Nuclear Medicine in Developing Countries: Perspective from Iran

Nuclear medicine has grown tremendously as a result of research investments over the past 50 y. It now plays an important role in all medical disciplines. The variety of technologies and procedures that make up nuclear medicine are a routine and vital part of diagnosing and treating many disorders and diseases (*1,2*). Extensive research and technological advances in developed countries have increased exponentially since the nuclear reactor in Oak Ridge, TN, was opened for the production of radionuclides in 1946 (*3*). However, medical imaging modalities have been adopted and developed under various scenarios in different countries and also proliferated within countries by differing routes and in various settings (*4*). Data from countries where nuclear medicine imaging modalities have been in clinical use and under insurance coverage for decades show that the number of installed nuclear medicine facilities and numbers and types of procedures continue to increase, confirming the consistent demand for clinical nuclear medicine imaging (*5,6*). In fact, despite their relatively high cost, these effective clinical imaging modalities have shown rapid diffusion, especially among high-income countries.

Diffusion of imaging modalities can be assessed on national, regional, and global levels (*4*). Analysis of diffusion patterns of clinical imaging technologies is important in setting up health systems, particularly in middle- and low-income nations (*7*). Unfortunately, little information is available about the process of diffusion of nuclear medicine, even from developed nations. We collected available data that provide insights into this process in a developing country, Iran.

Data Collection

Data were collected by questionnaire from 3 sources: the Medical Equipment Office of the Iranian Ministry of Health and Medical Education (the only regulatory body issuing permission letters for importing and installing imaging equipment throughout the country), the Iranian Society of Nuclear Medicine, and 3 major government insurance organizations (which collectively provide health coverage to >90% of the country's population) (*8*). The information was analyzed by the Iranian Research Institute for Nuclear Medicine Department in close cooperation with the Parliament Research Center.

Nuclear medicine was introduced into the Iranian medical community in 1960, when Professor Sadegh Nezam-Mafi and his colleagues began their studies in nuclear endocrinology (particularly thyroid function evaluation) with an early-generation thyroid probe and a rectilinear scanner. The first γ camera was installed at the Tehran University Center for Endocrinology and Nuclear Medicine in 1964. In the subsequent 46 y, 164 γ cameras have been purchased for the country (Fig. 1). The first γ camera for SPECT procedures was installed in the nuclear medicine department of Army Hospital No. 502 in Tehran in 1992.

Today, all 30 provinces of Iran have at least 1 nuclear medicine unit. Of the 117 nuclear medicine departments in the country, 51 (43.6%) are owned by the public sector and 66 (56.4%) by the private sector. Eighty departments (68.4%) are established in hospital settings, and 37 (31.6%) are free-standing centers. Of the 164 installed γ cameras, 85 (51.8%) are owned by the private sector and 79 (48.8%) by the public sector. Seventy-four γ cameras (45.1%) are installed in hospital settings, and 90 (54.9%) are in free-standing imaging centers. At the present time, the number of nuclear medicine departments per million inhabitants is 1.36, and the number of γ cameras per million inhabitants is 2.2. In 2009, 81 γ cameras (49.3% of the nation's total) had been installed in Tehran, representing 54 nuclear medicine departments (46.2% of the nation's total). Iran, with almost 75 million individuals, has only 2 SPECT/CT machines and no PET or PET/CT (although plans are being implemented now to install the first later this year).

Official sources have estimated overall insurance expenditures on medical imaging by the 3 government insurance institutes in fiscal year 2007–2008 at the equivalent of about US$96 million. Nuclear medicine's share was ~US$9 million or 9.5% of overall expenditures for medical imaging. The numbers of γ cameras per million inhabitants and health care expenditures (HCE) per capita in some developed and developing countries in 2004 and 2005 are represented in Figure 2.

Nuclear Medicine Challenges

Nuclear medicine continues to encounter significant delays and impediments in introduction into routine use in developing countries, despite the fact that 85 y have passed since Hermann Blumgart performed the first diagnostic procedure using radioactive isotopes (*9*). PET provides a good example: although the earliest developments date back to the 1950s and a PET instrument that employed the filtered backprojection reconstruction was described in 1975, no PET units have been installed in Iran or in many other developing countries (*10–12*).

(*Continued on page 17N*)

(Continued from page 14N)

The Human Development Index (HDI) is published by the Human Development Office of the United Nations (UN) and provides comparative indicators of overall living conditions around the world. For 2007 and 2008, the HDI ranked 107 countries, including ~80% of the earth's population, as medium-low (*13*). This suggests that the majority of individuals in the world today have insufficient health care. In these countries, nuclear medicine remains largely underutilized, and the gap between developed and developing countries is widening (*14*), a fact that is clearly evident in Figure 2.

Figure 1 indicates rapid growth in installation of nuclear medicine equipment in Iran in the past 20 y, coinciding roughly with the recognition of nuclear medicine as an independent residency program in the country (1984). This training is currently offered as a 3-y program, strictly supervised by the Ministry of Health and Medical Education. The increasing number of nuclear medicine facilities in the past 2 decades could also be explained by the growing numbers of physicians and specialists of all disciplines across the country, as well as other factors, including but not limited to enhanced awareness of potential benefits, rising incomes, wider health insurance coverage, and evidence of increased cost effectiveness and decreased complication rates (*4,15,16*). Palesh et al. (*4*) have written about MR imaging diffusion in Iran and tied this to the increasing numbers of physicians in all disciplines. Demand is doubtless a factor influencing the diffusion of all clinical imaging technologies (*17*). The UN data in Figure 2 shows Iran, Turkey, the Slovak Republic, and Poland with the lowest HCE per capita (<805), and these countries also had the lowest number of γ cameras per million inhabitants. The exceptions to this rule are The Netherlands and France, where controls on medical technologies are stringent and, despite high per capita health care spending, the ratios of γ cameras to population are relatively low.

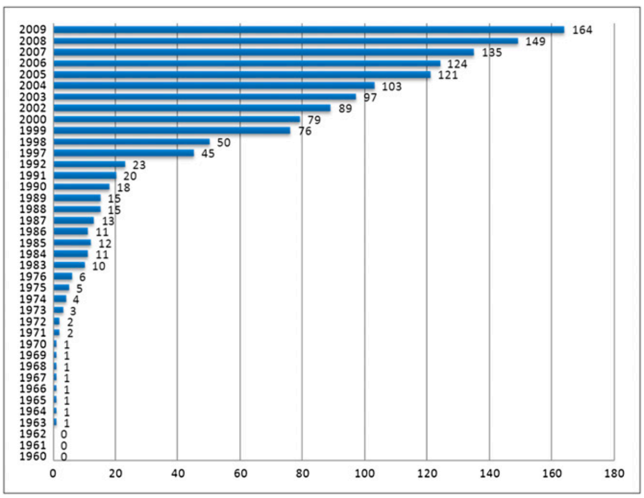

FIGURE 1. Number of γ cameras in Iran, 1960–2009. No data available for 1977–1982 and 1993–1996.

Although Iran has seen substantial growth in the number of nuclear medicine facilities/departments in the last few years, the total numbers of nuclear medicine units are still relatively low compared with those in developed nations. We believe more SPECT cameras should be installed in the country to reach a ratio of at least 1 SPECT camera per 100,000 inhabitants, a level suggested as appropriate by some analysts (*18*). Low gross domestic product appears to play a significant role in the shortage of nuclear medicine instrumentation (Fig. 2). At the same time, insurance companies in Iran have not agreed to cover procedures performed by some nuclear medicine departments (especially in the private sector), with crippling results on attempts to develop the country's fragile nuclear medicine infrastructure.

As mentioned previously, overall insurance expenditure on medical imaging in Iran in fiscal year 2007–2008 was ~US$96 million, with nuclear medicine's share at ~US$9 million (9.5% of overall insurance expenditure). It is instructive to compare these figures with those from Canada, a developed country with a population less than half that of Iran. In 2006, Canadian health care spending was at ~CA$6.8 billion, with medical imaging equipment reported to account for ~CA$223 million. Total capital spending on PET/CT and other nuclear medicine cameras installed in 2006 was estimated to be around ~CA$30 million and ~CA$25 million, respectively (a total of 24.6%) (*19*). Although total spending on medical imaging in Iran is low, (Fig. 2), Iran is one of the few countries with a relatively high number of available γ cameras per million population compared with the HCE. Our country has a low level of health expenditures per capita compared with

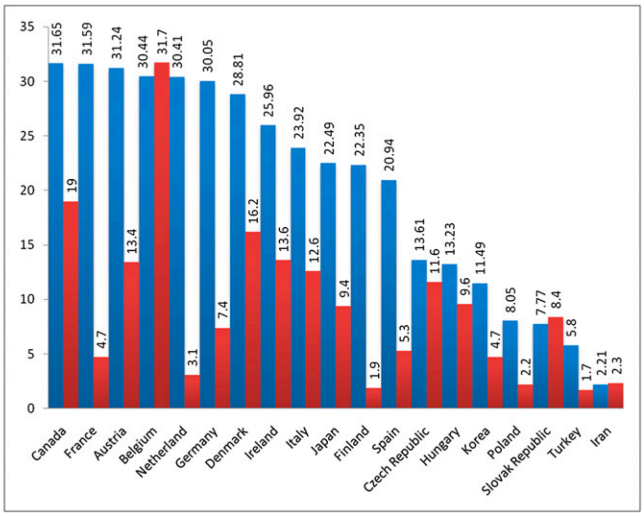

FIGURE 2. Number of γ cameras per million population (red) and health expenditure per capita (blue) in selected countries, 2004–2005. Expenditures are labeled at 1/100 of actual level (e.g., Canadian health expenditure per capita is $3,165/y) and include the provision of health services (preventive/curative), family planning activities, nutrition activities, and emergency aid designated for health.

developed countries, an unpleasant fact that, in turn, can adversely affect utilization of imaging techniques.

Nuclear Medicine for the Whole World

The fair and equitable distribution of medical facilities is an important and challenging task for those who allocate national resources. The same problems and patterns of diffusion in Iran are present in some other Middle East countries (e.g., Qatar, Afghanistan, Azerbaijan, Bahrain, Armenia, and others). The most significant problem in Iran is the lack of PET and PET/CT facilities. Efforts to introduce these technologies have encountered numerous governmental obstructions and barriers in both the ministry of health and the commission on health in the parliament. In contrast, PET technologies have proliferated rapidly in developed countries. As early as 1997, for example, Japan had 24 PET facilities performing 11,040 examinations per year (*20*). In 2005–2006, 1,725 hospital and nonhospital sites in the United States offered PET imaging. Nearly 1,000 of these sites provided the services in mobile vans. In 2005, 326 PET scanners were sold in the U.S. This, however, represented more than half of the 608 scanners sold in the world that year (*21*), a clear indication that some countries, particularly developing nations, lag behind.

PET is making inroads in other countries. As early as 2003, 11 PET and 18 PET/CT systems were operating in South Korea (*22*). Mut et al. (*23*) reported that about 10 PET units were operating in Latin America (in Argentina, Brazil, Chile, Mexico, and Venezuela) in 2004, and this number has doubtless grown significantly since that report.

A number of factors may account for delayed introduction of PET and PET/CT as well as relatively lower proliferation/use of other nuclear medicine techniques in Iran. These factors, which may be present to varying extents in other developing countries, include the changing health care economy, the high cost of PET, the length of time it takes to develop a PET facility, and the inherent complexity of the technology (*24*). Other important contributing factors in Iran include:

(1) The nuclear medicine community in our country tends to be noncommunicative and noninteractive, with limited interest and effort in productive interaction with other medical disciplines (*25*). Moreover, in our country as in some other countries (*17*), nuclear medicine is not a part of the medical school curriculum, so that new physicians are not familiar with its benefits, capabilities, and advantages. All these factors contribute to continued minimal demand for nuclear medicine imaging modalities from the medical community (*25*). Encouragement of active communication and interchange with other professional disciplines can lay the groundwork for increased referrals and provide the basis for nuclear medicine growth and diffusion. This communication should begin in medical schools, each of which should have clinical and investigational positions for nuclear medicine (*17*) and include nuclear medicine in the curriculum for both medical students and some specialty training areas.

We believe that lack of knowledge of the capabilities of nuclear medicine among clinicians in other specialties has not only resulted in minimal demand for dedicated imaging modalities such as PET and PET/CT but has been a strong factor in health policy decisions impeding the introduction of these modalities in the community. In developed countries the introduction of PET was accompanied by a variety of promotional techniques to market the new service, including broadcast e-mails, postings on medical Web sites, and communication through both the popular and professional media (*26*). Nuclear medicine practitioners in those countries worked to educate major insurance providers about PET and its benefits (*26,27*).

(2) The fragile infrastructure of social insurance organizations in Iran and some other developing countries has resulted in increasing resistance to the introduction of dedicated nuclear medicine modalities. State authorities impose many confounding conditions on the introduction or utilization of new medical technologies. It is predictable that after the installation of the first PET/CT in Iran, health insurance organizations will evince substantial resistance to providing coverage. This problem was solved in the United States more than a decade ago with the approval of Medicare coverage codes for PET imaging (*28*). In the United Kingdom (both public and private insurance), Germany (private health insurance companies), and Belgium (public insurance) providers are reimbursed for performing clinical PET (*29*). At the same time, partly because of expansion in demand for other diagnostic modalities and the general explosion of costs, insurance carriers are now holding diagnostic techniques, including PET, to stricter rules and conditions for coverage (*24*). In Iran, introduction of PET/CT will impose an economic burden on these companies and will increase the threat of bankruptcy. These economic considerations are among the most important in explaining the slow adoption of PET/CT in Iran and even in some developed countries. Lottes et al. (*30*) noted that 1 of the major arguments against acceptance of PET as a regular benefit in the German statute-mandated medical insurance system was its putative high cost.

Lack of knowledge about cost effectiveness studies for assessment of new health technologies and cost-saving algorithms is another underlying factor. We strongly support the contention of Conti et al. (*24*) that "For many reasons, not every hospital should necessarily develop PET services." Health policy makers should clarify potential organizational configurations that may enable PET to be applied in a reasonable and effective manner throughout the medical community without the risk of underutilization or the possibility of unethical relationships between investors and referring clinicians. The latter is among the most significant concerns of insurance organizations and health sector authorities in our country. Establishing a clear list of clinical indications for PET investigation is also important (*29*).

(3) Many health sector authorities infer from data such as that in Figure 1 that the introduction of the first PET/CT to the Iranian medical community will open the floodgates for the next generation of such technologies, threatening the financial solvency of health insurance organizations and the stability of the current health system. These fears are not baseless; the uncontrolled condition of the health sector is a problem in developing countries and even some developed nations (such as Canada) (*21*). In Iran, this problem is illustrated by the large regional variations in ratios of nuclear medicine facilities per million inhabitants, ranging from .43 to 3.2. In our country almost half of the nuclear medicine facilities are concentrated in Tehran, which has $<18\%$ of the total population.

(4) Some authorities have argued that our health care system can ill afford to allocate funds for new medical modalities such as PET and PET/CT. In our view, if appropriate resource allocation and cost accounting standards operate efficiently and effectively, the health care system will not face a budgetary crunch. Since 2003, more than 80 MR scanners have been installed in our country (*4*). Most insurance analysts agree that no available data justify the continuing increase in MR services in Iran. Reductions in inappropriate spending on some diagnostic procedures could improve the health care system, and savings could go toward new medical imaging such as PET and PET/CT. As in other countries, self-referral by clinicians to facilities in which they have financial interests (with costs increased by up to 54%) is a challenge in Iran, with insurance companies concerned about conflicts of interest leading to overutilization (*31*).

It is our recommendation that Iranian insurance organizations review the extensive analyses performed elsewhere (*32*) to identify the benefits and cost-effectiveness of PET procedures. We also urge insurance companies, medical societies and authorities, and health sector policy makers to work together to provide clear clinical practice guidelines to ensure appropriate use not only of PET technologies but all highly reimbursed advanced imaging modalities (*33*).

Equity in Nuclear Medicine

The authors believe that good health and timely treatment of illness are among the most basic of human rights and that no government should be allowed to restrict patient access to diagnostic and therapeutic modalities with confirmed effectiveness and benefits. Several studies have confirmed the fact that even when governmental insurance organizations are unable to cover the costs of PET imaging procedures, "individuals are willing to pay additional out-of-pocket costs for diagnostic imaging to reduce their perception of risk and improve their quality of life"—especially when they are provided with background PET information (*34*). This is another strong reason that governments should allow introduction of these highly valuable imaging modalities to medical communities in developing countries without additional delay.

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(Continued on page 22N)

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Each year SNM's Annual Meeting incorporates more diverse imaging modalities as the society's mission expands to include emergent molecular imaging (MI) technologies.

At this year's SNM meeting, held June 5–9 in Salt Lake City, UT, SNM's Molecular Imaging Center of Excellence (MICoE) is again sponsoring a number of activities for scientists, laboratory professionals, technologists, and physicians interested in innovative MI applications.

Educational offerings include the categorical seminar, An Overview of Molecular Imaging: From Basic Concepts to Translational Medicine, on Saturday, June 5. Other continuing education courses will explore apoptosis, preclinical imaging, nanoparticle probes, optical imaging, proliferation, neuroPET imaging, and cardiovascular imaging. Sessions emphasizing clinical trials include a Saturday categorical and continuing education sessions on The Ins and Outs of Imaging Research, Basics of Clinical Research, Standardization in Clinical Trials, and The Basics of Clinical Research for NM Technologists. Two special Emerging Technologies sessions will cover instrumentation and new MI agents.

The Molecular Imaging: Nonradioactive/Multimodal Imaging abstract track will include a poster session and 4 oral sessions, 1 of which will be the new MICoE Young Investigator Award symposium. Wolfgang Weber, MD, Eva Sevick, PhD, and I will review the most notable abstract presentations during the MI track basic science summary session.

Henry VanBrocklin, PhD

The popular MI Gateway exhibits will be returning this year, giving academic and governmental molecular imaging programs space to display their latest achievements. All first-time annual meeting attendees are invited to attend either the Technologist Section First-Timers Brunch on Sunday morning or the Young Professionals Committee–sponsored breakfast Saturday morning. On Sunday, the Radiopharmaceutical Sciences Council and the MICoE will host an evening of lively scientific exchange that will feature hors d'oeuvres and beverages and give all attendees a chance to meet poster authors and MI Gateway exhibitors in a relaxed environment.

We hope you will join us in Salt Lake City for this outstanding educational experience—and some Old West–style fun as well. Visit our Web site at www.snm.org/am.

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(Continued from page 19N)

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