Public Health England

Protecting and improving the nation's health

The Regulation and Quality Improvement Authority

Northern Ireland CT equipment survey 2017

About Public Health England

Public Health England exists to protect and improve the nation's health and wellbeing, and reduce health inequalities. We do this through world-leading science, knowledge and intelligence, advocacy, partnerships and the delivery of specialist public health services. We are an executive agency of the Department of Health and Social Care, and a distinct delivery organisation with operational autonomy. We provide government, local government, the NHS, Parliament, industry and the public with evidence-based professional, scientific and delivery expertise and support.

Public Health England
Wellington House
133-155 Waterloo Road
London SE1 8UG
Tel: 020 7654 8000
www.gov.uk/phe
Twitter: @PHE_uk
Facebook: www.facebook.com/PublicHealthEngland

Prepared by: Medical Exposures Group, Public Health England
For queries relating to this document, please contact: MedicalExposures@phe.gov.uk

Report Number CRCE-RAD-005-2018
December 2018

PHE supports the UN
Sustainable Development Goals

Contents

Executive summary

The Regulation and Quality Improvement Authority (RQIA) is the independent body responsible for regulating and inspecting the quality and availability of health and social care (HSC) services in Northern Ireland.

An element of RQIA's broad remit is for monitoring, inspecting and enforcement of the Ionising Radiation (Medical Exposures) Regulations [IR(ME)R][1] which is legislation, implemented in 2000, intended to protect the patient from the hazards associated with ionising radiation. Since completing work on this survey new Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2018[2] have come into force.

RQIA have a well-established proactive inspection programme which over a number of years has completed inspections of providers from the NHS and independent sectors undertaking medical examinations involving ionising radiation.

RQIA looked to develop a different approach to enhancing their intelligence gathering and assessing compliance across Northern Ireland. This involved establishing a picture of the current CT equipment and services provision at each site across the region to inform the Authority's work programme over the coming years in relation to IR(ME)R.

As part of the programme of work RQIA commissioned the Medical Exposures Group in Public Health Engand (MEG) to design and compile a modality specific online survey to build a picture of the current CT equipment and services available across the five Northern Ireland Health and Social Care Trusts.

Data from the completed survey demonstrated the age and standards of technology available across the region. The results showed sites using the latest dose reduction technologies and so provides an indication of where scan protocols may have been optimised with the ultimate intention of encouraging and sharing safe and effective clinical practice. This information will also lead to a better understanding where there is aging technology that perhaps should be on an equipment replacement programme.

Introduction

The current focus in radiation protection in the UK and Europe is still on high dose, high risk medical exposures CT and interventional studies. Dose limitation and optimisation remain the key principles of radiation protection as described by the International Commission on Radiological Protection(ICRP)[3].

The aim of the survey is to gain a better understanding of current CT practice and service delivery of these potentially high dose/risk examinations across the Northern Ireland region.

The survey is intended to guide the focus for future RQIA compliance approaches and provide an indication as to where new CT equipment and practices have been introduced.

MEG proposed a survey that would look at a number of key questions in specific clinical areas with the following rationale:

- Paediatric CT
  It was expected these examinations would be low in number but inclusion in the survey might demonstrate where paediatric centres are optimising doses
- Interventional CT and CT Fluorography
  It is also expected these examinations would be low in numbers but potential for higher doses and increased need for optimisation
- Cardiac CT
  Cardiac Dose Reference Levels (DRLs) have been published by Public Health England[4]. Inclusion of Cardiac CT exams in the survey might indicate if these have been adopted for benchmarking purposes and to gauge local levels of optimisation
- CT Colonography
  Inclusion of CT Colonography examinations might provide an insight into training, practice and optimisation of this multi-phase technique
- CT Perfusion Studies
  It was expected these examinations would be low in number but potentially resulted in high doses of radiation to the patient. Inclusion of these examinations in the survey might indicate what levels of optimisation was in place.

The survey also gathered data on equipment manufacturers, models, year of installation, software technologies available and the number of procedures carried out in a 12 month period.

Under IR(ME)R, the practitioner and operator must ensure that doses arising from the exposure are kept as low as reasonably practicable (ALARP). The use of technology such as Iterative Reconstruction (IR) software, dose alerts and Automatic Tube Current

Modulation (ATCM) were identified on each of the CT scanners who completed the survey. Adoption of these technologies are indicative of local optimisation culture.

Methodology

The modality specific questions for inclusion in the survey were developed by MEG to address the key questions highlighted in the introduction above (Appendix 1). RQIA sent a letter (Appendix 2) to each Radiology Service Manager requesting their cooperation in the survey. Guidance was supplied on how to complete the survey which comprised of 28 questions to be completed for each CT scanner at each hospital site. The survey was conducted using an on-line survey tool called Select Survey. Respondents were asked to exclude any hybrid nuclear medicine CT systems or radiotherapy planning CT scanners. .

Access to the survey was available from Friday 31st March 2017 and following an extension (to allow a number of respondents to complete the data input) the survey closed on 30th June 2017.

The data was analysed to establish a number of key factors such as

- Equipment specification:
  -age
  -make
  -model of scanner
  -number of slices
- Dose modulation and notification capabilities
- Protocol optimisation
- Use of local DRLs
- Types of examinations and numbers of scans being performed over a 12 month period.

Results

Survey responses were received from each of the five Health and Social Care Trusts and two Independent Providers from the region and is presented below. This represents a 100% response rate.

Table 1: List of hospitals that participated in the survey

H&SC Trust	Hospital	No. of CT Scanners
Belfast Trust	Royal Victoria	3
	Musgrove Park	1
	Belfast City	4
	Mater	1
	Royal Ulster Hospital for Sick Children	1
Northern Trust	Antrim Area	2
	Causeway	1
	Mid Ulster	1
South Eastern Trust	Downe	2
	Lagan Valley	1
	Ulster	2
Southern Trust	Craigavon Area	1
	Daisy Hill	1
Western Trust	South Western Acute Hospital (SWAH)	1
	Altnagelvin	3
Independent Hospitals	Ulster Independent	1
	Kingsbridge	1

Table 1 shows the number of CT scanners at each hospital that participated in the survey. The Health and Social Care Trust that each hospital is affiliated to is also included. Data was collected on 27 CT scanners from 17 hospitals which included two independent providers. Hospitals with multiple scanners were asked to complete a separate questionnaire for each CT scanner.

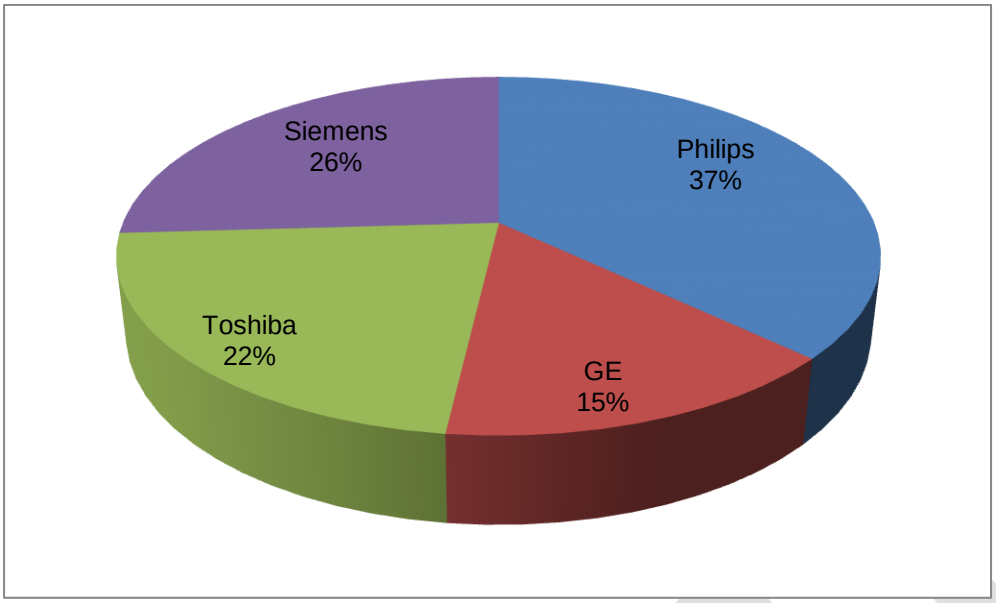
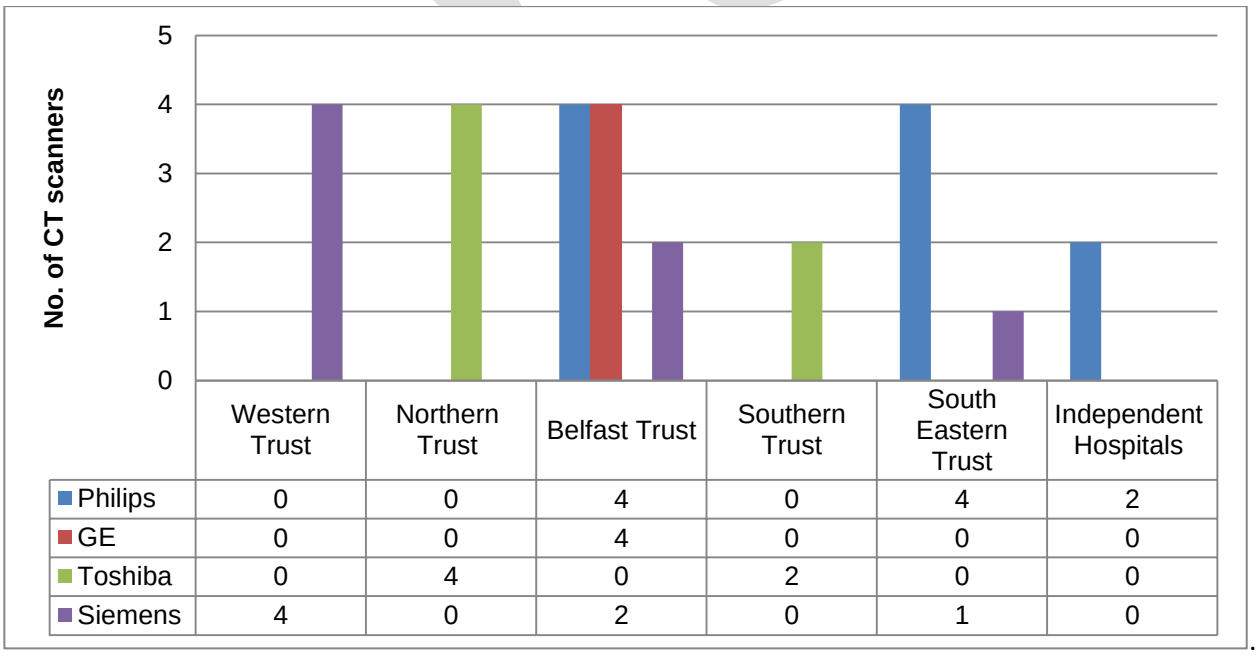


Figure 2: Percentage of CT scanners for each manufacturer

The survey collected information on the make and model of the CT scanners. The data showed that four manufacturers provided scanners in the Region; Philips Healthcare, Siemens Healthineers, Toshiba Medical Systems and GE Healthcare. Philips had the largest install base of CT scanners in Northern Ireland with 10 scanners representing 37% of the market share.



	Western Trust	Northern Trust	Belfast Trust	Southern Trust	South Eastern Trust	Independent Hospitals
Philips	0	0	4	0	4	2
GE	0	0	4	0	0	0
Toshiba	0	4	0	2	0	0
Siemens	4	0	2	0	1	0

Figure 3: Distribution of CT scanners by manufacturers by Trust

Figure 3 shows the distribution of manufacturers across the five Trusts and two independent sector hospitals.

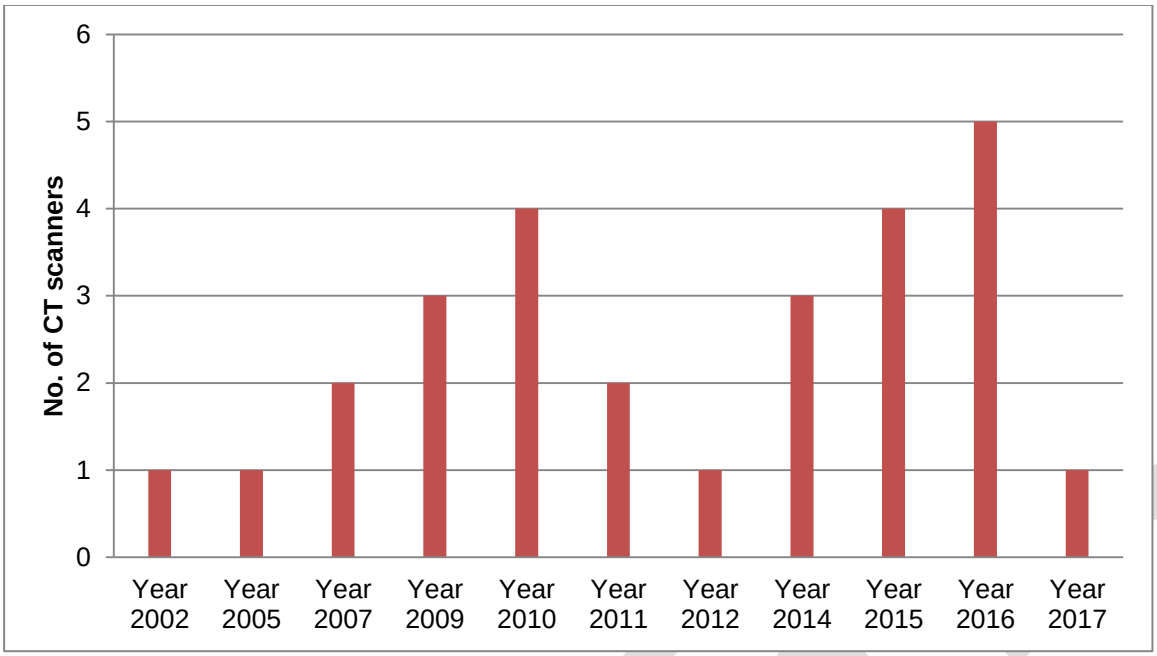


Figure 4: Year of installation/approximate age of scanner

The results of the survey showed the year with the most capital investment in CT scanners was 2016 with five new CT scanners installed across the Region. The oldest scanner in the region was a Philips 16 slice in Belfast City Hospital installed in 2002. The data describes this scanner as a 'backup scanner carrying out cancer staging scans and CT colonography imaging (CTC)'. The newest scanner in the region was a Philips 256 slice in Ulster Hospital, installed in 2017 performing a wide range of examination including cardiac, interventional CT and perfusion imaging.

Table 2: CT scanners older than 7 years

Hospital	Make	Number of slice	Year of installation
Belfast City Hospital	Philips	16	2002
Belfast City Hospital	GE	32	2005
Mid Ulster Hospital	Toshiba	16	2007
Lagan Valley	Siemens	64	2007
Kingsbridge	Philips	64	2009
Downe (both scanners)	Philips	64	2009
Antrim	Toshiba	64	2010
Belfast City Hospital	GE	64	2010
Daisy Hill	Toshiba	64	2010
Royal Victoria Hospital	Philips	128	2010

The average age of the scanners included in the survey was 7.4 years. A report commissioned by the Clinical Imaging Board[5] in 2015 included data from the National Audit Office survey[6] that the life span of a CT scanner was expected to be 7-10 years. Table 2 shows a list of 11 CT scanners in this survey that could be considered for replacement by end of 2018.

Automatic Tube Current Modulation (ATCM)

The survey looked at CT scanners with ATCM technology (also known as automatic exposure control (AEC)). This technology allows the scanner to automatically adjust the tube current according to the patient size while maintaining a constant image quality regardless of patient attenuation characteristics. Therefore, when used appropriately allowing radiation dose to the patient to be reduced.

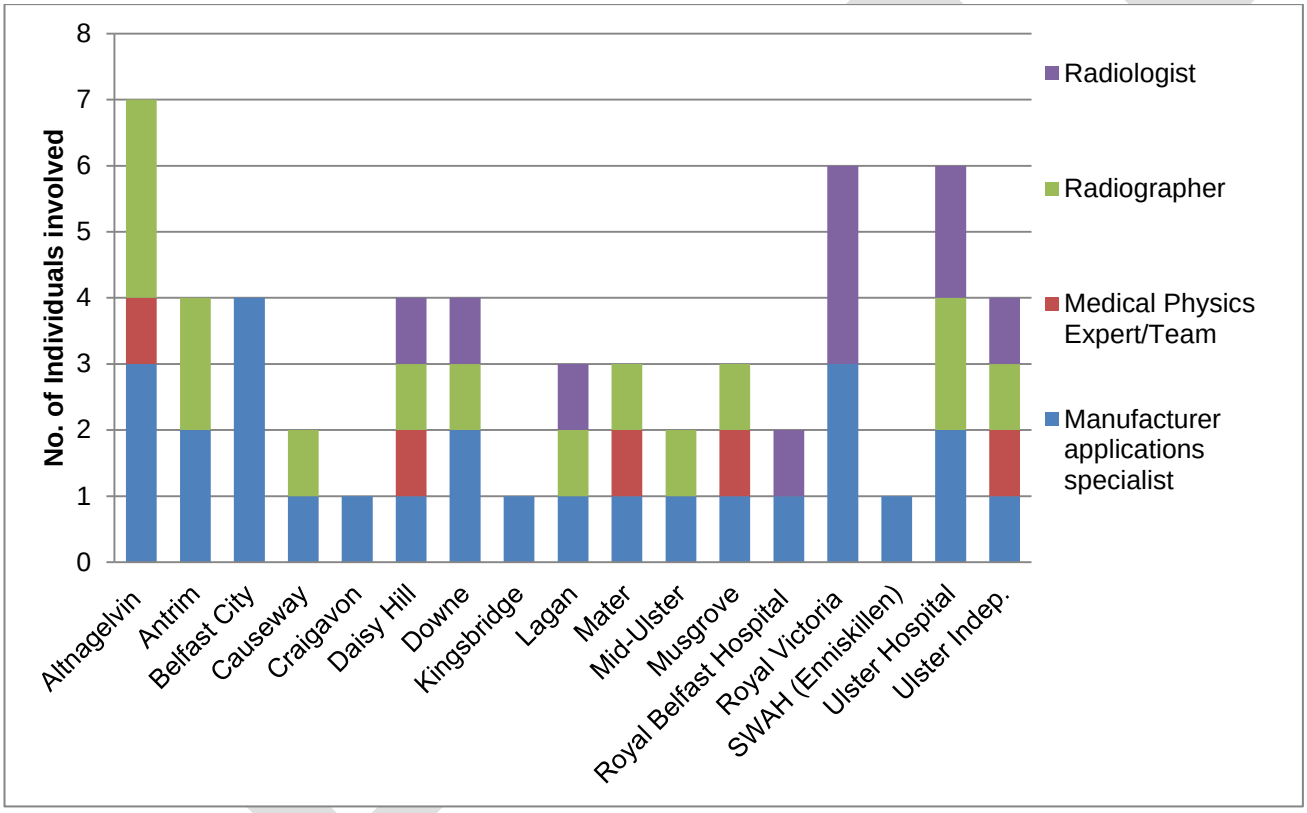


Figure 5: Staff involved in setting Automatic Tube Current Modulation (ATCM) values

The data showed that the application specialists were involved in setting the ATCM values on all CT scanners in this survey. The medical physics team were involved in setting the ATCM standards in five of the hospitals.

A paper published by the MRHA stated 'It is essential that operators and the medical physics support have full understanding of the operation and implications of the use of these AEC systems, since inappropriate use can easily result in increased radiation dose'[7].

Iterative Reconstruction (IR)

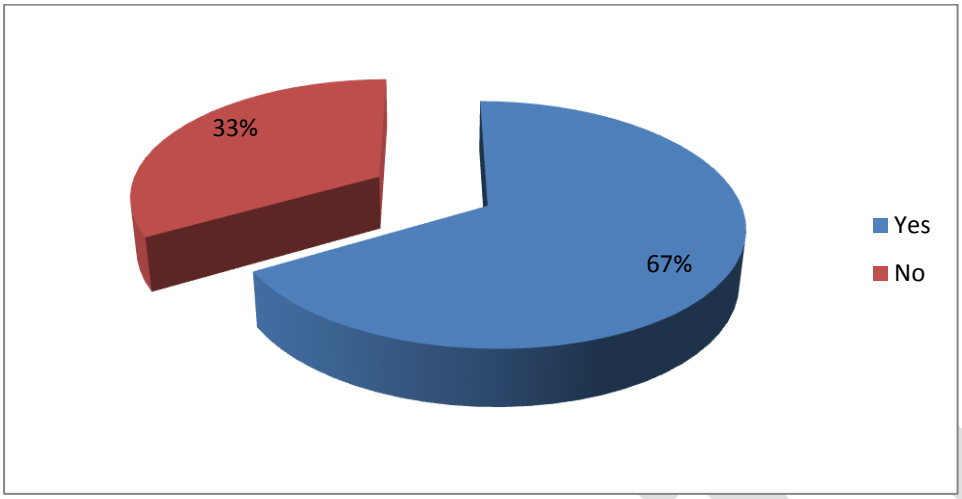


Figure 6: Percentage of CT scanners with Iterative Reconstruction (IR) capabilities

The survey asked if the CT scanner had iterative reconstruction software available and if so who was responsible for setting the standards for IR in the CT scanning protocols. Examples of IR software were given within the survey question for clarification. These included: ASIR/Veo, iDose/IMR, IRIS/SAFIRE and AIDR.

It was reported the following scanners did not have IR software :

- 2 X Toshiba Aquilion 64 slice 2011, 2010 (Antrim)
- GE Lightspeed 64 slice 2010 (Belfast City Hospital)
- GE Pro 32 slice 2005 (Belfast City Hospital)
- Philips Brilliance 16 slice 2002 (Belfast City Hospital)
- Toshiba Aquilion 64 slice 2010 (Daisy Hill Hospital)
- Philips Brilliance 64 slice 2009 (Kingsbridge)
- Toshiba Aquilion 16 slice 2007 (Mid Ulster Hospital)
- Philips Brilliance iCT 128 slice 2010 (Royal Victoria Hospital)

The initial introduction of IR in modern scanners was in 2008. The survey showed that the CT scanners that did not have IR were installed between 2002 and 2011. The average age of the CT scanners without IR software is 8.7 years. IR may not have been available or budgeted for at the time of installation on some of these CT scanners.

The COMARE 16 report describes ‘ the aim of IR is to keep image quality the same and lower doses, keep doses the same and improve image quality or a balance of both lowering doses and achieving better image quality’[8].

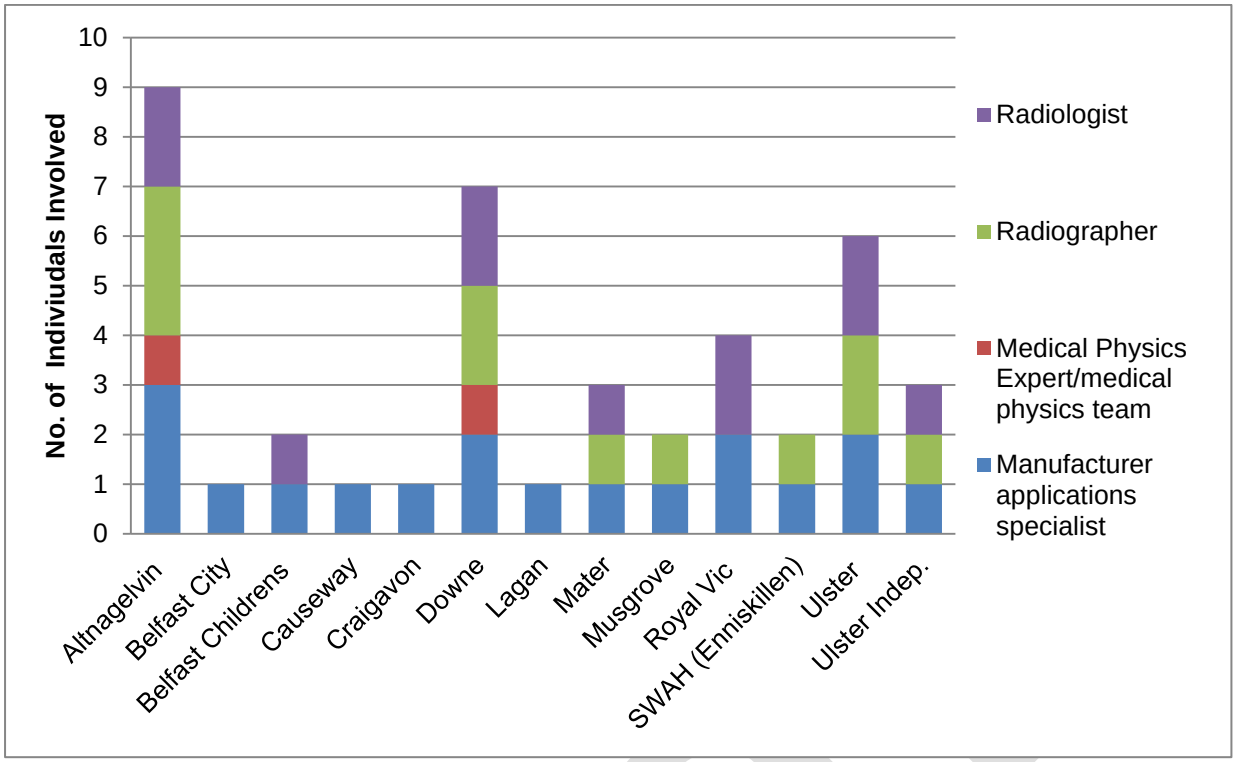


Figure 7: Staff groups involved in setting the standards for IR

The survey found that only two centres, Altnagelvin Area Hospital and Downe Hospital involved the medical physics department to support setting IR standards. The CT scanner at Altnagelvin Area Hospital is located in the North West Cancer Centre.

The manufacturer applications specialists are predominantly involved in setting the standards in most centres which would be expected as they are the experts on new systems being installed. An equal proportion of Radiographer and Radiologists were found to be involved in agreeing the standards which again is to be expected as the level of image quality required will be informed by the Radiologists and Radiographers.

Dose Alerts/notification capability

Figure 8 shows the number of CT scanners that have dose alert/notification capability. Examples of manufacturers dose alerts systems include ‘Dose Check’ and ‘Dose Alert’.

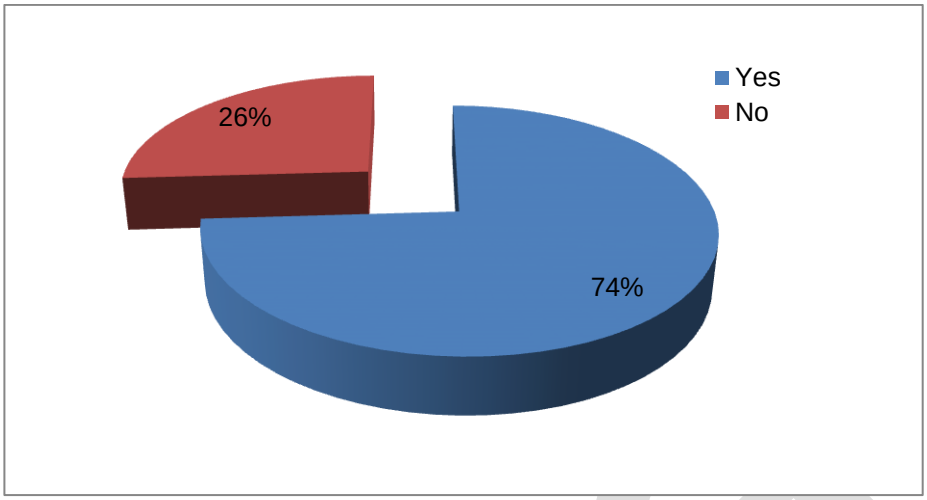


Figure 8: Percentage of CT scanners with dose alert/notification capability

Seven CT scanners indicated that they do not have dose alert/notification capability. These are listed below:

- Antrim Hospital Toshiba 64 slice (2010 & 2011)
- Belfast City Hospital Philips 16 slice CT scanner (2002)
- Kingsbridge Hospital Philips Brilliance 64 slice (2009)
- Craigavon Toshiba Aquilion 80 slice, (2016)
- Mid Ulster Toshiba Aquilion 16 slice (2007)
- Royal Victoria Philips Brilliance iCT 128 slice (2010)

Table 3 shows the hospitals where dose alerts are in place by individual CT scanner.

Table 3: Hospitals that are using dose alerts/notification systems

Hospital	Manufacturer	Model	No. Slice	Year
Causeway	Toshiba	Aquilion	128	2014
Belfast City	GE	Lightspeed	64	2010
	GE	Discovery	128	2014
	GE	Pro	32	2005
Altnagelvin	Siemens	Definition AS	64	2016
	Siemens	Definition Edge	128	2016
	Siemens	Definition AS	40	2011
Royal Belfast Hospital for Sick Children	GE	Optima	64	2014
Ulster	Philips	iCT	256	2016
	Philips	IQon	256	2017
Musgrove Park	Siemens	Definition AS	64	2015

Hospital	Manufacturer	Model	No. Slice	Year
Lagan Valley	Siemens	Definition	64	2007
Royal Victoria	Philips	Ingenuity Elite	128	2015
	Philips	Ingenuity	128	2015
SWAH (Enniskillen)	Siemens	Definition AS	128	2012
Mater	Siemens	Definition	64	2015
Ulster Independent	Philips	IQon	256	2016
Daisy Hill	Toshiba	Aquilion	60	2010
Downe	Philips	Brilliance	64	2009
	Philips	Brilliance	64	2009

Altnagelvin did not appear to have input from the applications specialist in setting the dose alert standard but instead involved the Medical Physics Team (MPT) and Radiographers. All other scanners with this capability involved the applications specialists along with input from MPT and Radiographers. Those scanners with the capability at Causeway, Daisy Hill, Ulster and Ulster Independent stated in their submission that only the applications specialist was involved in setting this function. This is represented in Figure 9.

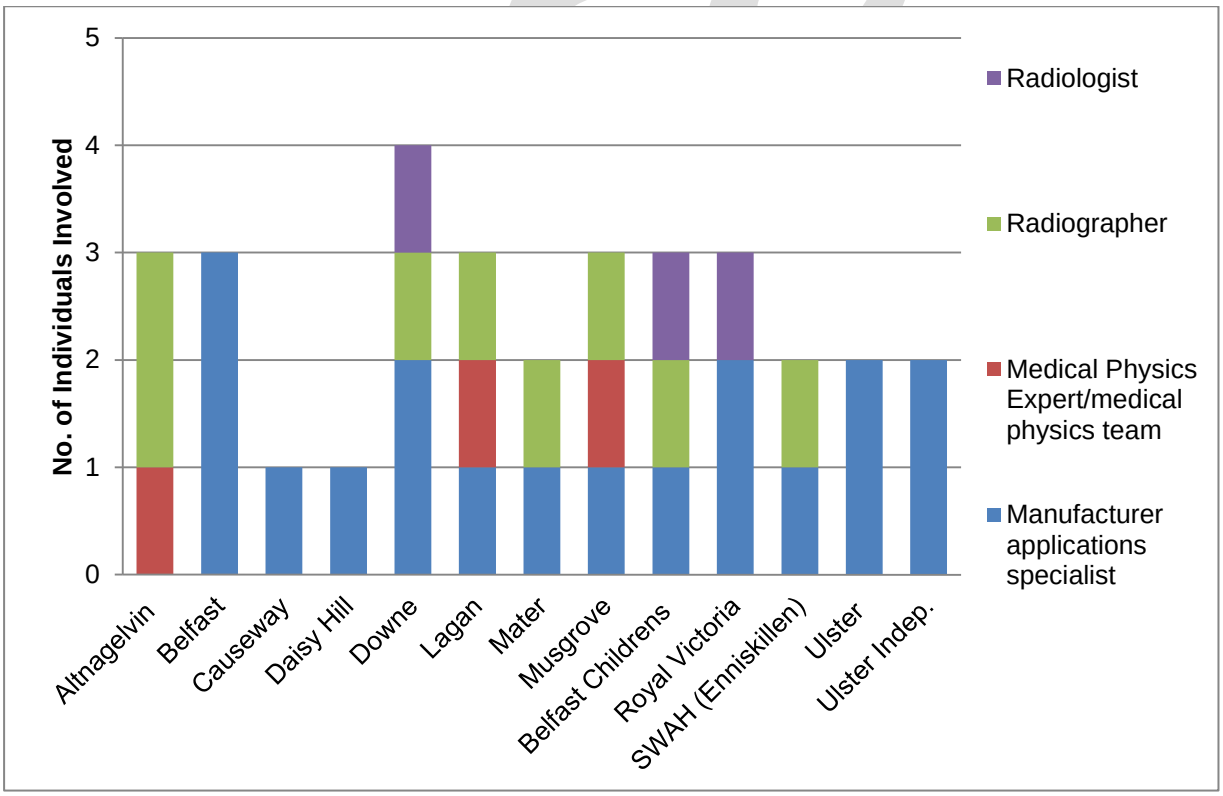


Figure 9: Staff involved in setting the standards for dose alert/notification capability

Dose Tracking/monitoring systems

Dose tracking software can be used to monitor radiation exposures in either individual patients or groups of patients or examinations. The software can either be equipment specific i.e. monitoring doses from one CT scanner or be installed as part of a Radiology Information System (RIS) or Picture Archiving and Communication System (PACS) where all equipment doses are tracked. The data can be used to inform the establishment of local DRLs (LDRLs), identify trends in patient dose including potential issues, support optimisation and provide a consistent approach to protocols setting across scanners and sites.

The survey found only two scanners had dose tracking systems as seen in Table 4.

Table 4: Hospitals using dose tracking/monitoring systems

Hospital	Manufacturer	Model	No. Slice	Year
Mater Hospital	Siemens	Definition	64	2015
Musgrove Park	Siemens	Definition	64	2015

The dose information is generally automatically captured and analysed at a later date by medical physicists, Radiographers or applications specialist as shown in Table 5.

Table 5: Individuals who review the dose data collected by the dose tracking/monitoring system

Hospital	Apps. Specialist	MPE/Physics Team	Radiographer	Radiologist
Mater Hospital	✓	-	✓	-
Musgrove Park	✓	✓	✓	-

Authorisation to make permanent changes to CT protocols

The survey asked if there were restrictions on who is authorised to permanently change optimised stored CT protocols. It was reported that 23 out of the 27 scanners included in the survey had restrictions on amendment of the CT protocols as represented in Figure 10 below.

The data showed that four scanners within Belfast City Hospital were reported to have no restrictions on who could make changes to saved CT protocols.

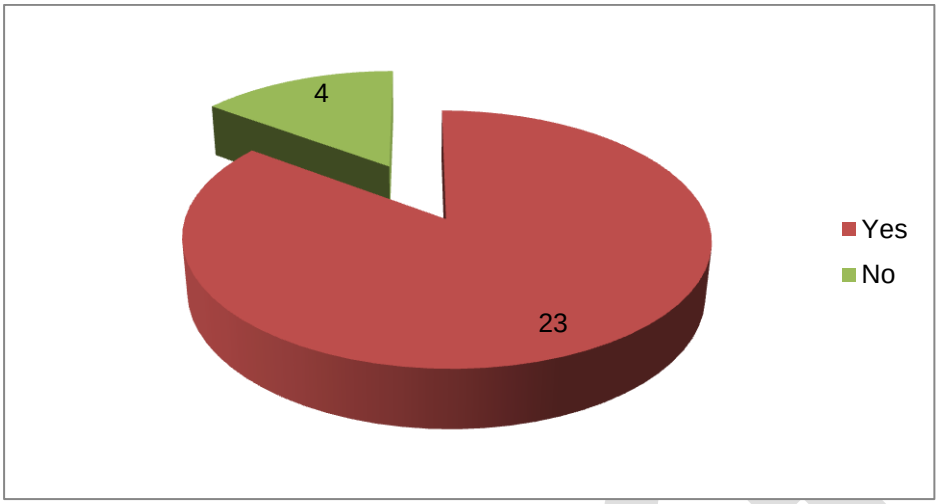


Figure 10: Number of CT scanners where there is restricted access for authorised staff to change optimised CT protocols

A number of factors influence the radiation exposure delivered during CT examinations. CT technology has a high in-built tolerance to radiation dose and overexposure of the patient is not revealed by obvious changes in the resulting image. Therefore it is important for those making changes to fully understand the implications of making permanent changes to stored protocols and how those changes will directly affect the patient dose.

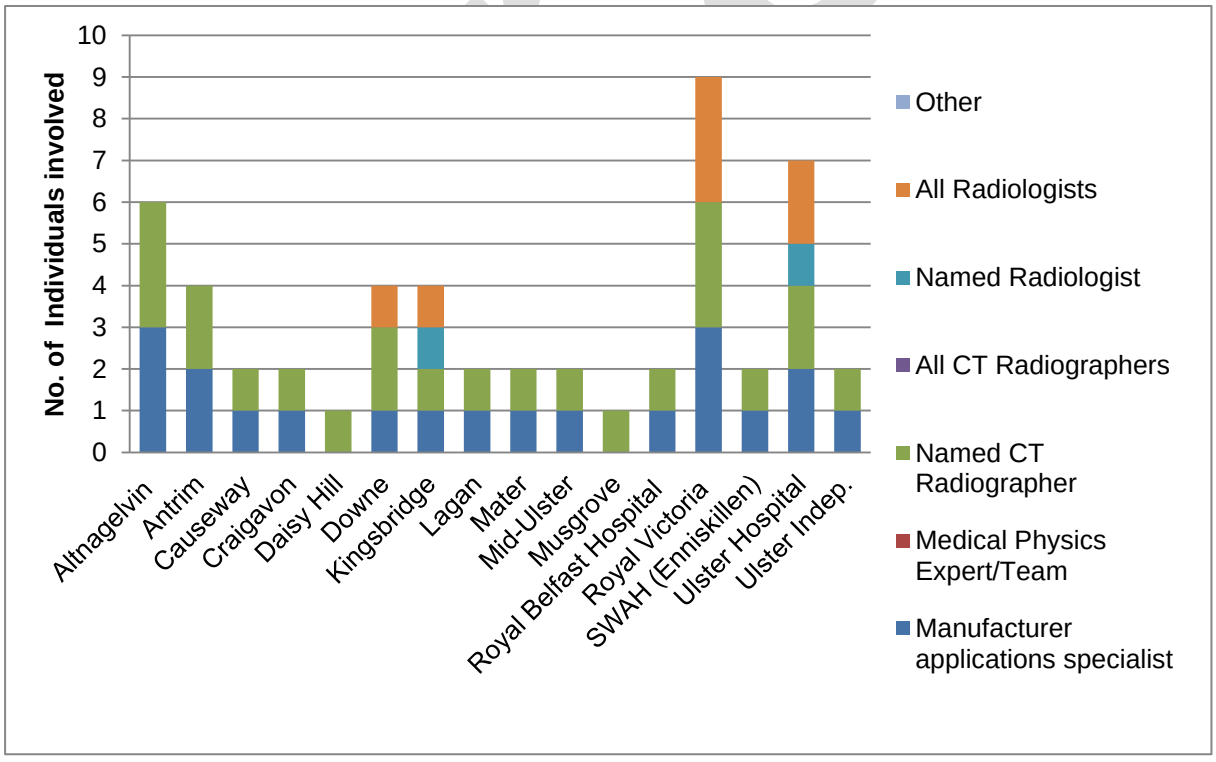


Figure 11: Staff authorised to modify and save optimised CT Protocols

It was reported the majority of protocol setting was done by named CT Radiographers in conjunction initially with an application specialist and supported by the Radiologists. Belfast City Hospital were the only site who stated they had no restrictions on who can make changes to the saved optimised CT protocols.

Diagnostic Reference Levels (DRLs)

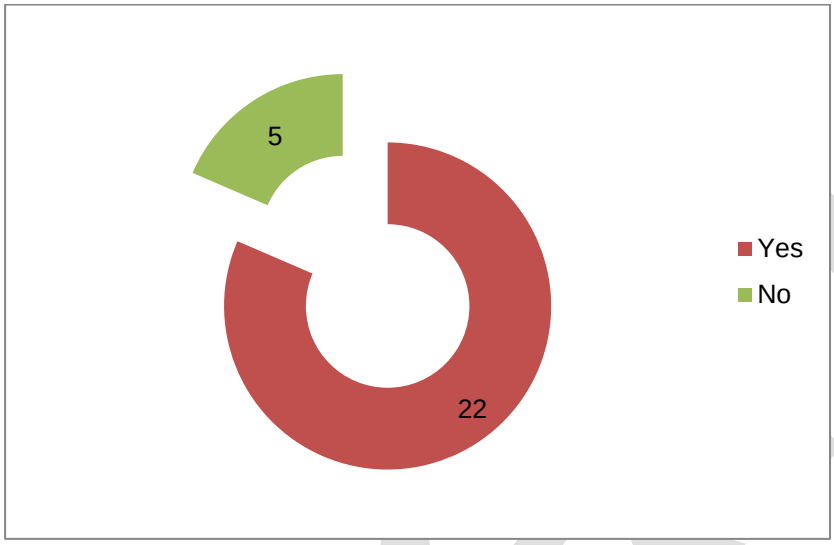


Figure 12: Number of CT scanners using Local Diagnostic Reference Levels (LDRLs)

Twenty-two of the 27 CT scanners included in the survey stated they are using local DRLs. For the five scanners (listed below) not using the locally established levels the National DRLs were being used.

- Antrim (2)
- Mid Ulster
- Causeway
- SWAH (Enniskillen)

DRLs are used as a guide to help promote improvements in radiation protection practice. They can help to identify issues relating to equipment or practice by highlighting unusually high radiation doses[9].

The data demonstrates 81% of the CT scanners in the region having established local DRLs to reflect local practice, equipment and patient cohorts.

Justification of Referrals

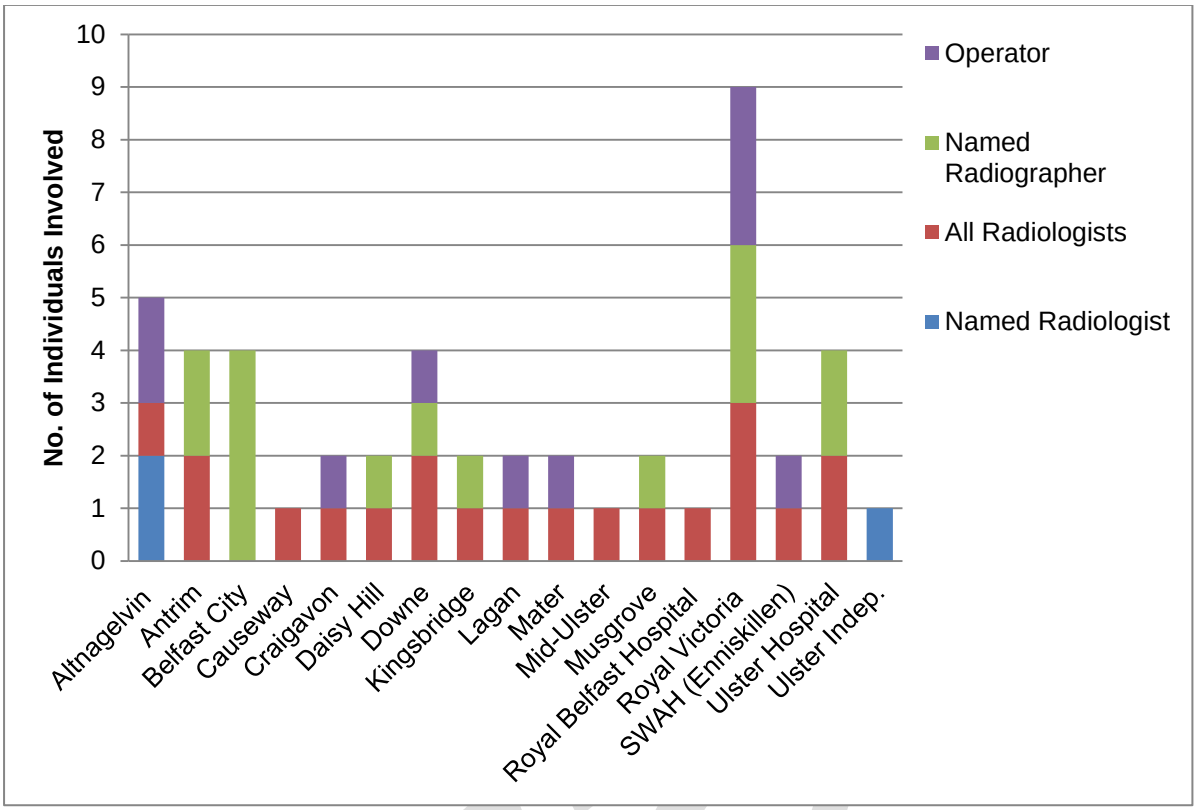


Figure 13: Staff groups involved in the justification of CT referrals

This graph shows the distribution of staff responsible for justifying CT referrals across the region. The study showed that 15 CT scanners had Radiographers entitled as practitioners to justify CT requests. A further 11 CT scanners had operators (Radiographers) authorising to guidelines produced by the practitioner.

Clinical Evaluation

The survey asked who performed clinical evaluation (written report) on CT images at each hospital. Thirteen CT scanners in eight hospitals used a combination of external providers and Trust employed Radiologists for clinically evaluating CT images.

There were two external providers of clinical evaluation services; Medica and Radiology Reporting Online (Now Everlight).

The hospitals that used external providers for clinical evaluation are listed below:

- Altnagelvin
- Antrim
- Causeway
- Craigavon

- Daisy hill
- Mater
- Royal Victoria
- SWAH (Enniskillen)

According to the data submitted to the survey there were no CT reporting Radiographers in Northern Ireland.

Number of patients scanned on each CT scanner

Hospital	Number Scanner	Scanner 1	Scanner 2	Scanner 3	Scanner 4
Antrim	2	10309	8511		
Altnagelvin	3	561	9392	5039	
Belfast City	4	***5.25****	5250	7250	350
Causeway	1	9236			
Craigavon	1	12018			
Daisy Hill	1	4800			
Downe	2	2000	5665		
Ulster Independent	1	2938			
Kingsbridge	1	4000			
Lagan Valley	1	5281			
Mater	1	7866			
Musgrove Park	1	2951			
SWAH (Enniskillen)	1	7395			
Ulster Hospital	2	9857	8000		
Mid Ulster	1	4544			
Royal Belfast Hospital for Sick Children	1	1000			
Royal Victoria	3	14308	10079	4927	

Table 6: Number of patients scanned for a 12 month period

*It would appear that the data inputted for Belfast City Hospital CT scanner 1, patient throughput, may be incorrect as the data captured stated 5.25 patients scanned over a 12 month period.

Each hospital had a differing number of CT scanners ranging from 1 to 4 as represented in Table 6. Some descriptors on the use of the scanners was also included in the responses and is included below.

- Altnagelvin CT scanner 1 was a newly opened service at the time of the survey. The scanner is located in the North West Cancer Centre on the Altnagelvin hospital site.
- Antrim Hospital CT scanner 2 which is situated in the emergency department is primarily utilised for emergency CT scans and scans performed outside of core work hours. Craigavon Hospital use their CT scanner for acute on site in-patients only and the scanner is operating seven days a week.
- Musgrove Park Hospital is a dedicated musculo-skeletal hospital and does not provide an out of hour's emergency service.
- Royal Victoria Hospital's CT scanner 1 provides a 24/7 service with trauma and emergencies combined with planned in and out patient work.
- Belfast City Hospital CT scanner 4 is used only as a backup scanner.

Paediatric

The CT scanners providing a paediatric imaging service range from a Toshiba Aquilion, 40 slice (installed 2011) at Altnagelvin through to a Philips IQon, 256 slice CT scanner (installed 2017) at Ulster Hospital. All CT scanners performing paediatric CT scans utilised ATCM which had been set up by the manufacturers' applications specialists.

Table 7 below demonstrates the age, slice number, year of installation and dose optimisation features of those scanner performing paediatric CT examinations.

Hospital	Manufacturer	No. Slices	Year Install.	IR	Dose Alert	Dose monitoring
Causeway	Toshiba	128	2014	Yes	Yes	No
Antrim	Toshiba	64	2011	No	No	No
Altnagelvin	Siemens	128	2016	Yes	Yes	No
	Siemens	40	2011	Yes	Yes	No
Royal Belfast Hospital for Sick Children	GE	64	2014	Yes	Yes	No
Ulster	Philips	256	2016	Yes	Yes	No
	Philips	256	2017	Yes	Yes	No
Musgrove Park	Siemens	64	2015	Yes	Yes	Yes
Craigavon	Toshiba	80	2016	Yes	No	No

Table 7: Hospitals providing a paediatric CT imaging

There was only one CT scanner performing paediatric CT scans that did not have IR or dose alerts. This was based in Antrim.

From the data provided Musgrove Park Hospital appears to be the only CT scanner using the dose monitoring function.

The average age of the CT scanners performing paediatric work was 2.5 years. All of the CT scanners are using the available software functionality to optimise and reduce patient dose. Seven of the CT scanners have established LDRLs and all of the CT scanners performing paediatric CT scans restrict who is authorised to permanently change and save CT protocols.

Working hours

The survey data found that Belfast City Hospital is the only hospital working extended hours (8.00-20.00) routinely on their scanners. Generally all the other CT scanners are open core hours 08.00-18.00 or 09.00-17.00.

The following five hospitals are providing a weekend booked inpatient and outpatient CT scanning service:

- Altnagelvin Hospital 10.30-15.00
- Antrim Hospital 09.00-17.00
- Belfast City Hospital 08.30-16.30
- Craigavon Area 09.00-15.00
- Royal Victoria 09.00-12.45

Five of the CT scanners providing trauma CT scans were also providing core weekend working for booked in and out patients. Twenty-one of the 27 CT scanners included in the survey provide an emergency/trauma service outside of their core working hours.

Twelve of the CT scanners providing trauma CT examination use external providers to make clinical evaluations.

CT scanners performing a range of examinations

The data showed that all 27 CT scanners within the survey were performing cancer staging scans.

Two CT scanners were performing perfusion CT scans. Royal Victoria Hospital use the Philips Ingenuity 128 slice installed in 2015 and Ulster Hospital use Philips IQon, 256 slice installed in 2017 for this purpose. The perfusion of the organ being imaged can ascertain data on blood flow to vital organs such as the brain and heart.

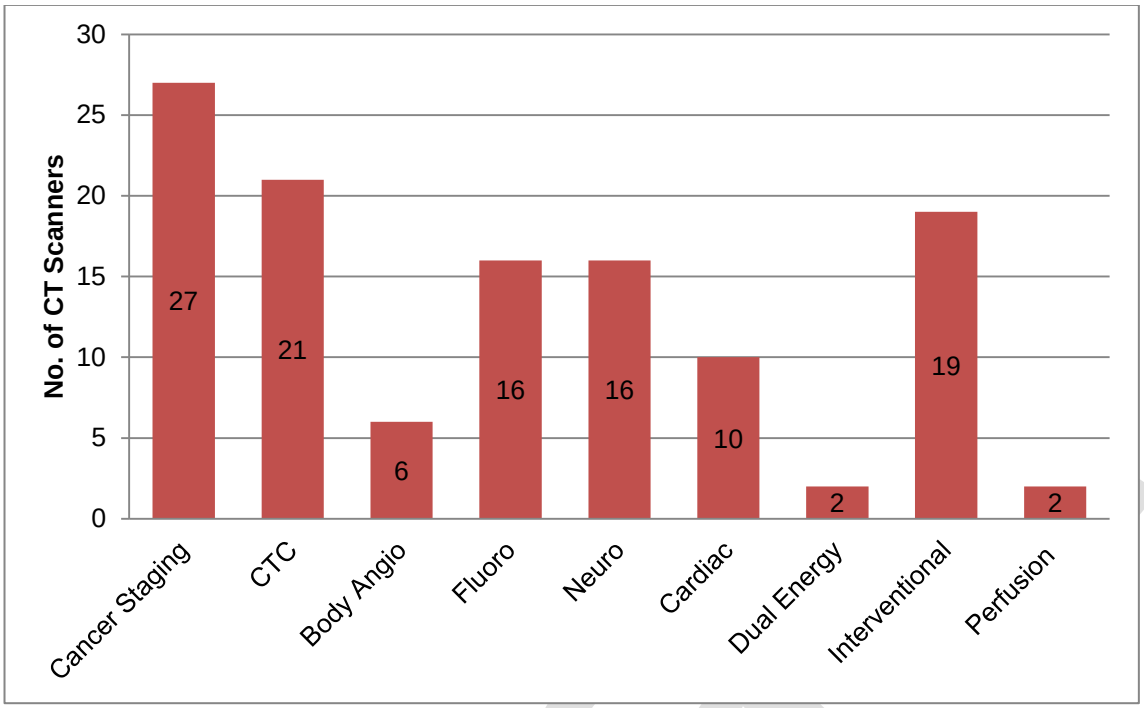


Figure 14: Range of CT examinations performed

The hospitals listed in Table 8 provided a cardiac CT scanning service. The table also demonstrates the software technologies available on each scanner performing cardiac CT. Appropriate use of all the available dose reduction technologies along with protocol optimisation would demonstrate good clinical practice.

Table 8: Hospital performing cardiac CT Imaging

Hospital	Manufacturer	No. of Slices	Year	IR	Dose Alert
Causeway	Toshiba	128	2014	Yes	Yes
Downe (2)	Philips	64	2009	Yes	Yes
Kingsbridge	Philips	64	2009	No	No
Royal Belfast Hospital for Sick Children	GE	64	2014	Yes	Yes
Ulster Independent	Philips	256	2016	Yes	Yes
Royal Victoria	Philips	128	2010	No	No
SWAH (Enniskillen)	Siemens	128	2012	Yes	Yes
Ulster Hospital	Philips	256	2017	Yes	Yes
	Philips	256	2016	Yes	Yes

The data showed the hospitals carrying out CT cardiac imaging and the CT scanners that have dose alert systems. Kingsbridge according to the survey did not have iterative reconstruction or dose alerts on their CT scanner. This may be due to the age of the scanner as it is 8 years old. The survey found only two CT scanners with Dual Energy (DE) capability, Belfast City Hospital and Musgrove Park.

DE CT uses two separate energies to examine differing attenuation properties. Some of the clinical applications for DE scanning include reduced artefact for metal implant imaging, virtual non contrast urinary tract imaging to identify the properties of kidney stones and gout imaging.

Table 9: Hospital providing CT interventional scanning

Hospital	Manufacturer	No. Slice	Year	IR	Dose Alert	Dose Monitoring
Antrim	Toshiba	64	2011	No	No	No
Altnagelvin	Siemens	128	2016	Yes	Yes	No
Belfast City	GE	128	2014	Yes	Yes	No
	GE	32	2005	No	Yes	No
Causeway	Toshiba	128	2014	Yes	Yes	No
Craigavon	Toshiba	80	2016	Yes	No	No
Daisy Hill	Toshiba	64	2010	No	Yes	No
Downe	Philips	64	2009	Yes	Yes	No
SWAH (Enniskillen)	Siemens	128	2012	Yes	Yes	No
Kingsbridge	Philips	64	2009	No	No	No
Lagan valley	Siemens	64	2007	Yes	Yes	Yes
Mater	Siemens	64	2015	Yes	Yes	No
Musgrove Park	Siemens	64	2015	Yes	Yes	Yes
Ulster Hospital	Philips	256	2016	Yes	Yes	No
	Philips	256	2017	Yes	Yes	No
Royal Belfast Hospital for Sick Children	GE	64	2014	Yes	Yes	No
Royal Victoria	Philips	128	2015	Yes	Yes	No
	Philips	128	2010	No	No	No
	Philips	128	2015	Yes	Yes	No

Interventional CT procedures are being carried out in 19 CT scanners across Northern Ireland. A number of these CT scanners are also providing interventional services using CT fluorography.

Five scanners providing an interventional CT service did not have iterative reconstruction software available on their CT scanners.

The CT scanners being used for interventional CT examinations ranged from 32 slices to 256. The oldest scanner is in Belfast City Hospital. The GE Pro 32 slice is 12 years old and did not have iterative reconstruction or dose monitoring according to the answers submitted to the survey.

There are 16 CT scanners performing CT colonography of which nine did not have iterative reconstruction software.

Discussion

PHE received 27 completed responses from 17 hospitals which included two independent providers.

The survey showed that the average age of a CT scanner in Northern Ireland is 7.4 years. The European Society of Radiologists (ESR) published a statement on renewal of radiological equipment in 2014[10]. It recommended replacing equipment more than 10 years old, citing obsolescence and reduced image quality. Older equipment has the potential for increased operating costs and may have a higher incidence of unreliability. Based on a 7-10 year lifespan renewal programme, the survey showed 11 scanners potentially due for renewal by end of 2018.

All 27 CT scanners captured in this survey were reported to have automatic tube current modulation capabilities. This is reassuring from a dose optimisation perspective as the ATCM aim is to deliver a specified image quality across a range of patient sizes which allows the dose to be tailored to the specific patient rather than a one size fits all approach. “Automatic exposure control has demonstrated reductions in dose of about 20-40% when image quality is appropriately specified” [11].

The survey found that the manufacturer applications specialists are predominantly involved in setting the IR standards in most centres. An equal proportion of Radiographers and Radiologists were found to be involved in setting these standards. The challenge for operators setting up IR for each individual protocol is gaining a consensus of agreement from clinicians as to acceptable image quality. The average age of the CT scanners that do not have IR software is 8.7 years. IR may not have been available at the time of installation on some of the older scanners however there is the opportunity to retrospectively install this software in some instances.

Twenty CT scanners within this study have dose alert/notification capability. CT scanners compliant with this standard can be configured to inform users prior to exposure when a planned CT scan could deliver exposures that would exceed a pre-assigned value for an average patient . This allows users, before proceeding with scanning, to confirm or correct factors that influence dose that might otherwise lead to unnecessarily high exposures.

Only two hospitals, both in the Belfast region, reported that their CT scanners had dose tracking software capabilities such as DoseWatch, DoseTrack or DoseMonitor

The survey asked whether processes are in place to restrict who is authorised to permanently change and save optimised CT protocols. Belfast City Hospital was the only hospital to state that they had no restrictions, therefore this would allow anyone to make changes. This could be considered as a potential risk if changes were made by an inexperienced staff member. The study results showed that the overall majority of protocols were set up by a named CT

Radiographer in conjunction initially with a manufacturer applications specialists and supported by the Radiologists.

Local DRLs were established and being used in 81% of the CT scanners captured in this survey. For the six CT scanners not using the locally established DRLs the National DRLs were reported as being used. The availability of dose data nationally can help to encourage higher standards of practice[4.]

According to the data submitted to the survey there were no CT reporting Radiographers in the region. The study showed that 15 CT scanners had Radiographers entitled to act as practitioners justifying CT referrals. A further 11 CT scanners had Radiographers authorising CT referrals using justification guidelines.

A practitioner entitled to justify referrals must have adequate training, be competent to consider the potential detriment of the exposure against the potential benefits for that individual and the scope of practice should reflect this additional responsibility[9].

The core working hours across the region was generally consistent throughout the Trusts with the vast majority of CT scanners running a standard 8 hour day. Five CT scanners offer a weekend service, scanning booked in and out-patients.

All 27 CT scanners in the survey were providing cancer staging scans. Twenty-two out of the 27 were providing emergency/trauma CT scans and nine scanners were performing paediatric CT imaging. It was found that all CT scanners performing paediatric work had restrictions on who is authorised to make permanent changes to the saved protocols.

There are a small number of CT scanners performing more advanced CT imaging such as perfusion, and dual energy. The data showed that nine CT scanners were performing cardiac CT imaging such as calcium scoring and/or CT cardiac angiograms. Seven CT scanners performing cardiac CT imaging in the study were using both the dose alert function and IR to optimise image quality while keeping doses ALARP. Two of the CT scanners however did not have either function set up/available.

Conclusion

The aim of the survey was to establish a better understanding of current CT equipment services across Northern Ireland. Through the submission of 27 respondents, PHE have been able to provide information on the current CT practice and service delivery across the region.

The data also demonstrated which scanners and sites have the latest dose reduction technologies and so provide an indication of where scan protocols may be optimised with the ultimate intention of encouraging and sharing safe and effective clinical practice.

It also provides detail on where new CT equipment and practices have been introduced and where potentially high dose procedures are being performed. The survey also provides information on any ageing equipment due for replacement in the next five years.

The survey results can be used to inform future RQIA IR(ME)R compliance approaches and future inspection planning.

References

1. The Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2000 (SR 2000 No. 194). Belfast: HMSO

2. The Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2018 (SR 2018 No. 17). Belfast: HMSO

3. International Commission on Radiological Protection. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103, *Ann. ICRP,* 37, (Nos 2-4), 2007

4. https://www.gov.uk/government/publications/diagnostic-radiology-national-diagnostic-reference-levels-ndrls/ndrl

5. https://www.rcr.ac.uk/posts/clinical-imaging-board-publishes-results-ct-scanner-survey

6. National Audit Office. Department of Health. Managing high value capital equipment in the NHS in England. A report by the comptroller and auditor general National Audit Office, HC822 Session 2010–11. London: The Stationery Office, 2011.

7. Keats, N., CT Scanner Automatic Exposure Control Systems, MHRA Rep. 05016, Medicines and Healthcare products Regulatory Agency, London (2005)

8. Public Health England. Committee on Medical Aspects of Radiation in the Environment (COMPARE) Sixteenth Report (2014) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/343836/COMARE_16th_Report.pdf

9. https://www.rcr.ac.uk/publication/guide-understanding-implications-ionising-radiation-medical-exposure-regulations

10. Renewal of radiological equipment. Statement from European Society of Radiology. Insights Imaging 2014; 5: 543–546

11. McCollough CH, Primark A N, Braun N, Kofler J, Yu L and Christner J (2009) Strategies for reducing radiation dose in CT. Radiol Clin North Am 47, 27-40

Appendix 1 – Survey Questionnaire

1. **Details of survey participant**:*
   Name
   Role
   Email

2. **Radiology Manager responsible for the service**:*
   Name
   Email

3. **NHS Trust**:*
   Belfast
   Northern
   South Eastern
   Southern
   Western
   Independent provider (non-NHS)

4. **Please state provider**:*

5. **Hospital name**:*

6. **Equipment details**:
   Manufacturer
   Model name (in full e.g. Somatom Definition Edge, Optima CT660)
   Number of slices
   Year of installation or approximate age of scanner

7. **Does this scanner have automatic tube current modulation capability (ATCM)?***
   Some examples of ATCM are AutomA/SmartmA, CAREDose, DoseRight, SureExposure
   Yes
   No

8. **Who is involved with setting the standards for ATCM in the CT scanning protocols?***
   Select all that apply:
   Manufacturer applications specialist
   Medical Physics Expert/medical physics team
   Radiographer
   Radiologist
   Other, please specify

9. **Does this scanner have iterative reconstruction (IR) capability?***
   Some examples of IR software are ASIR/Veo, iDose/IMR, IRIS/SAFIRE, AIDR
   Yes
   No

10. **Who is involved with setting the standards for IR in the CT scanning protocols?***
Select all that apply:
Manufacturer applications specialist
Medical Physics Expert/medical physics team
Radiographer
Radiologist
Other, please specify

11. **Does this scanner have dose alert/notification capability?***
Some examples of dose alert systems are DoseCheck, Dose Alert
Yes
No

12. **Who is involved with setting the standards for the dose alert/notification system?***
Select all that apply
Manufacturer applications specialist
Medical Physics Expert/medical physics team
Radiographer
Radiologist
Other, please specify

13. **Is the scanner connected to a dose tracking/monitoring system?***
Some examples of dose monitoring/tracking systems are DoseWatch, DoseTrack, DoseMonitor
Yes
No

14. **Who reviews the dose data collected by the dose tracking /monitoring system?***
Select all that apply:
Manufacturer applications specialist
Medical Physics Expert/medical physics team
Radiographer
Radiologist
Other, please specify

15. **Do you restrict who is authorised to permanently change and save CT protocols?***
Yes
No

16. **Who has authorisation to modify and save optimised CT protocols?***
Select all that apply
Manufacturer applications specialist
Medical Physics Expert/medical physics team
Named CT radiographers
All CT radiographers
Named radiologists
All radiologists
Other, please specify

17. **Do you use locally defined diagnostic reference levels (LDRLs) for this scanner?***
Yes
No

18. **Do you use national diagnostic reference levels (NDRLs) for this scanner?***
Yes
No
Don't know

19. **Who justifies referrals for this scanner?***
Select all that apply:
Named radiologists
All radiologists
Named radiographers entitled as practitioners
Operators authorising to guidelines
Other, please specify

20. **Who performs clinical evaluation (written report) on CT images at this hospital?***
Select all that apply:
Trust employed radiologists
Trust employed radiographers
External provider, please specify

21. **Total number of patients scanned on this scanner (1st April 2016-31st March 2017)**

22. **Do you routinely scan paediatric patients on this scanner?***
Yes
No

23. **What are the core working hours for this scanner (when planned inpatient and outpatient appointments are booked)?***
07:00-19:00
07:30-18:00
08:00-20:00
08:00-18:00
08:30-18:00
09:00-17:00
Other, please specify

24. **Do the core working hours for this scanner include Saturday and Sunday (when planned inpatient and outpatient appointments are booked)?***
Yes
No

25. **Is the scanner also in use outside of core working hours for emergency/trauma patients?***
Yes
No

26. **Does this scanner perform the following examinations?***
Select all the apply:

Cancer staging
CT colonography
CT body angiography
Cardiac CT
CT intervention
CT fluoroscopy
CT perfusion imaging
CT dual energy imaging
CT neuro angiography
Other, please specify

27. **Please provide any further information below that you feel would be helpful in relation your CT service**:

28. **Would you be happy to be contacted about your survey responses?***
Yes
No

Appendix 2 - Letter to Radiology Service Manager

Dear …….

As part of our responsibility for monitoring, inspecting and enforcement of the Ionising Radiation (Medical Exposures) Regulations [IR(ME)R], the Regulatory and Quality Improvement Authority (RQIA) is requesting your cooperation in undertaking short surveys of CT scanning and nuclear medicine equipment and services across the region.

You will be aware of our well established proactive inspection programme which over a number of years has completed inspections of providers undertaking medical examinations involving ionising radiation. These snapshots of clinical practice and of the framework employers are required to provide to assure patient safety, have raised awareness, understanding and indeed improved compliance with the regulations.

Over the next few months we will be developing a different approach to assessing compliance across Northern Ireland. The first step is to build a picture of the current CT and nuclear medicine equipment and services available across each site. With the support of Public Health England, we have compiled two modality specific (CT and nuclear medicine) online surveys, accessed via the links below. A separate spreadsheet is also attached for completion of nuclear medicine workload data (to be returned separately to MedicalExposures.phe.gov.uk).

The data collected will be used to inform our work programme over the coming years in relation to IR(ME)R.

We ask for your help in ensuring the links to the appropriate surveys (CT and /or nuclear medicine) are sent to the most suitable members of your team for completion.

An individual survey will need to be completed for every CT scanner (excluding hybrid NM CT systems or radiotherapy planning CT scanners) on each hospital site. There is not an option to pause/save the data once you have started the online survey, so your teams may find it helpful to gather data for the following areas, prior to commencing:

- Total patient throughput on each piece of equipment (e.g. each CT scanner or gamma camera) from 1st April 2016 - 31st March 2017
- Manufacturer, model, number of slices and year of installation (not required for hybrid NM CT systems or radiotherapy planning CT scanners)
- Dose optimisation packages available on each CT scanner (not required for hybrid NM CT systems or radiotherapy planning CT scanners) for example automatic tube current modulation, iterative reconstruction, dose alert/notification, dose monitoring/tracking

We would ask that your teams submit their completed survey(s) by Friday 12th May 2017.

Please feel free to contact and involve your medical physics team for support with any queries arising from the survey questions.

I thank you in anticipation of your co-operation with this piece of work.

Hall Graham

Head of Programme Reviews/Primary Care Advisor

The Regulation and Quality Improvement Authority

9th Floor, Riverside Tower

5 Lanyon Place

Belfast

BT1 3