Assessing the Use of Nuclear Medicine Technology in Sub-Saharan Africa: The Essential Equipment List

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Objective: The primary aim of the survey was to determine the core equipment required in a nuclear medicine department in public hospitals in Kenya and South Africa, and evaluate the capital investment requirements.

Methods: Physical site audits of equipment and direct interviews of medical and clinical engineering professionals were performed, as well as examination of tender and purchase documents, maintenance payment receipts, and other relevant documents. Originally, 10 public hospitals were selected: 6 referral and 4 teaching hospitals. The 6 referral hospitals were excluded from the survey due to lack of essential documents and records on equipment. The medical and technical staff from these hospitals were, however, interviewed on equipment usage and technical constraints. Data collection was done on-site and counter-checked against documents provided by the hospital administration.

Results: A list of essential equipment for a nuclear medicine department in sub-Saharan Africa was identified. Quotations for equipment were provided by all major equipment suppliers, local and international.

Conclusion: A nuclear medicine department requires eight essential pieces of equipment to operate in sub-Saharan Africa. Two additional items are desirable but not essential.

Key Words: nuclear medicine technology; sub-Saharan Africa; technology assessment; essential equipment list

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Sub-Saharan Africa is facing challenging times. The population is growing, while economic growth in most countries is minimal or negative. In the face of increasingly limited resources, major reforms and restructuring are taking place in the health care system. Health care budgets are diminishing in real terms. Spending behavior in hospitals is under scrutiny, with issues of value-for-money and cost-effectiveness being raised in both private and public sectors. Much of the cost cutting in the public sector is directed at putting a lid on the use of high-technology medicine.

African countries need both preventive and high-tech curative technologies. The two groups of technologies are not mutually exclusive in a sustainable health care system. The challenge to governments in African countries is to make strategic technological choices to meet the health needs in primary, secondary, and tertiary health care. The use of nuclear medicine as a high-tech investigation tool is discussed.

MATERIALS AND METHODS

Equipment Survey

A survey was done in Kenya and South Africa during 1996–97 to establish the essential equipment for a nuclear medicine department in provincial (regional) and academic hospitals. The survey covered 10 hospitals in Kenya and South Africa. Each hospital was required to list the essential equipment for core services in a nuclear medicine department. The essential equipment list was developed after a physical equipment audit in four selected hospitals (two from each country) to establish the authenticity of the survey results. Interviews with nuclear medicine clinicians, radiographers, clinical engineers and technologists were performed to establish the appropriateness of equipment in the essential equipment list. The essential equipment list for a nuclear medicine department is shown in Table 1. To establish budgetary estimates, equipment quotations were requested from various suppliers.

RESULTS

A nuclear medicine department requires only about eight essential pieces of equipment to operate in sub-Saharan Africa. According to interviews with nuclear medicine clinicians and radiographers, a dual-head gamma camera and treadmill are desirable but not essential. If funds are available the two equipment systems are nice to have, especially in an academic hospital, but their inclusion will increase the initial capital investment from $436,835 US to about $1 million US. The budget assumes that civil and energy source installations are in place.

Groote Schuur Hospital in Cape Town was used as a benchmark in this study. The capital investment on the essential

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TABLE 1
Essential Equipment List for a Nuclear Medicine Department in Sub-Saharan Africa

Equipment	Quantity	Cost ($ US)*
Lean capital investment budget option		
Single-head gamma camera with all attachments	1	342,613.00
Dose calibrator	1	6,424.00
Centrifuge	1	2,142.00
Laminar flow cabinet	1	4,284.00
Radiation monitor	1	1,071.00
Radiation protection monitor (for personnel safety)	1	1,071.00
Film developer	1	14,990.00
Computerized data processing system (LAN system)	1	25,696.00
Well counter (for blood and urine samples)	1	2,120.00
Maintenance instruments (scopemeter, fault locater, multimeter, basic tools, etc.)		6,424.00
	Total	$436,835.00
Full capital investment budget option		
Dual-head gamma camera plus attachments	1	535,332.00
Exercise treadmill	1	8,566.00
	Total	$980,733.00

*Approximate exchange rates: $1 US = R6.20 (South African rands) $1 US = KSh61.87 (Kenyan shillings).

equipment was found to be approximately $430,411 US. The cost of radiopharmaceuticals averaged $85,653 US per year; the cost of maintenance and spare parts was about 12% of capital investment if both in-house staff and external maintenance providers are used. Cost maintenance is lower where in-house engineers are well trained and motivated. The competency of an in-house technical manager is of pivotal importance in the management of equipment installation, calibration, commissioning, warranty and supervision of external maintenance providers. Most of the nuclear medicine equipment has an average economic life span of 12 y with an effective utilization capacity of 10–12 h per day.

The basic minimum staff requirement in the nuclear medicine department is one nuclear medicine physician, one nuclear medicine radiographer and one clinical engineering technologist.

The clinical benefits to patients from nuclear medicine investigations far outweigh the capital outlay, especially when one considers that the majority of patients who visit a nuclear medicine department are already chronically ill people. Furthermore, in the case of academic hospitals, additional benefits are derived from training and research. Financial investment in a nuclear medicine department is modest compared to the radiology or radiation oncology departments. For example, at Groote Schuur Hospital, with an annual budget of $112 million US, the nuclear medicine department budget only constitutes 0.5% of the facility budget while the radiology and radiation oncology departments allocations are 3.6% and 3.2%, respectively.

Ironically, the nuclear medicine department was one of the departments targeted for closure in the effort to cut down hospital expenditures and yet its budgetary consumption is comparatively small when viewed against the clinical contributions and support it provides to other departments, such as surgery and radiation oncology. The lack of technology assessment information can lead to irrational decisions by governments and hospital administrators. Figure 1 shows a typical budgetary distribution in a 1175-bed teaching hospital in sub-Saharan Africa.

Although not all countries of sub-Saharan Africa present exactly the same set of health problems, and markedly different stages of socioeconomic development can be identified, their health sector is characterized uniquely by mortality rates that are consistently worse than what usually is observed in the richer countries (*1*). This observation holds for classical indicators (life expectancy, bed occupancy rates) and infectious and parasitic diseases, and chronic diseases are becoming glaringly significant causes of death which before were regarded as exclusive to industrialized nations. This latter group includes cardiovascular diseases, renal diseases and lung cancer. These diseases demand the investigative techniques of nuclear medicine.

It is this commonality of health problems in the region that makes the authors believe that, although the equipment survey was performed only in two sub-Saharan African countries, the essential equipment list for a nuclear medicine department, with minor adjustments, is applicable to other countries in sub-Saharan Africa.

EQUIPMENT SELECTION AND PROCUREMENT

The selection of equipment with respect to manufacturer, model type, and so on should be based not only on its suitability for the particular procedures to be performed, as judged from its technical specifications, but also on such considerations as its

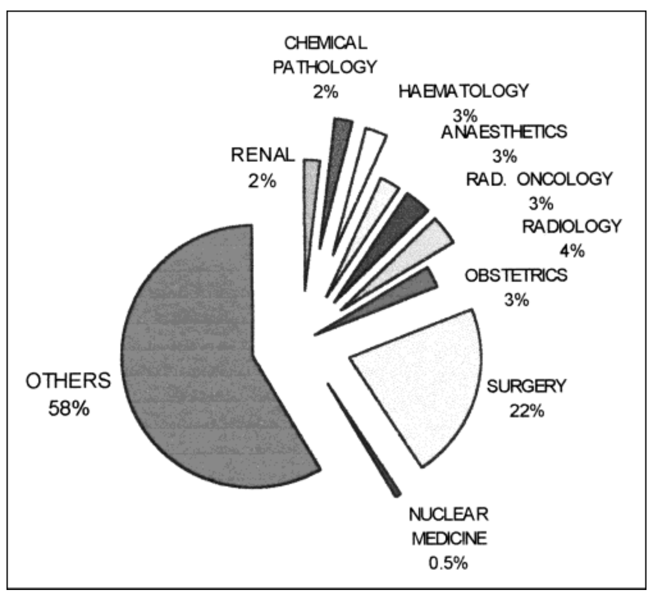

FIGURE 1. A typical budget distribution in a teaching hospital. (Diagram courtesy Groote Schuur Hospital, Cape Town, South Africa.)

ease of use, reliability, safety, compatibility with other equipment and other interface systems, the organizational support infrastructure, the technical expertise available for its maintenance, and the availability of spare parts. Technical advice on these points is often needed. The experience from other hospitals with similar equipment can be valuable.

Much care is necessary in negotiating an equipment purchase. Full technical specifications should be solicited from manufacturers. Such specifications should cover all components in the equipment, and all options, and should include: power supply requirements (phase, voltage and frequency); operational limitations as to temperature, humidity, etc.; requirements for expendable items, such as films and magnetic tapes; availability of such items locally; and there should be compliance with national or international standards. Quotations should indicate the price and terms: the date, mode and cost of delivery; the nature and duration of warranty; and cost of specific coverage of service contracts. The quotations also should include: the manufacturer's arrangement for installation; the accessories, spare parts, manuals, test instruments and consumables to be provided; the training and its location to be given to different categories of staff; the servicing facilities and personnel available; and the supply of spare parts. Further, the quotation should detail the purchaser's (hospital's) arrangements for testing, the minimum acceptable performance characteristics, and the action to be taken if these are not met. The hospital's equipment committee, user department, clinical engineering department, and/or the tender board should compare quotations from different suppliers with this in mind.

The wise purchaser will examine especially the servicing facilities and technical backup offered by different manufacturers or their representatives. The maintenance of equipment, including the supply of spare parts, must be anticipated for its expected economic life span. The purchase price is an unreliable guide as to what may be the actual total cost of equipment to the hospital, yet most tender boards' decisions are more often than not based on the purchase price because of lack of economic and technical evaluation information on the equipment. The more realistic guide when considering what factors to include in cost comparisons of competing equipment is the cost of ownership. Cost of ownership encompasses all direct and indirect expenses associated with the equipment over its economic lifetime (*2*).

It is essential that fully updated operation and service manuals accompany all equipment. Special tools, testing meters and other items needed for maintenance procedures also should be purchased with the equipment.

Purchase orders should define clearly the equipment's technical and performance specifications, and should again indicate: the price and terms; the date, mode and cost of delivery; the arrangements for installation, calibration and acceptance testing; the minimum acceptable performance characteristics and the action to be taken if these are not met; the nature and duration of the warranty; the accessories, spare parts, manuals, test devices and expendables to be included; the training to be given; and the service contract involved. To have a total understanding of the equipment needed, the purchase orders should be prepared by administrative and technical staff in close consultation with the nuclear medicine physician.

EQUIPMENT INSTALLATION

The installation of equipment is determined largely by its expected use in relation to work patterns within the hospital or department. The availability of space, electrical power supplies, and environmental factors, such as temperature, humidity and air pollution, should be taken into consideration.

The availability of sufficient space for the equipment seems an obvious requirement, but consideration also should be given to the separate needs of clinical practice, quality testing and maintenance procedures, especially if these involve the use of other equipment and interface systems in conjunction with the equipment.

Poor quality of electrical power is recognized as a major cause of equipment malfunction and failure (*2,3*). This has been identified as the main source of equipment failure in African countries with unstable electrical power systems. Power supplies must, of course, match equipment specifications with regards to phase, voltage and frequency. When deemed necessary, additional protection against poor-quality power should be provided through power conditioners incorporating constant voltage transformers, which suppress voltage fluctuations and surges and filter out transients and noise. Unreliable power supply systems and power failures are common problems in many countries of sub-Saharan Africa.

DISCUSSION

Technologies of acute care medicine (generally known as high-technology medicine) are the forms of health care technology that receive the most discussion and generate the most controversy in the popular news and electronic media. These ''big ticket'' technologies include the intensive care equipment, nuclear medicine instruments and kidney transplants.

In any developing country, the overriding goal of the government should be to minimize, or significantly reduce, the levels of morbidity and mortality in its population. High-technology medicine and preventive care are distinguished as different methods of attaining this goal. High-technology medicine includes all the types of medical care that attempt to restore health and normal functioning to an individual after illness or disability already has occurred. Nuclear technology belongs to this class. Preventive health care is based on a completely different premise. It includes all types of health care that prevent or significantly delay the occurrence of illness and disability in the first place.

These two groups of technologies lie at the extreme ends of the health care spectrum. The ideal at which preventive medicine aims, and which it will never attain entirely, is to make high-technology medicine unnecessary. This is not possible even in developing countries where preventable infectious diseases are still a major threat. The lifestyles in the urban centers of developing countries are rapidly becoming replicas of the lifestyles in the industrialized world and, along with them, have come chronic diseases that need high technology for investigation and treatment.

Health care systems in developing countries need both preventive and high-technology care, although in different proportions. The proportionality of investments in these two groups of technologies differs from country to country depending on available health resources and the national disease profile.

The general goal of health planners in developing nations has been to shift health care away from physician specialists to primary health care givers with a hope of reducing health costs. It has been rightly argued (*4*) that the claim that the bulk of health expenditures in referral and academic hospitals is used for high-technology medicine services is rather misleading, because teaching hospitals deliver a relatively small volume of high-technology services and a considerable volume of community services. Through historically well-established health referral systems, these hospitals receive and cater to not only most of the chronically ill, but also socially disadvantaged, patients from the district and community hospitals.

An independent facility (referral hospital) -based study (*5*) in Kwazulu-Natal Province, in South Africa, covering 350 inpatients and 150 outpatients, showed that hospitalization accounted for the largest costs (42.3%), followed by drugs (19.5%), intravenous fluids (15.4%), laboratory investigations (12.9%), radiology (10%) and others (4.4%). During the field study in Kenya and South Africa, the authors found a similar cost distribution.

One fact that must be recognized in the developing nations is that teaching hospitals are state institutions. These hospitals receive and cater to the poorest of the poor. Such patients are expensive to treat, monitor treatment progress in, and rehabilitate. The bulk of health care expenditures in these institutions can be attributed to hospitalization and care, rather than high-technology services.

The challenge for developing countries is to select technologies that meet the broad range of the national disease pattern, covering primary, secondary and tertiary health care. Nuclear medicine has developed a diagnostic niche in secondary and tertiary health care. Diagnosis is a first step on the long journey of health care. A key purpose of health care is therapy. But accurate diagnostic information can assist the physician in making the best choice of therapy. Early and accurate diagnosis of disease usually reduces the cost of health care. Advances in nuclear medicine will add more value to modern medicine and health care services in developing countries if appropriate technological choices are made and management capacity is improved.

Limitations of This Survey

The main limitation was that this survey could cover only two countries and was limited to the public sector due to lack of funds. Inclusion of for-profit hospitals would have provided data for comparative analysis of technical and allocation efficiencies. It also would have given insight into functional indicators for equipment, such as availability and failure rate, for comparative analysis of equipment use and cost-effectiveness.

Other limitations were the inadequate equipment records in some hospitals and a total lack of equipment inventory management systems in most hospitals. Documents from several departments, finance, purchase and clinical engineering, had to be compared critically to establish actual capital investments on equipment and maintenance expenditures.

CONCLUSION

There is a myth, among health planners and policy makers in African countries, that nuclear medicine technology is not only expensive, but also does not offer much health benefit to the majority of the population. The argument goes on to suggest that a better health status could be achieved by investing more in primary health care.

The question is, what do we do with the already chronically ill patients in developing countries? First, disease and illness are not optional, be they infectious or chronic. Second, diseases become chronic due to the failure or nonexistence of preventive measures or early cure. Surely, even though palliation and postponement of death are not as good as prevention and cure, they are better than nothing. The state should fulfill its social obligation to its citizens, especially the poor and the disadvantaged, by providing specialized health care services.

Technology for preventive care and curative services should be balanced based on the national disease pattern and health needs. Preventive health care and curative care are not mutually exclusive, and, therefore, technological investments in both areas should be geared towards health service synergy. Preventive and acute care services are part and parcel of a sustainable health system.

Although allocation of scarce health resources remains a fundamental issue in health care in most African countries, it is important that both ends of the health care spectrum be strategically funded to enhance the free flow of patients through the primary, secondary and tertiary health referral chain. Imbalance in funding of either end is bound to create a service bottleneck in the health care system.

With growing populations and severe economic constraints, the issue of value for money and cost-effectiveness of health care services is more urgent in sub-Saharan Africa than any other region in the world. In such a socioeconomic environment, nuclear medicine techniques increase specificity, certainty and quantifiability of diagnosis, and better decision making about treatment and it is a cost-effective way to monitor whether the treatment is helpful or not. Today it is in the economic interest of patients, their families, the public and health care providers to evaluate the cost-effectiveness of diagnostic and therapeutic procedures. It is evident that uncertainty is what makes medical care so expensive.

The problems with health care technology investments in developing nations have more to do with technology assessment and management rather than with the technologies themselves. The common problems are:

1. Poor technology selection and procurement;
2. Mismatch of technology and available human resources and expertise;

3. Lack of strategic synchronization of new technology with existing technologies and services; and
4. Lack of planning of budgetary support for maintenance services and spare parts, training of users and clinical engineering staff, and other operating costs.

Most of the problems are organizational and financial and have nothing to do with clinical quality and benefits derived from nuclear medicine technology. It must be recognized that management inefficiencies negatively influence the cost-effectiveness of technology-oriented medical services.

The disease spectrum in developing countries is slowly changing from an infectious to a chronic bias, especially in urban areas, because of a change in lifestyles. This will increase the demand for more clinical investigations of the various physiological systems and essential organs, where nuclear medicine techniques are the methods of choice.

African countries cannot afford to screen themselves out of modern advances in nuclear medicine technology because of lack of technical management capacity. Strengthening the management of technical organization and equipment maintenance is one of the several health system reforms needed to achieve health goals in Africa. It is becoming more and more evident that nuclear medicine technology has a significant role to play in the modern medicine and health services in sub-Saharan Africa. The challenge to African governments is to make wise and strategic technological choices and to manage the health care services more cost-effectively.

In many countries in Africa, the clinical practice of nuclear medicine languishes due to lack of equipment, specialists and training programs. But even in countries where equipment is available, the budgetary support for equipment maintenance, spare parts, quality assurance and purchase of radiopharmaceuticals remains a problem. Poor budgetary support can be attributed to a lack of awareness by health planners on the benefits and cost-effectiveness of nuclear medicine diagnostic and treatment techniques.

Although most African countries are net importers of nuclear medicine technology, a country with an emerging industrial base, such as South Africa, has the capacity to manufacture basic instruments such as dual-channel spectrometers, manual well counters and survey counters (*6*). The Atomic Energy Corporation of South Africa is capable of ensuring the quality of manufacture. Long-term sustainability of health care services in African countries can be achieved only through planned and managed health care technology transfer from industrialized countries to African countries.

Individual nuclear medicine organizations and departments in African countries have received great support from the International Atomic Energy Commission (IAEC), in Geneva, in upgrading instruments, documentation and personnel training. It is reassuring to note that under the auspices of IAEC, the international nuclear medicine community has developed sustainable professional networks with nuclear medicine institutions in developing nations.

To make people aware of nuclear medicine practice, especially in developing nations, nuclear medicine scientists and practitioners must learn to disseminate information on the clinical benefits and capabilities of nuclear medicine techniques in a language understood by health policy makers and planners. It is only then that decision makers and the public will see the worth of nuclear medicine and provide appropriate funding. Health care budgetary allocations are based on statistics and politics. Nuclear medicine seems to be winning on the statistical battlefront, but more remains to be done on the political front. If this is not done urgently and efficiently, then the practice of nuclear medicine will remain the best kept secret of medicine.

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