

Future of Nuclear Medicine, Part 2: Assessment of the U.S. Diagnostic Radiopharmaceuticals Market (2001–2020)

This section provides an overview of the current nuclear diagnostics market in the United States and opportunities and challenges in the market through 2020.

MARKET OVERVIEW

Diagnostic radiopharmaceutical agents allow nuclear physicians to obtain valuable information of a patient's condition by imaging organ metabolism. Currently there are over 100 diagnostic radiopharmaceutical products available in the U.S. Although market growth was sluggish during the early 1990s, nuclear diagnostics are beginning to experience renewed growth. This expansion is a consequence of new applications for nuclear diagnostics, as well as the introduction of new radiopharmaceutical products.

The presence of other imaging modalities, such as magnetic resonance imaging (MRI), ultrasound, x-ray, and computed tomography (CT), has resulted in intense competition in the U.S. diagnostics imaging market. Table 2-1 shows total diagnostic imaging market shares by imaging modality. Competition from these above mentioned modalities has prevented nuclear diagnostics from achieving widespread acceptance.

Through 1997, nuclear medicine diagnostic imaging focused on developing radiopharmaceutical products for cardiology applications. This is expected to change in the near future with the availability of newer imaging agents for applications in oncology. In 1997 the FDA approved four radiopharmaceutical products for oncology. Their entry into the marketplace is expected by the end of the year [1997].

Additionally, a number of other oncology radiopharmaceuticals are currently awaiting FDA approval. Frost & Sullivan expects all these product introductions to boost sales of diagnostics radiopharmaceuticals.

The U.S. diagnostics radiopharmaceutical market was worth approximately \$531 million in 1996. The United States accounts for 48 percent of world radiopharmaceutical revenues. At a yearly rate of about 8 percent, estimated growth in this market has not met industry expectations. The nuclear medicine industry had expected growth to be closer to 15 percent annually. However, the introduction of new radiopharmaceutical agents is expected to spur growth in the near future.

The most commonly used radioisotope in nuclear medicine imaging is Technetium-99m (Tc-99m, daughter isotope of Molybdenum-99). According to nuclear physicians interviewed by Frost & Sullivan, Tc-99m is used in more than 68 percent of the nuclear medicine diagnostic procedures performed in the United States.

The constant and stable supply of Tc-99m is a key concern

Note: This material was reprinted from *FFTF Medical Isotopes Market Study (2001–2020)* [1997] with permission of Frost & Sullivan, Mountain View, CA, and Battelle Pacific Northwest National Laboratory, Richland, WA.

TABLE 2-1
Diagnostic Radiopharmaceuticals Market:
Market Share by Modality (U.S.), 1997

Diagnostic Imaging Modality	Market Share (%)
X-ray	35
Ultrasound	24
Computed tomography	20
Nuclear medicine	13
Magnetic resonance	8
TOTAL	100

*Note: All figures are rounded.
Source: Frost & Sullivan*

to nuclear physicians. Any disruption in the supply of isotopes can cause significant revenue losses, not only in the United States, but also around the world. The strike at MDS Nordion in June, 1997, sent a chill through the nuclear medicine community. Disruption of shipping at MDS Nordion, which supplies over 80 percent of the Tc-99m used in the United States, can affect treatment of thousands of patients and also impact the revenues of radiopharmaceutical companies.

Radiopharmaceutical companies are developing newer products and entering new disease applications. In previous years, nuclear medicine focused on cardiology. Nonetheless, fierce competition from other imaging modalities has forced the industry to seek other areas for product expansion. To enlarge its market, nuclear medicine is expanding into applications where competition from other imaging modalities is not as fierce. This has led to the large number of new diagnostic radiopharmaceuticals for oncology currently awaiting FDA approval.

REVENUE FORECASTS (2001–2020)

Frost & Sullivan forecasts that from 2001 to 2020, nuclear medicine diagnostic imaging will grow into a multibillion dollar industry in the United States. Revenues in the U.S. market for this imaging modality will be about \$17 billion in 2020. The forecast compounded annual growth rate is approximately 16.8 percent. Table 2-5 exhibits revenue forecasts for nuclear diagnostics from 2001 to 2020. (Note: Tables 2-2 through 2-4 and additional text and tables from the original report are not included in this article.)

Analysts expect that the large number of diagnostic radiopharmaceutical products recently approved by the FDA, as well as those products that are awaiting approval, will significantly increase revenues in the future. Table 2-6 lists the diagnostic radiopharmaceuticals approved by the FDA in 1997. The new group of diagnostic radiopharmaceuticals focuses on areas previously ignored by nuclear medicine.

Table 2-5*
Diagnostic Radiopharmaceuticals Market: Revenue Forecasts (U.S.), 2001–2020

Year	Revenues (\$ Billion)	Revenue Growth Rate (%)
2001	0.869	—
2002	0.999	15
2003	1.169	17
2004	1.368	17
2005	1.600	17
2006	1.873	17
2007	2.191	17
2008	2.564	17
2009	2.974	16
2010	3.449	16
2011	4.001	16
2012	4.682	17
2013	5.478	17
2014	6.409	17
2015	7.498	17
2016	8.773	17
2017	10.264	17
2018	12.009	17
2019	14.051	17
2020	16.439	17

Compound Annual Growth Rate (2001–2020): 16.8%

**Note: Tables 2-2 through 2-4 and additional text and tables from the original report are not included in this article.*

*Note: All figures are rounded.
Source: Frost & Sullivan*

Table 2-6
Diagnostic Radiopharmaceuticals Market: Radiopharmaceuticals Approved by the FDA (U.S.), 1997

Radiopharmaceutical	Company	Application
Miraluma (Tc-99m)	DuPont	Breast tumor
ProstaScint (In-111)	Cytogen	Prostate cancer
Verluma (Tc-99m)	DuPont/NeoRX	Non-small cell lung cancer
CEA-Scan (Tc-99m)	Immunomedics	Colorectal cancer

Source: Frost & Sullivan

MARKET DRIVERS

New Radiopharmaceuticals for Oncology Applications Are Likely to See Strong Demand

Nuclear medicine has proven its worth in tumor localization, tumor staging, identifying metastatic sites, and judging response to therapy.

Cancer is still one of the main causes of death in the United States and worldwide. It drains healthcare budgets and creates untold despair among its victims. With the development of newer diagnostics radiopharmaceuticals for oncology, nuclear medicine has found a new source of growth, particularly in the near future. The nuclear medicine industry is awaiting the entry of these radiopharmaceuticals with renewed hope.

Interviewees have high hopes that these new radiopharmaceuticals for oncology will have a deep and positive effect on the future of nuclear medicine diagnostic imaging. Some of these new agents are designed for:

- Breast cancer imaging
- Neuroendocrine tumor imaging
- Colorectal cancer imaging
- Small-cell lung cancer imaging

Frost & Sullivan expects that revenue growth could reach 15–17 percent per year by the 2020s. This expectation is based on the revenue potential held by the new radiopharmaceuticals which are about to enter the market.

Cost-Effectiveness of Nuclear Medicine Imaging Contributes to Healthcare Costs Reduction

Since nuclear medicine procedures can detect abnormalities smaller than those identified by other imaging modalities, it is

intrinsically cost-effective. Since diagnostic radiopharmaceuticals act as indicators of specific physiological processes, they provide a survey of the disease that anatomic imaging often is unable to provide.

The cheapest imaging tool is an x-ray, which provides a considerable amount of information. MRI and computed tomography (CT) are more expensive, yet they also provide important anatomic information. Each of these modalities has its own niche in the imaging market.

Nuclear medicine uses radiopharmaceuticals to provide a more sensitive image. In the case of small-cell lung cancer, for example, using one injection of the diagnostic radiopharmaceutical might make some of the currently used five-stage tests for lung cancer detection unnecessary. This is cost-effective because one nuclear medicine procedure has the potential to save society thousands of dollars in unnecessary diagnostic procedures.

Diagnostic radiopharmaceuticals, for example, can differentiate between a growing tumor and scar tissue. Since the modality images physiological function, it can tell if an abnormality is living or not. If the abnormality is living, nuclear imaging allows for early and prompt treatment. If the scar tissue is dead, nuclear imaging avoids unnecessary procedures and expenses. Consequently, nuclear medicine contributes to the cost-effectiveness of preventive medicine.

Nuclear physicians interviewed by Frost & Sullivan support these statements. They also deeply regret the fact that nuclear medicine diagnostic imaging has failed to attract more physicians and a loyal customer base. Respondents think that the nuclear medicine community has not fully explained the cost-effectiveness of this imaging modality to potential end-users.

In a managed care environment, where cost savings and outcomes are the primary indicators of product acceptance, such benefits of radiopharmaceuticals can result in significant market opportunities.

Nuclear Diagnostics for Older Patients Is Likely to Result in Healthcare Savings

The population of the industrialized world is aging rapidly. The process is not the same for each country in this group, but there certainly will be fewer people contributing towards the healthcare expenses of the next generation of retirees. In the United States, many healthcare analysts already are claiming that the Medicare system will face financial collapse early in the next century. This is a major problem throughout the industrialized world.

Since the late 1980s, radiopharmaceutical companies have been developing new agents for oncology applications. An aging

population will create a higher need for cancer identification. For example, 1 in 23 men between the ages of 60 and 79 is a victim of colorectal cancer; for women, the rate is 1 in 30. In comparison, from birth to the late 30s, 1 in 1,667 men and 1 in 2,000 women develops colorectal cancer. Hence the need for promoting the use of nuclear medicine imaging (NMI) as the diagnostic tool of choice among the elderly.

Neurological disease is another area into which this imaging modality is likely to expand. Neurological diseases, particularly Alzheimer's and Parkinson's disease, are more prevalent among the elderly. NMI can provide the elderly with better management of the debilitating neurological diseases that attack them, while also saving money through early identification of these diseases.

Nuclear medicine's ability to image organ function is advantageous for the identification and treatment of these diseases. This can reduce the cost of healthcare by making treatment of elderly patients less wasteful and more effective while improving the patient's quality of life.

Educating General Practitioners on NMI Would Raise the Referral Rate

Nuclear physicians, as members of a specialty field, do not manage patient care. Patients are provided by referrals from general and family practitioners. Traditionally, this group of doctors have been ignored by nuclear medicine. As a result, fewer patients are referred to nuclear medicine than to CT and ultrasound, for example.

Since its introduction in the 1940s, nuclear medicine has remained a relatively low-key imaging modality. One industry participant called it "an imaging modality kept hidden in the basements of hospitals." This has seriously hurt prospects for nuclear medicine.

Through educating patients and general practitioners, nuclear medicine can enlarge its patient and physician base. The Society of Nuclear Medicine and many radiopharmaceutical companies have developed educational programs to bring nuclear medicine into the mainstream of diagnostic imaging.

Frost & Sullivan believes that education and awareness are critically needed if the industry is going to retain its position. Both are necessary for the growth of NMI. Patients and general practitioners should be better informed of the benefits of radiopharmaceuticals in imaging disease sites and in reducing healthcare costs. A better-informed population can help secure and expand the niche that nuclear medicine has built for itself.

Referring physicians have a strong role in the expansion of nuclear medicine. Their cooperation and referral services could provide nuclear medicine diagnostic imaging with a widely expanded patient population.

Nuclear Medicine Improves Pediatric Survival Rate

Diagnostic radiopharmaceuticals have also developed a solid reputation in pediatric care. Children frequently undergo nuclear medicine procedures to evaluate bone pain, injuries, infection, or kidney and bladder function.

Bone-seeking radiopharmaceuticals have uniform uptake throughout much of the pediatric skeleton. Because the pediatric skeleton is in a state of flux, maturing from birth to adulthood, it easily absorbs the tracer. Pediatric urinary studies are also very

effective since 50 percent of the radiopharmaceutical is excreted via the kidneys.

Radiopharmaceuticals which are absorbed by the pediatric skeleton can also detect cases of child abuse. When high-specificity lesions are encountered in an otherwise healthy child, a diagnosis of abuse can be made with a high level of certainty. These abnormalities are often subtle and require the high-detail imaging that radiopharmaceuticals can provide.

Nuclear medicine has yet another opportunity for expansion in pediatrics. As more children are being evaluated locally, imaging physicians should be able to offer a broad spectrum of nuclear imaging procedures for pediatric patients. Treatment of these patients is often urgent, and well-performed nuclear imaging procedures may provide information which is pivotal in their care. Frost & Sullivan believes that the pediatric population is likely to be a major driver for diagnostic radiopharmaceuticals.

Early Detection Is a Key Advantage

Nuclear medicine diagnostics have the capability to image tumors even while they are still very small. This capability enables nuclear diagnostics to play an important role in preventive medicine. By finding abnormalities when they are in the developing stage, doctors can treat these lesions before they spread throughout a patient's body and become life-threatening.

Other Disease Applications Can Also Generate Demand

Besides expanding into oncology applications, nuclear medicine diagnostics is examining its potential in other disease applications. These include infection imaging and neurology applications, which are likely to have great demand among the elderly. Nephrology is another developing field.

MARKET RESTRAINTS

High Cost of NMI Concerns Managed Care Organizations

Primary care physicians perceive NMI as too expensive. This perception rests on the fact that one nuclear medicine scan is costlier than diagnostics procedures done by other imaging modalities, such as ultrasound. Yet patients not receiving NMI will almost certainly need several ultrasound scans to obtain a solid diagnosis. In contrast, nuclear medicine can arrive at that diagnosis with only one scan.

Nuclear medicine procedures are not inexpensive. Nuclear physicians and industry experts readily accept this reality. Prices for nuclear medicine diagnostic procedures range from \$1500 to \$6000. This compares to about \$50 for an x-ray, for example.

Observers of the nuclear medicine industry strongly believe that the industry has failed to explain the difference between apparent costs—the prices quoted above—and total costs. Real cost is lowered by the fact that nuclear imaging is one of the most effective imaging modalities available to healthcare. While an ultrasound can identify an abnormality that is 15 mm in diameter, radiopharmaceuticals can image one that is 5 mm in diameter. This is an impressive advantage, particularly when trying to image minute abnormalities, such as small-cell lung cancer.

Although the cost of a nuclear medicine procedure is high, the precision and accuracy of the diagnosis far outweigh this cost.

Real price should not be deduced from the actual cost of the procedure, but from the real benefits that the procedure provides. The nuclear medicine industry as a whole, and radiopharmaceutical companies in particular, should better communicate the pharmacoeconomic benefits of nuclear medicine diagnostics to potential end-users.

The cost conscious nature of managed care has been an obstacle for the expansion of nuclear medicine. Healthcare in the United States is in a period of long-term permanent restructuring. Managed healthcare continues to evolve, and reimbursement is in the process of changing as well. In this atmosphere, nuclear medicine has found it hard to convince managed healthcare of the modality's advantages.

Competition from Other Imaging Modalities Shrinks the Utilization Rate

Medical imaging is a tremendously competitive market, and nuclear medicine is the most expensive of the available modalities. As a result, nuclear medicine's market is relatively restricted. The current market for nuclear diagnostics is saturated because nuclear diagnostics has failed to expand its patient and physician base.

The state of the market spells serious problems for NMI and radiopharmaceuticals. To address this problem, companies in the NMI industry should continue their efforts to provide new diagnostic radiopharmaceuticals for additional applications. Radiopharmaceutical companies should break new ground and enter applications where competing modalities do not have a strong presence.

Lack of Patient and Physician Education and Awareness Reduces Market Penetration

Nuclear medicine is faced with a slowing market because it has failed to attract new end-users. Nuclear medicine also has failed to educate patients as to the benefits of physiological imaging. While other imaging modalities actively pursued acceptance among referring physicians and promoted themselves to patients, nuclear medicine remains hidden from the mainstream. Consequently, a substantial part of nuclear diagnostics' potential remains unfulfilled.

Educating patients and physicians can popularize nuclear medicine and convince both groups of the economic benefits of nuclear medicine.

Shrinking Number of Nuclear Medicine Physicians Limits Growth

The declining number of nuclear medicine programs is a cause for concern. This is a consequence of both the industry's sluggish growth and the absence of career opportunity for younger nuclear physicians. In the United States, there are only about 1500 nuclear physicians. There is a need for a broad educational program in nuclear medicine and radiopharmacy at leading universities in the United States.

Frost & Sullivan believes this is a major problem for the nuclear medicine industry. If the number of nuclear medicine physicians decreases, consumption of radiopharmaceuticals also is likely to decline. Without sufficient nuclear physicians, there is likely to be a vicious circle of declining use.

Not only would a reduced number of nuclear physicians result in reduced use, it would also negatively affect research trials. Fewer opportunities for a new generation of nuclear physicians would deter research and expansion into new applications.

Current Production Capacity for Radiopharmaceuticals Exceeds Demand

Many industry analysts and respondents agree available capacity for medical isotopes far outweighs the present market demand. This has led to industry consolidation in recent years.

Radiopharmaceutical companies have the capacity to manufacture large quantities of radiopharmaceuticals. Many of the nuclear physicians interviewed think that too much product is being manufactured. Respondents believe that nuclear medicine is failing to expand to meet the consumption levels planned for by the radiopharmaceutical companies. Overproduction may be fueling perception of a shrinking market. Competing modalities are gaining ground, and the market share of nuclear medicine diagnostics is falling.

Investments in educational programs that focus on increasing awareness and safety of nuclear medicine can contribute to market growth and may thereby reduce the problem of excess capacity. If the client base can be expanded, demand would rise to meet capacity.

Fear of Radioactivity Keeps Patients and Referring Physicians at Bay

Another restraint that radiopharmaceuticals face is the fear of radioactivity held by most patients. By their very nature, radiopharmaceuticals carry the stigma of radiation. This poses a concern among patients as well as among referring physicians. Nuclear physicians, on the other hand, believe that this fear is ungrounded. The amount of radiation to which a nuclear medicine diagnostic patient is exposed is very small.

Additionally, radiopharmacies have been established to handle the isotope for the preparation of the dose. Professional handling of isotopes reduces the risk of radiation. The disposal issue related to patients is not a major concern, since most of the radioactive dose is excreted by the patient's body in a controlled environment and following federal guidelines.

COMPETITIVE ENVIRONMENT Structure

Since 1995, the diagnostic radiopharmaceutical market has witnessed a strong move towards industry consolidation. In this time-period alone, three radiopharmaceutical companies have been absorbed by other, much larger, companies. Close to 80 percent of the total U.S. diagnostic radiopharmaceutical market is held by three companies: Amersham Medi-Physics, Mallinckrodt and DuPont Merck.

The remaining 20 percent is held by smaller companies such as CIS USA, Bracco Diagnostics, Centocor, NeoRX, Immunomedics, and Cytogen. Frost & Sullivan believes that industry consolidation has peaked, leaving the radiopharmaceutical industry with about 15 companies.

Characteristics of the U.S. Market

Frost & Sullivan estimates that the size of the total U.S. diag-

nostic radiopharmaceutical market was approximately \$531 million in 1996. This dollar figure was arrived at by estimating the sales of the radiopharmaceutical companies with a presence in the U.S. market. Although the growth rate forecast for this market is somewhat low at about 10 percent, it is expected to receive a much-needed boost from new agents being developed, as well as from the evolution of therapeutic nuclear medicine.

The largest source of radioisotopes for the United States is MDS Nordion, located in Canada. MDS Nordion supplies about 68 percent of the Tc-99m used by the U.S. nuclear medicine industry. There are several sources of radioisotopes in the United States, such as the Missouri University Research Reactor, Brookhaven National Laboratory, and Oak Ridge National Laboratory. Yet, for the most part, the United States remains dependent on overseas sources for radioisotopes used in nuclear medicine.

In the United States, most radiopharmaceuticals are used for cardiology applications. This situation is likely to change in the future as newer imaging agents and therapeutic radiopharmaceuticals become available. Several oncological radiopharmaceuticals are about to enter the market, and it is expected that these agents will boost sales.

Characteristics of the World Market

Nuclear medicine is underutilized in many regions of the world. While the United States makes up approximately 47 percent of the world market, South America's share is a paltry 2.5 percent. Differences from country to country, particularly within a region, are considerable. Table 2-7 exhibits shares of the world diagnostic radiopharmaceutical market by region in 1997.

The Pacific Rim has witnessed strong growth of nuclear medicine. Japan, in particular, has witnessed increasing use of radiopharmaceuticals. Taiwan and Korea have also experienced considerable growth. China remains underdeveloped in radiopharmaceuticals, mainly because of a lack of incentives for companies to enter this piracy-plagued market. Companies are greatly concerned about the lack of intellectual property protection for their formulations in China.

Nuclear medicine also has enormous potential elsewhere in the Pacific Rim. The modality is seriously underutilized in countries such as Indonesia, where there are 100 million people but only 25 gamma cameras.

The Pacific Rim has experienced growth that ranges from 10 to 15 percent per annum. In 1996, the Pacific Rim market was around \$298.3 million, or 26.4 percent of the total world radiopharmaceutical market.

In Europe, nuclear medicine has lost ground to other imaging modalities. This market has suffered cost-cutting by several European governments, which are faced with shrinking health-care budgets. Some industry experts have argued against implementing a U.S.-style radiopharmacy in Europe, since it is believed that this would cut radiopharmaceutical companies' profits.

Nonetheless, Europe is filled with possibilities. The continent has an aging population, giving radiopharmaceuticals for oncology a very positive outlook. Neuroscience is yet another area of possible expansion. Cost-effectiveness is likely to be a

Table 2-7
Diagnostic Radiopharmaceuticals Market: Percent of Revenues by Geographic Region (World), 1996

Region	Revenues (\$ Million)	Percent of Total
United States	531.0	47.0
Asia/Pacific	298.3	26.4
Europe	220.4	19.5
Latin America	28.5	2.5
Rest of the world	51.8	4.6
TOTAL	1,130.0	100.0

*Note: All figures are rounded.
Source: Frost & Sullivan*

major consideration in this region, particularly as the population ages and healthcare budgets shrink.

The main concern of the radiopharmaceutical companies in South America is retaining their presence in the marketplace. The region has tremendous potential, particularly in Brazil, Argentina, Colombia, and Chile. Other countries, such as Mexico, have been affected by financial problems. Nevertheless, the prospects of the region are positive.

Radiopharmaceutical companies wishing to participate in this developing market must adapt to it. As in some Pacific Rim countries, the threat of patent infringement is a major concern for global companies doing business in Latin America. In several cases, local atomic agencies produce cheap radiopharmaceuticals of disputable quality. These same agencies routinely impose regulatory obstacles to protect their market share and avoid competition from radiopharmaceutical companies.

The South American radiopharmaceutical market hovers around \$28.5 million, or 2.5 percent of the world market. The market in this region is growing around 10 percent per annum, in the judgment of the radiopharmaceutical industry.

In South America, radiopharmaceuticals are priced differently than in the other three regions covered in this study. Mainly because of economic reasons, radiopharmaceutical companies cannot sell their products at the same prices as in the other regions. Companies also face strong competition from local atomic energy agencies that manufacture and distribute tracers.

The initial cost of the procedure hampers NMI's expansion into the less affluent healthcare markets. This is not to say that nuclear medicine has no future in developing regions. With the current transition to privatization, many countries, particularly in South America, find nuclear medicine a tempting imaging tool because of its cost-effectiveness.

Expansion is not far away if strategic actions are taken by the industry. More emphasis should be placed on developing new radiopharmaceuticals. In the developing world, with its large number of patients and physician base, the goals should be to raise public awareness of the benefits of nuclear medicine and to educate physicians.

Note: This is the second of a three-part series. Part 1 appeared in the February issue of *Newsline*. Part 3 will appear in a future issue.