

# Use of radiation in medicine in the Asia-Pacific region

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**ABSTRACT** Rapid technological developments in medicine have taken place in the Asia-Pacific region over the last decades. Radiology, in particular, has seen enormous growth with the latest medical equipment and practices being commonplace in this region. The use of radiation in medicine must be carefully considered with regard to the potential side effects, such as radiation-induced cancer. There are very limited published papers on the use of radiation in medicine in this region. Hence, in this paper, we present an overview of the use of radiation in medicine in the Asia-Pacific region.

*Keywords:* Asia-Pacific, medicine, radiation, risk  
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## INTRODUCTION

The use of radiation in medicine is rapidly increasing worldwide due to advancing and fast-evolving technologies in diagnostic imaging techniques and interventional radiological procedures. In particular, the use of computed tomography (CT) has been growing progressively worldwide. The estimated annual number of CT examinations in the United States rose steadily from 2.8 million in 1981 to 20 million in 1995, 46 million in 2000 and more than 67 million in 2006, including 4 million for children.<sup>(1-3)</sup> Comparable trends have been reported in European countries such as Germany, Switzerland, Norway and the United Kingdom.<sup>(4)</sup> The Asia-Pacific region is no exception in following this trend.<sup>(5)</sup> In Australia alone, the number of CT services from 1992 to 2006 increased by more than 140%.<sup>(6)</sup> These imaging techniques have played an important role in the diagnosis and treatment of patients in a variety of clinical settings, including emergency situations.<sup>(7)</sup> However, inappropriate use of these techniques can lead to unnecessary radiation exposure for patients. It has been estimated that patients undergoing CT examinations may have a slight risk of developing cancers at a later point in time due to the radiation doses involved.<sup>(2,8,9)</sup> Chhem et al had raised the issue of the need for better radiation protection in medicine and highlighted that the use of radiation in medicine must be carefully considered, as there exists potential risks of radiation-associated cancer.<sup>(10)</sup>

The Asia-Pacific region generally covers East Asia, South-East Asia, Australia, New Zealand and the Pacific Islands. Asia-Pacific is now home to more than half of the world's population. It has been reported that the region contributed 60.95% of the world's population in 2005.<sup>(11)</sup> According to a medium estimate of the United Nations, this contribution is expected to increase to 70.88% in 2050.<sup>(12)</sup> Countries in this region have a wide diversity of sociocultural backgrounds and are at different levels of economic and technological developments.

In Asia-Pacific, the medical use of ionising radiation remains a rapidly changing field, and medical radiation exposure has

been on the rise,<sup>(13)</sup> with 39% of the Asia-Pacific countries in healthcare level I, 27% in level II, 29% in level III and 5% in level IV. According to the 2008 UNSCEAR report, the number of radiological examinations and associated radiation dose is closely related to the healthcare level of the countries.<sup>(13)</sup> The number of physicians per capita has been shown to correlate relatively well with the number of medical examinations performed using ionising radiation.<sup>(14)</sup> Two-thirds of the diagnostic medical and dental examinations are performed on approximately 25% of the world population residing in level I countries, while CT comprises 8% of the examinations performed in level I countries although it contributes 47% of the total effective dose. CT only makes up 2% of the radiological examinations and 15% of the total effective dose in level II countries.<sup>(15)</sup> Data from levels III and IV countries are limited and not available due to unreliability. The number of CT examinations in most countries has been increasing annually during the last decades, with variable CT doses reported. The annual per capita effective dose associated with CT ranges from 0.27 mSv in the UK and 0.7 mSv in Canada to 1.5 mSv in the USA and 2.2 mSv in Japan.<sup>(16-19)</sup> A review of Australian practices shows that centres which frequently carry out paediatric CT tend to have the lowest radiation dose while those performing the least number of paediatric CT are prone to have greater variability in CT doses.<sup>(20)</sup>

The situation in Asia-Pacific is unique because many countries in this region are emerging economies where rapid development is a feature. The Asia-Pacific region is booming economically despite the economic downturn elsewhere in the developed countries. Naturally, there would also be swift expansion of radiological technologies. Radiology has seen enormous growth in this region over the last few decades. Many practices and equipment that did not exist a decade ago are now commonplace. However, the fundamental ethical use of these equipment, especially in radiation protection, has not seen a corresponding level of engagement. This is possibly an oversight, and may be

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particularly important given that these innovations have taken place over a period of changing social attitudes in these developing countries.<sup>(21)</sup>

## IMAGING MODALITY USAGE TRENDS AND AWARENESS OF RADIATION DOSE IN ASIA-PACIFIC

Radiation exposure from medical procedures is the largest source of average annual radiation exposure. Over the last decades, the most significant changes in medical imaging are reflected in major increases in higher-dose procedures, particularly CT and cardiac nuclear medicine.<sup>(22)</sup> The major categories of medical procedures using ionising radiation include diagnostic radiology, nuclear medicine and radiation therapy. There are a number of current trends in the use of ionising radiation, which have led to some current issues that deal with radiation protection for patients. These three modalities used to be relatively distinct from each other, but in recent times, combined modalities in hybrid equipment have been increasingly used in daily practice. Integrated positron emission tomography (PET)/CT scanners and combined CT-guided accelerators for radiotherapy are examples of this trend.<sup>(23)</sup> Due to the technological advances and increased use of these modalities in medicine, the medical community has become aware of the importance of radiation protection.<sup>(10,24)</sup>

### Justification of the use of medical radiation procedures

The International Commission on Radiological Protection has recommended a multilevel approach to justify the use of medical radiation procedures.<sup>(25,26)</sup> This multilevel approach provides an excellent intellectual framework for justification of the use of radiation in medicine. Guidelines have been available to all clinicians who request imaging studies.<sup>(27,28)</sup> Tracking the radiation exposure of patients represents another approach to monitor the cumulative dose received by patients undergoing a number of CT imaging over a few years or even in a single year.<sup>(27)</sup> The International Atomic Energy Agency (IAEA) Smart Card project is a recently introduced effort to enhance justification for physicians by enabling quick access to the previous exposure data of patients.<sup>(29)</sup>

Improving safety in radiotherapy is also of key concern. This treatment modality is associated with a low risk of injury or death from adverse events,<sup>(30)</sup> and has recently attracted wide attention on safety-related issues in the public press.<sup>(31)</sup> Over the past decade, the practice of radiation oncology has undergone rapid expansion, in both complexity (e.g. intensity-modulated radiation therapy, image-guided therapy, high-dose rate brachytherapy) and the number of treatment facilities.<sup>(32)</sup> It is generally agreed that one aspect of achieving improvement in radiotherapy safety is to establish a comprehensive global safety reporting and learning system, as there is a growing interest in the anonymous reporting of mistakes and equipment failures in radiation oncology. Through a reporting process, safety promotion in

radiotherapy can be achieved by alerting new hazards, sharing experiences on the prevention of errors, analysing many reports to reveal trends and specific hazards, and recommending 'best practices' based on analyses.<sup>(33,34)</sup> Another way to improve radiotherapy safety is to undertake external audits on a regular basis to ensure consistency of radiotherapy dosimetry and to minimise the likelihood of errors.<sup>(35,36)</sup> It has been reported that the publication of audit results promotes audit activity and provides a wider appreciation of the agreement of basic radiation dosimetry parameters between clinical centres.<sup>(37)</sup>

The IAEA has recently launched a voluntary reporting system entitled Safety in Radiological Procedures (SAFRAD) to include patients who are exposed to defined trigger levels or events in fluoroscopically-guided diagnostic and interventional procedures into an international database.<sup>(38)</sup> The Safety in Radiation Oncology (SAFRON), which is in the process of being developed by the IAEA, compiles reports of medical radiation incidents that put patients at risk.<sup>(39)</sup> The process of entering information related to radiation dose into the SAFRAD/SAFRON systems may lead to an increased focus on the safety and quality of service in medical imaging procedures.

### Awareness of radiation risk by physicians

Although ionising radiation has been established to be linked to cancer development, with increased concern widely expressed in the literature, the knowledge of healthcare professionals about radiation doses arising from radiological examinations, especially CT imaging, is limited and inadequate, regardless of the field of expertise.<sup>(4,40-45)</sup> Studies have shown that there is a widespread underestimation of radiation dose and safety during common radiological and CT examinations.<sup>(40,41)</sup> Jacob et al, in their questionnaire study, reported that only 12.5% of doctors were aware of the 1/2,000 risk of induction of a fatal cancer for children resulting from abdominal CT imaging.<sup>(42)</sup> Krille et al conducted a systematic review of 14 primary research articles on physicians' knowledge of radiation dose from CT and other diagnostic imaging procedures, and their associated risks. Their analysis showed that there is a moderate to low level of knowledge and radiation-risk awareness among the physicians.<sup>(43)</sup> Yucel et al, in their recent study, indicated that medical practices do not enhance the level of awareness of ionising radiation among physicians.<sup>(44)</sup>

While studies concerning radiation dose awareness or knowledge among healthcare professionals have been conducted in Europe and North America, reports on Asian doctors' awareness of radiation dose are scarce. Wong et al, in their recent questionnaire survey conducted in Hong Kong Authority hospitals, reported that the general awareness of radiation exposure associated with radiological imaging among local physicians, radiologists and interns is unsatisfactory.<sup>(45)</sup> This could imply a tendency toward radiation misuse or underutilisation of alternative imaging modalities such as ultrasonography (US) or magnetic resonance (MR) imaging, as some medical practitioners

in their survey may have failed to recognise that US and MR imaging are radiation-free modalities. Lee et al reported that the knowledge of radiation doses of common radiological examinations is poor among non-radiologists and inadequate in radiologists, according to their recent survey conducted in a university teaching hospital in Hong Kong.<sup>(46)</sup> This again emphasises the importance of raising awareness of the radiation risks of radiological examinations among medical professionals.

In many developing countries, there is still a lack of stringent radiation safety regulations and proper implementation. In a survey conducted in 19 developing countries on paediatric CT examinations, the paediatric CT frequency in Asian countries is found to be higher than in Eastern Europe, with the exposure parameters used for paediatric patients being similar to those for adults.<sup>(47)</sup> The recently published IAEA survey of paediatric CT practice in 40 countries in Asia, Europe, Latin America and Africa shows that CT has been increasingly used in both paediatric and adult imaging from 2007 to 2009, with the highest frequency of paediatric CT observed in Asia and Africa (double that of Europe). In about one-third of situations, past images and information on previously received patient doses when referring for CT were not available.<sup>(48)</sup> This nonavailability of past images will add to unjustified examinations. Appropriate guidelines, such as the European Commission's Referral Guidelines for Imaging,<sup>(49)</sup> the National Institute for Health and Clinical Excellence,<sup>(50)</sup> and the American College of Radiology appropriateness criteria,<sup>(51)</sup> are not always followed and have not been effectively implemented in clinical practice with regard to the referral of radiological examinations by requesting physicians. Thus, there is an urgent need for physicians to educate themselves as well as to increase their awareness of ionising radiation and its associated risks.

### Awareness of radiation risk by patients

There is a growing trend in medical practice where patients are becoming more involved in medical decision-making.<sup>(52-54)</sup> Prudent and ethical medical practice requires close communication between the patient and the physician. Clearly, shared medical decision-making requires dialogue between patients and their healthcare providers.<sup>(55)</sup> Degner et al have found that 44% of patients with breast cancer want to make treatment decisions in collaboration with their physician, while 34% want to leave the decision to their physician.<sup>(53)</sup> Similarly, it was reported in a recent study by Caoili et al that 83% of their patients stated that they had discussed the reasons for obtaining a CT examination with their physician and that the decision to undergo CT imaging was shared by both the physician and patient in 44% of the cohort.<sup>(54)</sup> However, their patients' knowledge about ionising radiation associated with CT examination was limited and their survey showed that most of them were not aware of the risks associated with medical imaging, with only 6% of respondents having knowledge that radiation exposure from CT increases the lifetime risk of cancer.

Some researchers have suggested that the referring physician should be the one to explain radiation-related information to the patients.<sup>(56)</sup> Another approach to increasing awareness of radiation safety could be through providing leaflets and educational posters in the hospitals. It has been shown in a study that brief brochures with information about CT imaging could improve the understanding of parents of paediatric patients without increasing the refusal rate.<sup>(57)</sup> Although there have been no similar reports about patients' awareness of the radiation risk associated with radiological examinations in Asian countries, it is assumed that the patients' involvement in medical decision-making is limited, as the healthcare system in this region determines the dominant role of doctors.

### MEDICAL TOURISM IN ASIA-PACIFIC

Medical tourism is already a US\$60 billion global business and growing by 20% every year.<sup>(58)</sup> Asia has become the most popular destination for medical tourists in the world. This is because Asia offers high-quality, world-standard medical treatment at only 20% of the cost of treatment in the USA and UK. Furthermore, many of the doctors in this region hold qualifications from internationally recognised institutions in developed regions. The number of medical tourists to Asian countries has been increasing by about 20%–30% each year. It is estimated that medical tourism in Asia could generate as much as US\$4.4 billion by 2012.<sup>(59)</sup>

There is tremendous utilisation of ionising radiation-based imaging in health screening in this region. While whole-body CT imaging is just one component of health screening, some centres are even using PET/CT due to the wider availability of PET/CT scanners. Although combined PET/CT may introduce a higher radiation dose to the patients for certain imaging protocols, it delivers lower doses to the individual compared to CT. This is because PET/CT usually uses a much lower tube current-time product for the CT images, which are often used as a background anatomical reference for PET images. If left unchecked, radiation exposure to the public from this form of health screening would be considered unjustifiable. In order not to compromise patient safety, greater effort must be put into the education and training of healthcare professionals. Toward this end, the IAEA has organised several activities for the region, such as regional projects and workshops that assess the appropriateness of imaging examinations and their indications and estimate patient radiation doses of commonly performed CT examinations and interventional procedures. Through these regional networks, local radiology teams are encouraged to review and analyse their radiology practice, as well as meet together to compare data and their practice with those of other countries in the region.<sup>(60)</sup>

### COLLABORATIVE EFFORTS TO REDUCE RADIATION DOSE

While the benefits of radiation in medicine are well known, increasing concerns about the radiation dose associated with

CT, nuclear medicine procedures, fluoroscopy and radiography have captured the attention of imaging professionals, referring practitioners, the general public and news media.<sup>(61)</sup> In June 2009, The American College of Radiology and the Radiological Society of North America established the Joint Task Force on Adult Radiation Protection to address how dose optimisation could be incorporated into all imaging practices and the concept of radiation dose disseminated to healthcare professionals. Efforts have been made in recent years to increase awareness about adult and paediatric radiation protection, with the Image Wisely and Image Gently campaigns representing these efforts.<sup>(62-64)</sup>

Demographic transition in the Asia-Pacific region is taking place at a rapid rate compared to that in other regions of the world, whether in terms of fertility reduction, ageing population or rural-to-urban migration. According to a recent report in *Lancet*, rapid epidemiological transition is also occurring, with the disease burden shifting from infectious to chronic diseases.<sup>(65)</sup> Countries in this region have a wide diversity of sociocultural backgrounds and are at different levels of economic and technological developments, including evolution of imaging techniques. The rapidly increasing rates of overweight and obesity, hypertension, high cholesterol, diabetes mellitus and smoking are responsible for the great burden of cardiovascular disease in the Asia-Pacific region.<sup>(66-68)</sup> Therefore, cardiovascular disease must become a priority for this region, as the clinical diagnosis of cardiovascular disease greatly depends on medical imaging examinations, such as CT and invasive angiography.<sup>(69)</sup> However, the highly diverse healthcare systems in this region contribute to the difficulty in implementing effective guidelines with regard to monitoring radiological procedures in terms of radiation safety and dose reduction.

## SUMMARY AND CONCLUSION

In order to ensure judicious and safe practice of radiation in medicine, there must be concerted efforts to strengthen regulations, ethics and professionalism within the discipline. Medical physicists may play vital roles in the education and formulation of guidelines,<sup>(70,71)</sup> but they would most likely be part of a much larger effort, with the help of major national and international organisations, professional bodies and regulatory organisations. The expansion of radiotherapy has put a strong demand on more medical physicists working in a larger number of institutions to provide quality assurance for machines and treatments, as well as to verify that equipment malfunctions and human mistakes do not put patients at risk.<sup>(72,73)</sup> A recent survey on profession and practice of radiation oncology medical physicists in the Asia-Pacific region has shown that medical physics is being recognised as a profession.<sup>(74)</sup> However, there is still a lot of work required to establish an adequately trained and resourced medical physicist workforce in this region. Education and re-education are needed to ensure that referring physicians are not confused by the new imaging techniques or variations of existing imaging techniques, and how they fit into the management of the patient. The sooner

all these steps are taken, the sooner the crisis of ionising radiation misuse will be checked. A new order will eventually return to ensure that patient safety is, as always, a priority.

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