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Sustainable development and radiology

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ABSTRACT

Purpose: The purpose of this study is to highlight the relationship between radiology and sustainable development, with an emphasis on the UK and European countries, and to spotlight its possible application in developing countries.

Methodology: This is a review article where data about sustainable development and radiology are collected from selected journals, websites, articles and conferences, for example, Royal College of Radiology (RCR), European Society of Radiology (ESR), WHO and other different radiology societies.

Findings: In Europe and the UK, most medical and radiological organisations adopt and support sustainable development to allow people to live in a healthy environment. This trend is new in developing countries.

Practical implications: Limiting the use of radiologic examinations, guiding the clinicians to use clinical skills before rushing to radiology examinations, will save money, preserve equipment and protect patients from possible radiation hazards. The use of teleradiology will indirectly reduce global warming, and will deliver medical services to poor countries.

Social implications: Improving the health of people in poor countries will improve their socioeconomic level.

Originality: This article focuses on the value of applying sustainable development in radiology, not only in general medicine.

***Keywords*:** radiology; sustainable development; teleradiology; developing countries; Europe; radiation hazards.

INTRODUCTION

This is a review article covering the following points: a short note about sustainable development, an overview of radiology as an important branch of medicine, the relationship of radiology to the society, economics and environment. We will then try to find a relationship between radiology and sustainable development with some examples from Europe and how it has been applied in the UK. Following this, we move into a major problem in radiology that may affect human health, society and environment, which is the overuse of radiologic diagnostic tests, and suggest solutions for this problem. The last part of the paper covers sustainable diagnostic radiology in developing countries, and how it could be provided; this includes teleradiology with its advantages and disadvantages.

SUSTAINABLE DEVELOPMENT

The World Commission on Environment and Development (WCED), presented in 1987 states that "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Sustainable development means that social, environmental and economic developments are going to be achieved within the limits of the natural resources (un.org).

WHAT IS RADIOLOGY?

Radiology is a crucial component of medicine that is of major importance to medical practitioners, healthcare workers and health policy makers. Essential diagnostic technologies are considered an integral component of primary healthcare by the World Health Organisation (WHO) (Jha and Tahvildari, 2015). Radiological investigations include imaging using ionising radiation, including X-rays, Fluoroscopy, Computed Tomography (CT) and nuclear medicine, and imaging using non-ionising radiation, including Ultra Sound (US) and Magnetic Resonance Imaging (MRI). Radiology includes diagnostic imaging and image-guided intervention procedures that could replace many sophisticated

surgical interventions, thus reducing the length of time a patient stays in hospital, hazards of general anesthesia and all possible post-operative complications. Most radiology investigations are expensive, need costly infrastructure and expert personnel, including radiology technologists capable of performing images with the least radiation exposure and highest image quality, skilled radiologists who can professionally interpret images and perform intervention techniques, and trained specialists in maintenance, radiation protection and quality control.

According to the WHO, basic imaging investigations like plain X-rays and US are essential, not only in the diagnosis and follow up of diseases after treatment, but also in the surveillance and prevention of many diseases and epidemics (who.int). Unfortunately, radiology services are not be available in all regions all over the world. About two-thirds of the world's population has a shortage of basic diagnostic investigations, either due to a lack of resources for purchasing equipment and constructing special buildings, a lack of expert radiographers and radiologists, or a lack of maintenance and safety requirements (ELM, 2012).

RELATIONSHIP OF RADIOLOGY TO THE SOCIETY

People are normally exposed to radiation that may be natural or man-made. There is a direct relationship between radiology services and society. In addition to its great role in intervention that could replace many surgical procedures, radiology imaging has a major role in diagnosing diseases and monitoring results of treatment. Financially, it costs nations a great deal to establish a radiology centre within a health facility or as a private sector.

The safe annual exposure to radiation is about 310 millirem (mrem). Radiation used in clinical imaging is not usually harmful. The average radiation exposure during routine X-rays is usually within the accepted non-harmful levels; however, more sophisticated techniques, for example, CT scans, exposes the patients to more radiation, which may be serious. For example, repeating CT scans of the head five times may increase the risk of cancer development to 1:1000 patients, even higher in young patients (http://www.epa.gov). Therefore, there should be a weighing of the radiation risks versus medical benefits.

Other relationships of radiology to society are the possible hazards of some imaging tests. There is a danger of exposure to ionising radiation in cases where strict radiation protection procedures are not followed, or exposing the patients to unnecessary radiation during non-essential techniques. In addition, some contrast agents that are used as complementary procedures during radiology studies are not entirely safe. Some patients may experience reactions to iodinated contrast agents, which may range from mild to severe reaction, even sudden death.

RADIOLOGY AND ECONOMICS

Radiology departments cost a great deal of money to be established: modern diagnostic equipment is expensive and needs special infrastructure. Machines that depend on X-rays, for example, plain X-rays, fluoroscopy and CTs, need lead shielded walls and ceiling to protect other staff members and other personnel in the department. Patients and technologists need special protective procedures as well. An MRI is one of the most expensive machines; they need a spacious area with special preparation and great precautions that cost too much money. Recently, almost all the new generation of radiology machines have been digitalised and connected to hospital information systems. This needs expert IT specialists, powerful Internet communication and a solid maintenance system. In addition, working as a radiologist is one of the highest paid jobs. Therefore, establishing a modern radiology department with highly specified equipment and highly qualified personnel costs too much.

RADIOLOGY AND ENVIRONMENT

According to the United Nation Environment Programme (UNEP), nuclear medicine is a branch of radiology that uses radioactive materials for imaging patients and diagnosing many important diseases. These materials are harmful if not stored, transported, handled, used and the waste removed properly. The hazards vary according to the level of radioactivity and life time of these materials. High contamination may destroy human health, genetic structure, reproductive outcome and the environment. In paragraph 23 of the Johannesburg Plan of Implementation (JPOI, 2002), the commitment to the thorough assessment and management of hazardous wastes for sustainable development and for the protection of human health and the environment was raised, aiming to achieve, by 2020, the minimum adverse effect of waste on human health and environment. The problem is very evident in developing countries where they suffer from a lack of enough information for radioactive waste risk assessment, in addition to a lack of resources for dealing with this waste. In Principle 15 of the Rio Declaration on Environment and Development (RDED), it was set out to provide developing countries with technical and financial aids to help them manage their hazardous waste wisely (http://www.unep.org).

Most modern radiology departments are now provided with a Picture Archiving and Communicating System (PACS), which allows storage, transportation and reporting of images without the need of manual files, papers or traditional films to display images of different

modalities. PACS has led to much saving of paper and films with less pollution and a healthier environment.

WHAT IS THE POSSIBLE RELATIONSHIP BETWEEN RADIOLOGY AND SUSTAINABLE DEVELOPMENT?

We see that both radiology services and sustainable development share the same goal of providing an important service efficiently and effectively, taking into consideration the following targets: the patient's health, community and environmental safety, wise financial utilisation, sustainable management in construction and infrastructure, professional training and maintenance.

RADIOLOGY SOCIETIES AND SUSTAINABLE DEVELOPMENT: APPLICATIONS FROM EUROPE

The European Society of Radiology (ESR) is an organisation dedicated to supporting sustainable development and the rights of people to live in a healthy environment. They are concerned with the sustainable use of natural resources, awareness of sound economic practice, environmental concerns and social responsibility. They have several aims, but human health, natural resources and innovative events are the most important. They have certain guidelines to perceive the principles of sustainability:

- an advance assessment of the environmental impact and sustainability of new radiology projects;
- taking all necessary measures to prevent contamination of the environment and to support social sustainability;
- informing all stakeholders concerned with the environmental and social aspects of the society activities;
- ensure their partners meet the appropriate environmental standards and
- continually increase environmentally and socially responsible behaviour within the organisation in an appropriate manner.

This belief consists of:

- an understanding of the importance of environmental protection and the provision of comprehensive information to their partners and employees;

- active encouragement of the responsible use of resources such as electricity, water and paper;
- a commitment to buying, as far as possible, only local, eco-friendly and fair-trade products;
- the promotion of environmental awareness as a major objective of the company and
- the involvement of all partners in this important task (http://www.myesr.org).

SUSTAINABLE DIAGNOSTIC RADIOLOGY IN THE UK

Another example of the application of sustainable development in the field of radiology shows how much developed countries have major challenges to adopt the values of sustainable development in the health arena. According to the Royal College of Radiology (RCR), radiology services in the UK have faced a great challenge in the past few years where the continuous increase in requests for imaging by different modalities surpassed the capacity of the available services. This challenge includes difficulties in recruiting to radiologist' vacancies and the need for imaging and reporting, and sometimes interventional radiology, seven days a week. These obstacles have resulted in delays in reporting and diagnosing some serious conditions such as cancer and emergency surgical cases, and impairment of the main role of the clinical radiologists in supporting patient care (http://www.rcr.ac.uk). There is no single solution to these problems, but some suggestions have been made to maintain and enhance radiology services and to overcome the gap between supply and demand, taking into consideration the radiologists' welfare, patient health and environmental safety. These suggestions include:

- making full use of radiologists who wish to work part-time;
- making full use of radiologists after retirement from permanent posts;
- enabling flexible working from home;
- new service models, such as networking with other organisations for on-call, general or specialist services;
- teleradiology/outsourcing (http://www.rcr.ac.uk).

OVERUSE OF DIAGNOSTIC RADIOLOGY: THE PROBLEM, CAUSES AND SOLUTIONS

As we have seen, some countries, such as the UK, suffer from a lack of radiology services despite its high income and considering that it is

one of the highest developed countries. Other countries suffer from non-professional overuse of radiology services; this may harm patients, waste time and, more importantly, is a waste of national resources. This problem is not only seen in developing countries but also in some developed countries.

Overuse of diagnostic imaging burdens the radiology departments of hospitals, especially during emergencies. Unfortunately, the trend in medicine has now become to practice evidence-based medicine, based on radiological and laboratory findings, rather than skill-based medicine. It should be noted that there is no substitute for a good clinical examination and examining a patient's history. Each investigation requested should have a proper aim and objective, based on the history and detailed clinical examination of the patient. All such non-selective investigations add to the overall health cost of developed countries and burden the scarce healthcare resources in developing country (Kumar, 2014). The Influential Group American Health Insurance Plans (2) reported that about 20% to 50% of all 'high-tech' imaging 'did not offer valuable information and may be unnecessary. This includes some CT scans, MRI and nuclear medicine examinations, which are expensive and some have high radiation doses (Rao and Levin, 2012).

In a study undertaken in Iran, it was found that about 37% of patients with minor head trauma referred to the emergency department had no indication for the need for a CT scan, and approximately 86.5% of CT scan results were normal (Jame et al., 2014). This, if frequently repeated, may lead to great hazards to patients in addition to being a waste of money. The Consumer Reports magazine (2015) mentioned many examples about unnecessary radiation exposures. For example, "exposure to chest X-ray equals to exposure to radiation from natural resources such as Radon for 12 days" (consumerreports.org).

In addition to the cost, unnecessary imaging exposes patients to excessive and harmful radiation. This harm increases if the patient and doctor decide to do another complementary imaging, which is usually more sophisticated, to confirm or exclude possible disease, or treat these incidental findings through certain radiological intervention procedures that require a high radiation dose and contrast injection. Another problem related to overuse of diagnostic imaging is over diagnosis, when patients are diagnosed with incidental findings that are symptomless and never fatal (incidentaloma) (Welch et al., 2012). This will consequently lead to unnecessary treatment in some cases, mostly due to patient anxiety. This 'overtreatment' may be non-beneficial, complex, and expensive and may lead to unwanted side effects. A report by the Academy of Medical Royal Colleges claimed that "doctors have an ethical responsibility to reduce this wasted use of clinical resource because, in a healthcare system with finite resources, one doctor's waste is another patient's delay" (aomrc.org.uk).

CAUSES OF OVERUSE OF DIAGNOSTIC RADIOLOGY

One of the main causes of diagnostic imaging overuse is the decline in the quality of physicians' clinical skills (Kumar, 2014). Many physicians worry about malpractice responsibility and the fear of missing important clinical diagnosis. So they order too much imaging to avoid patient claims. An increase in patient awareness and patient education is another important reason. Many patients are affected by what they hear from their friends or media about new imaging techniques, and they may ask for it (Rao and Levin, 2012). This often leads to over investigation of simple diseases with more waste of resources and harm to patients. The financial interests of doctors represent a small, but an important cause of overuse of radiology imaging (Kumar, 2014). Modern imaging equipment is now frequently fixed in non-radiologist physician's offices. This causes them to order a great many imaging examinations for their patients, just to increase their income. Many previous studies in the USA have shown that self-referral always leads to more consumption of imaging tests (Levin and Rao, 2011). One more important and mounting reason for such overuse is the increase in medical insurance and broader medical facilities offered to employees and their family members in various public and private sectors (Kumar, 2014).

SOLUTIONS TO OVERUSE IN DIAGNOSTIC IMAGING

Some suggestions to avoid overuse of imaging investigations are frequently raised. These include regular checks of the validity of using different imaging modalities, developing protocols for each clinical condition, continuous educational programmes for clinicians, and taking patients' feedback. We see that radiologists have a major role concerning this problem. They should have the authority to accept or refuse doing certain radiologic studies unless its appropriateness has been discussed with the referring physician. They should also try to educate physicians in how to select the most valuable technique and modality according to the patient's clinical problem. Radiologists should also advise clinicians to start with non-radiation, non-invasive imaging tests, for example, US, and not to rush into the more complex modalities such as CT scans, invasive techniques such as angiography, or expensive modalities such as MRI. Radiologists themselves must avoid overuse of imaging studies for the purpose of getting more money.

SOME MODELS OF SOLUTIONS TO PREVENT THE OVERUSE OF DIAGNOSTIC IMAGING

Some trials have been done in the past to control clinical practice in the UK, for example, The National Institute for Health and Care

Excellence (NICE), which was set-up in 1999. Choosing wisely is a recently developed campaign in the USA and Canada; it aims to establish a healthcare system where the patients' needs and the cost-effective management of clinical resources go hand-in-hand. They try to prevent doctors using various procedures that are not necessary and may cause harm to patients, including duplicate imaging tests, intervention procedures that have already been done or repeated at short intervals during the follow up care of a disease after treatment. Choosing Wisely agree that at least 16 imaging studies are considered to be overused such as a CT of the head for patients with headache without evident structural abnormality, and routine preoperative chest X-rays where the patient does not complain of any cardiopulmonary problems, and much more (choosing http://www.wisely.org).

Choosing Wisely has been implemented in many countries including Germany, Italy, the Netherlands, Japan, Australia and Switzerland. This is a clear indication that wasteful medical practices and overuse of radiological imaging are a worldwide problem (Levinson et al., 2015). The Academy of Medical Royal Colleges (AMRC), which represents all royal medical colleges in the UK, is initiating a Choosing Wisely programme in cooperation with other medical, patient, and healthcare organisations and partners, including the BMJ. They aim to raise discussions about the dangers and benefits of radiological diagnostic examinations and intervention procedures, so both physicians and patients will agree that a slight possible benefit may not outweigh possible harm, the minimal evidence base, and considerable economic cost. Therefore, in some cases, doing nothing might be the right choice (Malhotra, 2015).

Another example of solving the problem of overusing imaging tests is the American College of Radiology (ACR), which frequently updates the appropriateness criteria for imaging and radiological intervention procedures. They cover many clinical conditions and interventions, including cardiac imaging and other imaging studies (Rao and Levin, 2012). Another model is introduced by the European Commission (EC); the EC Imaging Referral Guidelines Project workshop was held in Vienna, 2012. Examples and good practices regarding the significance and use of imaging referral guidelines in Europe and worldwide were introduced. It included speakers from Europe, Canada, the USA and Australia, in addition to speakers representing the WHO, International Atomic Energy Agency (IAEA) and the European Association of Nuclear Medicine (EANM), as well as representatives from radiology societies, general practitioners and patient groups (Remedios, 2014).

The balance between risk and benefit is crucial. The clinical condition of patients is very important in deciding which imaging modality is more beneficial to the patient. Guidelines are required and are useful, but they must be carefully chosen, updated and regularly checked. These international efforts to regulate diagnostic imaging services start to gain optimistic results ensuring that the control in usage of diagnos-

tic imaging, saving associated costs and protecting human health are already in hand. For example, in the USA, the use of advanced, modern imaging techniques has actually begun to decrease (Levin et al., 2011), and overall costs for non-invasive diagnostic imaging procedures declined by 21% between 2007 and 2010 (Levin et al., 2012). Such efforts should be conveyed to developing countries where the establishment of radiology departments, purchasing diagnostic and intervention radiology equipment, and hiring highly qualified radiology technologists and radiologists represent a great burden on the governments.

SUSTAINABLE DIAGNOSTIC RADIOLOGY SERVICES IN DEVELOPING AND UNDERDEVELOPED COUNTRIES

The WHO estimates that about 20% to 30% of clinical conditions cannot be diagnosed only with patient history and clinical examination: two-thirds of the world's population has no access to even one of the basic diagnostic studies of medical imaging. The problem is not purely financial. Non-profits and private donations offer the money to provide imaging equipment and establish modern radiology departments to countries in need. However, when the images are produced, the problem becomes finding qualified radiologists to interpret them. That 'is where teleradiology was evoked (Humanitarian Teleradiology, 2013).

TELERADIOLOGY

In developing and underdeveloped countries that lack trained radiologists to read the images, volunteer radiologists around the world offer their help. The images are transferred through countries to be made available to physicians and reported on, resulting in better management and health for patients in some of the world's most poor nations. A report from the 2010 RAD-AID Conference on International Radiology for Developing Countries, defined sustainability in radiology as

> "the ability to develop and maintain knowledge, equipment, skills, and other resources as part of an enduring radiology infrastructure that addresses the health-care needs of a community by integrating with existing health-care infrastructure" (Welling et al., 2011).

Teleradiology is beneficial to poor countries and is helpful in improving patients' health. However, most organisations see it as a short-term solution to the problem of a lack of radiologists, not a long-term solution of establishing sound radiology services in these countries. They see that an important link in the care supply chain is missing, limiting the country's ability to withstand radiology services and health-care

improvements without external help (Welling et al., 2011). However, we see that practicing teleradiology is not only of great help to poor countries as mentioned, but it also helps, in some way, to reduce global warming with all its deleterious effects on the environment and humans.

In the UK, the government's Carbon Reduction Commitment Energy Efficiency Scheme asks all large UK organisations, including many National Health Service (NHS, 2009) trusts, to declare their energy usage; they would then be punished for using too much, and rewarded for efficiency achievements. Part of this carbon is produced from vehicle emissions (http://www.sdu.nhs.uk). In the field of radiology, reductions in carbon footprints can be partially achieved through teleradiology to avoid unnecessary travel and transportation of radiologists. The impacts of sustainable thinking on radiology are optimistic. As we see in this example, radiologists and radiology residents can share effectively in improving the environment and so have real influence as exemplars of low-carbon living (Thompson and Ballard, 2011).

OTHER SOLUTIONS FOR DEVELOPING COUNTRIES

There are continuous efforts from developed countries to help developing and poor countries to maintain sustainable development in radiology. This is one of the greatest challenges of developed countries in supporting developing countries in this field, hoping to promote human health and keep a healthy environment for all people. One of these efforts is the radiology outreach educational and training programmes. Ultrasound, being the safest imaging modality, radiation free, portable, and of high diagnostic accuracy, is highly useful in many medical and surgical conditions. However, it is operator dependent, so many organisations have focused on providing under-served countries with both the machines and training programmes.

The International Society of Ultrasound in Obstetrics and Gynaecology (ISUOG), UK, has an outreach programme in ultrasound training for under-served regions that have ultrasound machines available in hospitals from donations, but which are not used due to a lack of qualified radiology personnel. Their first outreach programme was conducted in Manila in 1996. They provided hands-on training on ultrasound machines and continuous education and training so national radiology personnel could manage different cases and use the machines effectively (isuog.org).

Another example is the Physicians Ultrasound in Rwanda Education (PURE) initiative, which was established in 2010 to train physicians to operate ultrasound machines in Rwanda that had been donated by volunteers from many countries (ELM, 2012). The Radiological Society of

North America (RSNA) also has many outreach programmes and online resources available for developing countries. One of these countries, Malaysia, has benefitted from the RSNA International Visiting Professor Programme, 2011 (ELM, 2012).

RAD-AID is a dynamic non-profit international organisation that is determined to help developing countries establish and improve radiology and medical imaging services: they have volunteers from all over the world. According to RAD-AID, half the population has no access to radiology services. They served many developing and under-developed countries and have many activities in exchanging information and experience between countries, for example, China, and in establishing mobile clinics to serve poor regions, for example, in India. They are also concerned with continuous education programmes and offer free conferences on international radiology for developing countries. Sustainable strategies have been identified, including "financing models, donor education, practitioner education, public health efforts, technology innovation and implementation, as well as sustainable clinical models" (Welling et al., 2011).

CONCLUSIONS

The adoption of sustainable diagnostic radiology by many countries in Europe and the UK helps to provide imaging services efficiently and effectively, with simultaneous preservation of natural resources, patient health and environment much better than previously. The developing and underdeveloped countries should follow this knowledge hoping to reach the same goals.

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