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Avoidable challenges of a nuclear medicine facility in a developing nation

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ABSTRACT

The role of nuclear medicine in disease management in a developing nation is as impactful as it is in other regions of the world. However, in the developing world, the practice of nuclear medicine is faced with a myriad of challenges, which can be easily avoided. In this review, we examine the many avoidable challenges to the practice of nuclear medicine in a developing nation. The review is largely based on personal experiences of the authors who are the pioneers and current practitioners of nuclear medicine in a typical developing nation. If the challenges examined in this review are avoided, the practice of nuclear medicine in such a nation will be more effective and practitioners will be more efficient in service delivery. Hence, the huge benefits of nuclear medicine will be made available to patients in such a developing nation.

Keywords: Avoidable challenges, developing nation, nuclear medicine, Nigeria

INTRODUCTION

Nuclear medicine is the branch of medicine that uses the tracer principle, most often with radiopharmaceuticals, to evaluate molecular, metabolic, physiologic and pathologic conditions of the body for the purposes of diagnosis, therapy and research. It involves the use of suitable pharmaceuticals labeled with radioisotopes to form radiopharmaceuticals. This enables imaging of the body using a special device known as a gamma camera. Depending on the type of examination required, the radiotracers may be administered by injection, ingestion or inhalation. The resulting gamma emissions from the patient are captured by the gamma camera detector and the image is displayed on the acquisition computer. This process enables the study of physiological processes and diagnosis of abnormal conditions. Radioisotopes are used because of the penetrating and ionizing characteristics of the radiations emitted from their decaying atoms. In comparison to conventional radiology, diagnostic nuclear medicine is essentially a functional imaging process reflecting physiological processes, whereas conventional radiology aims predominantly at obtaining anatomical images reflecting form and structure.

Apprehensions about radiation exposure are common among the general public, but nuclear medicine procedures are relatively safe. Effective doses from ⁹⁹mTc based procedures are said to be within range of the values for plain film X-ray procedures. They are generally less than the range for computed tomography and do not exceed twice the average dose to the general population from natural background radiation. Moreover, these procedures are relatively painless and free of side effects. Benefits derived definitely outweigh the risks.

Penetrating radiation can produce physiological images of internal structures for the purpose of diagnosis. For therapeutic purposes on the other hand, radiation delivered to diseased cells disrupts normal cells moderately as the radiation delivered is mostly from β-particles which have quite a short range in tissue.

The practice of nuclear medicine has clinical applications in virtually all systems of the body, for example, the skeletal, cardiac, endocrine, oncologic, gastrointestinal and renal systems. The commoner nuclear medicine procedures in developing countries are the bone scan, thyroid scan and the renal scan respectively. Some nuclear medicine techniques are also performed in vitro. Examples of these are glomerular filtration rate estimation, the C-14 urea breath test, detection of occult blood loss and the Schilling's test.

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Another clinical application of nuclear medicine is in the field of oncology. Cancer is a major public health concern in our country. From observations at our nuclear medicine center, breast cancer is the most common malignancy observed in oncology referrals among Nigerian women. It is often associated with a poor prognosis for a variety of reasons especially late presentation. Prostate cancer remains the most common malignancy among oncology referrals for men in the country. These observations are in agreement with those of other authors.[7,8] The authors’ country has an estimated cancer incidence rate of about 100,000 new cases yearly,[9] but presently has only two functional public nuclear medicine facilities. These centres are inadequate to match the rising demand for nuclear medicine services especially in the management of cancer, cardiovascular and other non-communicable diseases in the country. To this end, factors which impede the smooth running of nuclear medicine services at these centres are discussed.

TECHNICAL CHALLENGES

Local unavailability of radioisotopes and kits

The “workhorse” of nuclear medicine is technetium-99m ($^{99m}$Tc) obtained from a molybdenum-99 ($^{99}$Mo)/$^{99m}$Tc generator. $^{99}$Mo is derived from nuclear fission reactions in nuclear reactors. Nuclear reactors are usually found in developed countries, such as USA, Canada, South Africa and some countries in Europe. Many developing countries do not have nuclear reactors and have to rely on imported generators and kits. Locally in the authors’ context, importation of these products is performed fortnightly or monthly. Importation, clearance and local transportation costs incurred in turn increase the cost of care for patients. Bureaucratic hitches with customs clearing issues also have to be surmounted each time the Mo-99/Tc-99m generator is procured.[10]

It is desirable that imported radioisotopes should have relatively long half-lives. Thus, cyclotron products such as fluorine-18 ($^{18}$F), carbon-11 ($^{11}$C) and iodine-123 ($^{123}$I) (with half-lives of 110 min, 20 min and 13 h, respectively) will not be available in these countries except at enormous cost to patients by ordering additional quantities of radioactivity (higher activity) to compensate for the short half-lives. This precludes the option of positron emission tomography (PET) imaging, as PET radiotracers are notoriously short-lived. A shortage of $^{99}$Mo/$^{99m}$Tc generators has experienced in recent times. Understandably, countries which produce these generators would then reduce their exports in order to satisfy local demands. This shortfall in exports in turn adversely affects their foreign clients.[6]

These challenges might be overcome if radiopharmaceutical production facilities were made available in these developing countries as obtains in the advanced world. This will also lead to saving of the foreign exchange for the importation of radiopharmaceuticals. Amendments of unnecessary aspects of government bureaucracy would also help.

In Nigeria, the Nigeria Atomic Energy Commission (NAEC) has begun plans for a new nuclear reactor. Although it is meant to help boost electric power generation, it is hoped that radioisotopes will also be produced from the reactor for use in nuclear medicine. Provision of small cyclotrons to provide nuclear medicine centers with desired radioisotopes is another way that this challenge might be overcome.

Electricity supply

In the authors’ experience, the national power supply is not dependable, erratic and prone to surges. There are frequent interruptions in power supply, necessitating the need for uninterruptible power supplies and fuel generator back-up. As such, establishments rely on alternate sources of power. These activities once again increase the cost of service delivery. Power cuts also have an adverse effect on equipment, leading to a shortened lifespan of these machines. Their maintenance and replacement subsequently become more frequent than obtains in environments with constant, reliable and adequate power supplies. Power cuts also interrupt air-conditioning, which is essential in order to maintain the optimal temperature of equipment and components of the gamma camera such as the sodium iodide crystal; this affects the performance of these equipments.[11] In a ripple effect, camera down-time also delays and suspends availability of services to patients and the necessary changes in patient management that these procedures might have provoked. Such delays, especially in cancer patients, have grave consequences. Improvement in public power supply in countries such as ours would go a long way in overcoming these challenges.

Infrastructure and equipment

Aged equipment

A recent survey published in 2011 by the International Atomic Energy Agency (IAEA) indicated that most gamma cameras in developing countries were over 6-year-old, with some even over 30-year-old.[8] In the authors’ own country, the two available gamma cameras have been in use since 2006, with these centres performing between 600 and 700 studies per annum. Aged equipment functions sub-optimally and spare part production for these machines have often been discontinued. Coupled with the issues addressed in the section under electricity, this factor is another cause of poor service in nuclear medicine units in some developing countries. Regular replacement of equipment and their parts in these developing countries through government support or a revolving fund system is recommended.

Local service centers

Another challenge in most developing nations is that the manufacturers of gamma cameras and other nuclear medicine equipment do not provide adequate local services. This creates difficulty in maintenance of equipment and results in substantial dependence on external technical support which consumes time and financial resources.[12] In order to improve the situation, it is therefore important to have locally trained personnel available for preventive and first-line maintenance to curtail equipment downtime during which patients suffer. This will also improve
communication between manufacturers and users of equipment when a break down occurs. In local practice, we have experienced situations whereby the service engineer for the gamma camera in use had to be contacted to come in from overseas several times to repair the gamma camera when it breaks down. The fees for such consultations by the engineer are usually huge. The cost is borne by the host department and ultimately increases the cost of service delivery to patients.

**Information technology**

There is a need for improvement in this field in developing countries if the benefits of the use of the internet in disease management can be derived from it especially in nuclear medicine practice. Teledmedicine communication between doctors and picture archiving and communication system are currently unavailable in many government health centres in developing economies. Telemedicine should be rapidly expanded to many hospitals, both government and private and hence that the benefits, which are enormous, will consolidate the efficiency of services provided by the few nuclear medicine physicians available in these countries.

**Medical physics equipment**

Another challenge faced in the practice of nuclear medicine in a developing nation is in the area of limited availability of basic equipment such as phantoms and some important radiation sources for quality control of equipment; radiation protection and medical physics research facilities. Furthermore, there is presently a dearth of workshops where some of these phantoms may be fabricated.

**Radiation safety**

Along with the practice of nuclear medicine is the attendant challenge of radiation safety. Each radiation worker is meant to be monitored for occupational radiation exposure. Personnel monitoring services in some advanced nations are provided by government agencies, such as the radiation regulatory agencies. However, this is not always the case; sometimes these services are provided by licensed companies which are basically profit oriented. Therefore, their charges for services rendered are more expensive, as experienced in the authors’ country.

The annual renewal of licenses issued by the radiation regulatory body (for importation of radionuclides and for practice) also adds to the financial burden as nuclear medicine centres have to source for funds to pay for these expensive renewals.

**Radioactive waste management**

The dearth of radioactive waste disposal facilities in some developing countries is a big challenge in nuclear medicine centres. Spent radionuclide generators accumulate over time, in contrast to practice in developed nations where these generators are recycled. Shipping of these spent generators back to the manufacturer for recycling will be capital-intensive since the burden of packaging and shipping would be borne by the centre.

Governments of developing countries can mitigate the challenge of radioactive waste disposal by making available radioactive waste disposal facilities up to the regional level, such that radioactive waste is properly disposed of. To the best of the authors’ knowledge, only the Centre for Research and Training Zaria has such a facility in Nigeria. Although NAEC is constructing a central facility at its complex in SHETSCO, Abuja, more of such facilities are needed across the country especially in areas where nuclear medicine and other radioactive waste generating centres are located.

**Level of radio-pharmacy practice**

Most radio-pharmacy units in developing countries operate at levels 1 and 2 standards. These are the most basic levels of radio-pharmacy practice, therefore, the quality control of radiopharmaceuticals and research capabilities are limited. Inadequately trained and insufficient personnel in this area also pose a big challenge to the practice of nuclear medicine in a developing nation. This is due to the paucity of local training programmes which can attract more personnel to this field. If training programs were available and necessary infrastructure put in place to improve the level of operation of radio-pharmacies in these developing countries, the challenges of substandard radiopharmaceutical practice would be overcome.

**HUMAN RESOURCE CHALLENGES**

**Referring clinicians**

It has been our observation that most referring clinicians are not adequately informed about the discipline of nuclear medicine. Of those who do, not all seem to be aware of current recommended protocols/good practice in the discipline. Inappropriate referrals have also been received, reflecting a need for further education of these clinicians. This is evident, for instance in the persistent practice of thyroidectomy without lymph node clearance in the management of thyroid cancer. In some centers, subtotal thyroidectomy or mere lobectomy is performed, making radioiodine ablation of these patients cumbersome.

In order to overcome these challenges, there is the need to commence at the foundational level of medical training by revising medical and allied student’s curricula to include introductory courses to nuclear medicine. There should also be a revision of postgraduate medical curricula across medical colleges to include relevant topics on nuclear medicine. Other suggestions include the development and maintenance of nuclear medicine websites, participation of nuclear medicine personnel in continuous medical education (CME) activities (grand rounds, seminar, conferences, for example), the formation of multidisciplinary hospital groups and the convening of regular interdisciplinary meetings, at which further education is provided about the role of nuclear medicine in clinical decision making.

**Training and research in nuclear medicine**

The need for highly trained professionals needed to practice nuclear medicine must also be stressed. There is a need for more nuclear
medicine physicians, medical physicists, imaging scientists (nuclear medicine technologists) and radiopharmacists. Currently, in the authors’ home country, there is no facility available locally for the training of these personnel. Personnel must be trained overseas, incurring relatively greater costs than would obtain if training in Nuclear medicine were to be done locally. As well, the ever-present problem of “brain drain” may result in the country losing qualified personnel to “higher bidders” in greener pastures.

Medical physicists play a significant role in the overall health care rendered by the nuclear medicine team. In their capacity as radiation safety officers, they are responsible for ensuring safe and reliable service to patients. It is evident that safe practice of radiation medicine in general and nuclear medicine in particular depends on well-trained medical physicists. The challenge today, especially for developing nations, is the large deficit of qualified and capable medical physicists. Inadequate recognition of medical physicists in developing nations results in the exodus of the few trained personnel from the field. The recognition of medical physics as a career path in these countries is necessary in order to ensure the provision of an excellent service that can guarantee a high quality of patient care.

Research projects in these situations are usually of a retrospective nature, due to limited allocations for research. We have earlier alluded to the cost of nuclear medicine studies; thus, funding for prospective studies will also be required in order to pay for the radioisotopes and other resources required. Access to current nuclear medicine literature – journals and texts – is another hurdle that academics face in a setting with limited resources, such as the one found in a developing economy.

To stem these challenges, apart from training personnel overseas, national projects should be developed toward planning and financing of local nuclear medicine training. Eventually, residency and other professional programmes in nuclear medicine would become available in such developing countries. In areas where national programmes are not feasible, regional training programmes may be conducted. Short-term training courses, such as the Africa Regional training courses organized by the IAEA in conjunction with participating countries are also good sources of CME. Institutional subscription to nuclear medicine journals will increase the availability of such literature to nuclear medicine personnel, providing CME and ensuring compliance with current good practice of nuclear medicine.

CHALLENGES TO PATIENTS AND THEIR CAREGIVERS

Cost of nuclear medicine services
The overall burden of constraints enumerated above directly impact on patients who because of lack of health insurance and inadequate insurance cover for nuclear medicine have to pay out of their pockets and from funds from relatives as seen in our centre. Therapy, in particular, has been delayed or deferred for many patients on account of the “prohibitive costs” of the procedures to such patients. For example, ablation of residual thyroid tissue with 3700 MBq (100 mCi) of iodine-131 ($^{131}I$) would cost approximately $2,500 (N400,000). This figure includes the cost of investigations in preparation for therapy. Meanwhile, the average monthly income of a sizeable proportion of citizens of this country is $62.50 (N10,000); this underscores the need for health insurance for patients. In addition to the need for health insurance for nuclear medicine patients, the cost of these procedures can further be reduced by government subsidy, establishment of foundations for nuclear medicine procedures by philanthropic individuals and organizations and the mitigation of the challenges that are responsible for the cost burden as enumerated above.

Quality of care/inadequacy of nuclear medicine facilities
The availability of only two Government Hospitals/Centers in the authors’ home country of an estimated population of over 170 Million people and an area of about 923,769 km$^2$ means that patients have to travel considerable distances to access care. The good news is that there are ongoing efforts by government agencies to increase the number of these facilities over the country in the near future. This would enable citizens to benefit more readily from this very important diagnostic and therapeutic modality of care. Strategic planning and localization of more nuclear medicine centres to cater for regional needs will also mitigate this challenge. Another way to stem this challenge is the purchase of mobile nuclear medicine units, which would visit hospitals on a rotational basis in order to cater for those areas without ready access to nuclear medicine facilities. This will be in place until more nuclear medicine centers are available to the populace.

GOVERNMENT SUPPORT

In the authors’ country, the health spending in the national budget of 2011 is estimated to be 1.6 billion U.S. dollars, which represents approximately 6% of the total national budget. This includes the federal budget (about $1 billion) and the states’ budget (about $0.6 billion). It is intended that this figure will be increased to 10% of the total budget in the near future. With limited allocation from the government, the challenges of health funding are enormous and therefore, there is the need for public-private partnership in the health sector as exemplified at the University College Hospital, Ibadan, where a building was donated by a philanthropist to house the nuclear medicine facility.

The current global economic crisis has not helped matters, as allocations to the health sector have largely remained paltry with only marginal increments, if any. Furthermore, continuity of projects is difficult to maintain; decisions made by successive governments keep changing bringing about more challenges to the practice of nuclear medicine in a country such as ours. To overcome this challenge, government need to increase allocations to the health sector substantially and there should be legislation...
to the effect that government projects cannot be overturned with impunity by government officials who take over from their predecessors, especially in the health sector, as is the case in our country.

**CONCLUSION**

Limited undergraduate and postgraduate teaching of nuclear medicine in our country coupled with lack of nuclear medicine techniques hitherto, means that many clinicians know little about how radionuclide techniques can contribute to the management of patients. Consequently, patients who would benefit from such procedures are not referred. When the above scenario is added to the general public’s phobia for radiation, the need for enlightenment workshops to increase the use of this technology cannot be overemphasized. Avoiding all the challenges enumerated in this review based on the recommendations made on how to avoid them will also greatly enhance the efficiency of the various professionals in the field of nuclear medicine. This will also lead to increased response of the specialty to the emerging needs in chronic disease and non-communicable disease, especially cardiovascular diseases and cancer management.

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