A comparison of Saudi Arabian and Australian radiographers' perceptions of computed tomography radiation dose

Al Mohiy H[1]
PhD, ADip, BSc, MSc(MI), GDM

Sim J[1]
BSc, MSc, PhD

Annabell N[1]
Msc

Seeram E[2]
BSc, MSc

Davidson R[1,3]
MSc, PhD

[1]Discipline of Medical Radiations, School of Medical Sciences, RMIT University, Bundoora, Victoria 3083, Australia.

[2]Medical Imaging, British Columbia Institute of Technology, Burnaby, Canada.

[3]School of Dentistry and Health Science, Charles Sturt University, Wagga Wagga, New South Wales 2650, Australia.

Correspondence to
hussain.almohiy@rmit.edu.au

Abstract ***Background:*** Computed tomography (CT) is a powerful diagnostic tool, but the radiation delivered to paediatric patients needs to be kept to a minimum. Thus, CT education and protocols must be continuously reviewed, particularly with respect to paediatric CT examinations. ***Purpose:*** To investigate the knowledge and perceptions of paediatric CT radiographers from Australia and Saudi Arabia regarding paediatric CT dose. ***Methods:*** Interviews were conducted with CT radiographers working in dedicated paediatric hospitals during 2010. Their training and perceptions of paediatric CT radiation dose were evaluated, along with their departments' policies. Actual dose measurements from their departments were compared to their perceptions to reveal radiographers' awareness of their department's typical dose relative to those delivered by their contemporaries. ***Results:*** Almost all surveyed radiographers were willing to minimise their radiation dose, but many Saudi Arabian radiographers were not allowed to make any changes to their CT protocols. CT protocols in Saudi Arabia were wholly defined by the CT machine vendors' recommendations, whereas most Australian CT protocols were established following reviews of the appropriate literature. ***Conclusion:*** Australian and Saudi Arabian CT radiographers' training and perceptions of paediatric CT dose vary substantially, and differences exist in terms of workplace culture. Continuous professional development will assist Saudi Arabian radiographers to reduce CT radiation doses.

Keywords:

Introduction

Computed tomography (CT) scanning is used extensively by medical professionals in diagnostic radiology, primarily for the examination of human soft tissues.[1] The use of CT has increased rapidly since the technology's inception in the 1970s, with approximately 62 million CT examinations performed in 2006.[2] CT scans are also widely used in the paediatric population due to short scan time,[3] and offer ease of application to non-sedated, unwell and/or uncooperative patients.[4] Despite these undoubted advantages, CT has drawbacks: the approximately 600,000 abdominal and head CT examinations undertaken annually in children under the age of 15 years in the United States could result in 500 deaths from cancer attributable to CT radiation.[5] It is also reported that patients often have a poor concept of the radiation dose and risk associated with CT.[6] Therefore, radiographers – the professionals who operate CT machines and communicate directly with patients – should understand the importance of minimising radiation dose.

In America the "Image Gently" campaign worked to encourage radiographers to minimise imaging dose by providing recommendations and instructions for implementing paediatric CT protocols based on adult-equivalent scans.[7,8] Improving radiographers' knowledge of patient doses in CT is usually considered the first step in optimisation strategies[9], and the International Atomic Energy Agency (IAEA) recommends education and training of radiographers involved in paediatric CT.[10] Unfortunately, as Mettler[11] pointed out, radiographers' basic education and training often overlooks paediatric CT radiation doses.

An early study of CT dose found that variation of between 10–40% in the typical doses delivered by individual scanners was largely due to imaging technique,[12] something easily rectified with improved education. Similarly, a survey of health professionals in Northern Ireland on awareness of radiation doses imparted during common diagnostic imaging procedures and their long-term impact on patients demonstrated a knowledge gap which could be improved with appropriate training.[13] A survey in New South Wales, Australia showed the need for continuing education and protocol review, particularly in paediatric CT examinations.[14]

No research to date has investigated whether radiographers' knowledge and attitudes impact on the radiation dose delivered to CT paediatric patients, a topic vital to the development of effective continuing professional development (CPD) programmes. This research investigates Australian and Saudi Arabian radiographers' knowledge of, and attitudes to, paediatric CT radiation doses for the purpose of aiding the development of clinically useful CPD material.

Methods

This research was approved by the RMIT Human Research Ethics Committee (approval #42– 09) and the Ministry of Health of Saudi Arabia (approval #37/61317).

Table 1: Actual and perceived ranks (A = lowest dose) of head CT radiation dose.

Hospital code	Perceived ranking on graph (mGy.cm)	Actual ranking on graph (mGy.cm)	Reason for selection of perceived ranking
Australia[1]			
A1			
	C (229.1)	F (315.1)	Other centres probably have newer scanners and we are definitely not one of the highest two.
A2 a	A (137.6)	C (229.1)	We have the lowest dose.
A2 b	D (273.6)	C (229.1)	From previous studies, not all are comparatively low.
A2 c	D (273.6)	C (229.1)	Probably somewhere in the middle, I have no idea.
A3	A (137.6)	B (194.3)	We have the lowest dose, best scanner in the world.
A4 a	A (137.6)	A (137.6)	We have very good protocols.
A4 b	A (137.6)	A (137.6)	I think we are one of the lowest dose.
A5	C (229.1)	D (273.6)	I don't think we are A or B, but we are not as high as the others.
A7	A (137.6)	G (528.0)	I hope we are the low one.
Mean	188.2	252.6	
Saudi Arabia			
B1	F (383.4)	F (383.4)	Because there is no good background knowledge about paediatric CT.
B2	B (226.1)	C (270.7)	We are not giving higher doses.
B3a	D (325.3)	B (226.1)	I believe our CT section has high radiation because I heard from the company, from one of the company reps, he said we have a high protocol radiation dose.
B3b	B (226.1)	B (226.1)	I think we are in the range.
B4a	D (325.3)	E (359.7)	Because our radiation is high to get good image resolution.
B4b	B (226.1)	E (359.7)	Because I think we need more improvement in CT scan.
B5a	H (416.3)	G (408.3)	I think our protocol is very high compared with other protocols. I think, this is only my guess.
B5b	B (226.1)	G (408.3)	I think we are in the range.
B6	G (408.3)	D (325.3)	Because we have an old machine and so I think we have more radiation.
B7	B (226.1)	H (416.3)	Because we are the lowest in the Ministry of Health.
B8	B (226.1)	A (196.7)	Because it is an old machine.
Mean	292.3	325.5	

Data collection 1: CT protocols

In mid-2010, the heads of the radiology departments of all exclusively paediatric public hospitals in Australia (n = 7) and Saudi Arabia (n=8) were contacted by telephone and invited to take part in the study (all agreed). Between September and October 2010 (in Saudi Arabia) and December 2010 and January 2011 (in Australia), the first author collected CT dosimetry readings from each site. A 16 cm-diameter solid water phantom with a free air ionisation chamber (PTW-Freiburg TM3009-00749) located in the central socket was used, connected to a DIADOS dosimeter.[15] Each hospital's default CT protocol for a 3–6 year old patient was used to collect radiation dose readings for head, chest and abdomen/pelvis CT scans.

Data collection 2: Interviews

Prior to collection of CT protocols and dosimetry readings, quantitative questionnaires were sent to the 15 heads of radiology departments to distribute to all the radiographers they employed.[16] Fifty-six Saudi and 50 Australian radiographers returned completed questionnaires. All 106 respondents were invited to participate in qualitative interviews post-dosimetry and 11 Saudi and nine Australian respondents agreed.

The dosimetry results were anonymised and used to create a dose distribution for the participating radiographers. As part of the interview, participants were asked to identify the position of their hospital's typical dose for head, chest and abdomen/pelvis scans on bar graphs. Saudi radiographers were shown only data from the eight Saudi hospitals, and Australian paediatric CT radiographers were shown the dosimetry data from the seven Australian hospitals. Radiographers were asked to give a rating of 0–10 for dose (0 meaning no radiation and 10 meaning high radiation) for each scan area and a rating of 0–10 for the risk associated with this scan. The Australian interviews were completed face-to-face, but the Saudi Arabian dosimetry comparisons were completed by telephone. Each interview lasted between 45 and 50 minutes; the final interview was conducted in January 2011.

The interview was divided into several different themes in order to

Table 2: Comparison of perceived and actual paediatric CT doses – Australia and Saudi Arabia.

Australia

Dose	Scan regions	Mean	Standard deviation	t	*P*
Perceived	Head	188.2	62.0	-1.462	0.182
Actual	Head	252.6	118.2		
Perceived	Chest	25.7	4.5	-2.322	< 0.05
Actual	Chest	51.1	32.5		
Perceived	Abdomen/Pelvis	35.2	15.0	-2.546	< 0.05
Actual	Abdomen/Pelvis	68.0	45.3		

Saudi Arabia

Dose	Scan regions	Mean	Standard deviation	t	*P*
Perceived	Head	292.3	81.0	-1.125	0.287
Actual	Head	325.5	81.9		
Perceived	Chest	53.4	16.7	-0.651	0.530
Actual	Chest	59.3	20.2		
Perceived	Abdomen/Pelvis	69.2	13.3	-0.045	0.965
Actual	Abdomen/Pelvis	69.6	27.7		

add structure to the line of inquiry.[25] Interview questions were drafted for each theme after reviewing similar literature.[17] The themes explored in the interviews were:

- Section A: CT paediatric radiographer history
- Section B: CT Protocols (dose intervention)
- Section C: Understanding of CT dose
- Section D: CT dose intervention
- Section E: Continuous education/training
- Section F: Perceptions of radiation dose level relative to their national counterparts.

The interview was piloted with practising radiographers and academic staff from RMIT University experienced in qualitative techniques.[18-20] Following each interview, the interviewer re-read and added to the notes taken during the interview to provide a backup to the digital record and to highlight points of interest in the discussion.[21,22] Interviews were then transcribed using a professional service and the transcriptions were checked for accuracy. Finally, the researcher's notes were inserted into the transcriptions.

Interviewee identities were encoded using NVivo[23] and answers to each question aggregated to facilitate thematic analysis.[24] Numerical results were compared using Student's t-tests in MINITAB v16 with confidence level set at 95%. The constant comparative method was used to assure the credibility of the results.[24]

Results

Eleven Saudi Arabian and nine Australian radiographers participated in the survey.

Section A: CT Paediatric radiographer training

Three Australian paediatric radiographers reported some initial training in CT image quality and dose through attending conferences and seminars. A common theme within the responses was that these programmes offered minimal knowledge on CT. Prior training was less common for Saudi Arabia radiographers, with only one reporting attending a two-week course on CT dose, although several respondents indicated they felt their course was extensive enough to become adept at managing CT dose.

Section B: CT protocols

Six Australian participants indicated that their protocols were established after a literature review. All the Australian radiographers were allowed to modify established protocols, which they did routinely for individual patients. In most instances parameters were altered based on the experience of the radiographer.

All of the Saudi Arabian radiographers indicated that their scan protocols were defined by the CT machine vendor. Two respondents mentioned the radiologist as a secondary source for parameter selection. Fewer than half reported that they were allowed to modify established protocols; concern over making a mistake was cited as the reason for not being allowed to make changes by two participants.

Section C: Understanding of CT dose

Table 1 shows the distribution of the surveyed Australian and Saudi Arabian radiographers' perceptions of radiation dose and risk from a paediatric head scan.

When asked *"Do you believe that the patient's cancer risk is increased as a result of a CT scan?"*, 89% of the Australian radiographers agreed, with only one hesitating on the basis that the literature was not conclusive. In contrast, only 45% of the Saudi Arabian radiographers indicated that they thought cancer risk was increased by a CT scan, with 10% offering no certain opinion.

Section D: CT dose intervention

Participants were asked: *"What is your understanding of CT dose intervention?"* Twenty-two per cent of the Australians responded that they had "some" understanding of the concept, as opposed to 9% of the Saudi Arabians.

When asked *"Do you practise CT dose intervention? When? Why? How Often?"* after the concept was explained, 67% of the interviewed Australian radiographers claimed they practiced dose intervention and 27% of the Saudi Arabians.

In response to the question *"Does your department have a process in place for dose intervention?"*, 11% of Australians responded in the affirmative, and 9% of Saudi Arabians (who then explained that the policy was never followed).

Section E: Continuous education/training

When asked *"Do you regularly attend paediatric, workshops, seminars, home-study, online courses or conferences?"*, 89% of the Australians replied that they did, but only 45% of the Saudi Arabians.

Participants were asked: *"What is your department's policy on Continuous Professional Development? Specifically, are you encouraged to attend courses, and is financial support available?"* All of the Australian radiographers reported that their department encouraged CPD, and 78% said that financial support for CPD was offered. In contrast, only 18% of the Saudi Arabians reported that their department encouraged CPD, and none reported that their department offered financial support.

Section F: Relative perceptions of radiation dose level

As noted in the Methods section, the participating radiographers were presented with actual dosimetry data from their respective countries' hospitals for paediatric CT scans of the head, chest and abdomen/pelvis regions and asked to select the data point they believed represented their department's typical scan for each body region. The Saudi Arabian dataset is shown in Figure 1.

Table 2 summarises Australian and Saudi Arabian radiographers' perceived and actual CT doses for head, chest and abdomen/pelvis scans.

Table 2 shows that Australian respondents systematically gave lower ratings than Saudi Arabian respondents. Australian and Saudi Arabian paediatric CT radiographers did not perceive any difference in radiation dose between head, chest and abdomen/pelvis scans.

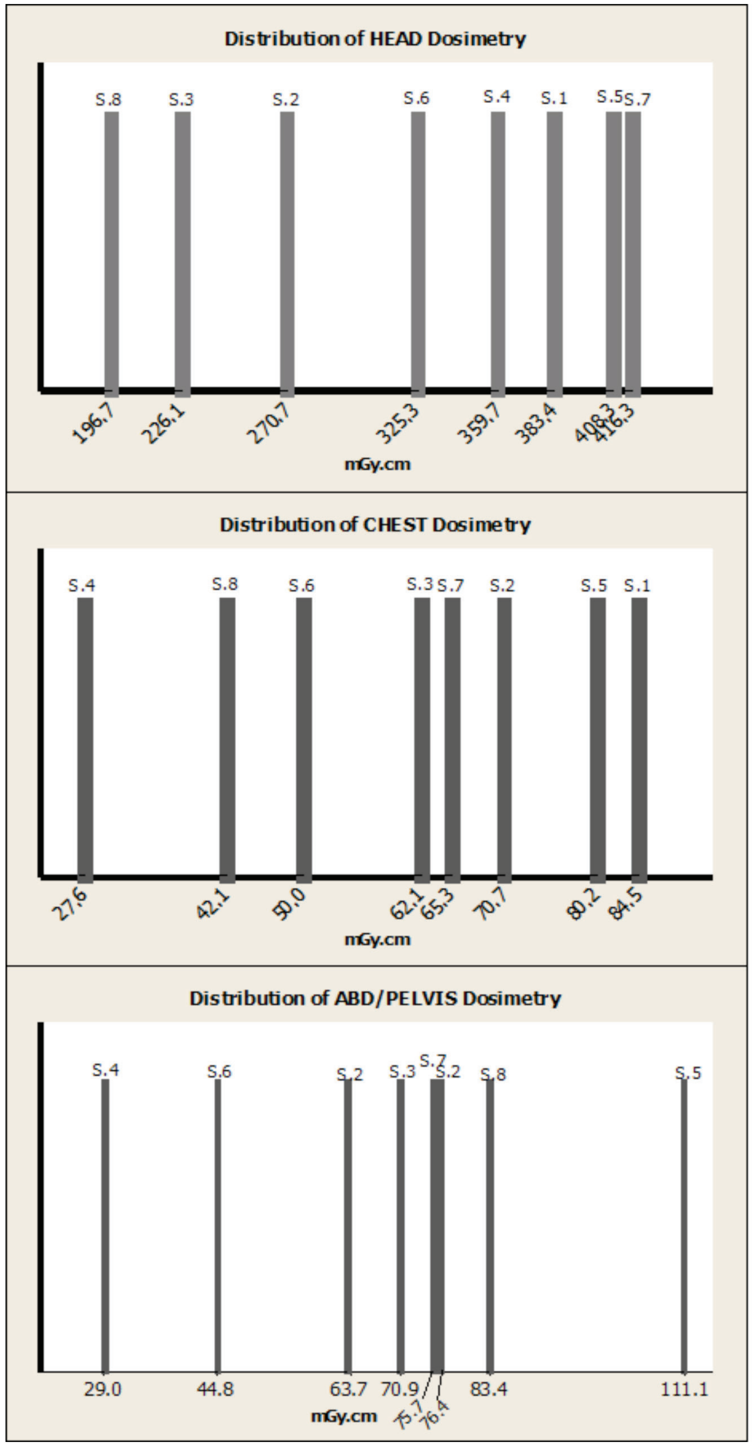

Figure 1: Dosimetry distribution shown to interviewees - Saudi Arabian dataset shown for a) Head, b) Chest and c) Abdomen/Pelvis Scan Regions.

Discussion

This study revealed several differences between Australian and Saudi Arabian paediatric CT radiographers in training and perceptions regarding CT radiation dose.

The results presented in Section A show that neither Australian nor Saudi Arabian paediatric CT radiographers arrived at their current positions with much experience in paediatric CT practice. For this reason, CPD activities can have both a direct and indirect influence on the acquisition and continuous development of professional skills.

Section C shows that Australian and Saudi Arabian paediatric CT radiographers did not perceive any difference in radiation dose between head, chest and abdomen/pelvis scans. The dosimetry data show that actual head doses are substantially higher than perceived in both countries (Table 2).

Analysis of responses in Section C established that both Australian and Saudi paediatric CT radiographers perceived the radiation risk from an abdomen/pelvis scan to be higher than the risk from a head scan. While this is generally true of adult CT, due to the increased organ sensitivity of the pelvis,[2] Huda's[25] adult/paediatric CT comparison illustrates that the opposite is true for paediatric CT. This result confirms the arguments of Mettler[11] and Moss and McLean[14] that better paediatric CT dose training is required in undergraduate radiography courses.

Perhaps the most alarming result reported in Section C is that Saudi paediatric CT radiographers are not generally convinced of the carcinogenic potential of CT radiation. The belief that CT scans do not increase the lifetime risk of cancer has been well documented in physicians and radiologists,[26,27] but to our knowledge this is the first time it has been reported in paediatric CT radiographers.

The interview data highlight the existence of a relatively less interventionist attitude among Saudi paediatric CT radiographers in terms of modifying protocols and practising dose intervention. Some Saudi paediatric CT radiographers claimed that dose intervention was not their responsibility. This may be a reflection of a workplace culture that does not value the experience of CT radiographers.

The level of involvement in CPD revealed in Section E differed markedly between Australian and Saudi paediatric CT radiographers, as did the relevant departmental policies and financial support. The participating Saudi paediatric CT radiographers acknowledged this as a serious deficiency in their education, and cited funding as the main barrier to increasing CPD in Saudi Arabia.

The Australian paediatric CT radiographers substantially underrated their department's CT dose ranking, thus believing their department's typical dose to be much lower than the reality. In contrast, the Saudi paediatric CT radiographers gave accurate estimates of their department's dose ranking. The Australian paediatric CT radiographers' optimism may reflect a well-known bias known as illusory superiority.[28] Since the Saudi respondents believed that their scanners were old and their protocols were poor, the illusory superiority bias was negated, resulting in a more accurate overall judgement of their rank among peers. The results shown in Section F also provide an explanation for paediatric CT radiographers' reasoning for their rating. Three of the nine Australian paediatric CT respondents (33%) believed that their department's dose was lower because they had a new scanner; similarly, three of the 11 Saudi paediatric CT respondents (27%) also mentioned the age of their equipment when comparing their dose ranking with other hospitals. This indicates that some paediatric CT radiographers falsely assume that newer and higher-resolution scanners give a lower dose. In fact, as the results of previous studies[29,30] illustrate, newer multi-slice CT scanners actually give a higher dose than their single-slice equivalents.

This study had several limitations. The participating radiographers were volunteers rather than being randomly selected from the 106 quantitative survey respondents, so their representativeness of all Saudi and Australian radiographers is unknown and our findings may not be generalisable.

It is now necessary to design an education programme for paediatric CT radiographers to increase their knowledge on radiation dose, including the risks associated with CT and techniques for minimising the dose to each patient. It is also necessary to re evaluate paediatric CT radiographer knowledge after the implementation of this course, to verify its effectiveness.

Conclusion

This study has shown gaps in paediatric CT radiographer knowledge concerning paediatric CT dose, and differences between Australian and Saudi Arabian CT radiographers' levels of experience, knowledge and workplace culture. The lack of CPD activity and financial support in Saudi Arabia, and the Saudi Arabian radiographers' lack of recognition of the carcinogenic potential of CT scans are particularly important findings and must be addressed. Similarly, Australian radiographers' underestimation of the radiation dose delivered by their CT scans should be recognised in training and CPD. This study recommends that more CPD funding be made available for Saudi Arabian paediatric CT radiographers in order to better educate the profession and foster a more active role in minimising the dose from paediatric CT examinations.

Acknowledgements

This study was funded by the Government of Saudi Arabia and RMIT University. The authors are grateful to the participating Australian and Saudi Arabian radiographers, heads of radiology departments in both countries, and the Government of Saudi Arabia and RMIT University for funding the research.

References

1 Buzug TM. Computed tomography: from photon statistics to modern cone-beam. Connecticut: Springer Verlag; 2008.

2 Brenner D, Hall E. Computed tomography – An increasing source of radiation exposure. *N Engl J Med* 2007; 357: 2277–84.

3 Donnelly LF, Emery KH, Brody AS, Laor T, Gylys-Morin VM, Anton C, *et al*. Perspective: Minimizing radiation dose for pediatric body applications of single-detector helical CT: Strategies at a large children's hospital. *AJR Am J Roentgeno,* 2001; 176 (2): 303–6.

4 White KS, Helical/spiral CT scanning: a pediatric radiology perspective. *Pediatr Radiol* 1996; 26 (1): 5–14.

5 Brenner DJ, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol* 2001; 176 (2): 289–96.

6 Bulas D, Goske M, Applegate K, Wood B. Image Gently: improving health literacy for parents about CT scans for children. *Pediatr Radiol* 2009; 39(2): 112–6.

7 Goske MJ, Applegate KE, Boylan J, Butler PF, Callahan MJ, Coley BD, *et al*. The "Image Gently" campaign: Increasing CT radiation dose awareness through a national education and awareness program. *Pediatr Radiol* 2008; 38(3): 265–9.

8 Strauss KJ, Goske MJ, Kaste SC, Bulas D, Frush DP, Butler P, *et al*. Image gently: ten steps you can take to optimize image quality and lower CT Dose for pediatric patients. *AJR Am J Roentgenol* 2010; 194 (4): 868–73.

9 Muhogora WE Nyanda AM, Ngoye WM, Shao D. Radiation doses to patients during selected CT procedures at four hospitals in Tanzania. *Eur J Radiol* 2006; 57 (3): 461–7.

10 IAEA, International Atomic Energy Agency. International action plan for the radiological protection of patients (Report by the Director General) GOV/2002/36-GC(46)/12, B.o.G.G. Conference 2002. p. 1–9.

11 Mettler FA, Training users of medical radiation in current trends in radiation protection. In: Metivier H, Gallego E, Sugier A, editors. Title of book. Les Ulis (France): EDP Sciences; 2004.

12 Shrimpton P, Edyvean S. CT scanner dosimetry. *Br J Radiol* 1998; 71 (841): 1–3.

13 Soye JA, Paterson A. A survey of awareness of radiation dose among health professionals in Northern Ireland. *Br J Radiol* 2008; 81 (969): 725–9.

14 Moss M, McLean D. Paediatric and adult computed tomography practice and patient dose in Australia. *Australas Radiol* 2006; 50 (1): 33–40.

15 PTW-Freiburg. User manual DIADOS PTW diagnostic dosimeter T11003. Freiburg (Germany): PTW; 2008.

16 Al Mohiy H, J Sim J, Seeram E, Davidson R, Differences between Saudi Arabian and Australian radiographers' knowledge and attitudes about paediatric CT doses. *The Radiographer* 2011; 58 (3): 21–7.

17 Minichiello V. Designing qualitative research. CRC seminar series. Melbourne: Victoria University of Technology; 1995.

18 Lewis SJ, Robinson JW. Role model identification by medical radiation science practitioners—a pilot study. *Radiography* 2003; 9 (1): 13–21.

19 Gruppetta E. Ethical issues for radiographers: general observations and a pilot qualitative study. *Radiat Prot Dosimetry* 2009; 135 (2): 88–9.

20 Thoirs K, Giles E, B. W, The use and perceptions of simulation in medical radiation science education. *The Radiographer* 2011; 58 (3): 5–11.

21 Davies MB. Doing a successful research project: using qualitative or quantitative methods New York: Palgrave Macmillan; 2007.

22 Rubin HJ Rubin I. Qualitative interviewing: The art of hearing data (2nd edition). Thousand Oaks CA: Sage Publications; 2005.

23 Bazeley P. Qualitative data analysis with NVivo. Los Angeles: Sage; 2007.

24 Dawson C. A practical guide to research methods: A user-friendly manual for mastering research techniques and projects. Oxford: How To Books Ltd; 2007.

25 Huda W. Effective doses to adult and pediatric patients. *Pediatr Radiol* 2002; 32 (4): 272–9.

26 Lee CI, Haims AH, Monico EP, Brink JA, Forman HP. Diagnostic CT Scans: assessment of patient, physician, and radiologist awareness of radiation dose and possible Risks. *Radiology* 2004; 231 (2): 393–8.

27 Rice HE, Frush DP, Harker MJ, Farmer D, Waldhausen JH; APSA Education Committee. Peer assessment of pediatric surgeons for potential risks of radiation exposure from computed tomography scans. *J Pediatr Surg* 2007; 42 (7): 1157–64.

28 Hoorens V, Bram P, Buunk BP. Social Comparison of Health Risks: Locus of Control, the Person-Positivity Bias, and Unrealistic Optimism. *J App Soc Psychol* 1993; 23 (4): 291–302.

29 Brix G, Nagel HD, Stamm G, Veit R, Lechel U, Griebel J, *et al*. Radiation exposure in multi-slice versus single-slice spiral CT: results of a nationwide survey. *Eur Radiol* 2003; 13(8): 1979–91.

30 Kato Y, Nair S, Sano H, Sanjaykumar MS, Katada K, Hayakawa M, *et al*. Multi-slice 3D-CTA – An improvement over single slice helical CTA for Cerebral Aneurysms. *Acta Neurochir* (Wien) 2002; 144 (7): 715–22.