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Quality Assurance in Diagnostic Medical Exposures in Ghana - A Medical Physicist's Perspective

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<http://dx.doi.org/10.5772/51445>

1. Introduction

It is well known that medical exposure procedures such as diagnostic radiology, nuclear medicine and radiotherapy remains the largest source of man made exposure to ionising radiation and continues to grow substantially. This makes the role of quality assurance (QA), an important tool in medical exposure procedures. This paper reviews the future of quality assurance in diagnostic medical exposures in Ghana from the perspective of a Medical Physicist, since a viable QA programme must be developed under the guidance and supervision of a medical physicist who is qualified in this area of expertise by education, training and experience. The Medical Physicist is expected to give guidance and supervision to the Technologists and other staff to execute the programme but should be prepared to perform higher level QA procedures as required. The focus of this review is on diagnostic radiology since it is the dominant mode of medical exposure as compared to nuclear medicine and radiotherapy procedures in Ghana as per the database of the Regulatory Authority Information System "(RAIS)" of the Radiation Protection Institute. It is also worth noting that most of the issues under consideration for discussion mirrors similar conditions in many developing countries. The main goal of a diagnostic quality assurance programme is to make sure that radiation doses to patients, staff and public are as low as reasonable achievable (ALARA) consistent with high quality diagnostic images of patients. An adequate diagnostic QA program involves periodic checks of all major components in the respective diagnostic imaging modalities. On the other hand, an optimum QA programme for any individual diagnostic facility will depend on some items such as the type of procedures performed, type of equipment utilized, patient workload, etc. The current scope of diagnostic imaging procedures in Ghana covers conventional, fluoroscopy, dental, computed tomography, interventional procedures and nuclear medicine scans. Interventional radiology procedures performed are

quite few but the future looks promising in this field. The performance of QA practices are done on three fronts; namely at the hospital, equipment engineers and the Regulatory Authority (RA). The hospital based QA are done mainly by the Radiographic Technologist through their routine equipment warm ups and minor quality checks. Equipment Engineers perform engineer related QA checks through installation and acceptance testing, performance tests and periodic preventative maintenance procedures. On the other hand, the RA is largely in charge of major QA procedures through it's on site safety assessment inspections by assessing the compliance of the equipment within regulatory requirements. This is largely so because the RA has the technical expertise and equipment. Due to the expansion of diagnostic imaging procedures in medicine coupled with rapid technological advances, the availability of qualified and trained personnel is crucial if the desired quality is to be achieved. Some measures have been put in place for human resource development, but there is room for improvement. On the way forward, there is a strong need for the establishment of National Quality Control Centre for Diagnostic Radiology. This body must be equipped with the requisite state of the art equipment, highly qualified and trained personnel in order to coordinate all QA activities in the country. Such a body can initiate some guidelines on the minimum instrumentation requirements for all imaging modalities. Nevertheless, a good QA programme is not a guarantee for the assurance of the radiation safety of patients, staff and public. What is also needed is a separate radiation safety programme, which is very essential in every diagnostic imaging facility and must also be under the direction of a qualified expert in radiation protection.

2. Overview of quality assurance

The 2008 United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report on medical exposures from the assessment of the global population dose from medical exposures for the period 1997-2007 indicates that medical exposure remains the largest source of man made exposure to ionizing radiation and continues to grow substantially. (UNSCEAR, 2008). A summary of the annual per caput effective dose to the global population due to all sources of ionizing radiation is illustrated in Table 1.

It is evident that diagnostic examinations result in a per caput effective dose of 0.66 mSv, while medical exposures now contribute around 20% of the average annual per caput dose to the global population. Medical exposures are defined as; (i) exposure of patients as part of their medical diagnosis or treatment; (ii) exposure of individuals as part of health screening programmes; and (iii) exposure of healthy individuals or patients voluntarily participating in medical, biomedical, diagnostic or therapeutic research programmes. These exposures include diagnostic radiology, nuclear medicine and radiation therapy (Fig. 1), out of which diagnostic radiology accounts for the largest contribution. Diagnostic radiology generally refers to the analysis of images obtained using x-rays. In nuclear medicine, a radiopharmaceutical is administered to the patient and concentrates primarily in a specific region of the body which allows: (i) external imaging of the body to evaluate structure and/or function, and (ii) or delivery of a large radiation dose to control a specific disease. Radiation therapy

involves the use of intense radiation beams and high-activity sources for the treatment of many types of cancer.

Source	Annual per caput effective dose (mSv)	Contribution (%)
Natural background	2.4	79
Diagnostic medical radiology	0.62	20
Diagnostic dental radiology	0.0018	<0.1
Nuclear medicine	0.031	1.1
Fallout	0.005	<0.2
Total	3.1	100

Source: UNSCEAR 2008 report on medical radiation exposures. (UNSCEAR, 2008).

Table 1. Sources of ionizing radiation and the annual per caput effective dose to the global population.

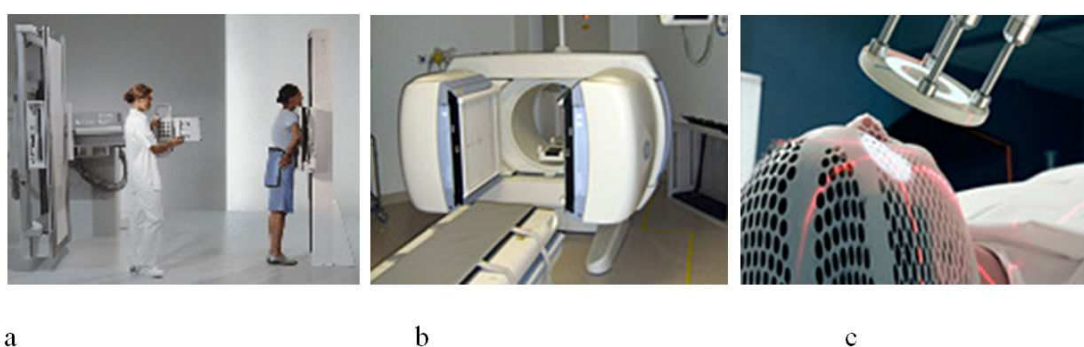


Figure 1. An illustration of (a) diagnostic radiology, (b) nuclear medicine and (c) radiation therapy procedures.

This makes the role of (QA), an important tool in medical exposure procedures. Quality assurance procedures must aim at to produce images of optimal diagnostic quality while ensuring that the radiation exposures to patients, staff and the public are kept as low as practicable. In achieving this goal, QA procedures if well implemented would ensure that any problem in the imaging chain will be dealt without a compromise in the diagnostic quality of the images. The World Health Organization (WHO), (WHO, 1982), indicates that achieving adequate diagnostic information and least possible exposure of the patient to radiation should be done at the lowest possible cost. An adequate diagnostic QA program involves periodic checks of all major components in the respective diagnostic imaging modalities. On the other hand, an optimum QA programme for any individual diagnostic facility will depend on some items such as the type of procedures performed, type of equipment utilized, patient workload, etc. Any QA procedure must be in agreement with the relevant national and international legislation or regulations on the protection and safe uses of ionising radiation. Another form of QA is to establish clinical audit, which is an essential

tool for quality improvement in any diagnostic centre. For instance, the European Council directive (Commission of the European Communities, 1997) defines clinical audit as: “a systematic examination or review of medical radiological procedures which seeks to improve the quality and the outcome of patient care, through structured review whereby radiological practices, procedures, and results are examined against agreed standards for good medical radiological procedures, with modifications of the practices where indicated and the application of new standards if necessary.”

This paper reviews the future of quality assurance in diagnostic medical exposures in Ghana from the perspective of a Medical Physicist, since a viable QA programme must be developed under the guidance and supervision of a medical physicist who is qualified in this area of expertise by education, training and experience. The Medical Physicist is expected to give guidance and supervision to the Technologists and other staff to execute the programme but should be prepared to perform higher level QA procedures as required.

3. Current status of quality assurance in diagnostic medical exposures

The types of diagnostic medical exposure procedures in Ghana are;

- Plain radiography
- Mammography
- Fluoroscopy
- Computed Tomography
- Dental

In addition to the above procedures for diagnosis, some hospitals perform interventional or invasive procedures on a limited scale. On the other hand, the types of medical exposure in nuclear medicine procedures are the use of gamma camera and single photon emission computed tomography (SPECT/CT) for imaging various organs. Plain radiography (screen-film and digital systems) is the dominant mode of all the diagnostic medical procedures, accounting for more than 80% of the total contribution of all the imaging modalities. (RAIS, 2011).

The performance of QA practices are done on three fronts; namely at the hospital, equipment/service engineers and the (RA). The hospital based QA are done mainly by the Radiographers/Radiologic Technologist through their routine equipment warm ups and minor quality checks. In this scenario, a qualified Medical Physicist with the requisite expertise must supervise such QA procedures. Unfortunately, there are not many Medical Physicists in diagnostic departments as compared to radiation therapy centres. Equipment/service engineers perform engineer related QA checks through installation and acceptance testing, performance tests and periodic preventative maintenance procedures as well as when there is equipment down time. On the other hand, the RA is largely in charge of major QA procedures through it's on site safety assessment inspections by assessing the compliance of the

equipment within regulatory requirements. This is largely so because the RA has the requisite technical expertise and equipment.

In Ghana, Medical Physicists are engaged in service, teaching, research and administration activities. They perform some of the tasks outlined by the International Organisation for Medical Physics (IOMP) in its definition of who a Medical Physicist is and the roles and responsibilities (International Organisation for Medical Physics, 2010) such as:

- teaching principles of medical physics to physicians, residents, graduate students, medical students, technologists, and other health care professionals by means of lectures, problem solving, and laboratory sessions.
- conducting research into various human disorders, illnesses and disabilities, develop instrumentation, mathematical analysis and applications of computers in medicine; investigating biophysical techniques associated with any branch of medicine. Research is very important for advancement of medical physics as a profession and science.
- responsible for ensuring the quality, safety testing and correct maintenance of all radiation emitting devices in order to get an accurate diagnosis of illnesses. Medical Physicists also involved in the formulation of radiation protection guides and procedures specific to clinical environment and producing protocols to minimize radiation exposure of patients, staff and the general public.
- in administration, they supervise and manage radiation workers and other health professional workers.
- participating in and contributing to the development and implementation of national and
- prepares guidance on education and training drawing-up standards and guidance relating to medical devices.
- preparing, publishing and presenting scientific papers and reports

Ghana is involved in several International Atomic Energy Agency (IAEA) Technical and Research Projects. Some of the Projects in which Medical Physicists are involved are:

- RAF/9/033 - Strengthening Radiological Protection of Patients and Medical Exposure Control.
- RAF/9/034 - Establishment of National Capabilities for Response to a Radiological and Nuclear Emergency.
- RAF/9/035 - Education and Training in Support of Radiation Protection Infrastructure.
- RAF/9/032 - Development of Technical Capabilities for the Protection of Health and Safety of Workers Exposed to Ionizing Radiation.
- RAF/9/027 - National Regulatory Control and Occupational Radiation Protection Programmes.
- RAF/9/031 - Strengthening National Regulatory Infrastructure for the Control of Radiation Sources.

- GHA/6/015 - Upgrading and Expansion of Radiotherapy and Nuclear Medicine Services
- INT/6/054 - Strengthening Medical Physics in Radiation Medicine
- RAF/2/008 - Strengthening and Expanding Radiopharmacy Services in Africa (AFRA)
- RAF/6/032 - Promoting Regional and National Quality Assurance Programmes for Medical Physics in Nuclear Medicine (AFRA II-7)
- RAF/6/041 - Supporting the Development of Comprehensive National Cancer Control Programmes
- RAF/6/044 - Medical Physics in Support of Cancer Management (AFRA II-8)
- RAF/6/045 - Enhancing Accessibility and Quality in the Care of Cancer Patients (AFRA II-10)

The main objectives of some of the projects are discussed. For instance in RAF/9/033, the objectives are to upgrade / strengthen radiological protection of the patient in medical exposures due to:

- i. Diagnostic Radiology and Interventional Radiological procedures
- ii. Nuclear Medicine procedures
- iii. Radiotherapy practice

The objectives of other projects are as follows:

- GHA/6/015 - To consolidate existing radiotherapy and nuclear medicine facilities at two leading Teaching Hospitals located in the southern part of the country, and establish a third one in the northern part to cater for the diagnosis, curative and palliative treatment of cancer patients and the efficient diagnosis and management of other diseases.
- INT/6/054 - To promote the recognition of medical physics in radiation medicine and to harmonize educational material in order to ensure safe and effective diagnosis and treatment of patients.
- RAF/2/008 - To strengthen radiopharmacy in support of in vivo and in vitro nuclear medicine in Africa.
- RAF/6/032 - To improve the effectiveness and safety of nuclear medicine procedures by providing support for design and implementation of quality assurance (QA) programmes and by establishing training and education programmes in medical radiation physics, focusing on aspects related to the application of nuclear medicine techniques.
- RAF/6/041 - To assist Member States in performing comprehensive cancer capacity need assessments and national cancer strategic planning via collaboration with IAEA, WHO, and other partners under the Programme of Action for Cancer Therapy (PACT) umbrella.
- RAF/6/044 - To strengthen national and regional medical physics capabilities to ensure efficient support of cancer management in AFRA Member States and to sustain quality as-

urance/quality control (QA/QC) programmes, including the promotion of safety culture and innovative practices in dosimetry.

- RAF/6/045 - To establish national and regional networks in clinical radiation oncology. To interact with National Organizations with the aim to promote the comprehensive management of commonest cancers. Support academic education, training and accreditation, patients and personnel safety in radiotherapy improvement of documentation of clinical outcomes through regular patient assessment.

4. Regulatory guidelines for quality assurance procedures

The National Competent/Regulatory Authority in Ghana charged with the responsibility for authorization and inspection of practices using ionizing radiation sources and radioactive materials is the Radiation Protection Board (RPB) (Radiation Protection Instrument LI 1559, 1993). However, the operational functions of the RPB are carried out by RPI, which was established in 2000 to provide scientific and technical support for the enforcement of the provisions in LI 1559. Details about how the RA was established and the main activities have been described elsewhere (Inkoom et al, 2011). There are plans to establish a new Regulatory Body to regulate the peaceful uses of nuclear energy and technology which will be independent of any governmental agency. Currently, the RA is answerable to the Ghana Atomic Energy Commission (GAEC) which is a promoter for the peaceful uses of nuclear energy and technology and also plays the role of a regulator. However, the new RA is expected to be only a regulator and not a promoter of the application of nuclear technology.

5. Human resource development

The categories of Radiographic Staff available in Ghana are Radiologists, Medical Physicists, Biomedical Engineers and Radiographers/X-ray Technicians. Most of our Radiologists were trained overseas until the last few years when local training of Radiologists started and the accreditation is given by either the Ghana College of Surgeons or the West African College of Physicians and Surgeons. Similarly, the other professionals were also trained overseas. Currently, the School of Allied Health Sciences (SAHS), College of Health Sciences (CHS) of the University of Ghana (UG) is responsible for churning out medical and dental technical graduates in physiotherapy, medical laboratory science and radiography. There are plans to establish another Allied Health University and some private institutions are also running some of the programmes. A Post-Graduate School of Nuclear and Allied Sciences which was established jointly by the GAEC and UG, in co-operation with the IAEA is training the Medical Physicists, Radiation Protection Professionals, Nuclear Engineers, etc. at the National and Sub-Regional levels.

6. Recent trends in quality assurance

The increasing expansion of diagnostic imaging procedures in medicine coupled with rapid technological advances makes the availability of qualified and trained personnel to be very crucial if the desired quality is to be achieved. This comes with a lot of challenges to the medical imaging community. This offers practitioners the opportunity to continually undergo retraining and other continuous professional development programmes in their respective fields. Also with the emergence of picture archiving and communication system (PACS) in many hospitals, there is the need for the development of appropriate on-line QA procedures and in incorporating them into hospital PACS systems. Special attention must also be given to the emergence of digital technology over the last decade as one of the greatest technological advances in medical imaging. This new technology poses a great challenge in medical imaging, requiring re-training of staff on the safe use of equipment and radiation protection issues. In Ghana for instance, the RPI of GAEC, in collaboration with the IAEA, has in the previous years developed a lot of expertise in the training of occupationally exposed workers in Ghana and the rest of Africa, spanning a period of almost two decades (Boadu et al. 2011). This local expertise in training can be tapped. In this regard, a critical review of all QA procedures that were developed for screen-film systems needs special attention.

7. The way forward

Various practitioners in the medical imaging community must brace themselves in order to face challenges of technological developments. With the advent of digital radiography: advances in computed radiography, direct digital radiography, digital subtraction angiography, new digital receivers, image processing techniques, computer applications in radiology and PACS offers enormous challenges. The advantages of digital technology: post-processing capabilities, decreased costs, multiple viewing options, electronic transfer, possibilities of archiving, wide dynamic range of flat panel detectors and increased detection quantum efficiency has led to a high demand of this technology by the medical imaging community. Therefore, the development of the requisite human resource must be continued and sustained in order to deal with the challenges.

There is a strong need for the establishment of National Quality Control Centre for Diagnostic Radiology. This body must be equipped with the requisite state of the art equipment, highly qualified and trained personnel in order to coordinate all QA activities in the country. Such a body can initiate some guidelines on the minimum instrumentation requirements for all imaging modalities. With the training of more Medical Physicists and Radiation Protection Professionals, it is expected that they would take up positions

in all major hospitals which have a myriad of imaging modalities. The Ghana Society of Medical Physics, RA, Ministry of Health and other stakeholders must initiate procedures for the establishment of Medical Physics Departments in such hospitals. This would give the necessary recognition to the profession of Medical Physics in Ghana, which has been given recognition by the International Labour Organization (ILO) in its International Standard Classification of Occupations (ISCO) (ILO, 2008). With this recognition, Medical Physics has been accepted as modern applied branch of physics. Clinical audit should also be incorporated in the overall QA procedures in the country.

As the uses of ionizing radiation continue to increase in medicine, it is also expected that the services of Medical Physicist would increase. As such, more physicists would be required to be trained in subsequent years. Appropriate accreditation bodies charged with issuing accreditation certificates, for a period of years must be put in place to regulate the profession of Medical Physics and maintain international standards of practice.

8. Conclusion

The role of an effective QA programme in any diagnostic department cannot be overemphasized especially if the desired quality of producing good diagnostic images and the least radiation exposure are to be achieved. Nevertheless, a good QA programme is not a guarantee for the assurance of the radiation safety of patients, staff and public. What is also needed is a separate radiation safety programme, which is very essential in every diagnostic imaging facility and must also be under the direction of a qualified expert in radiation protection or a Medical Physicist expert. With significant contributions in clinical service, education, and research, Medical Physics continues to grow in importance both as a profession and as science, driven by the technological developments of societies in general and medicine in particular.

Acknowledgements

The support received from the Radiation Protection Institute of Ghana Atomic Energy Commission is appreciated.

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