Nuclear Medicine Research Council (NMRC) indicates that this percent is even higher suggesting that 95% of all medical isotopes are produced outside the U.S. [Nuclear Medicine Research Council]. One of the most commonly used radioisotopes, technetium –99 is a by-product of molybdenum (moly). All moly (Mo-99) is produced outside of the U.S. because there are no reactors currently operating in the U.S. with the production capability to produce the isotope. This is especially problematic when one considers that 65% of all nuclear medicine studies performed in the US use compounds derived from technetium 99 [Nuclear Medicine Research Council].

Another issue for users of radionuclides is the Department of Energy (DOE) policy known as the Nuclear Energy Protocol for Research Isotopes (NEPRI) [Tenforde, 2004]. This policy requires that a user preorder the needed supply of a radionuclide in the previous year for review and approval by an advisory panel. The policy requires that a “customer” have sufficient resources to pay for the materials and that the request has merit [Tenforde, 2004]. Based upon the volume of requests, the DOE determines which radionuclides it will produce in the following year. This is a particularly difficult policy for researchers who may not be able to adequately determine the exact need for a radionuclide early in the research process. It is also limiting in that the required radioactive material may not be produced in that year [Tenforde, 2004]

The medical isotope market is expected to increase over the coming decades but growth levels are inhibited by the lack of available resources for the medical community. Much of the production of radioisotopes for research has been under the auspices of the Department of Energy and there are constraints in funding, in availability, and in policy that contain growth. One author commented that nuclear medicine has progressed from a small research activity of the Department of Energy to a $10 billion dollar a year health service [Nuclear Medicine Research Council]. Investment in resources by the government would support the industry and likely be a profitable venture [Nuclear Medicine Research Council].

In the report, *Expert Panel: Forecast Future Demand for Medical Isotopes*, the authors identify several issues that affect the availability of medical isotopes to scientists, health care providers, and patients including

- Growth in the use of isotopes
- Lack of predictable supply of these isotopes
- Development of expected shortages of isotopes
- Cost of production of isotopes
- Dependence on foreign sources for isotopes
- Aging infrastructure of DOE production facilities
- A lack of support for basic research to develop new medical and biologic applications of radiotracers [Expert Panel, 1999].

Radioisotopes and PET Technology

Currently, most applications for PET/CT technology are in the field of oncology for staging disease and monitoring treatment efficacy. This technology permits the imaging of a tumor by observing cellular metabolism using a radiotracer. PET/CT is also an excellent tool to monitor the efficacy of cancer treatments. Applications of PET/CT in cardiology are also emerging since the technology can provide information about perfusion as well as vascular anatomy. Since most of these studies currently use a single radiopharmaceutical, FDG, the development of new tracers could significantly expand the number of applications for the technology. Promising research on a new radiotracer is currently being conducted at Duke University that evaluates cell syntheses and has applications for prostate cancer [Harvey, 2004]. New radiotracers will be important to expanded use of fused technology [Harvey, 2004]. However, development of new radiotracers is dependent on a number of unstable environmental factors.

Diagnostic vs. Treatment Applications in Nuclear Medicine Science

Although nuclear medicine studies have traditionally been identified as diagnostic tools to evaluate disease progression and efficacy of treatment protocols, more and more nuclear medicine is being used for therapy in the form of radiopharmaceuticals and specific radioimmunotherapy. Historically, therapeutic applications were mainly limited to treatment of hyperthyroidism and thyroid cancer and for palliation of pain in advanced metastatic bone cancer [Tenforde, 2004]. Radiopharmaceuticals continue to be used for palliative care and for thyroid conditions but applications have expanded to treatment of prostate cancer and non-Hodgkin's lymphoma [Tenforde, 2004]. These applications are expected to expand as new radiopharmaceuticals are introduced and as the number of approved applications in nuclear medicine expands.

Although some therapeutic applications are capable of providing cure in the form of cellular repair from radioimmunotherapy other applications are only capable of halting progression of a disease such as Alzheimer's. Many of the current NM therapies use beta emitters that are not as specific as certain alpha emitters currently in development that target therapy at the cellular level [Nuclear Medicine Research Council]. As the science develops, and as efficacy increases, therapeutic applications of nuclear medicine are expected to be in high demand for treatment of cancer, AIDs, arthritis, and other diseases.

Frost and Sullivan expect a 14% per year increase in the market for therapeutic isotopes and a 16% per year increase in demand for diagnostic isotopes. Other analysts suggest more modest growth in the 7 to 10% range [Expert Panel, 1999]. The diagnostic radiopharmaceuticals market is expected to be 18.7 billion by 2020 [Expert Panel, 1999] and the therapeutic radiopharmaceutical market is targeted at $1.11 billion by that same year [Expert Panel, 1999].

Animal Research in Pharmaceutical Development Using Nuclear Medicine

Scientists doing pharmaceutical research often work with laboratory animals to develop new applications. Whereas, much of this work has previously required numerous groups of animals, dissection of those animals and in vitro testing of animal tissue, there is currently a trend to in vivo testing of animals using radiotracers to understand drug action and efficacy. Although these imaging protocols do not always meet the requirements of the FDA, criteria for molecular imaging studies are being considered as an alternative method in drug development studies.

More and more in vivo animal testing is seen as both more humane and also as more efficacious. Transgenic mice used in this kind of research can be followed with radiotracers or other bioluminescent makers as they are treated with the drug that is in development [Ward, 2005]. Pharmaceutical research aided by nuclear tracers can detect absorption, distribution, metabolism, and excretion of new drugs as well as the ultimate effects of that drug. Since tracers have no physiological effects, the results of the research can be related directly to the drug in testing. Tracers also help with understanding levels of efficacy and of toxicity of new drugs [Ward, 2005]. The advantages of imaging in research are both economic and ethical. Transgenic mice are extremely expensive and many fewer mice would be required for molecular imaging research.

The FDA has generally only been accepting of endpoint studies to support new or altered applications for pharmaceuticals [Ward, 2005]. Molecular imaging studies are showing great promise as an alternative that would speed the approval process for new pharmaceuticals. The FDA is only slowly accepting non-invasive imaging as an alternative to end-point mice studies when bringing new applications to market [Ward, 2005]. The potential role of nuclear and optical imaging in drug research and trials is very promising and has many advocates. Should this become accepted standard in drug research, it would provide additional opportunities for nuclear medicine scientists.

The Scientists

As a group, nuclear medicine scientists are by far the most difficult to identify. Nuclear medicine scientists are educated in a wide variety of education programs including chemistry, physics, pharmacy, and engineering. In general, specialization in nuclear medicine science occurs in postdoctoral fellowship training programs, although scientists at all levels of educational attainment work in the field.

Because of the variety of disciplines from which nuclear medicine scientists are drawn, definitive data on numbers of scientists is difficult if not impossible to obtain. The Bureau of Labor

Statistics includes several occupational categories in which nuclear medicine scientists are probably contained including chemists and material scientists, biomedical engineers, biological scientists, and medical scientists. However due to the diffuse nature of the scientific workforce, it is not possible to determine accurate counts of scientists working in applications relevant to nuclear medicine science.

It is equally as difficult to determine a definitive number of education programs that feed the various scientific professions who work in nuclear medicine as it is to enumerate nuclear medicine scientists. The IMV study cited earlier estimates that there are 450 FTE physicists/engineers, 425 FTE computer professionals, and 160 FTE radiopharmacists working in facilities providing direct care nuclear medicine services [IMV, 2003]. This does not include those working in research institutions and industry so this is probably a significant underestimation of the actual workforce of nuclear medicine scientists. In fact, a recent report from the European Congress of Radiology indicates that much of the fundamental research and development being done in the imaging sciences is being performed by this scientific community and not by imaging physicians [Diagnostic Imaging, 2005] suggesting that the numbers of scientists in academic and research institutions and in industry might be greater than those working in patient care facilities

Education

Medical Physics

There are currently eight United States universities and three Canadian programs offering graduate study in Medical Physics. These programs vary in content and include postdoctoral programs, clinical residency programs, and bioengineering programs accredited by the Commission on Accreditation of Medical Physics Education Programs, Inc [CAMPEP, 2005].

Radiochemistry

There are forty-three programs listed for graduate study in radiochemistry, nuclear chemistry, and related disciplines by the Committee on Training of Nuclear and Radiochemists of the Division of Nuclear Chemistry and Technology of the American Chemical Society [The Radiochemistry Society, 2005]. Again, program curriculums vary and it is difficult to determine how many graduates from these programs work in nuclear medicine.

Radiopharmacy

Nuclear pharmacy education programs are difficult to find. Several pharmacy schools have certificate study available in radiopharmacy or have radiopharmacy courses available to students but detailing/defining these programs is difficult. The University of Arkansas for Medical Sciences and the University of New Mexico have created an online education program for nuclear pharmacy education that is intended to increase the opportunities for pharmacy schools/students to have nuclear pharmacy education. Since the program began in 2001, the program has educated 60 students from 27 countries [Nuclearonline, 2005].

Biomedical Engineering

One hundred and thirteen U.S. universities and colleges and 7 Canadian universities offer educational programs in biomedical engineering at various degree levels [The Whitaker Foundation, 2005]. In 2002 there were approximately 11,000 undergraduate students in bioengineering programs and about 3,400 graduate students in bioengineering programs [The Whitaker Foundation, 2005]. It is not possible to say how many of these students will work in applications relevant to nuclear medicine science.

Fellowships in Biomedical Applications

The Office of Science of the U.S. Department of Energy (DOE) through its Nuclear Laboratories provides a number of fellowship opportunities for study in biomedical applications in the fields of chemistry, physics, and engineering for qualified students. Oak Ridge National Laboratories has a nuclear medicine program that focuses on development of medical radioisotopes and a number of diagnostic and therapeutic applications. The American Chemical Society in collaboration with the U.S. Department of Energy, Brookhaven National Laboratory and San Jose State University sponsor a summer school program in nuclear and radiochemistry for undergraduate chemistry and physics majors to interest qualified students in the nuclear medicine field [Radiochemistry Society, 2005].

Certifications and Continuing Education

The American Board of Radiology and the American Board of Medical Physics certify medical physicists. The American Board of Science in Nuclear Medicine certifies a variety of scientists working in general nuclear medicine, nuclear medicine physics, radiopharmaceutical science, and radiation protection.

The American Board of Radiology (ABR) (Tucson, AZ) certifies medical physicists who are qualified to practice in *therapeutic radiologic physics*, *diagnostic radiologic physics*, or *medical nuclear physics*. Applicants must meet certain educational and experiential standards before applying for examination for certification. The ABR issues a ten-year certification that must be renewed through maintenance of certification process including a substantial requirement for continuing education and the attestation by others of good standing in the profession. For maintenance of certification, a scientist must complete 500 to 700 hours of continuing education over the ten-year period a portion of which may include 'self-directed education projects' (SDEP) [ABR, 2005]

The American Board of Medical Physics, Inc. (ABMP) certifies physicists and other scientists for the practice of clinical medical physics [ABMP, 2005]. Historically, the organization primarily provided certification in *MRI physics* and *medical health physics*. Effective in 2001 after agreement with the American Board of Radiology, the board no longer certifies new scientists in *medical physics (radiation therapy physics*, *diagnostic imaging physics,* and *nuclear medicine physics*). Prior to 2001 both boards had provided this certification. The ABMP maintains ongoing programs for maintenance of certification in *diagnostic imaging physics, medical health physics, magnetic resonance imaging physics*, and *radiation oncology physics* and will develop subspecialty certifications as the need emerges. [ABMP, 2005]. Recertification occurs every five years after the initial ten-year certification. 72 hours of continuing education credits are required in the immediate three years preceding recertification [ABMP, 2005].

American Board of Science in Nuclear Medicine (ABSNM) – (Reston, VA) was established in 1976. Sponsored by the American College of Nuclear Medicine (ACNM), the American College of Nuclear Physicians (ACNP), and the Society of Nuclear Medicine (SNM), the primary purpose of the board is to certify scientists practicing in nuclear medicine. Certification is accomplished through a two part comprehensive examination [ABSNM, 2005]. The association encourages study and improvement of practice in nuclear medicine and maintains a registry of all certificants [ABSNM, 2005].

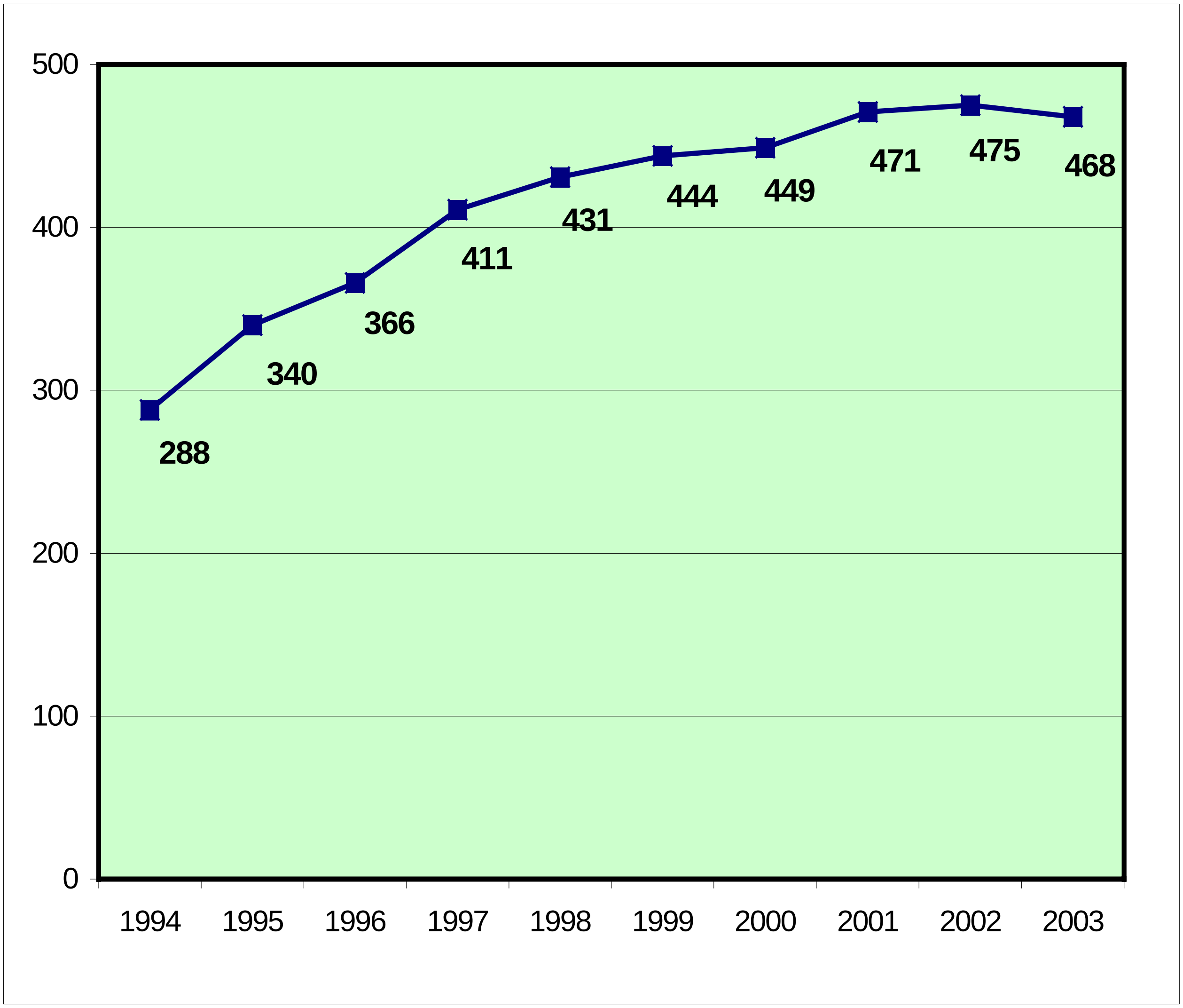
There are four specialty areas in nuclear medicine science defined by the ABSNM [ABSNM, 2005]:

- General nuclear medicine (physics and instrumentation, radiopharmaceutical science, radiation protection).
- Nuclear medicine physics (diagnostic and therapeutic applications of radionuclides, and equipment associated with production and use).
- Radiopharmaceutical science (preparation and use of radiopharmaceuticals for use in nuclear medicine, and radio-labeled chemicals for investigative studies).
- Radiation protection (protective measures for ionizing radiation from radionuclides).

The American Board of Health Physics (ABHP) is affiliated with the American Academy of Health Physics (AAHP). ABHP certifies health physicists through an examination that tests competency in the field. An applicant for certification must qualify by education in one of a number of sciences and by a minimum of six years experience in health physics. The credential is Certified Health Physicist (CHP) or Diplomate of the American Board of Health Physics (DABHP). Certification must be renewed every four years. Renewal requires active practice in professional health physics and 64 hours of continuing education credits during the renewal period [ABHP, 2005]

Board of Pharmaceutical Specialties (BPS) in Washington DC has provided a nuclear pharmacy specialty certification examination since 1996. The board is an independent agency founded by the American Pharmaceutical Association. Pharmacists must be competent in procurement, compounding, quality assurance, dispensing, distribution, health and safety, provision of information and consultation, monitoring patient outcomes, and research and development to pass the certification examination [BPS, 2005]. The following illustrates the number of pharmacists who are board certified in nuclear pharmacy by year.

Figure 12. Number of Pharmacists Holding Certification in Nuclear Pharmacy by the Board of Pharmaceutical Specialties, 1994 to 2003



Source: Board of Pharmaceutical Specialties, 2005

Professional Associations for Nuclear Medicine Scientists

The Health Physics Society (HPS) (McLean, VA) is a professional society for those working in occupational and environmental radiation safety [HPS, 2005)] Plenary members of the society must qualify by certification, education, or experience for full membership in the organization. There are a number of categories of membership available. The Health Physics Society also accredits Radiation Instrumentation Calibration Laboratories [HPS, 2005]. The society publishes a number of newsletters and a journal.

The American Association of Physicists In Medicine (AAPM) in College Park, MD is a professional association for medical physicists working in radiation safety, imaging, and therapy. The association currently has about 5,500 members from the United States and many international countries. The professional association "encourages innovative research and development, disseminates technical information, and fosters education and professional development" [AAPM, 2005]. Medical Physicists are qualified by advanced education at the master's or doctoral level in one of four sub-fields of practice including [AAPM, 2005]

- Therapeutic Radiological Physics
- Diagnostic Radiological Physics
- Medical Nuclear Physics – therapeutic and diagnostic applications of radionuclides (except those in sealed sources used for therapy), equipment associated with their production, use, measurement, and evaluation, the quality of images resulting from production and use, and medical health physics.
- Medical Health Physics

The association currently has 5,500 members. Not all members are involved in nuclear medicine but there is a subgroup within the association with that interest [AAPM, 2005]. Many of the members are radiation safety officers in a variety of facility including nuclear power plants. A small fraction work in medical centers in nuclear medicine departments [AAPM, 2005].

The American Pharmacists Association is a national professional association for pharmacists. Currently the society has about 50,000 members. Within the Association, the Academy of Pharmacy Practice and Management houses six sections for members in a primary area of practice interest. One of these sections is nuclear pharmacy practice. The section has members from a variety of practice settings as well as those in management, government, and academics [APA, 2005].

The Radiochemistry Society in Richland, Washington is an international professional and scientific association whose members work in radiochemistry, in environmental professions, and in nuclear sciences in both applied and research roles. This is a relatively new organization having just received its 501c3 designation as a non-profit organization in 2003. The organization provides informational resources, educational opportunities as well as public outreach [Radiochemistry Society, 2005].

The Society of Radiopharmaceutical Sciences (SRS) is an international association of multidisciplinary professionals who are interested in advancing the science of radiopharmaceutical chemistry. The organization encourages a high level of research, education and practice in the radiopharmaceutical sciences [SRS, 2005]. Currently, the society has 214 members located in all parts of the world. The society publishes a journal, Nuclear Medicine and Biology, that contains original research in radiochemistry, radiopharmacy, and associated areas [SRS, 2005].

Table 10. Society of Radiopharmaceutical Sciences Geographic Location of Members, 2005

Country	Members
United States	117
Canada	10
Europe	52
Middle East	1
Asia	25
Africa	2
Latin and South America	2
Australia	5
Total Members	**214**

Source: SRS, 2005

Other Professional Societies for All Professionals

The Academy of Molecular Imaging (AMI) is an organization of professional members including physicians, technologists and scientists with a primary focus on in vivo molecular imaging and on in vitro studies [AMI, 2005]. The members of the society are involved with various technologies including MRI, SPECT, CT and ultrasound.

Professionals in imaging, biological, physical and pharmaceutical sciences and from a variety of industries are involved with the organization [AMI, 2005]. The group has four distinct membership groups in the following interest areas:

- ➢ Institute for Molecular Imaging (IMI)
- ➢ Institute for Clinical PET (ICP)
- ➢ Society for Non-Invasive Imaging in Drug Development (SNIDD)

- Institute for Molecular Technologies (IMT)

American Society of Nuclear Cardiology (ASNC) in Bethesda, Maryland is a professional medical society with a goal of quality nuclear cardiology services delivered by professionals with optimal education and through the establishment of guidelines for training, practice and promotion of research [ASNC, 2005]. Founded in 1993, the organization has an international scope with 16% of the membership from countries other than the U.S [ASNC, 2005]. There are currently 4,500 members including cardiologists, nuclear medicine physicians, and radiologists, scientists, technologists, computer specialists and other personnel who work in the field. Industry representatives are also members [ASNC, 2005]. The organization publishes a bi-monthly newsletter, the *Journal of Nuclear Cardiology* that is available on line since January 2001.

Radiological Society of North America (RSNA) is an organization with a stated goal of advancing education and research in the radiologic and related sciences through the fostering of professional fellowship and encouragement of research in all aspects of radiology. The organization is international is scope and comprehensive in membership including not only physicians and scientists but also an associated sciences consortium including technologists, administrators, nurses, and students [RSNA, 2005].

There are a variety of other organizations/ groups that engage nuclear medicine professionals or that potentially impact the practice of nuclear medicine including the **American National Standards Institute,** the **National Council on Radiation Protection,** the **International Organization for Medical Physics**, the **World Health Organization Global Steering Group for Education and Training in Diagnostic Imaging,** the **Advisory Committee on the Medical Uses of Isotopes** (advisory to the NRC)**,** and the **Conference of Radiation Control Program Directors, Inc.**

Government Regulators of Nuclear Medicine Science

Since the nuclear medicine professions rely on highly regulated nuclear materials, the impact of government agencies on the professions is more profound than on many other practicing health professions. This must be acknowledged in any research regarding the professions since government regulation limits the environment in a number of ways. Although the government can be credited with significant historical support for the development of nuclear medicine, currently, limited funding and concerns about control of sources of radiation limit the byproducts available for nuclear medicine research and application.

Government Regulatory Bodies

The Nuclear Regulatory Commission (NRC) although not a certifying body, requires that an authorized physician user of radiopharmaceuticals is certified in either nuclear medicine or diagnostic radiology, has had training in a variety of subjects including handling of radioisotopes, radiopharmaceutical chemistry, radiation physics and radiation biology. The NRC also requires 700 hours of didactic training and supervised clinical practice before becoming an authorized user [NRC, 2005].

The Nuclear Regulatory Commission or the responsible agreement State regulates the manufacture, distribution and use of nuclear materials including having regulatory authority over the "possession and use of byproduct, source, or special nuclear material in medicine" [NRC, 2005]. The NRC has specific training and experience requirements for authorized physicians (detailed above), for radiation safety officers, for authorized medical physicists, and for authorized nuclear pharmacists.

An authorized medical physicist must be certified by the American Board of Radiology in either therapeutic radiological physics, roentgen ray and gamma ray physics, x-ray and radium physics, or radiological physics or certified by the American Board of Medical Physics in radiation oncology or must hold an advanced degree (master's or doctorate in physics, biophysics, radiological physics, or health physics with one year of training and an additional year of experience under supervision of a medical physicist in a medical institution providing nuclear medicine services [NRC, 2005].

An authorized nuclear pharmacist must be board certified by the Board of Pharmaceutical Specialties or have completed 700 hours in didactic training in radiation physics and instrumentation, radiation protection, chemistry of byproduct material for medical uses, mathematics of use and measurement of radioactivity, and radiation biology. A nuclear pharmacist is also required to have supervised training in nuclear pharmacy in the handling of nuclear materials as wells as in calculating, assaying, and preparing dosages, checking operations of instruments like dose calibrators and survey meters, and knowledge of administrative controls for safety of administration [NRC, 2005].

A radiation safety officer must be board certified by the American Board of Health Physics, the American Board of Radiology, the American Board of Nuclear Medicine, the American Board of Science in Nuclear Medicine, the Board of Pharmaceutical Specialties in Nuclear Pharmacy, the American Board of Medical Physics, the Royal College of Physicians and Surgeons, the American Osteopathic Board of Radiology or the American Osteopathic Board of Nuclear Medicine. Alternatively a radiation safety office may have didactic and laboratory training and experience in radiation physics, instrumentation, protection, measurement, biology, and chemistry along with one year of experience in a medical institution under the preceptorship of an identified radiation officer [NRC, 2005].

The U.S. Food and Drug Administration (FDA), its **Center for Drug Evaluation and Research (CDER)** and its **Center for Devices and Radiological Health (CDRH)** impacts the nuclear medicine scientific community in a number of ways. FDA houses a Division of Medical Imaging and Radiopharmaceutical Drug Products including an Office of Drug Evaluation. This office has a radioactive Drug Research Committee Program. All radioactive drugs are classified as being either for investigational use or recognized as safe and effective for use when administered under appropriate conditions [FDA, 2005]. Use of and investigation with radioactive drugs is highly regulated through a number of Federal policies.

The FDA also regulates the manufacture and use of radiation-producing machines, accelerators, and other radiation emitting electronic products [FDA, 2005] through its Center for Devices and Radiological Health [CDRH]. Modifications to existing technologies or new technological devices must be approved through the FDA before introduction for use by the public.

The U.S. Department of Energy maintains and manages the nuclear reactors that produce a supply of radionuclides used by commercial radiopharmaceutical manufacturers and biomedical researchers. As mentioned earlier in this report, the Department of Energy is responsible for encouraging the development of medical uses for radioactive isotopes by provision of radioactive byproducts to medical researchers soon after nuclear fission was accomplished. In recent years the Department of Energy has struggled with funding to maintain its infrastructure and many of its facilities are closed or limiting production. DOE has also struggled with providing an “reliable and consistent supply” of radionuclides for both public and private research or for production of radiopharmaceuticals [Expert Panel, 1999].

Nuclear Medicine Facilities

Although nuclear medicine facilities are not a major focus of this study, it is important to understand the settings and environmental context in which nuclear medicine professionals work. The IMV Study accomplished in 2003 estimates that there are 7,000 facilities in the United States that provide nuclear medicine imaging services. 59.7% of these (4,230 facilities) are hospitals and the remaining 40.3% (2,770) are non-hospital providers [IMV, 2003]. This latter category includes a variety of outpatient sites including physician offices and cardiac and oncology imaging centers.

Table 11. Nuclear Medicine Facilities, Procedures, and Patient Visits, 2002

Nuclear Medicine Provider Settings	Numbers of Facilities	NM Activity (millions) , 2002		NM Procedures per Facility
		Procedures	Pt Visits	
Hospital Less than 200 Beds	2,440	4.1	3.1	1,680
Hospital 200 to 399 Beds	1,220	5.2	4.1	4,262
Hospital with 400 or More Beds	570	4.1	3.3	7,193
Non-Hospital Facilities	2,770	5.0	4.4	1,805
Total	**7,000**	**18.4**	**14.9**	**2,629**

A 2003 study by the Society of Nuclear Medicine found that nuclear medicine professionals work in hospital facilities with a wide range in numbers of beds and communities served. Respondents to the SNM Staff Utilization Survey indicated employment in inpatient facilities that ranged from 15 beds to 1,100 beds. The average size of all hospitals represented in the responses was 212 beds [SNM, 2003].

The SNM survey found that 67% of the hospitals were community hospitals, 23% were private hospitals, 8% were government facilities, and 2% were university hospitals [SNM, 2003]. Size of hospital affects the availability of nuclear medicine services with more than 50% of hospitals with more than 300 beds offering nuclear medicine services either 6 or 7 days per week while 65%of hospitals with 125 or fewer beds offer nuclear medicine services only 45 hours per week or less (5 days) [SNM, 2003]. Interestingly, 87% of the hospitals in the survey require either certification or licensure of nuclear medicine professionals. This is supported by the IMV survey results reported earlier in this document.

The total number of procedures provided to patients increased by 9.5% from 2001 to 2002 [IMV, 2003]. Overall, there was only slight growth in the number of procedures that were performed per facility over that period suggesting that the growth occurred because of growth in the number of provider sites. In fact, there was a 28% increase in the number of non-hospital provider sites over the 2001 to 2002 year signifying that outpatient facilities are having an impact on the number of nuclear medicine services [IMV, 2003]. In fact, hospital facilities experienced a decrease in the number of patient visits per site over the time period 2001 to 2002 while non-hospital facilities experienced a 5% increase in patient visits per site [IMV, 2003].

Of the non-hospital sites providing nuclear medicine services 44% were private physician offices, 25% were clinic practices, 25% were imaging centers and 6% were other [IMV, 2003]. Of the over 7,000 sites providing nuclear medicine procedures, 300 are sites that are exclusively mobile units [IMV, 2003].

These findings are consistent with the corollary finding that there was a significant increase in the percent of nuclear medicine technologists working in non-hospital settings with much smaller growth in the number of technologists providing nuclear medicine services in hospitals.

An evaluation of the types of nuclear medicine procedures provided in facilities finds that 54% of all procedures (9.9 million) are cardiovascular studies [IMV, 2003]. 78% of all nuclear medicine studies performed in non-hospital sites are cardiovascular while 45% of NM studies in hospital settings are cardiovascular [IMV, 2003]. Bone studies are the second most common procedure at 23% of all NM studies performed [IMV, 2003].

Facility Accreditation

Although accreditation of facilities providing nuclear medicine services has been largely voluntary, the link to reimbursement for services now encourages facilities to seek accreditation either through the Intersocietal Commission for the Accreditation of Nuclear Laboratories (ICANL) or the American College of Radiology (ACR). Medicare currently requires accreditation of the nuclear medicine facility/department for reimbursement for certain nuclear medicine services. Several other insurers require accreditation for facilities providing certain procedures like nuclear cardiology.

The Joint Commission on Accreditation of Healthcare Organizations (JCAHO) also accredits many of the facilities with nuclear medicine departments/laboratories.

Intersocietal Commission for the Accreditation of Nuclear Laboratories (ICANL) is an organization that evaluates and accredits laboratories providing nuclear cardiology, nuclear medicine, and PET procedures. Standards established through a collaboration of physicians and technologists in the nuclear medicine field guide the evaluation and accreditation process [ICANL, 2005].

American College of Radiology accredits nuclear medicine facilities (evaluation of all units in a facility). There are currently four modules for accreditation [ACR, 2005]:

- General Nuclear Medicine – planar imaging
- SPECT – single photon emission computed tomography
- Nuclear Cardiology Imaging
- PET/ Coincidence Imaging (Positron emission tomography)

Geographic Location of Nuclear Medicine Facilities

Maps showing the locations of the hospital and non-hospital facilities providing nuclear medicine services are revealing. (See maps that follow.) Hospital provider sites are concentrated in the Northeast and the North Mid-Central Regions with a large number also in Florida, Texas, and California, states that are among the most populous. Non-hospital provider sites are similarly situated but more variously concentrated with more non-hospital than hospital sites in the Southwest and the South Mid Central regions while the North Mid Central region is noticeably lacking in availability of facilities providing nuclear medicine services.

Number of nuclear medicine procedures per population also reveals interesting differences in utilization of nuclear medicine imaging services. There are noticeably more procedures performed in the East and Mid Central regions than in the West. Data for these maps is from the IMV Survey [IMV, 2003].

It is interesting to note that education programs for nuclear medicine technologists and nuclear medicine physicians are noticeably lacking in the areas of the country where services are more limited. This suggests significant opportunity/ potential for the profession to locate education programs in areas that lack penetration. A subsequent increase in professionals capable of providing services in those areas might be an impetus to growth for nuclear medicine.

Figure 13. Number of Hospitals with Nuclear Medicine Programs, 2004

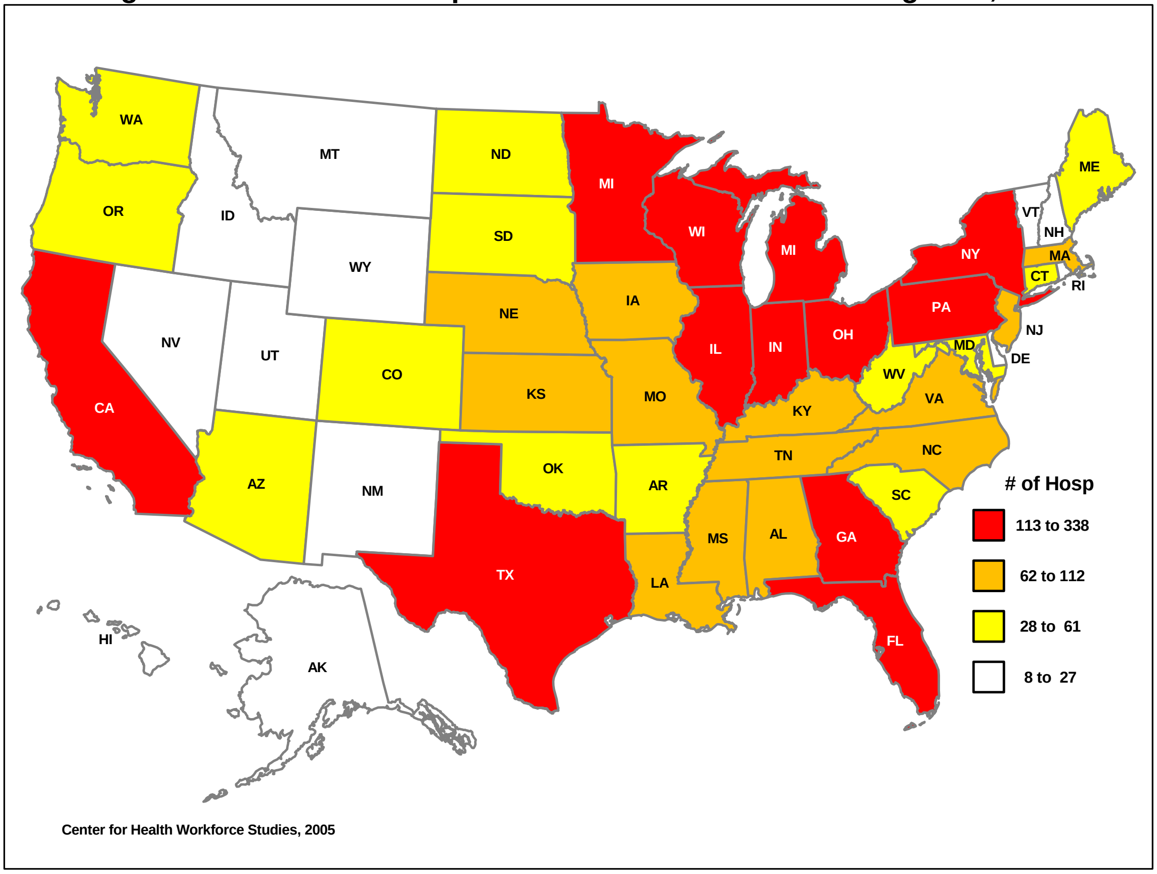


Figure 14. Nuclear Medicine Sites per Million Population, 2004

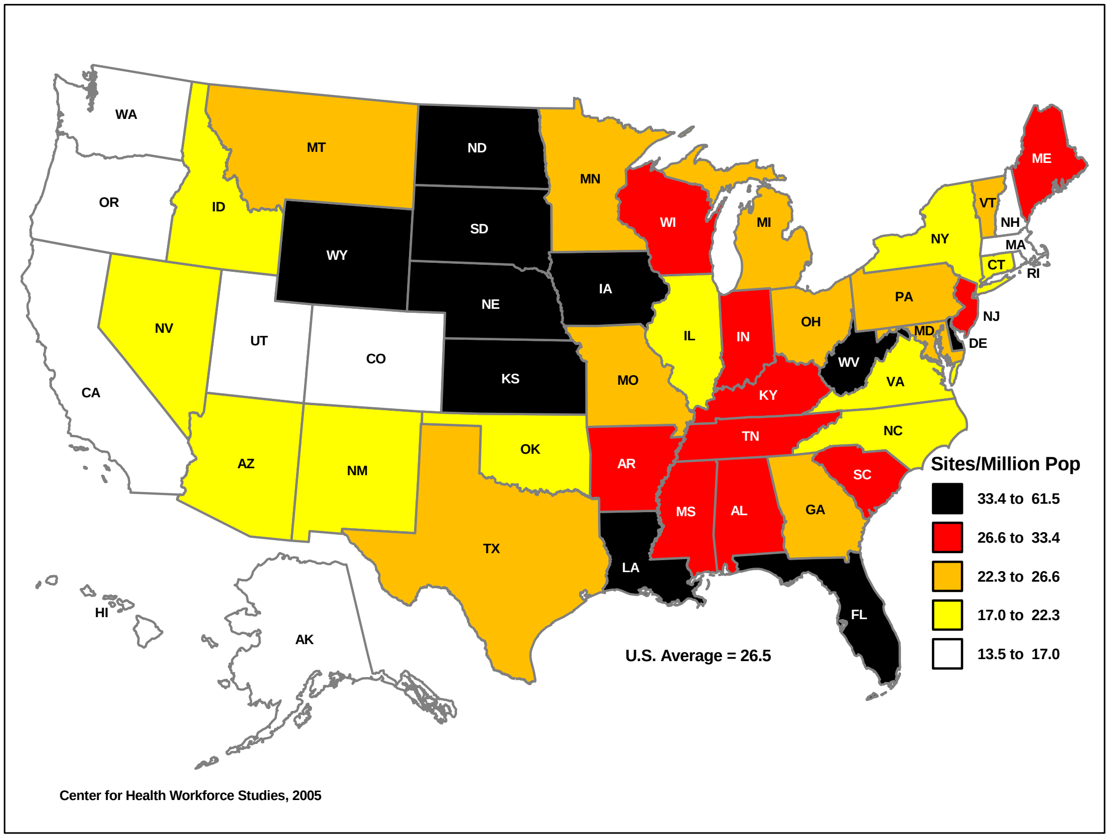
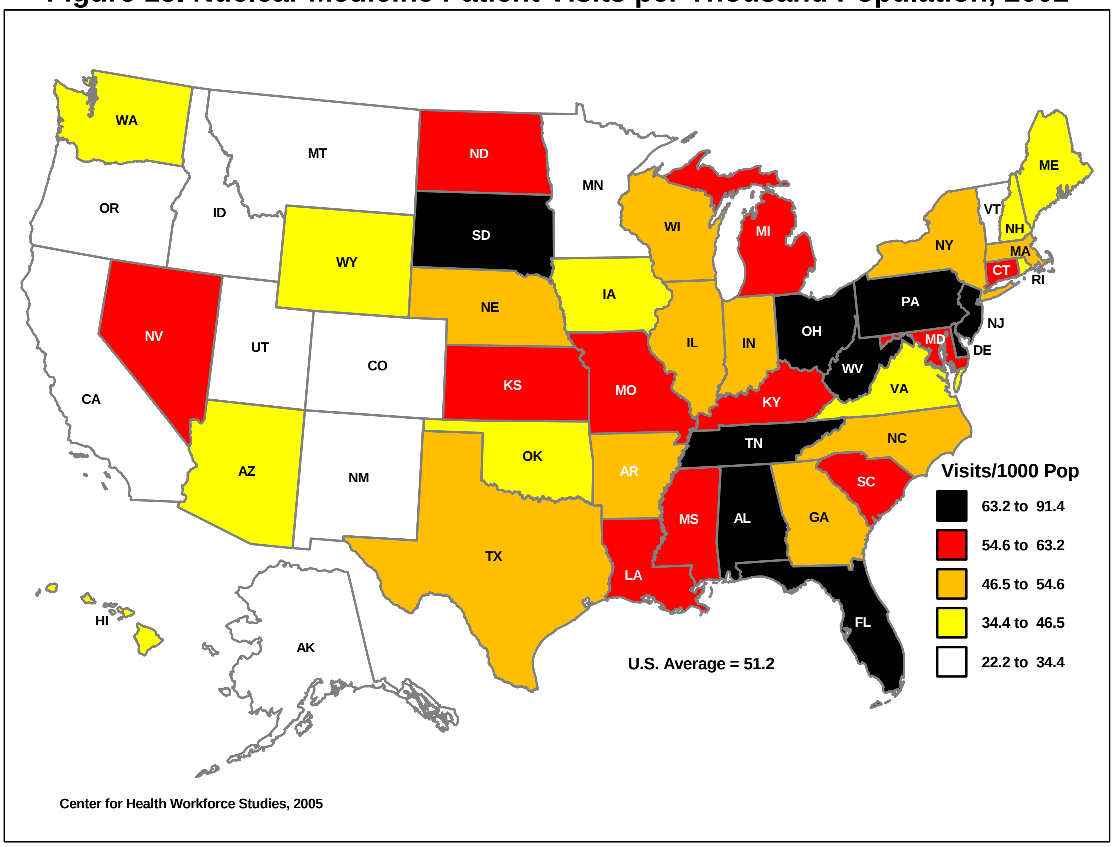


Figure 15. Nuclear Medicine Patient Visits per Thousand Population, 2002



Technology Suppliers and Vendors

Although in depth research on technology corporations is beyond the scope of this report, it is important to make note of the influence of these stakeholders on nuclear medicine professionals.

Research and development by a variety of corporations working in the pharmaceutical and the technology industries has advanced the science of nuclear medicine to a highly sophisticated level. Research and development with nuclear materials is challenging both from a regulatory and a financial perspective. Advancements in this small but defined segment of medicine require a high level of scientific and medical expertise. Industry provides a variety of differing career opportunities for professional nuclear medicine scientific researchers/practitioners with training or experience in nuclear medicine applications.

Development of new and/or improved technology in the field is expensive but the rewards for new and successful applications are exponential. There are a number of small companies attempting to make inroads in research and development of products and applications for nuclear medicine but generally, there are a limited number of large corporations who have successfully developed niches in the field.

Equipment and technology vendors include General Electric, Philips, Siemens, and Toshiba. Radiopharmaceuticals are manufactured and marketed by a number of corporations but the largest include Amersham (now General Electric), Bristol-Myers Squibb and Tyco/Mallinckrodt. Vendors of radiation safety products like Cardinal Health also impact the field. Corporations who market computer systems, picture archiving and communication systems (PACS)), and radiology information systems (RIS) also impact nuclear medicine professionals by providing new or improved professional tools and also with opportunities for employment.

Emerging Issues for the Professions

Impact of Technological Change

Initial investigation of the nuclear medicine professions is revealing. Nuclear medicine is particularly sensitive to changes in technology since imaging equipment and pharmaceuticals are important tools for the professions. Technologic innovation, therefore, has significant potential to impact nuclear medicine professionals creating fundamental changes in workflow and process and altering required professional competencies. Two concepts emerge which are applicable to current change for the nuclear medicine professions.

The context in which healthcare is provided in the first years of the twenty first century is an environment pervaded by change. In the context of occupational change, a main focus of our research efforts, an overriding theme is that proposed by Joseph Schumpter in the 1940s. In examining the structure of capitalism, socialism, and democracy, he advanced a concept called creative destruction. An understanding of this concept is essential to an understanding of current and expected change for nuclear medicine and other healthcare professions.

This theory, which is stated in biological terms, describes the process of change that occurs as technology and organizations develop. Schumpter posited that the economic structure of capitalism is constantly changing from within in an “incessant” process of simultaneous destruction and creation. This change occurs in “discrete rushes” that are separated from each other by “spans of comparative quiet” which we label as business cycles. [HIMSS, 2001]. This process has been more commonly labeled “the churn” [Federal Reserve Bank, 1992] and has been cited as an explanation for changes in occupations driven by technology and the market. A common example of the process is the effect of the introduction of the automobile on the blacksmith. Blacksmiths were in great demand when horse drawn carriages were a common mode of transportation. Automotive technology significantly changed that demand.

In the current “churn” for nuclear medicine professionals, the introduction of fusion technologies is an example of change in technology with repercussions on work processes, work content, and work structure. The introduction of this new paradigm in imaging impacts the professional identity of nuclear medicine professions. Understanding the importance of these technological shifts and responding to the resulting change is critical for the nuclear medicine professions.

A similar but more current concept advanced by an academic at Harvard University named Clayton Christensen, is called “disruptive innovation”. This concept addresses changes in the business environment that affect and ultimately create new business models [Prewitt, 2005]. Christensen suggests that organizations behave according to knowledge and process that is familiar. Innovation occurs when those patterns are disturbed by improvements that change established workflows and work process and improve outcomes. Example of disruptive technology abound including major innovations like the internet and wireless communication as well as alterations in business paradigms like mail order pharmacies [Prewitt, 2005]. Although Christensen labels health care as “the most entrenched, change-averse industry in the United States” [Christensen, 2000], he comments on innovations that have markedly affected health care in the U.S. such as angioplasty and self-monitoring of sugar levels by diabetics.

Essentially, this concept describes technological innovation that disrupts old processes and creates new paradigms. “Disruptive innovations” will have significant effect downstream for those who interface with, or use, or benefit from the technology. As technologies like this emerge, there is sometimes reluctance on the part of the seasoned users of older technology to change behaviors in relation to the new technology but as these technologies take hold, change occurs. The features of disruptive innovation include [Prewitt, 2005].

1) Technology that permits less skilled people to do something more simply
2) The technology has unique attributes and new applications
3) The technology disrupts underserved rather than over-served markets
4) The technology reshapes the business to earn profits in new ways
5) The technology facilitates existing behavior patterns of customers
6) The technology focuses specifically on a customer need

Another feature of disruptive technology is that it may be disruptive to one business model but be sustaining in another [Prewitt, 2005]. Technologies disrupt differently depending on the business (or in this case, professional) model. Fusion technologies may be a disruptive innovation to the nuclear medicine provider but may also be a sustaining technology to the vendor who has developed, produced, and marketed the technology.

These concepts provide an important framework from which to consider the nuclear medicine professions. The emergence of molecular imaging, the mapping of the human genome, the introduction of fusion technologies all suggests that “creative destruction” and “disruptive innovation” are at work.

Much of this change is driven by vendor sponsored research and development. Since these initiatives are beyond the control of the users of the applications, clinical nuclear medicine professions are often placed in a reactive mode rather than a proactive role at the introduction of new technology. However, the engagement of nuclear medicine professionals in both theoretical and applied scientific research and development that enables these innovations speaks well to the future of the profession.

The recent introduction of a variety of fused technologies for widespread use has created change in the imaging field. Technologies that incorporate nuclear medicine modalities like Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT) are proliferating. Importantly, these relatively new technologies are being fused with diagnostic radiology modalities that create images in different planes/dimensions. Current literature suggests that professionals have engaged with these new modalities as they provide enhanced diagnostic potential for a number of disease processes in a variety of body systems and also provide important new tools for assessment of treatment protocols.

In addition to the traditional skills of nuclear medicine professional, newer technologies require knowledge of cross sectional anatomy and of radiology modalities like Magnetic Resonance Imaging and Computed Tomography. These are not typically areas in which nuclear medicine technologists and physicians have education or experience with only minimal exposure to these subjects during professional education.

As a result, these new modalities are creating some professional competition from non-nuclear medicine technologists and physicians who have expertise in the diagnostic imaging competencies needed to fully interpret and understand the images produced. This suggests a need for immediate change in educational programs both in primary professional preparation and in continuing education curricula.

The science of molecular imaging is also affecting the kinds of work that must be accomplished, the professionals who perform the work, and the paradigm in which disease process and treatment will be viewed. Again, many of these changes will ultimately affect the nuclear medicine professionals who are currently the most apt to assume emerging roles and functions related to molecular imaging science because of their professional education and training.

The Production of and Availability of Radiopharmaceuticals

Radiopharmaceuticals are fundamental tools for research and applied science and for diagnostic and therapeutic applications for patient care. It is estimated that over 100 million laboratory tests use radiopharmaceuticals on an annual basis in the U.S. [Leemans, 2005]. In fact the demand for some radioisotopes is so great that they must be imported because U.S. capacity to produce them is limited. Technetium 99 is frequently imported from Canada [Leemans, 2005].

Production of radiopharmaceuticals is problematic since a cyclotron or conventional accelerator is needed. These are very large machines requiring significant space in an institution to safely house the equipment and also provide sufficient shielding [Leemans, 2005]. This limits the ability of many institutions to produce their own radiopharmaceuticals and has led to a dependence on commercial radiopharmaceutical providers.

The increasing demand for nuclear medicine procedures and for radioisotopes used for in vivo and in vitro testing suggests that the supply of radiopharmaceuticals may become an issue for the profession. The emergence of molecular imaging and the significant research on the human genome will drive increased demand for radioisotopes. Laser driven accelerators are currently in development that may be able to produce enough radioisotopes to attenuate need but this science is still not advanced sufficiently to satisfy current demand [Leemans, 2005]. This is an issue about which professionals should be concerned. The Department of Energy (DOE) in describing its current isotope program indicates that there are important medical applications of nuclear isotopes that show promise of improving quality of life [DOE, 2005]. The DOE further states that these benefits can only be realized if " the infrastructure for reliable production of isotopes is maintained" and if isotopes are available for research [DOE, 2005].

The issue is further complicated by regulation of nuclear material. Current discussion in the U.S. about limitations on the import of nuclear raw materials may also influence the availability of radioisotopes for medical applications. Advocacy by nuclear medicine professionals will be important in this policy debate.

Research Funds

For the past fifty years, the Federal government has provided funding for nuclear medicine research through the Department of Energy. This research has contributed to the development of PET technology among other essential nuclear medicine advances [The Scientist, 2005]. Proposed Federal budget cuts for the coming year (2006) include a significant change in the level of funding for nuclear medicine research through DOE. Currently, nuclear medicine at DOE is funded at about $38 million annually. Funding for 2006 could be cut as much as two thirds to about $14 million with no funds appropriated for nuclear medicine research for the subsequent 2007 fiscal year [The Scientist, 2005]. The rationale is that nuclear medicine research is better funded through the National Institutes of Health. However, currently, there are no plans to shift appropriated funds for nuclear medicine research to that department [The Scientist, 2005]. This is an important issue for the nuclear medicine profession and especially for the scientific community doing basic and advanced research. This is another area where advocacy efforts could have important outcomes.

Penetration of the Professions Across the United States

Another issue for the practice of nuclear medicine is the penetration of nuclear medicine professionals across the United States as depicted in the maps of facilities and services presented earlier in this report. There are geographic differences in the number of facilities providing nuclear medicine services as well as in the number of services provided (on a population basis). Should current and emerging technology become more generally embraced as fundamental imaging studies for diagnosis and treatment of disease, demand will increase in areas where services are not yet commonly available. As noted earlier, education programs for technologists and residency programs for physicians are similarly lacking in the same regions of the country with low numbers of facilities providing services. This suggests both challenges and opportunities for the nuclear medicine professions, for educators, and for the professional association.

Profession Specific Challenges

Each of the nuclear medicine professions—physician, technologist, and scientist—is affected similarly and differently by changes in professional practice. It is important to understand how the environment currently affects each professional group.

Nuclear Medicine Technologists

Regulation

As with many allied health professions, nuclear medicine technologists experience various regulatory environments in the states where they work. The wide array of inconsistent requirements for certification and/or licensure in states suggests that some standardization must occur in order for the profession to move forward. In some states, nuclear medicine technologists work exclusively through medical delegation while in other states there are provisions requiring licensure. Such variation makes it difficult for professionals to move across states and find employment despite the fact that clinical competencies do not vary geographically. Although individual competencies may vary, national accreditation of education programs suggests common curriculums for professionals and required standard outcomes for graduation. Mobility is an issue especially and typically for professions that are largely female. Convergence in scope of practice permitted across states will be required to move the profession forward over the coming decades.

Standardization in basic qualifications for practice as a nuclear medicine technologist will also be important to the success of an advanced practice model for the profession. Without common basic requirements for the profession, it will be difficult to develop a standard definition or legislate scope of practice for an advanced practice nuclear medicine professional.

The question of who is competent to operate new modalities is also an area of concern. For technologists who may or may not be licensed in particular states, professional issues emerge when regulation of the professionals permitted to operate technology using sources of ionizing radiation is in place. In some states currently, nuclear medicine professionals must work with a radiologic technologist who is licensed to operate a CT scanner when using PET/CT technology. Under these conditions, tasks traditionally associated with nuclear medicine could conceivably be co-opted by another professional group that already has regulatory legitimacy.

Education

The lack of a uniform standard for entry-level education for the technologist profession is also troublesome. Again some standardization in expected level of education for certification will need to occur in tandem with standardization in regulation. Preliminary research suggests that the body of knowledge in basic and advanced sciences and required competencies in current technology are substantial and that shorter curriculums may not be appropriate. The professional level of the graduates and the ability to provide quality care is jeopardized when entry to the profession is permitted through such a wide range of programs. This will be a major issue for the profession as nuclear medicine technologists struggle to maintain core competencies and gain new skills required by the ever-increasing complexity of radiopharmaceuticals and fusion technologies.

New technologies are also dictating additions to or alterations in the curriculum for nuclear medicine technologists. Emerging technologies will require competency in a number of imaging modalities and in cross sectional anatomy, subjects not currently included in the basic curriculum for NMTs.

Faculty

An associated issue for this and many allied health professions is the ability to provide faculty to staff professional educational programs. Many allied health professions find it difficult to attract competent professionals to teach when clinical practice is more lucrative. This is particularly true for nuclear medicine technologists who are among the most highly paid imaging technologists. Sustaining education programs will depend on a supply of educated and committed faculty. This promises to be a significant challenge for the future.

Competition from Other Health Professionals

As with many allied health professions, nuclear medicine technologists share certain competencies with other imaging professionals. Current changes in technology are affecting change in workflow and in the personnel designated to use new technologies.

Change is happening quickly making it difficult for this or any profession to be proactive in addressing challenges to their professional stature and to the domains of practice. It will be important for the profession and for the professional society to determine productive strategies to address these challenges and to form strategic alliances with other stakeholders in the environment who are commonly interested in advancing imaging professionals from a variety of specialty areas.

Demographics

The age of nuclear medicine technologists may be an emerging future issue. As the number of and variation in new technologies increase and as the fundamental capability of fused technologies becomes more recognized and more pervasively used, demand for imaging workforce will continue and most probably, increase. Attracting and retaining a replacement and supplemental workforce will be a challenge for educators, for the profession, and for all stakeholders.

Nuclear Medicine Physicians

Education

Changing technology suggests that nuclear medicine physicians will require more exposure in training to a variety of imaging modalities in order to develop dual competencies in nuclear medicine and diagnostic radiology. Providing training in these radiology modalities to currently practicing nuclear medicine physicians is also a challenge. How that is best achieved is an important area of exploration.

Demographics

The age and diversity of nuclear medicine physicians is of interest. Although diversity in a profession is highly desirable especially from the perspective of providing culturally competent care, the high number of international medical graduates (IMGs) in the profession is concerning especially since future changes in immigration policy could affect this medical profession more substantially than other specialties with smaller proportions of foreign trained physicians.

Literature review and interviews suggest that the practice of nuclear medicine is less restrained internationally than in the highly regulated environment in the U.S. Scientists and physicians comment on the use of a variety of radionuclides in other countries that permit better research and more innovative imaging studies. IMGs may have a more positive view of the nuclear medicine profession from their experience with nuclear medicine in their home countries than do US trained medical doctors. Further exploration of physician perception about the profession both prior to entering the field and currently should be a topic in our survey instrument. Some public education about nuclear medicine in general and about physicians and scientists might enhance interest in the profession. Ascertaining how current NM physicians learned of the profession is also an important area of inquiry.

The age of the profession is understandable since many physicians are older than the typical workforce because of prolonged education and training requirements. However, the median age of physicians in this workforce is threatening should wholesale retirement occur in a decade or two. Ensuring an adequate supply of nuclear medicine physicians to replace and supplement the current census of NM physicians is a challenge for the profession.

There is a gender gap in the profession. This may be changing, as a higher proportion of the professionals in the younger age cohorts are female. Attention to the specialty selection process of the female physician is an area of interest when collecting survey data.

Technology

Emerging technology and technology known to be in development suggests that demand will continue for nuclear medicine physicians at least in the near future. Advances in optical imaging must be watched carefully. Non-nuclear imaging of similar quality and outcome will be appealing to a public with a negative bias toward radioactivity. On balance, work in the human genome suggests that real time imaging with radionuclide tracers may in fact be in greater demand over time as work on rational therapies and radionuclide treatment therapies increases. Nuclear medicine physicians and scientists are well suited to evolving applications because of their basic and advanced understanding of anatomy and physiology. We need to explore physician attitudes toward technologies in development and how physicians expect it to affect work and workflow. We also need to explore gaps in competencies required by these new technologies that must be addressed in physician training and continuing education programs.

Work

The fact that so many facilities employ part time nuclear medicine physicians should be investigated. Only a limited percent of facilities employ nuclear medicine physicians full time. An understanding of how this impacts nuclear medicine physicians in their efforts to build a practice and how work is generally structured for these physicians should be a focus of the study.

Also, it will be important to determine the organizational structure of medical practices in which nuclear medicine physicians operate (e.g. are they typically radiology practices or specifically nuclear medicine practices).

Scientists

Professional Issues

Nuclear medicine science is not a singular profession. The considerable variety in the scientific orientation and education of nuclear medicine scientists is problematic both from a definitional and an identification standpoint. Obviously, a professional society addressing common interests is important in providing a consensus group for nuclear medicine practitioners. However, the variety of fundamental interests among scientists may draw a scientist to other professional associations and to identities within the primary scientific discipline (i.e. physics, chemistry, engineering).

Scientists in nuclear medicine appear to share some common threads. The complexity of nuclear medicine is intellectually intriguing and current innovations provide important reasons for engagement with a professional association that brings scientists of similar interests although varying orientations together. An investigation of the features of a professional association that attract professionals from such a myriad of backgrounds would help to identify areas of common interests for the scientific professions involved with the Society of Nuclear Medicine. Learning about this commonality may help to better define the "profession" of nuclear medicine scientist.

An issue for the scientist population is professional identity. We need to investigate how that is created, how that is encouraged, and how that can be maintained for the future. We need to learn more about the synergies between the particular sciences and scientists that are engaged with nuclear medicine. Are there overlaps in competencies? Are there other commonalities that attract them to nuclear medicine? How does scientific inquiry interface with patient care?

Education and Supply of Professionals

Knowledge of the opportunities in nuclear medicine science appears to be a well-guarded secret. Interviews with professional scientists suggest that attracting competent, bright students to the field is largely ad hoc, often achieved through mentoring and occasionally through focused educational programs that expose promising students to the opportunities in the field. Although to date, this has been effective in creating a supply of competent professionals, the future prospects for the field of nuclear medicine suggest that attracting new professionals to replace and supplement current workforce will be a critical issue. To assure a workforce for the future, educational programs/curriculum in nuclear medicine science may need to be more organized and more available. We need to examine existing pathways to nuclear medicine science to discover if there is any standardized process within current educational structures that can be encouraged/enhanced.

Regulation

The impact of federal and state regulation on the nuclear medicine professions is perhaps most strongly felt by the nuclear medicine scientific community. The limitations on importation of fundamental radioactive materials and the cumbersome review process required by the FDA for new pharmaceuticals are barriers to innovation and to advancement in the field. Although obviously regulation of nuclear material is in the best interest of the public, regulation of some pharmaceuticals may be overzealous considering the very small doses ingested by patients. We need to examine the advocacy process that is in place within the scientific community to understand how the future for the scientific community will unfold. Some investigation of international regulation and controls should be undertaken to understand the differences and similarities in nuclear medicine science in the U.S. and internationally.

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