Radiology and sustainable development

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Abstract

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

Design/methodology/approach – This is a review paper where data about sustainable development and radiology are collected from selected journals, websites, articles and conferences, e.g. Royal College of Radiology, European Society of Radiology, World Health Organization and other different radiology societies.

Findings – 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 the natural resources, patient health and environment much better than before. The developing and underdeveloped countries should follow this knowledge hoping to reach the same goals.

Practical implications – Limiting the use of radiologic examinations, guide 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 of poor countries will improve their socioeconomic level.

Originality/value – This paper focuses on the value of applying sustainable development in radiology not only in general medicine.

Keywords Sustainable development, Developing countries, Europe, Radiation hazards, Radiology, Teleradiology

Paper type General review

Introduction

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

Methodology

Data about sustainable development and radiology are collected from selected journals, articles, conferences and websites, e.g. Royal College of Radiology (RCR), European Society of Radiology, World Health Organization (WHO), and other different radiology societies.

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Sustainable development

The "World Commission on Environment and Development", 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". By sustainable development, 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 WHO (Jha and Tahvildari, 2015). Radiological investigations include imaging using ionizing radiation which are X-ray, fluoroscopy, computed tomography (CT) and nuclear medicine, and imaging using non-ionizing radiation which are ultrasound (US) and magnetic resonance imaging (MRI). Radiology includes diagnostic imaging and image-guided intervention procedures which could replace many sophisticated surgical intervention, thus reduce patient stay at hospital, hazards of general anaesthesia and all post-operative possible complications. Most radiology investigations are expensive, need costly infrastructure and expertise 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, in addition to trained specialists in maintenance, radiation protection and quality control. According to the WHO, basic imaging investigations like plain X-ray 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 could not be available in all regions all over the world. About two-thirds of populations have shortage of basic diagnostic investigations either due to lack of resources for purchasing equipment and construct special buildings, or lack of expert radiographers and radiologists or lack of maintenance and safety requirements (ELM, 2012).

Relation of radiology to the society

There is a direct relation between radiology services and society. Radiology imaging has a major role in diagnosing diseases and monitoring results of treatment in addition to its great role in intervention which could replace much surgical interferences. Financially wise, it costs the nations a lot to establish a radiology centre within a health facility or as a private sector. People are normally exposed to radiation which may be natural or man-made. The safe annual exposure to radiation is about 310 millirem (mrem). Radiation used in the clinical imaging are usually non-harmful. Routine X-ray techniques average radiation exposure is usually within the accepted non-harmful levels, whilst more sophisticated techniques, e.g. CT exposes the patients to more radiation which may be serious. For example, repeated CT of the head for five times may increase the risk of cancer development into 1: 1,000 patients, more in young patients (epa.gov). So, there should be a weighing of the radiation risks vs medical benefits. Other relation of radiology to the society is the possible hazards of some imaging tests. There is a hazard of exposure to ionizing radiation in case of not following the strict radiation protection procedures, 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 up to sudden death.

Radiology and economics

Radiology departments cost too much wedge to be established. Modern diagnostic equipment is expensive and needs special infrastructure. Machines that depend on X-ray, e.g. plain X-ray, fluoroscopy and CT need led shielded walls and ceiling to protect other staff members and other personnel in the department. Patients and technologists need special protective procedures as well. MRI is one of the most expensive machines that need spacious area with special preparation and great precautions that cost too much money. Recently, almost all new generation of radiology machines are digitalized and connected to the hospital information system. This needs expert IT specialists, powerful internet communication and solid maintenance system. In addition, working as a radiologist is one of the highest income jobs. So, 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", nuclear medicine is a branch of radiology that uses radioactive materials for imaging patients and diagnosing lot of important diseases. These materials are harmful if not stored, transported, handled, used and get rid of its wastes properly. The hazards vary according to the level of radioactivity and life time of these materials. Gross contamination may destroy human health, genetic structure, reproductive outcome and the environment. In paragraph 23 of the "Johannesburg Plan of Implementation (JPOI)", United nations environment programme, (2002) the commitment to 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, to reach the minimum adverse effect of wastes on the human health and environment. The problem is much evident in the developing countries where they suffer from lack of enough information for radioactive waste risk assessment, in addition to lack of the resources for dealing with these wastes. In principle 15 of the "Rio Declaration on Environment and Development", it was set out to provide developing countries with technical and financial aids to help them managing their hazardous wastes wisely (unep.org).

Most modern radiology departments are now provided with picture archiving and communicating system (PACS) which allows storage, transportation, 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 papers and films with less pollution and healthier environment.

How could be the possible relation 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 environment safety, wise financial utilization, sustainable management in construction and infrastructure, professional training and maintenance.

Radiology societies and sustainable development. Applications from Europe

The European Society of Radiology is an organization, dedicated to supporting sustainable development and the right of people to live in a healthy environment. They are concerned with sustainable use of the natural resources, awareness of sound economic practice, environment concerns and social responsibility. They have several aims with the human health, natural resources and innovative events are on the top. They have certain guidelines to perceive the principles of sustainability:

- in advance assessment of the environmental impact and sustainability of new radiology projects;
- taking all necessary measures to prevent environment contamination and to support social sustainability;
- informing all stakeholders in concern 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 organization 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 (myesr.org)

Sustainable diagnostic radiology in the UK

Another example of the application of sustainable development in the field of radiology showing that how much developed countries are in a major challenge to adopt the values of sustainable development in the health track. According to the RCR, radiology services in the UK faced a great challenge in the past few years where the continuous increase in requesting imaging by different modalities surpassed the ability of the available services. This challenge includes difficulties in recruiting to radiologists' vacancies and the need of imaging and reporting – and sometimes interventional radiology-daily for seven days/week. These obstacles have resulted in delays in reporting and diagnosing some serious conditions like cancer and emergency surgical cases, and impairment of the main role of the clinical radiologists in supporting patient care (rcr.ac.uk) There is no single solution to these problems, but some suggestions are raised to maintain and enhance radiology services and to overcome the gap between supply and demand taking into consideration the radiologist welfare, patient health and environment 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 organizations for on-call, general or specialist services; and
- teleradiology/outsourcing (rcr.ac.uk).

Overuse of diagnostic radiology: the problem, causes and solutions

As we see some countries like the UK suffers from lack of radiology services in spite of its great income and considering it one of the highest developed countries. Other countries suffer from non-professional overuse of radiology services which may lead to harm to patients, waste of time and more importantly waste of national resources. This problem could be seen not only in the 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 now has 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 patient's history. Each investigation requested should has a proper aim and objective based on the history and detailed clinical examination of the patient. All such unselective 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)2 reported that about 20-50 per cent of all 'high-tech' imaging don't offer valuable information and may be needless". This includes some CT, MRI and nuclear medicine examinations which are expensive and some have high radiation doses (Rao and Levin, 2012). In a study done in Iran, it was found that about 37 per cent of the patients with minor head trauma referring to the emergency departments had no indication of CT, and approximately 86.5 per cent of CT results were normal (Jame *et al.*, 2014). This- if frequently repeated- may lead to great hazards to patients in addition to waste of wedge. *Consumer Reports Magazine* (2015) mentioned lot of 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 cost reasons, 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 which require high radiation dose and contrast injection .Another problem related to overuse of diagnostic imaging is over diagnosis when patients are diagnosed with incidental findings which 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 clinical skills of physicians (Kumar, 2014). Many physicians worry about malpractice responsibility and the fear of missing important clinical diagnosis. So they order too

many imaging to avoid patient claim. 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 interest of the doctors represents a small, but an important cause of overuse of radiology imaging (Kumar, 2014). Modern imaging equipment is now frequently fixed in non-radiologist physician offices. This makes them order 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 insurances and broader medical facilities offered to employees and their family members in various public and private sectors (Kumar, 2014).

Solutions of overuse in diagnostic imaging

Some suggestions are frequently raised to avoid overuse of imaging investigations including regular checks of the validity of using different imaging modalities, developing protocols for each clinical condition, continuous educational programs for clinicians and taking patients' feedbacks. 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 discussing its appropriateness with the referral physician. They should also try to educate physicians how to select the most valuable technique and modality according to the patient's clinical problem. Radiologist should also advise clinicians to start with non-radiation, non-invasive imaging tests like US, and not to rush into the more complex modalities like CT, invasive techniques like angiography or expensive modalities like MRI. Radiologists themselves must avoid overuse of imaging studies for the reason of getting more money.

Some models of solutions of overusing diagnostic imaging

Some trials had been done years ago to control clinical practice in the UK like "The National Institute for Health and Care Excellence" which was set-up in 1999. "Choosing Wisely" is a recently developed campaign in the US and Canada aims is to establish a healthcare system where the patients' needs and cost-effective management of the 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 already done or repeated short interval follow up of a disease after treatment . Choosing wisely agree that at least 16 imaging studies are considered to be overused such as CT of the head for patients with headache without evident structural abnormality and routine preoperative chest X-ray with no cardiopulmonary patient complain and much more (choosing wisely.org). "Choosing Wisely" has been implemented by many countries including Germany, Italy, the Netherlands, Japan, Australia and Switzerland. This is a clear sign that wasteful medical practices and overuse of radiological imaging are a worldwide problem (Levinson *et al.*, 2015). The "Academy of Medical Royal Colleges", which represents all medical royal colleges in the UK, is initiating a "Choosing Wisely" programme in cooperation with other medical, patient, and healthcare organizations 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 to solve the problem of overusing imaging tests is the "American College of Radiology" which frequently updates the appropriateness criteria for imaging and radiological intervention procedures, and 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) where 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, USA and Australia, in addition to speakers representing the WHO, "International Atomic Energy Agency" and "European Association of Nuclear Medicine", as well as representatives from radiology societies, general practitioners and patient groups (Remedies *et al.*, 2014). The balance between risk and benefit is crucial. The clinical condition of patients is very important to decide 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 control of using diagnostic imaging, saving associated costs, and protecting human health are already at hand. For example, in 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 per cent between 2007 and 2010 (Levin *et al.*, 2012). Such efforts should be conveyed to the developing countries where establishment of radiology departments, purchasing diagnostic and intervention radiology equipment, and hiring highly qualified radiology technologists and radiologists represent great burden on the governments.

Sustainable diagnostic radiology services in the developing and underdeveloped countries

The WHO estimates that about 20-30 per cent of clinical conditions cannot be diagnosed with only patient history and clinical examination, two-thirds of the population living on earth has no access to even one of the basic diagnostic studies of medical imaging. The problem is not absolutely financial. Non-profits and private donations offer the wedge to provide imaging equipment and establish modern radiology departments to countries in need. But when the images are produced, the problem becomes finding qualified radiologist to interpret them. That's 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 reported and available to physicians, resulting in better management and health for patients in some of the world's most poor nations. A report of the "2010 RAD-AID (radiology 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 healthcare needs of a community by integrating with existing healthcare infrastructure" (Welling *et al.*, 2011). Teleradiology is beneficial to poor countries and is helpful in improving patients' health. However, most organizations see it as a short-term solution to the problem of 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 healthcare improvement 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 also it helps – in some way-in reducing 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 organizations, including many National Health Service trusts, to announce their energy usage, and be punished for using too much, and rewarded for efficiency achievements. Part of this carbon is produced from fuel burning of vehicles (sdu.nhs.uk). In the field of radiology, this can be partially achieved through teleradiology to avoid unnecessary travel and transportation of radiologist. 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 the developed countries to help developing and poor countries to maintain sustainable development in radiology. Actually this is one of the greatest challenges of the developed countries to support 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 most safe imaging modality, radiation free, portable, and of high diagnostic accuracy – is greatly useful in many medical and surgical conditions, but it is an operator dependent, so many organizations focused to provide underserved countries with both the machines and training programmes. The "International Society of Ultrasound in Obstetrics and Gynaecology (2010)", UK has an outreach programme in ultrasound training for underserved regions which have available ultrasound machines in hospitals from donations, but are not used due to 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 the national radiology personnel can manage different cases and use the machines effectively (isuog.org). Another example is the "Physicians Ultrasound in Rwanda Education" initiative which was established in 2010 to train physicians to operate donated ultrasound machines in Rwanda 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 organization 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 radiology services. They served many developing and underdeveloped countries and have many activities in exchanging information and experience between countries, e.g. China, and to establish mobile clinics to serve poor regions, e.g. in India. They also concern with continuous education programs 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).

Conclusion

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 the natural resources, patient health and environment much better than before. The developing and underdeveloped countries should follow this knowledge hoping to reach the same goals.

References

Consumer Reports Magazine (2015), "The surprising dangers of CT scans and X-rays", available at: www.consumerreports.org/cro/magazine/2015/01/the-surprising-dangers-of-ct-sans-and-x-rays/index.htm (accessed 11 September 2015).

ELM, H. (2012), "Social radiology: where to now?", *Biomedical Imaging and Intervention Journal*, Vol. 8 No. 1, p. e9. doi: 10.2349/biij.8.1.e9.

Humanitarian Teleradiology (2013), "Radiologists work together to help developing countries from Afar. But could short-term solutions undermine long-term progress?", March, available at: www.acr.org/News-Publications/News/News-Articles/2013/ACR-Bulletin/201303-Humanitarian-Teleradiology (accessed 5 October 2015).

International Society of Ultrasound in Obstetrics and Gynaecology (2010), "International aociety of ultrasound in obstetrics and gynaecology ISUOG outreach", available at: www.isuog.org/EducationAndTraining/Outreach+Program/ (accessed 1 November 2015).

Jame, S.Z.B., Majdzadeh, R., Sari, A.A., Rashidian, A., Arab, M. and Rahmani, H. (2014), "Indications and overuse of computed tomography in minor head trauma", *Iranian Red Crescent Medical Journal*, Vol. 16 No. 5, p. e13067.

Jha, Y. and Tahvildari, A.M. (2015), "Radiology in global health: strategies, implementation and aplications", *The Journal of Global Radiology*, Vol. 1 No. 1, Article 4, p. 265. doi: 10.7191/jgr.2015.1005.

Kumar, M. (2014), "Overuse of various radiological and pathological investigations: should we be safe or sorry?", *Journal of Family Medicine and Primary Care*, Vol. 3 No. 2, pp. 171-172.

Levin, D.C. and Rao, V.M. (2011), "The effect of self-referral on utilization of advanced diagnostic imaging", *American Journal of Roentgenology*, Vol. 196 No. 4, pp. 196848-196852.

Levin, D.C., Rao, V.M., Parker, L. and Frangos, A.J. (2012), "The sharp reduction in medicare payments for noninvasive diagnostic imaging in recent years: will they satisfy the federal policymakers?", *Journal of the American College of Radiology*, Vol. 9 No. 9, pp. 9643-9647.

Levin, D.C., Rao, V.M., Parker, L., Frangos, A.J. and Sunshine, J.H. (2011), "Bending the curve: the recent marked slowdown in growth of noninvasive diagnostic imaging", *American Journal of Roentgenology*, Vol. 196 No. 1, pp. 196W25-196W29.

Levinson, W1., Kallewaard, M2., Bhatia, R.S., *et al.* (2015), "'Choosing wisely': a growing international campaign", *BMJ Quality & Safety*, Vol. 24, pp. 164-167.

Malhotra, A. (2015), "Choosing wisely in the UK: the academy of medical royal colleges' initiative to reduce the harms of too much medicine", *British Medical Journal*, Vol. 350, p. h2308.

Rao, V.M. and Levin, D.C. (2012), "The overuse of diagnostic imaging and the choosing wisely initiative", *Annals of Internal Medicine*, Vol. 157 No. 8, pp. 574-576. doi: 10.7326/0003-4819-157-8-201210160.

Remedies, D., Hierath, M., Ashford, N., Bezzi, M., Cavanagh, P., Chateil, F., Paulo, G., Perez, M., Reed, M., Sardanelli, F., Son, R., Hughes, A.M., Pettmann, M., Jakson, S.E., Frija, G., Grenier, P., Hunink, M., Loose, R., Mendelson, R., Simeonov, G., Spiegel, W., Verzijilbergen, F. and Vilgrain, V. (2014), "Imaging referral guidelines in Europ", *Now and in the Future- EC Referral Guidelines Workshop Proceedings*, Vol. 5 No. 1, pp. 9-13. doi: 10.1007/s13244-013-0299-8.

Thompson, T. and Ballard, T. (2011), "Sustainable medicine: good for the environment, good for people", *The British Journal of General Practice*, Vol. 61 No. 582, pp. 3-4. doi: 10.3399/bjgp 11 X548875.

United nations environment programme (UNEP) (2002), "Johannesburg plan of implementation", available at: www.unep.org/tools/default.asp?ct=waste (accessed 23 October 2015).

Welch, H.G., Schwartz, L. and Woloshin, S. (2012), *Overdiagnosed; Making People Sick in the Pursuit of Health*, ISBN-13: 978-0807021996, 1st ed., Beacon Press, Boston, MA.

Welling, D.R., Azene, E.M., Kalia, V., Pongpirul, K., Starikovsky, A., Sydnor, R. *et al.* (2011), "White paper report of the 2010 RAD-AID Conference on International Radiology for Developing Countries: Identifying Sustainable Strategies for Imaging Services in the Developing World", *Journal of the American College of Radiology*, Vol. 8 No. 8, pp. 556-562. doi: 10.1016/j.jarc.2011.01.0112011;8.

Further reading

Choosing Wisely (2014), "An Initiative of the ABIM Foundation", available at: www.choosingwisely.org/ (accessed 20 November 2015).

Academy of Royal Medical Colleges (2014), "Protecting resources, promoting value: a doctor's guide to cutting waste in clinical care", London, available at: www.aomrc.org.uk/dmdocuments/Promoting%20value%20FINAL.pdf

EPA (2010), "What radiation levels are considered safe?, Sources of radiation exposure", available at: www.epa.gov/rpdweb00/sources/index.html (accessed 6 November 2015).

European Society of Radiology. available at: www.myesr.org/html/img/pool/ESR-_Green_Meeting_Concept_English.pdf (accessed 1 December 2015).

NHS Sustainable Development Unit (2009), "Saving carbon, improving health, NHS carbon reduction strategy for England", NHS Sustainable Development Unit: Cambridge, available at: www.sdu.nhs.uk/publications-resources/3/NHS-Carbon-Reduction-Strategy/ (accessed 2 December 2015).

Royal College of Radiology. available at: www.rcr.ac.uk/clinical-radiology/service-delivery/sustainable-future-diagnostic-radiology (accessed 22 September 2015).

The United Nations commission on sustainable development (2007), "Framing Sustainable development, the Brundtland report – 20 years on, sustainable development on action", available at: www.un.org/esa/sustdev/csd/csd15/media/backgrounder_brundtland.pdf (accessed 15 October 2015).

World Health Organisation. "Essential diagnostic imaging", available at: www.who.int/eht/en/DiagnosticImaging.pdf (accessed 1 September 2015).

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