UK Health Security Agency

UKHSA-RCE-1: doses from computed tomography (CT) exams in the UK

2019 review

Contents

Abstract

A fourth national computed tomography (CT) survey for the UK has provided a useful snapshot of patient doses between 2017 and 2019. Scan and dose details for some 769,711 individual patient scans relating to 13 common types of CT exam on adults were collected by electronic questionnaires voluntarily submitted by hospitals for a widely distributed sample of 266 scanners across the UK. This represented an estimated 55% of all NHS UK scanners. Typical practice for each scanner has been characterised by median values of the standard dose indices, Computed Tomography Dose Index volume ($CTDI_{vol}$) and dose length product (DLP), determined for samples of patients for each exam. The use of median values is a change to previous surveys which used the mean values.

Wide variations are still apparent in typical practice between hospitals for similar procedures, highlighting the need for continuing attention to the optimisation of patient exposure and the use of specific scanning protocols for each patient group (with due account of size) and clinical indication. The report includes summaries of the dose distributions observed and, on the basis of third quartile values from the distributions of typical (median) doses from individual scanners, proposes updated national diagnostic reference levels (NDRLs) for CT exams on adults. The proposed NDRLs represent a significant reduction for most exams in terms of both $CTDI_{vol}$ and DLP.

The updated central dose database at the UK Health Security Agency (UKHSA) will continue to represent a sustainable national resource for monitoring developments in CT practice through the ongoing collation of further CT scanner patient dose data.

Introduction

Periodic national reviews and surveys concerning frequency and dose for medical and dental X-ray procedures in the UK, conducted over the last 40 years by the UK Health Security Agency (UKHSA) and its predecessor organisations (the National Radiological Protection Board (NRPB) (1970 to March 2005), the Health Protection Agency (HPA) (April 2005 to March 2013) and by Public Health England (PHE) (April 2013 to October 2021)), have provided unique insight into national trends in population exposure (1).

These surveys have also formed the basis, since 1989, for setting NRDs (2, 3, 4, 5, 6, 7) and more recently national diagnostic reference levels (NDRLs) (8) as a quality improvement tool in promotion of the optimisation of patient protection.

Continuing advances in computed tomography (CT) technology, including improvements in multi-row detector arrays and computer processing, have facilitated the development of rapid scanning and information acquisition for sub-millimetre sections with almost instantaneous image reconstruction and options for multi-planar and three-dimensional (3-D) imaging (9, 10, 11).

CT exams have thus become more tolerable for patients, with associated possibilities for increased scanned volumes. Further developments – for example, in relation to tube-current modulation and image reconstruction – have allowed beneficial improvements in dose, image quality and patient protection (12, 13, 14, 15, 16).

Such technological advances have fuelled a steady growth in the application of CT in clinical practice and its expansion to provide new and more complex imaging procedures (17, 18, 19).

The resultant ongoing trend has therefore been for increasing annual numbers of CT exams, as illustrated in Figure 1 for the National Health Service (NHS) in England (20, 21).

Figure 1. Number of CT exams carried out in NHS England per financial year from 1996 to present (the source of the data changed in 2013 to 2014, which may account for the decrease in exams for that year compared to the previous year)

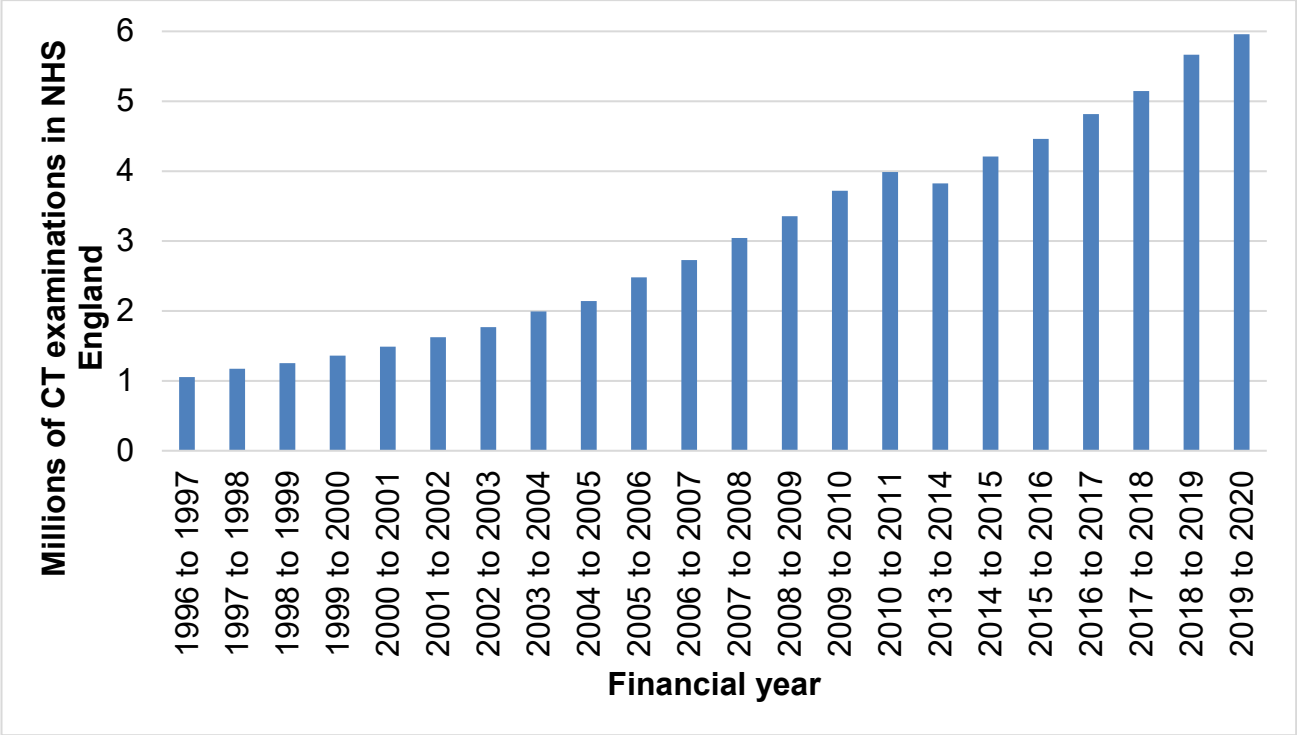
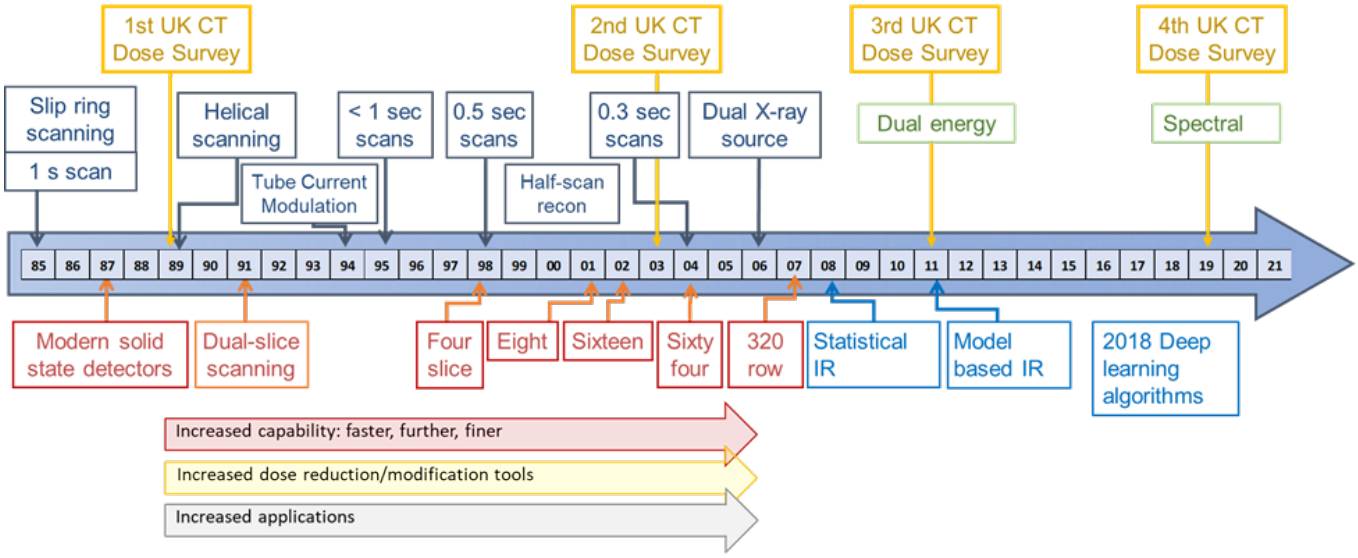


Figure 2. Timeline showing the schedule of national CT dose surveys in relation to technological advances in CT, 1985 to 2021 (a full description is given in the text below)



Such analyses serve to highlight the importance of CT in medical radiology and its need for special attention in relation to justification of exams and optimisation of patient radiation protection. Accordingly, 3 national CT dose surveys for the UK have already provided valuable snapshots of practice (see Figure 2).

The first survey was conducted around 1989 when UK practice largely involved single-slice, non-helical CT scanners (22, 23, 24). Using data from 83% of all UK scanners, this seminal survey provided estimates of typical organ and effective doses for standard protocols and established, for the first time, both the relatively high patient doses and also the importance of CT as a source of population dose (25). It also demonstrated significant variations in practice between CT centres for similar types of exams and hence the scope for improvement in patient protection (26). In addition, the work underpinned the development of specific reference dose quantities for CT (27, 28) and provided some initial values for Europe as part of quality criteria for CT (29).

The second national CT dose survey was conducted for 2003 on the basis of data collected from a sample of 27% of all UK scanners, of which 37% were multi-detector-row CT (MDCT) scanners (4,30,31). The survey included scan information in relation to both standard protocols for specific clinical indications and also individual patients, and provided updated typical effective doses and national reference doses (NRDs). The NRDs were widely utilised as National Diagnostic Reference Levels (NDRLs). Wide variations in practice were still apparent between CT centres, with doses from MDCT (four+ detector-row) scanners being in general slightly higher than those from single-slice scanners. This is understood by 4 slice scanners being less dose efficient than single slice scanners, and this difference decreases with higher detector row scanners. However, the study did demonstrate an initial trend for reduction by 10 to 40% in NRDs since the previous UK survey for 1989 for some common CT procedures.

Following further significant changes in UK CT practice, including increasing numbers of exam (Figure 1) and the implementation of new technology (Figure 2) since 2003, a third national survey was conducted in 2011 (Shrimpton and others, 2014) to provide updated information concerning typical doses for an expanded range of contemporary exams and an assessment of present trends. This survey included a sample of approximately 30% of all UK scanners, of which all were multi-detector-row CT (MDCT) scanners with over half having at least 64 detector rows (5). Whereas the previous 2 national reviews (4, 23) focused on standard CT protocols and necessarily included single-slice CT (SSCT), this survey collected information on technique for specific clinical indications and provided updated NRDs. Wide variations were still apparent in typical practice between CT centres for similar procedures. This observation highlights the need for continuing review of scanning techniques following advances in CT technology in order to ensure patient radiation protection remains optimised in relation to each type of exam and clinical indication. Values of NRDs (and by extension NDRLs) were recommended for more exams than previously and, compared to corresponding MDCT data from 2003 for adults, levels for $CTDI_{vol}$ were found to be within ±10%, whereas those for DLP were 5 to 90% higher.

Recent developments, including the increased use of wide-beam technologies, the use of dual energies and the adoption of iterative reconstruction (IR) methods which were not in common clinical use during the previous review, and alongside the continued emphasis on optimisation of practice, make this fourth review a timely analysis of current CT practice in the UK.

Method

Exam selection

Initial selection

This Fourth UK survey only considered adult exams. A complementary paediatric dose survey led by IPEM, supported by PHE (now UKHSA), was run at a similar time to collect information on paediatric exams (32).

The exams included were selected using a number of methods. Firstly, the exams in the previous, 2011, national survey were considered as to whether they still represented exams which are carried out in significant number, and also whether sufficient data was received in the previous survey to set an NDRL.

Secondly, the NHS England Diagnostic Imaging Database (DID) was utilised (21). This contains details of all requested exams carried out by the NHS in England. This database was queried to determine the most common CT exams carried out in England and by extension to the UK. A limitation of this dataset is that the exam is classed only by the body part examined rather than the additional required information of clinical indication for the imaging exam, however it enabled the first step in exam selection.

Preliminary survey

To ensure that no exams were missed from simply looking at a large national dataset, a more focussed, local approach was also used. A preliminary survey (see Appendix C) was distributed online in 2018 to the UK medical physics and radiography communities to gather information for which of the initial list of CT exams they would expect to be able to provide sufficient data. This survey also requested information on how data would be submitted to the survey, and the patient demographic information that could be provided (for example, age, weight and so on) The responses (see Table 2) showed that only patient age would be readily available. Although age would be useful to ensure only adults are selected, it is not useful as a means of selecting similar sized patients.

A final list of exams was then established (see Table 1). This needed to show a balance between having a sufficient number of exams to cover the wide range carried out, whilst being a small enough number to be manageable. In addition the exams needed to be performed frequently enough for sufficient data to be collected within the timescale required. For example, enteroclysis was included in the 2011 survey, however insufficient data was received to set a NDRL. The responses to this preliminary survey also indicated that not enough data would be received for this exam and so this exam was subsequently not included.

It was decided that 13 exams would be selected for the main survey. This is similar to previous surveys and at least 68% of respondents suggested they would be able to provide sufficient data for these exams (see Table 3).

Clinical indication

Previous national CT surveys for NDRLs have focussed on using a specific clinical indication as well as a body part to ensure some level of consistency of scan protocol purpose. The same approach was followed for this survey. The final list of exams was reviewed by 2 radiographers and a radiologist to identify the most common clinical indications for each exam as well as those clinical indications where similar exposure parameters would be expected to be used.
It is clear from previous surveys that clinical information associated with the scan protocol is often difficult to obtain from retrospective scan data. However, where exam protocols are well maintained and consistently used, this can often provide adequate information to select the exams to include in the survey. Table 1 shows the final list of exams and clinical indications.

Table 1. List of exams included in this dose survey

UKHSA CT protocol	Clinical indication
Head	Acute stroke
Paranasal sinuses	Paranasal sinuses
Cervical spine (C-spine)	Fracture
Neck, chest, abdomen and pelvis	Cancer
Chest	Lung cancer
Chest – high resolution	Interstitial lung disease
Chest and abdomen	Lung cancer
Chest-abdomen-pelvis (CAP)	Cancer
CT pulmonary angiography (CTPA)	Pulmonary embolism
Abdomen and pelvis	Abscess
Colonography/virtual colonoscopy (VC)	Polyps/tumour
Kidney-ureters-bladder (KUB)	Stones/colic
Urogram	Stones/colic or tumour

Dose collection survey workbook

A dose collection survey form designed in Microsoft Excel was used to collect survey data. A survey form used for previous surveys was used (33), with some minor modifications, which would be familiar to the UK diagnostic radiology medical radiation community.

The use of an Excel form allowed any method of initial data collection. Local dose audits are undertaken using various methods of data collection, whether from the dose data, manually

input into the radiology information system (RIS), or from a dose image or the DICOM radiation dose structured report (RDSR); either directly from the scanner, or indirectly from the picture archiving and communication system (PACS) or dose management system. Suppliers of dose management systems were approached to include an automatic export from their systems into the UKHSA Excel template to make dose submission as simple as possible for users of these systems. However, there was limited success with this approach in the timescale required to participate in this survey.

Guidance was provided in the survey form with respect to patient selection. This covered various aspects of the data collection, and whether information was essential or optional to provide.

For any dose audit, ideally, patients are selected of similar size as the indicated dose index is related to a patient's cross-sectional dimensions. Therefore if the dose index data from different scanners have very different associated patient size demographics the values cannot be directly comparable. Weight is used as the most convenient surrogate for patient size, however, from previous surveys it is known that patient weight is often not available to provide alongside the patient dose data. For this survey it was asked that large samples of patient dose data be submitted to minimise the effects of a range of patient weights. By using a large sample the typical (median) dose should give a good representation of a typical patient size. This is in keeping with ICRP recommendations (34). Sample sizes of at least 20 patients per exam were requested, and ideally a larger sample be provided wherever possible. This was a significant increase from a minimum sample of 5 patients used in the Third CT survey.

Data could be submitted as either a list of individual patient data, or as summary statistics from a local dose audit. For the latter, additional information regarding the data collection and analysis methods was requested.

Results

Exam selection and feasibility

Preliminary survey

Table 2 shows the responses received for the different patient characteristics that were investigated as to whether to be practical for collection for this survey. Apart from age, the characteristics relate to indicators of patient size, and how the data would be obtained - either 'automatically' without user input, or 'manually' requiring a user to find the information for each patient. Table 3 shows the number of responses received and the percentages that could provide data for the different exams.

Table 2. Patient age and size characteristics that could be provided by respondents, according to automatic data collection methods or by manual data collection

Parameter	Automatic data collection		Manual data collection	
	Total number of respondents	% who could supply data	Total number of respondents	% who could supply data
Age	44	84	24	79
Patient diameter	41	15	40	33
Height	42	5	39	8
Weight	43	7	38	8
Size specific dose estimate (SSDE)	41	27	34	24
Water equivalent diameter, D_w	41	24	33	21

Table 3. Respondent's ability to provide a patient sample of at least 100 patients. The number of respondents is in brackets. The exams below the dotted line were not included in the survey

Exam	Percentage of respondents who could provide the requested patient data for the exam
Kidney-ureters-bladder (KUB) (stones/colic)	89% (39)
Chest-abdomen-pelvis (CAP) (cancer)	87% (39)
Chest – high resolution (interstitial lung disease)	86% (38)
CT pulmonary angiography (CTPA) (pulmonary embolism)	84% (36)
Head (acute stroke)	84% (36)

Exam	Percentage of respondents who could provide the requested patient data for the exam
Urogram (stones/colic or tumour)	79% (34)
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	79% (33)
Chest and abdomen (lung cancer)	76% (32)
Cervical spine (C-spine) (fracture)	71% (30)
Paranasal sinuses (sinus disease)	71% (30)
Abdomen and pelvis (abscess)	69% (29)
Neck, chest, abdomen and pelvis (cancer)	68% (28)
Chest (lung cancer)	68% (30)
CT angiography (CTA) (abdominal aorta/blood vessels)	60% (25)
CT angiography of lower limb artery (ischaemic limb, claudication)	51% (21)
Abdomen (liver metastases)	50% (21)
Pelvis (fracture)	35% (13)
Enteroclysis (crohn's disease)	16% (6)

Data sample characteristics

Scanner distributions

Figure 3 shows the locations of the hospitals that submitted data to the main survey. There are submissions from all 4 nations of the UK. Data was received for 266 scanners from 147 hospitals representing 769,761 patients. Data was received both as individual patient data and as a summary of a local dose audit. There were 145 submissions from NHS hospitals and 2 submissions from independent healthcare providers. Table 4 shows a breakdown of the data received per exam and Table 5 shows how many scan sequences were used for each exam. These numbers do not include scan projection radiographs and contrast bolus scans, as these were requested to be excluded from the submission or were manually removed from the data submission. Table 6 shows the range of scanner models for which data was received.

Figure 3. Map showing locations of hospitals that submitted data to this survey. Map Data © 2021 Google

Summary of data submitted to this survey

Table 4 Summary of data submitted to this survey

Exam	Patients	Hospitals	Scanners
Head (acute stroke)	280,417	135	225
Paranasal sinuses (sinus disease)	12,627	97	144
Cervical spine (C-spine) (fracture)	15,380	71	103
Neck, chest, abdomen and pelvis (cancer)	10,347	68	106
Chest (lung cancer)	35,565	103	183
Chest – high resolution (interstitial lung disease)	23,737	94	154
Chest and abdomen (lung cancer)	23,227	89	145
Chest-abdomen-pelvis (CAP) (cancer)	133,248	128	240
CT pulmonary angiography (CTPA) (pulmonary embolism)	47,820	111	180
Abdomen and pelvis (abscess)	107,100	123	217
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	16,842	92	103
Kidney-ureters-bladder (KUB) (stones/colic)	45,945	111	194
Urogram (stones/colic or tumour)	17,506	84	130
Total	**769,761**	**140**	**266**

Table 5. Summary of sequences used for each exam (*includes 4 scanners that used 4 sequences)

Exam	Number of Sequences			Total scanners
	1	2	3	
Abdomen and pelvis (abscess)	217	0	0	217
Cervical spine (C-spine) (fracture)	103	0	0	103
Chest – high resolution (interstitial lung disease)	105	32	12	153*
Chest (lung cancer)	183	0	0	183
Chest and abdomen (lung cancer)	85	60	0	145
Chest-abdomen-pelvis (CAP) (cancer)	138	102	0	240
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	0	103	0	103
CT pulmonary angiography (CTPA) (pulmonary embolism)	180	0	0	180
Head (acute stroke)	225	0	0	225
Kidney-ureters-bladder (KUB) (stones/colic)	194	0	0	194
Neck, chest, abdomen and pelvis (cancer)	47	47	12	106
Paranasal sinuses (sinus disease)	144	0	0	144
Urogram (stones/colic or tumour)	26	81	23	130

Scanner models

The CT scanner models included in this survey are shown in Table 6.The scanners have been broadly categorised by the number of detector rows. For some models the number of detector rows show a range, which is where a specific model can be configured with a range of detectors and detailed information had not been received. The detector rows relate to the physical number of detector elements on a single detector, so that the use of dual-energy systems or the use of oversampling to increase the number of reconstructed slices would not influence this value.

Table 6. Summary of CT scanner models included in this survey

Manufacturer	Model	Number of detector rows	Number of scanners
Canon (Toshiba)	Aquilion 64	64	10
	Aquilion CX/CXL	64	12
	Aquilion Lightning	80	2
	Aquilion One	320	23
	Aquilion Prime	80	25
GE	Brightspeed 16	16	1
	Discovery 710 PET CT	64	1
	Discovery CT750HD	64	14
	Lightspeed Pro 32	32	2
	Lightspeed VCT	64	22
	Optima 660	64	18
	Revolution	64	2
	Revolution CT	256	3
	Revolution Evo	64	15
	Revolution Go	64	3
	Revolution GSI	64	4
	Revolution HD	64	2
Marconi	MX8000	16	1
Philips	Brilliance	64	7
	Brilliance iCT	128	3
	Ingenuity	64	10
	IQon	256	2
Siemens	Biograph mCT Flow (Edge CT)	64	1
	Somatom Definition AS	32	21

Manufacturer	Model	Number of detector rows	Number of scanners
	Somatom Definition AS+	64	18
	Somatom Definition Edge	64	21
	Somatom Definition Flash	64	9
	Somatom Drive	64	2
	Somatom Emotion 16	16	1
	Somatom Force	96	2
	Somatom Perspective	64	3
	Somatom Sensation	32 to 64	5
	Symbia Intevo 16	16	1

Exposure technique

The main survey requested mandatory data around 2 aspects of exposure technique: whether automatic exposure control (AEC) was used during the exposure; and whether iterative reconstruction (IR) was the reconstruction technique (rather than filtered back projection (FBP)). Further details on the specific settings of these techniques and other aspects of the exposure (such as tube voltage and tube current) were requested as optional data. Table 7 shows the percentages of protocols that used these techniques. For multi-sequence exams, if at least one sequence used AEC and/or IR then it is counted as using that function for the purposes of this table.

Table 7. Percentage of CT scanners that used AEC or IR for each exam

Exam	AEC (%)	IR (%)
Abdomen and pelvis (abscess)	98%	77%
Cervical spine (C-spine) (fracture)	97%	77%
Chest – high resolution (interstitial lung disease)	92%	75%
Chest (lung cancer)	98%	75%
Chest and abdomen (lung cancer)	97%	77%
Chest-abdomen-pelvis (CAP) (cancer)	98%	78%
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	98%	73%
CT pulmonary angiography (CTPA) (pulmonary embolism)	97%	77%
Head (acute stroke)	77%	73%
Kidney-ureters-bladder (KUB) (stones/colic)	98%	80%
Neck, chest, abdomen and pelvis (cancer)	96%	74%
Paranasal sinuses (sinus disease)	33%	69%
Urogram (stones/colic or tumour)	98%	75%

Selection of scanner typical values (mean versus median)

Previous dose surveys used the mean dose value from a specific patient sample as the indicator of the typical dose from that scanner for a specified exam. Since the previous survey was published, the International Commission on Radiological Protection (ICRP) has advocated the use of median values in place of mean values in terms of the data submitted from each scanner (34). As this survey is also requesting larger data samples than previously, and these may well be less curated than previous surveys due to the use of automated dose management systems, the median will be less influenced by any outliers in the patient sample and therefore better represent a typical dose. The mean and median were both calculated in order to be able to view trends from previous NDRLs, but also to establish a new way forward by using the median values.

Table 8 shows the influence of using the mean or median as the typical scanner dose when determining the third quartile value of the dose distribution.

Table 8. Comparison of third quartile values of the dose survey when either the mean or median of each scanner patient sample is used. The difference (%) compares the median to the mean value. Doses for the head and paranasal sinus exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom. Where an exam used more than one sequence, the DLP is the sum of sequences and the CTDIvol is the average of the sequences.

Exam	DLP (mGy.cm)			$CTDI_{vol}$ (mGy)		
	Using median of sample	Using mean of sample	Difference (%)	Using median of sample	Using mean of sample	Difference (%)
Abdomen and pelvis (abscess)	531	621	-14	10	12	-17
Cervical spine (C-spine) (fracture)	397	421	-6	16	17	-4
Chest – high resolution (interstitial lung disease) helical scan only	303	325	-7	8	8	-5
Chest (lung cancer)	295	328	-10	9	9	-8
Chest and abdomen (lung cancer)	472	540	-13	9	10	-12
Chest-abdomen-pelvis (CAP) (cancer)	657	725	-9	9	10	-15
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	685	750	-9	6	7	-8
CT pulmonary angiography (CTPA) (pulmonary embolism)	304	337	-10	9	10	-5
Head (acute stroke)	788	804	-2	46	46	0
Kidney-ureters-bladder (KUB) (stones/colic)	291	338	-14	6	7	-11
Neck, chest, abdomen and pelvis (cancer)	851	941	-10	9	11	-11
Paranasal sinuses (sinus disease)	163	172	-5	12	12	0
Urogram (stones/colic or tumour)	888	981	-9	9	10	-12

Exams

Data are presented for each exam included in this review. Data are first presented for those exams which only involved one sequence, and then for exams where the data sample included exams with one or more sequences. Doses for the head and paranasal sinus exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom.

Exams with only one sequence

Use of contrast

Table 9. Summary of contrast use for each exam

Exam	Contrast			
	None	Oral	IV	No data
Abdomen and pelvis (abscess)	9	1	111	96
Cervical spine (C-spine) (fracture)	55	0	2	46
Chest (lung cancer)	30	0	72	81
CT pulmonary angiography (CTPA) (pulmonary embolism)	2	0	101	77
Head (acute stroke)	118	0	2	105
Kidney-ureters-bladder (KUB) (stones/colic)	108	0	4	82
Paranasal sinuses (sinus disease)	86	0	0	58

Selection of scan technique

Table 10. Summary of axial or helical scan technique used for each exam

Exam	Scan technique		
	Axial	Helical	No data
Abdomen and pelvis (abscess)	0	135	82
Cervical spine (C-spine) (fracture)	2	66	35
Chest (lung cancer)	0	117	66
CT pulmonary angiography (CTPA) (pulmonary embolism)	0	116	64
Head (acute stroke)	17	129	79
Kidney-ureters-bladder (KUB) (stones/colic)	0	127	67
Paranasal sinuses (sinus disease)	7	88	49

Selection of operating potential

Table 11. Summary of choice of operating potential used for each exam

Exam	Operating potential (kV)							
	100	110	120	130	135	140	Auto	No data
Abdomen and pelvis (abscess)	5	0	76	1	0	0	45	90
Cervical spine (C-spine) (fracture)	1	0	46	1	1	3	12	39
Chest (lung cancer)	7	0	63	2	0	0	40	71
CT pulmonary angiography (CTPA) (pulmonary embolism)	41	1	26	0	0	0	44	68
Head (acute stroke)	2	0	117	1	0	0	17	88
Kidney-ureters-bladder (KUB) (stones/colic)	8	0	70	1	0	0	39	76
Paranasal sinuses (sinus disease)	15	0	71	1	0	2	12	43

Patient dose indices

Head (acute stroke)

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	165	620	686	776	695
No	60	719	770	894	794
All scanners	225	636	717	788	722

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	126	34.3	39.0	43.9	39.4
No	39	44.3	48.6	55.9	49.8
All scanners	165	36.1	40.9	46.4	41.9

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	61	14.9	16.5	17.2	16.6
No	20	14.9	17.3	18.9	16.7
All scanners	81	14.9	16.5	18.0	16.6

Paranasal sinuses (sinus disease)

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	99	73	97	145	120
No	45	116	155	192	162
All scanners	144	79	115	163	133

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	73	5.0	7.7	10.5	8.5
No	30	9.1	11.5	15.8	12.8
All scanners	103	5.8	8.8	11.6	9.7

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	38	11.5	12.4	15.0	13.3
No	16	11.5	12.7	16.6	14.0
All scanners	54	11.5	12.4	15.3	13.5

Cervical spine (C-spine) (fracture)

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	79	195	285	362	305
No	24	358	404	436	395
All scanners	103	218	301	397	326

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	60	8.0	11.6	14.0	11.7

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
No	10	16.5	17.6	20.1	18.4
All scanners	70	8.4	12.6	16.1	12.7

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	25	19.8	21.1	24.5	21.7
No	6	18.9	19.8	20.9	20.4
All scanners	31	19.6	20.6	24.3	21.5

Chest (lung cancer)

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	137	145	198	258	214
No	46	217	277	349	290
All scanners	183	155	215	295	233

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	98	4.2	5.3	7.2	6.0
No	29	6.2	8.4	9.5	8.6
All scanners	127	4.6	6.0	8.5	6.6

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	48	31.4	33.8	37.8	34.7
No	15	30.4	35.6	37.9	34.3
All scanners	63	31.0	34.2	37.9	34.6

CT pulmonary angiography (CTPA) (pulmonary embolism)

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	138	161	204	292	227
No	42	222	269	362	292
All scanners	180	169	223	304	242

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	105	4.8	6.3	9.0	7.3
No	25	6.6	8.1	11.3	9.9
All scanners	130	5.0	6.7	9.1	7.8

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	46	28.3	30.3	35.0	32.0
No	13	26.0	30.2	34.4	30.6
All scanners	59	28.2	30.3	34.9	31.7

Abdomen and pelvis (abscess)

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	167	320	393	497	425
No	50	437	472	615	525
All scanners	217	333	428	531	448

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	124	6.4	7.9	9.4	8.4

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
No	32	9.0	9.7	12.0	11.1
All scanners	156	6.5	8.1	10.0	9.0

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	58	44.9	46.7	49.5	47.4
No	12	45.3	49.2	50.6	48.1
All scanners	70	44.9	46.9	49.8	47.5

Kidney-ureters-bladder (KUB) (stones/colic)

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	156	162	214	269	229
No	38	224	282	390	313
All scanners	194	169	223	291	246

IR	$CTDI_{vol}$ (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	115	3.2	4.4	5.8	4.8
No	23	4.8	6.1	8.7	6.8
All scanners	138	3.4	4.7	6.3	5.1

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	57	40.8	43.6	45.5	43.4
No	5	40.4	41.7	43.6	42.7
All scanners	62	40.7	43.5	45.4	43.3

Exams with both single and multiple sequences

A number of exams included in this survey were carried out using a variety of sequences. For example a CAP exam may be undertaken as a single sequence or as 2 separate sequences, one for the chest and one for the abdomen and pelvis. The sequences may use different exposure settings and therefore it is difficult to compare exams in terms of $CTDI_{vol}$. Previous surveys have used an average $CTDI_{vol}$ of all sequences to provide a comparison between exams that use different number of sequences. However without clear information on what the sequence covered (in terms of body part and the use of contrast amongst other information) the average $CTDI_{vol}$ does not provide useful information. Therefore for these exams they will be compared in terms of DLP only which gives the best comparator between exams using multiple sequences. $CTDI_{vol}$ and scan length are presented only for exams which used a single sequence. The use of different operating potential, contrast and scan techniques are presented separately for each exam.

Neck, chest, abdomen and pelvis (cancer)

Data was received for 106 scanners. Of these, 47 scanners used protocols with a single scan sequence, 47 used 2 sequences and 12 used 3 sequences.

Single sequence exams only

IR	CTDI (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	24	6.0	7.9	10.2	9.5
No	7	7.6	10.0	12.4	10.4
All scanners	31	6.2	8.0	10.8	9.7

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	8	76.0	78.8	79.9	78.0
No	2	78.1	79.3	80.4	79.3
All scanners	10	76.5	78.8	80.1	78.2

All exams

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	78	530	683	841	698
No	28	622	792	927	797
All scanners	106	572	713	851	724

Operating potential
Of those that provided data, 41 scanners used 120 kV and 4 used 100 kV. A total of 23 scanners used an automatic kV selection programme.

Contrast
Of those that provided data, for single scan exams 19 used IV contrast and 1 did not use contrast. For 2 scan exams, 37 used IV contrast, 2 used IV then no contrast and 3 did not use contrast for either acquisition. For 3 scan exams, 6 used IV contrast for each scan.

Scan technique
71 used helical mode, for either 1, 2 or 3 scan protocols. One provider used 2 helical and 1 axial mode.

Chest – high resolution (interstitial lung disease)

Data was received for 153 scanners. Of these, 105 protocols used a single scan sequence, 32 used 2 sequences, 12 used 3 sequences and 4 used 4 sequences. Data are presented separately and combined.

Scan technique
For those using a single sequence, 71 used helical mode and 2 used axial mode. For those using 2 sequences, 5 used helical mode for both, 3 used axial mode for both and 10 used an axial and helical scan. For those using 3 sequences, 4 used axial mode for each sequence and 8 used a helical scan and 2 axial scans.

Due to the paucity of data, it is presented differently for this exam. A single helical exam accounted for approximately 70% of protocols, therefore data is presented for this exam as for each other exam in this study. As axial sequences are used by a number of centres, but often as part of an exam which uses an axial sequence as well as a helical sequence the data for each axial sequence has been grouped together to provide some analysis. This has not been separated by reconstruction technique, again due to the small numbers.

Single sequence helical exams only

IR	CTDI (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	47	4.3	5.4	8.1	6.2
No	8	6.3	6.5	7.2	7.1
All scanners	55	4.4	6.3	8.0	6.3

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	31	31.3	33.4	36.3	33.9
No	5	35.2	36.4	39.8	36.0
All scanners	36	31.4	34.0	36.5	34.2

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	58	161	211	301	232
No	13	210	230	240	245
All scanners	71	169	225	297	234

Summary of axial sequences

CTDI (mGy)				
Number of scanners	Percentile			Mean
	25th	50th	75th	
18	1.2	1.9	2.1	2.0

Scan length (cm)				
Number of scanners	Percentile			Mean
	25th	50th	75th	
6	26	27	27	27

DLP (mGy.cm)				
Number of scanners	Percentile			Mean
	25th	50th	75th	
18	23	55	62	55

Operating potential

Of those that provided data, 54 scanners used 120 kV and 4 used 100 kV. A total of 25 scanners used an automatic kV selection programme.

Contrast

Of those that provided data, for single scan exams 10 used IV contrast. For 2 scan exams, 2 used IV contrast and 44 used IV then no contrast. For 3 scan exams, 13 used IV contrast for each scan, 3 used IV for only one scan and one did not use contrast.

Chest and abdomen (lung cancer)

Data was received for 145 scanners. Of these, 85 protocols used a single scan sequence and 60 used 2 sequences. Data are presented separately and combined.

Single sequence exams only

IR	CTDI (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	53	5.7	7.5	9.0	8.3
No	14	6.8	8.3	13.8	10.1
All scanners	67	6.0	7.7	9.4	8.7

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	19	43.9	46.2	48.8	47.0
No	6	47.4	48.9	51.0	48.9
All scanners	25	44.9	47.7	49.0	47.5

All exams

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	112	292	357	440	386
No	33	344	443	534	448
All scanners	145	307	370	472	400

Operating potential
Of those that provided data, 49 scanners used 120 kV and 3 used 100 kV. A total of 37 scanners used an automatic kV selection programme.

Contrast
Of those that provided data, for single scan exams 39 used IV contrast and 2 did not use contrast. For 2 scan exams, 37 used IV contrast, 1 used IV then no contrast and 2 did not use contrast for either acquisition.

Scan technique
A total of 88 used helical mode, for either one or 2 scans protocols.

Chest-abdomen-pelvis (CAP) (cancer)

Data was received for 240 scanners. Of these, 138 protocols used a single scan sequence and 102 used 2 sequences.

Single sequence exams only

IR	CTDI (mGy)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	88	6.1	7.3	8.6	8.3
No	19	7.0	7.8	12.0	9.9
All scanners	107	6.2	7.3	9.1	8.6

IR	Scan length (cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	40	63.8	66.0	68.6	66.1
No	9	66.5	68.0	68.7	67.2
All scanners	49	63.8	66.3	68.7	66.3

All exams

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	188	448	508	612	545
No	52	505	648	736	650
All scanners	240	455	536	657	568

Operating potential
Of those that provided data, 135 scanners used 120 kV and 9 used 100 kV. A total of 50 scanners used an automatic kV selection programme.

Contrast
Of those that provided data, for single scan exams 124 used IV contrast, 1 oral and 6 did not use contrast. For 2 scan exams, 56 used IV contrast for both scans, 2 used IV then no contrast and 2 did not use contrast for either scan.

Scan technique
A total of 156 used helical mode, for either 1 or 2 scans protocols.

Colonography/virtual colonoscopy (VC) (polyps/tumour)

Data was received for 108 scanners. Of these, 103 used a 2 scan sequence. Due to this, only data using a 2 scan sequence was included.

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	75	388	491	613	519
No	28	566	674	720	694
All scanners	103	403	555	685	566

Operating potential
Of those that provided data, 39 scanners used 120 kV for both scans, 4 scanners used 120 kV and 100 kV and 1 used 100 kV for both. A total of 12 scanners used an automatic kV selection programme.

Contrast
Of those that provided data, 11 used IV contrast for both scans, 26 used IV then no contrast, 2 used one IV and one oral scan and 10 did not use contrast for either scan.

Scan technique
A total of 60 used helical mode for both scan protocols.

Urogram (stones/colic or tumour)

Data was received for 130 scanners. Of these, 26 protocols used a single scan sequence, 81 used 2 sequences and 23 used 3 sequences. Due to $CTDI_{vol}$ only being available for 9 single sequence protocols and scan length for 1, this data is not presented.

IR	DLP (mGy.cm)				
	Number of scanners	Percentile			Mean
		25th	50th	75th	
Yes	98	459	639	875	673
No	32	618	734	974	792
All scanners	130	503	676	888	703

Operating potential
Of those that provided data, 54 scanners used 120 kV and 4 used 100 kV. A total of 25 scanners used an automatic kV selection programme.

Contrast
Of those that provided data, for single scan exams 10 used IV contrast. For 2 scan exams, 2 used IV contrast and 44 used IV then no contrast. For 3 scan exams, 13 used IV contrast for each scan, 3 used IV for only one scan and one did not use contrast.

Scan technique
A total of 88 used helical mode for either 1, 2 or 3 scan protocols.

Other exams

Data was also received for a number of different exams not requested for this survey. However, data was not received in sufficient numbers for any specific exam to be sufficient to consider for setting a NDRL and therefore are not discussed further.

Summary of exam doses

Figure 4 and Figure 5 show the range of $CTDI_{vol}$ and DLP values submitted to this survey. Table 12 shows a comparison between third quartile doses for FBP and IR. Appendices A and B show the entire dose distributions for each exam and a comparison between using FBP or IR methods.

Figure 4. Box and whisker plot of median $CTDI_{vol}$ values for each exam. Doses for the head and paranasal sinuses exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom

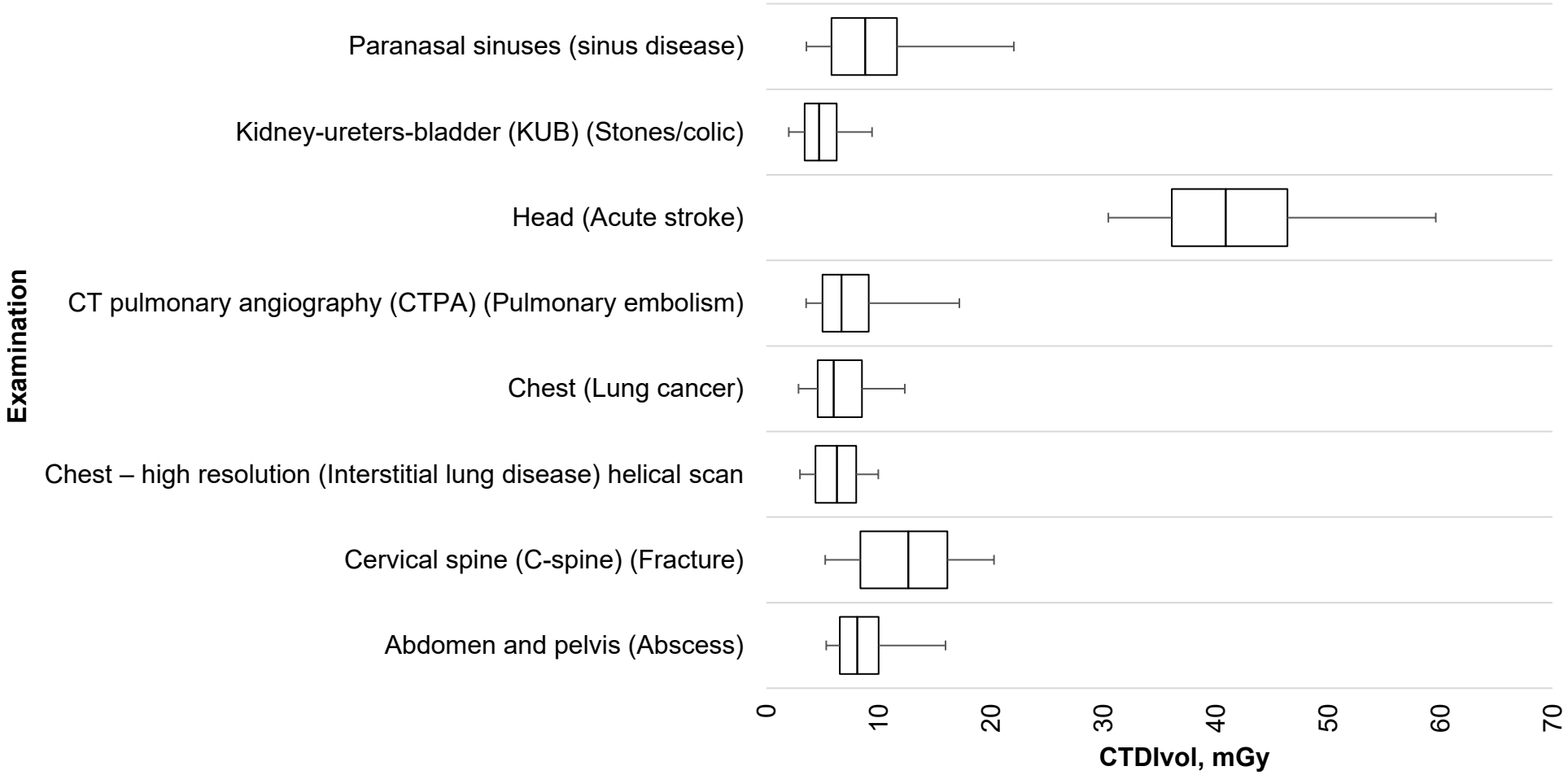


Figure 5. Box and whisker plot of median DLP values for each exam. Doses for the head and paranasal sinuses exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom

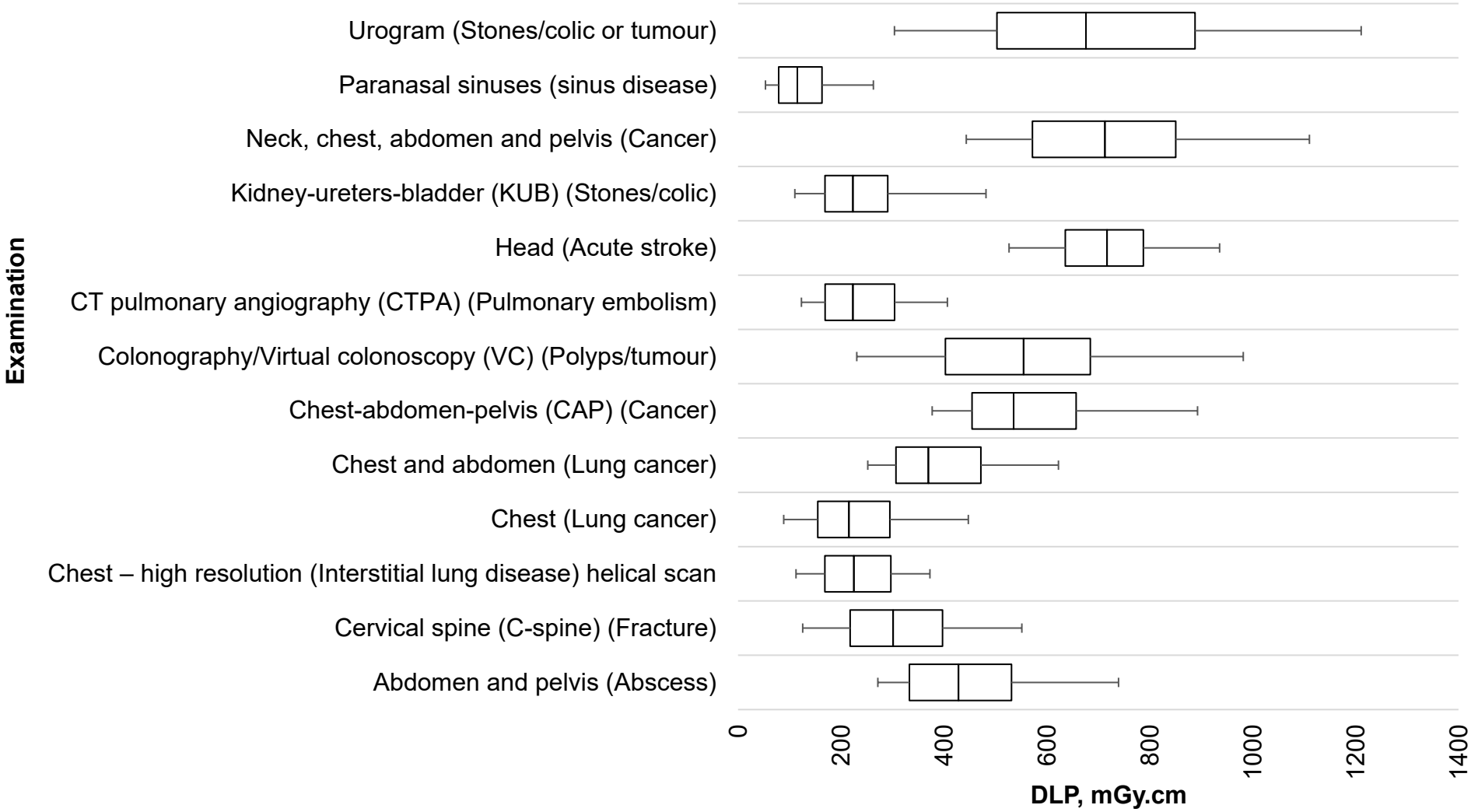


Table 12. Comparison of third quartile values for FBP and IR. Doses for the head and paranasal sinuses exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom

Exam	DLP (mGy.cm)			$CTDI_{vol}$ (mGy)		
	IR	FBP	Difference (%)	IR	FBP	Difference (%)
Abdomen and pelvis (abscess)	497	615	-19	9	12	-21
Cervical spine (C-spine) (fracture)	362	436	-17	14	20	-30
Chest – high resolution (interstitial lung disease) - helical scan only	301	240	26	8	7	14
Chest (lung cancer)	258	349	-26	7	9	-24
Chest and abdomen (lung cancer)	440	534	-18			
Chest-abdomen-pelvis (CAP) (cancer)	612	736	-17			
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	613	720	-15			
CT pulmonary angiography (CTPA) (pulmonary embolism)	292	362	-19	9	11	-20
Head (acute stroke)	776	894	-13	44	56	-21
Kidney-ureters-bladder (KUB) (stones/colic)	269	390	-31	6	9	-33
Neck, chest, abdomen and pelvis (cancer)	841	927	-9			
Paranasal sinuses (sinus disease)	145	192	-24	11	16	-33
Urogram (stones/colic or tumour)	875	974	-10			

Discussion

Sample size

Table 4 shows that the data submitted to this survey was higher than the previous survey in terms of the number of hospitals (127 to 147, 16% increase) and scanners (182 to 266, 46% increase) that data was received from. Data was received covering some 16-fold increased number of patients. This is due both to the survey design, where there was no limit placed on the number of patients submitted to this survey, and the prevalence of automated dose monitoring systems, making the collection of larger data samples easier.

All 4 major scanner manufacturers had data included in this survey. In the Third CT survey, 45% of scanners had 64 detector rows and 11% had a higher number of detector rows. For this survey it is 65% with 64 detector rows and 23% with a higher number, showing the continuing trend to move to scanners with a significantly higher number of detector rows.

For this survey, data from only 2 scanners from hospitals outside of the NHS was received. Data for 7 scanners (4% of the total) was received from outside the NHS for the previous survey, showing a continued trend for a lack of engagement outside of the NHS. It should be considered in future surveys how better to engage this sector to improve the number of submissions.

The previous survey was estimated to cover some 30% of all CT scanners in use in the UK spread across all 4 nations of the UK.

There is no data available at present of the number of scanners currently in use in the UK. The latest available data, from 2012, estimates that there are 406 scanners installed across the NHS in England (35) which is consistent with the estimate made in the previous survey. Assuming this number hasn't increased significantly and scaling this up to the UK based on population size (56.5M England versus 67M UK) (36) would estimate there are 481 scanners. The previous survey estimated that 20.7% of scanners were installed in private hospitals. Assuming the same for this study would give a total number of scanners of 607. This would predict that this study covered 55% scanners within the NHS and 44% within the whole of the UK. This is a reasonable increase on the 30% included in the previous survey, but still significantly lower than the amount included in the first CT survey in 1989.

The collection of data to update NDRLs forms a key part of understanding changes to the population radiation dose from medical imaging and so it is important that sufficient data is collected to represent UK practice. The Ionising Radiation (Medical Exposure) Regulations 2017 (and the The Ionising Radiation (Medical Exposure) Regulations (Northern Ireland) 2018) (37,38) require employers to collect dose estimates from medical exposures and submit those to the Secretary of State when requested to do so. Therefore a more formal requirement to submit data to national dose surveys may be explored for future dose surveys.

Exposure technique

Table 7 shows that AEC was used for almost all exams, except for paranasal sinuses where a fixed mA program was preferred. The universal use of AEC is anticipated as it is a key tool in the optimisation of patient dose. The use of fixed mA for sinus exams is likely due to the typically low dose and simple exam of the head where significant changes in patient anatomy are not expected and so AEC would not have significant benefits.

When data was collected for the 2011 survey, data on IR was not requested as this was a relatively new technique first introduced around 2008 (14). As the results of this study show, it is now in widespread use with approximately 75% of protocols using it. This is comparable to a study conducted in Australia which found 69% of scanners used iterative reconstruction (39) and higher than the recent PHE authored report looking at cervical spine exams which showed 60% of scanners used IR (33). Iterative reconstruction is claimed to allow a dose reduction whilst still maintaining a similar image quality to conventional filtered back projection (FBP) reconstructed images (14, 15) therefore the proportion of scanners using IR is likely to increase as more scanners are adapted to use IR or older scanners are replaced with modern models that provide IR as standard. Table 12 shows a comparison of third quartile doses for each reconstruction technique. The doses, in terms of DLP, are approximately 10 to 30% lower for IR techniques and in terms of $CTDI_{vol}$, 20 to 30% lower for this technique.

Dose samples

Table 8 shows there is around an average of a 10% decrease in the third quartile value when using the median as opposed to the mean dose for each scanner. As it is intended to use median values for proposing new NDRLs from this survey, and for future surveys, it is important to ensure the results of local surveys which are to be compared to the national DRL use the median value to ensure an accurate comparison.

Exams

Head exams

In the previous survey the head exam was often undertaken as 2 separate scans, covering the post fossa and cerebrum. For this survey, almost all the data received carried out the exam using a single scan.

There was a mix of using AEC for this exam whereas for body exams AEC was used almost exclusively. The reported third quartile dose values for AEC and fixed mA showed very similar DLP values.

High resolution chest CT

The high resolution chest CT had the greatest variation between centres. There was a variety of data received ranging from a single axial or helical scan to a combination of up to 4 sequences. This is perhaps in part due to a range of clinical indications associated with this technique which were not adequately filtered.

There are currently NDRLs set for axial and helical exams. As the choice of axial or helical was not mandatory information for this survey, the amount of data submitted to this survey that could be included for setting a NDRL was limited as it is clearly important to know the scan technique due to the difference in dose as identified in the 2011 survey. The use of axial scanning only contributed a small amount to the data in this survey, therefore only helical exams will be considered for setting a NDRL. For those using axial scanning, attention should be made to the axial results presented in the results above as doses were much lower than the NDRL proposed in this survey which is only based on helical scanning.

Proposed NDRLs

The third quartile values of the distribution of scanner median values have been rounded to the nearest 2 significant figures and are shown in Table 13. These are proposed as new or updated NDRL values for the UK.

Table 13. Proposed new NDRL values. Doses for the head and paranasal sinuses exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom

Exam	$CTDI_{vol}$	DLP
Head (acute stroke)	47	790
Paranasal sinuses (sinus disease)	12	160
Cervical spine (C-spine) (fracture)	16	400
Neck, chest, abdomen and pelvis (cancer)	--	850
Chest (lung cancer)	8.5	290
Chest – high resolution (Interstitial lung disease) (helical scan)	8.0	300
Chest and abdomen (lung cancer)	--	470
Chest-abdomen-pelvis (CAP) (cancer)	--	660
CT pulmonary angiography (CTPA) (pulmonary embolism)	9.1	310
Abdomen and pelvis (abscess)	10	530
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	--	690
Kidney-ureters-bladder (KUB) (stones/colic)	6.3	290
Urogram (stones/colic or tumour)	--	890

Typical doses

Typical doses from common CT exams in the UK are summarised in Table 14 in terms of $CTDI_{vol}$ and DLP. Data is presented for the median (50th percentile) values for the distributions of the typical (median) doses observed for each scanner in the survey. The recent ICRP report (34) recommended that doses below the 25th percentile may also require investigation to establish if the dose is adequate to obtain sufficient image quality and so the 25th percentiles are also provided in Table 14.

Table 14. 25th and 50th percentile values of the median dose distribution. Doses for the head and paranasal sinuses exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom

Exam	25th percentile		50th percentile	
	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP
Head (acute stroke)	36.1	640	41	720
Paranasal sinuses (sinus disease)	5.8	80	8.8	120
Cervical spine (C-spine) (fracture)	8.4	220	13	300
Neck, chest, abdomen and pelvis (cancer)	--	570	--	710
Chest (lung cancer)	4.6	160	6.0	220
Chest – high resolution (Interstitial lung disease) (helical scan)	4.4	170	6.3	230
Chest and abdomen (lung cancer)	--	310	--	370
Chest-abdomen-pelvis (CAP) (cancer)	--	460	--	540
CT pulmonary angiography (CTPA) (pulmonary embolism)	5.0	170	6.7	220
Abdomen and pelvis (abscess)	6.5	330	8.1	430
Colonography/Virtual colonoscopy (VC) (polyps/tumour)	--	400	--	560
Kidney-ureters-bladder (KUB) (stones/colic)	4.7	220	4.7	220
Urogram (stones/colic or tumour)	--	500	--	680

Trends in UK NDRLs

Trends in the third quartile data from the periodic national surveys are summarised in Table 15 and Table 16. For the current survey the mean values of each scanner sample have been used for this table, as this is how previous dose surveys were carried out and therefore provides the most accurate comparison.

Table 15. Comparison of $CTDI_{vol}$ values to previous dose surveys

Exam	$CTDI_{vol}$^			% change from 2011 to present
	2003*	2011	2019	
Head	59/80	60	46	-27
Paranasal sinuses			12	--
Cervical spine		28	17	-39
Chest	11/13	12	9	-25
Chest – high resolution (helical scan)	3/7	12	8	-11
CT pulmonary angiography (CTPA)		13	10	-23
Abdomen and pelvis	13/14	15	12	-20
Kidney-ureters-bladder (KUB)		10	7	-30

* Data for 2003 was collected separately for single-slice CT (SSCT) and multi-slice CT (MSCT). The first number is for SSCT and the second for MSCT.

^ From the third quartile of the mean dose from the scanners. The 2019 data is presented this way for comparison, however proposed new NDRLs are based on the median.

Table 16. Comparison of DLP values to previous dose surveys

Exam	DLP^			% change from 2011 to present
	2003*	2011	2019	
Head	760/931	973	804	-17
Paranasal sinuses			172	---
Cervical spine		606	421	-31
Neck, chest, abdomen and pelvis			941	---
Chest	427/575	614	328	-47
Chest – high resolution (helical scan)	77/174	350	311	-28
Chest and abdomen			540	---
Chest-abdomen-pelvis (CAP)	762/937	1003	725	-28
CT pulmonary angiography (CTPA)		441	337	-24
Abdomen and pelvis	508/559	745	621	-17
Colonography/Virtual colonoscopy (VC)		947	750	-21
Kidney-ureters-bladder (KUB)		458	338	-26
Urogram		1148	981	-15

* Data for 2003 was collected separately for single-slice and multi-slice CT. The first number is for SSCT and the second for MSCT.

^ From the third quartile of the mean dose from the scanners. The 2019 data is presented this way for comparison, however proposed new NDRLs are based on the median.

Figure 6. Comparison of $CTDI_{vol}$ values to previous dose survey (third quartile of mean doses). Doses for the head and paranasal sinuses exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom

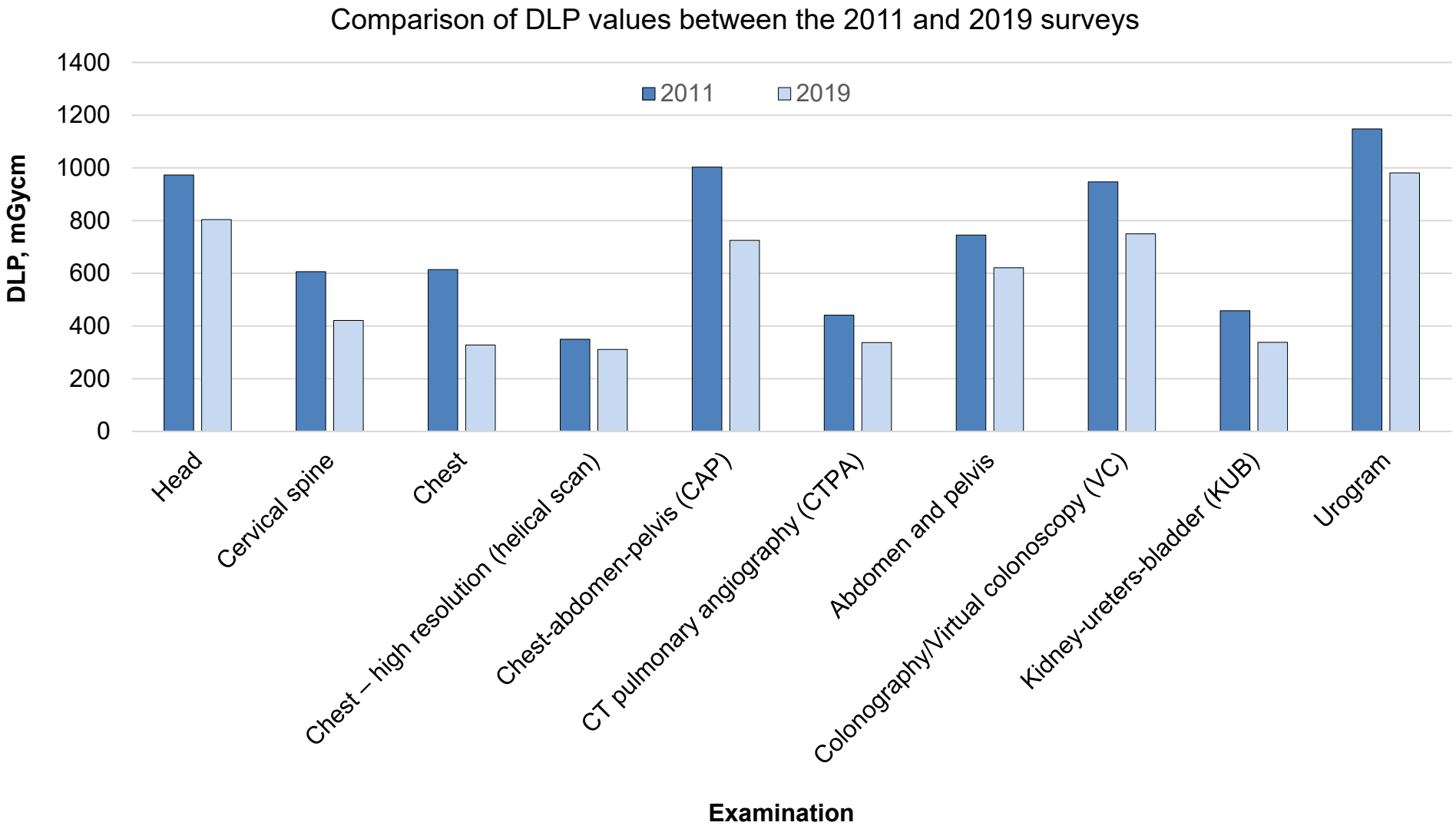
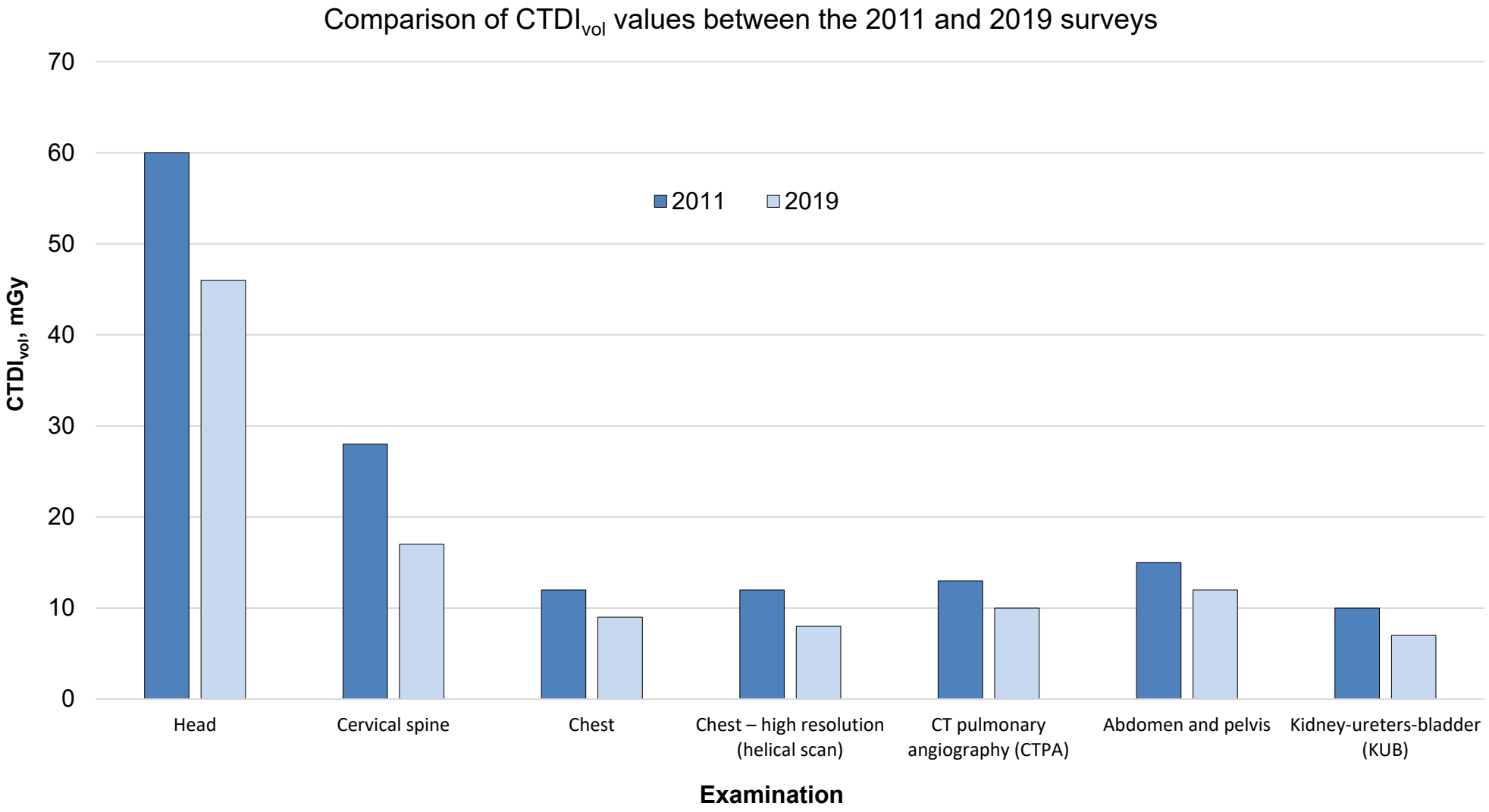


Figure 7. Comparison of DLP values to previous dose survey (third quartile of mean doses). Doses for the head and paranasal sinuses exams refer to measurements in the 16cm standard CT dosimetry phantom. All other doses refer to measurements in the 32cm standard CT dosimetry phantom



These tables and figures show a significant reduction across the range of exams considered in this study, both in terms of $CTDI_{vol}$ and DLP compared to the 2011 survey. It is not unreasonable to assume that this reduction arises from a combination of improved optimisation and improvement in scanner dose efficiency perhaps primarily driven by the use of IR and AEC, as shown in table 12 and data in Appendices A and B.

International comparison

Tables 17, 18 and 19 compare the proposed NDRLs from this survey with NDRLs set in other countries. The proposed NDRL values are generally lower than those in the compared countries. The date of the dose survey may account for some of the difference, as the dose saving from the use of iterative reconstruction may not be fully realised for some of these surveys. Although the current UK NDRLs are lower for many cases indicating that patient doses in the UK are typically lower than other countries.

Table 17. Comparison of proposed $CTDI_{vol}$ NDRL values from this survey with those carried out in other countries

Exam	This study	Australia (40)	USA (41)	Germany (42)	Canada (43)
Head	47	52	57 (nc)	60	82
Paranasal sinuses	12			8	
Cervical spine	16	21	28 (nc)	20	
Chest	8.5	10	15/16*	10	14
Abdomen and pelvis	10	13	20/19*	15	18
Kidney-ureters-bladder (KUB)	6.3	10			

* The first figure is without contrast and the second figure is using contrast.

nc = non-contrast.

Australia and USA use median values of the patient dose index data. It is not clear what metric is used for the German and Canadian dose index data.

Table 18. Comparison of proposed DLP NDRL values from this survey with those carried out in other countries

Exam	This study	Australia (40)	USA (41)	Germany (42)	Canada (43)
Head	790	880	1,011 (nc)	850	1,302
Paranasal sinuses	160			90	
Cervical spine	400	470	602 (nc)	300	
Chest	290	390	545/596*	350	521

Exam	This study	Australia (40)	USA (41)	Germany (42)	Canada (43)
Chest and abdomen	470			450	
Chest-abdomen-pelvis (CAP)	660		1,193 (c)	1,000	1,269
Abdomen and pelvis	530	600	1,004/995*	700	874
Kidney-ureters-bladder (KUB)	290	460			

* The first figure is without contrast and the second figure is using contrast.
nc = non-contrast
c = contrast
Australia and USA use median values of the patient dose index data. It is not clear what metric is used for the German and Canadian dose index data.

Table 19. Percentage difference between national DRLs set in other countries to those in this survey

Exam - % difference to this study	Australia (40)		USA (41)		Germany (42)		Canada (43)	
	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP	$CTDI_{vol}$	DLP
Head	11	11	21	28	28	8	74	65
Paranasal sinuses					-33	-44		
Cervical spine	31	18	75	51	25	-25		
Chest	18	34	82*	97*	18	21	65	80
Chest and abdomen						-4		
Chest-abdomen-pelvis (CAP)				81		52		92
Abdomen and pelvis	30	13	95*	89*	50	32	80	65
Kidney-ureters-bladder (KUB)	59	59						

* Using the average of the contrast and non-contrast dose values.
Australia and USA use median values of the patient dose index data. It is not clear what metric is used for the German and Canadian dose index data.

Conclusion

New NDRL values are proposed for adult CT imaging. These will update the current values set from data collected up to 2011 and use the median of individual scanner patient dose samples rather than the mean dose value used in previous national surveys. This change can account for around a 10% reduction in the NDRL. However, doses have reduced significantly in this time, on average between 20 to 30%, in terms of $CTDI_{vol}$ and DLP, across the range of exams considered. This is thought to be due to a combination of new dose saving technologies such as iterative reconstruction, the increased importance placed on dose optimisation, high standards of radiographic technique and the frequent national dose surveys carried out in the UK.

Acknowledgments

The authors wish to acknowledge the crucial support received from all the healthcare professionals who kindly participated in the survey and without whom this report would not have been possible. The promptness and robustness of answering the authors' questions regarding their submissions is also hugely appreciated. The names of the hospitals that contributed to this survey are shown in Appendix D.

We are also grateful to:

- CT Users Group for its promotion of this survey on its website, hosting of the survey forms and facilitating the wide collection of data
- The Society and College of Radiographers for encouraging active participation in the survey through its endorsement as a valid activity in continuing professional development (CPD) via CPD Now
- UKHSA colleagues Gail Woodhouse and Yvonne Sullivan for their invaluable clinical CT expertise in designing the survey and examining the results
- UKHSA NDRL working party colleagues for their support and review of the survey methods and this report

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Appendix A. Histograms for distributions of $CTDI_{vol}$ results

The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL where one exists.

Head (acute stroke)

Figure 8. Histogram of scanner median $CTDI_{vol}$ values for head (acute stroke) exams. Doses refer to the 16cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

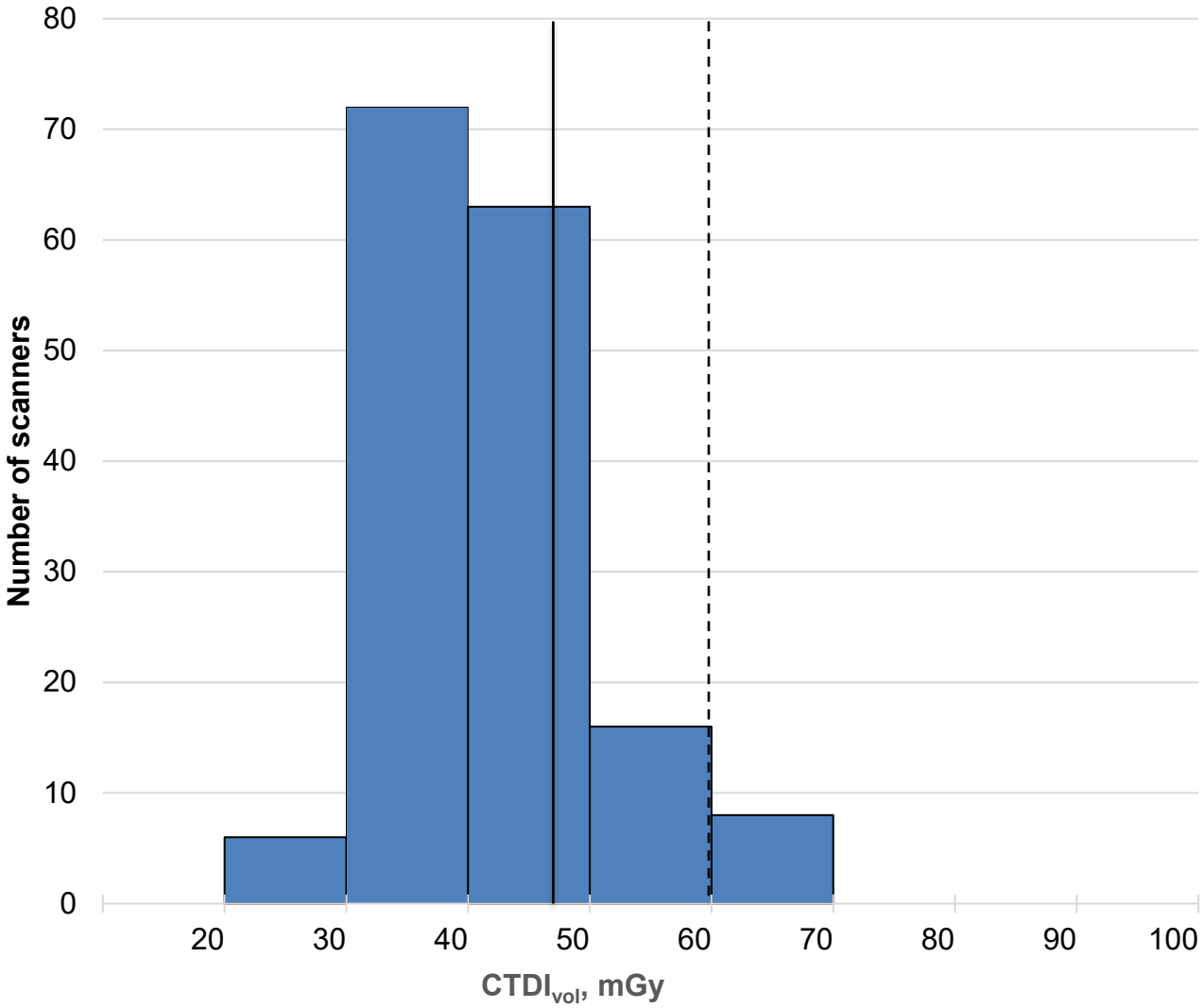
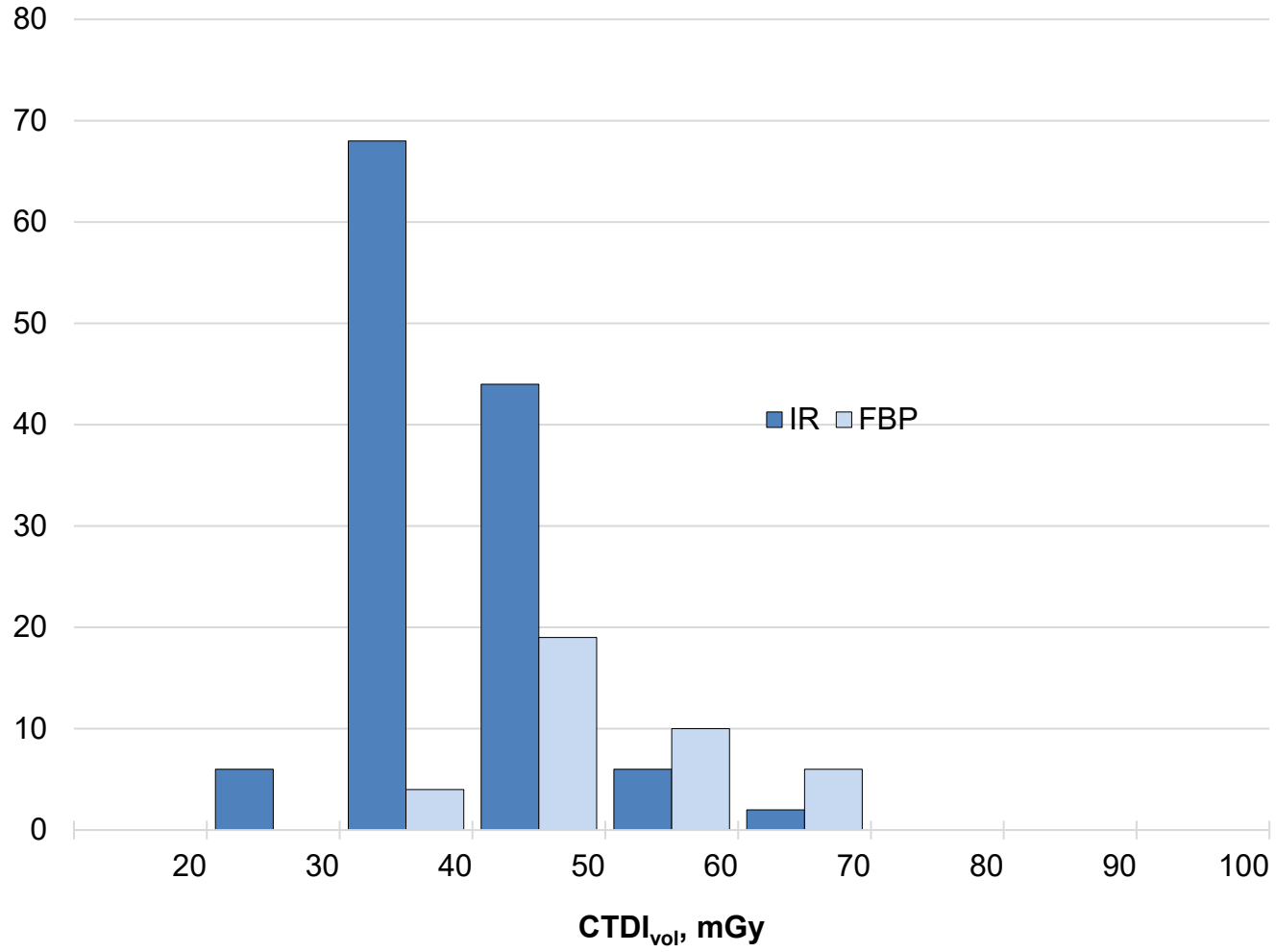


Figure 9. Histogram of scanner median $CTDI_{vol}$ values for head (acute stroke) exams separated by reconstruction technique. Doses refer to the 16cm standard CT dosimetry phantom



Paranasal sinuses (sinus disease)

Figure 10. Histogram of scanner median $CTDI_{vol}$ values for paranasal sinuses (sinus disease) exams. Doses refer to the 16cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey

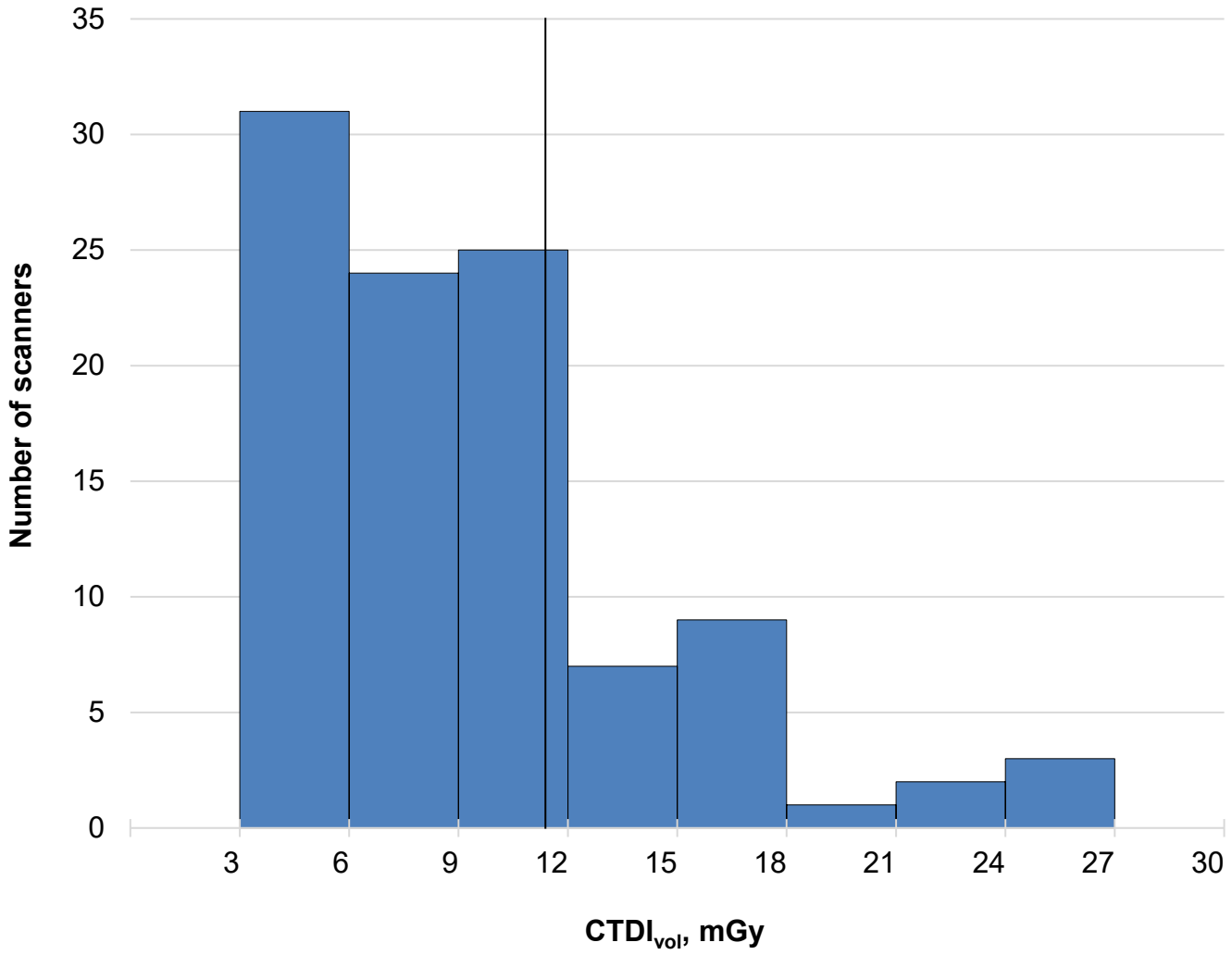
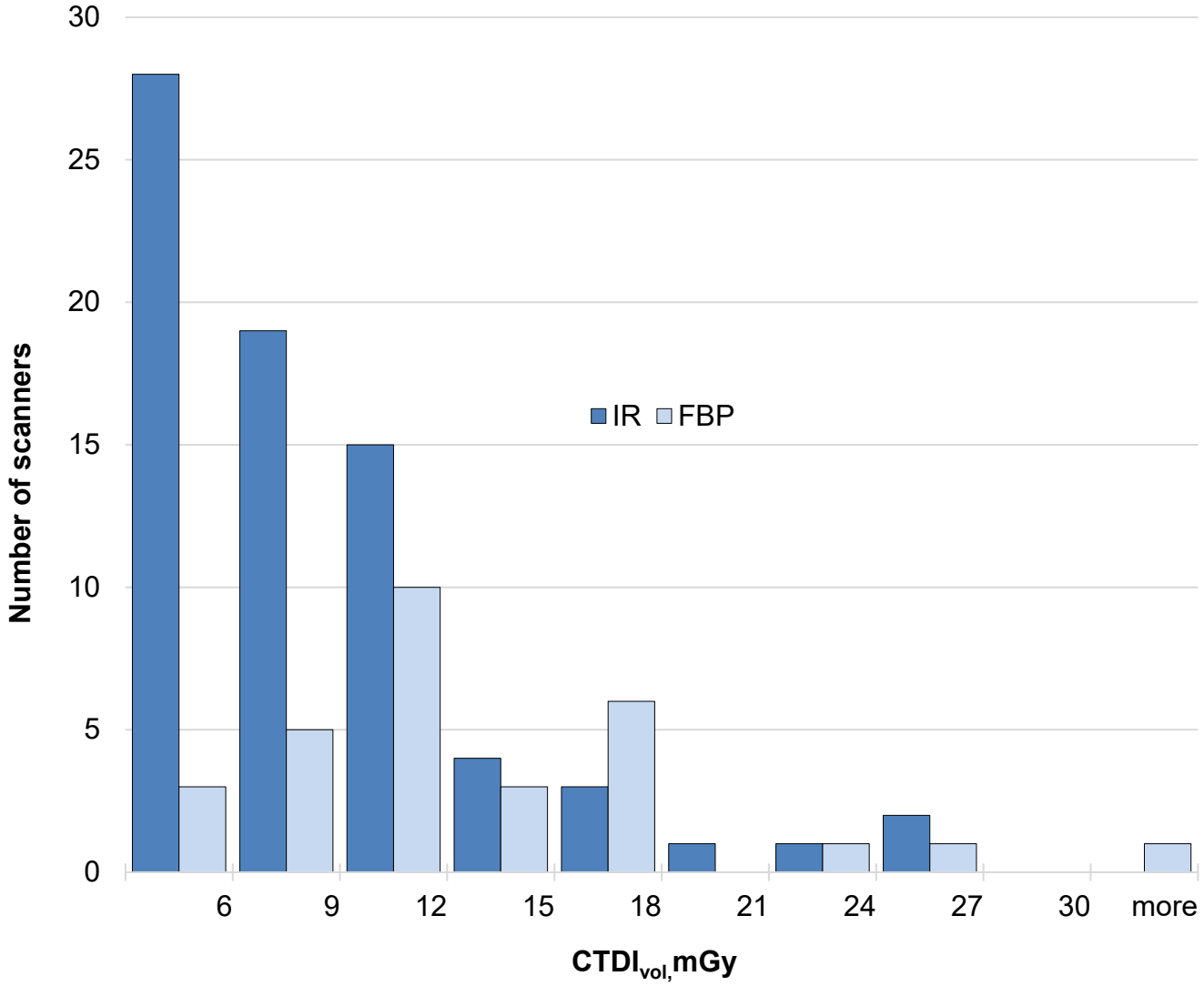


Figure 11. Histogram of scanner median $CTDI_{vol}$ values for paranasal sinuses (sinus disease) exams separated by reconstruction technique. Doses refer to the 16cm standard CT dosimetry phantom



Cervical spine (C-spine) (Fracture)

Figure 12. Histogram of scanner median $CTDI_{vol}$ values for cervical spine (c-spine) (fracture) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

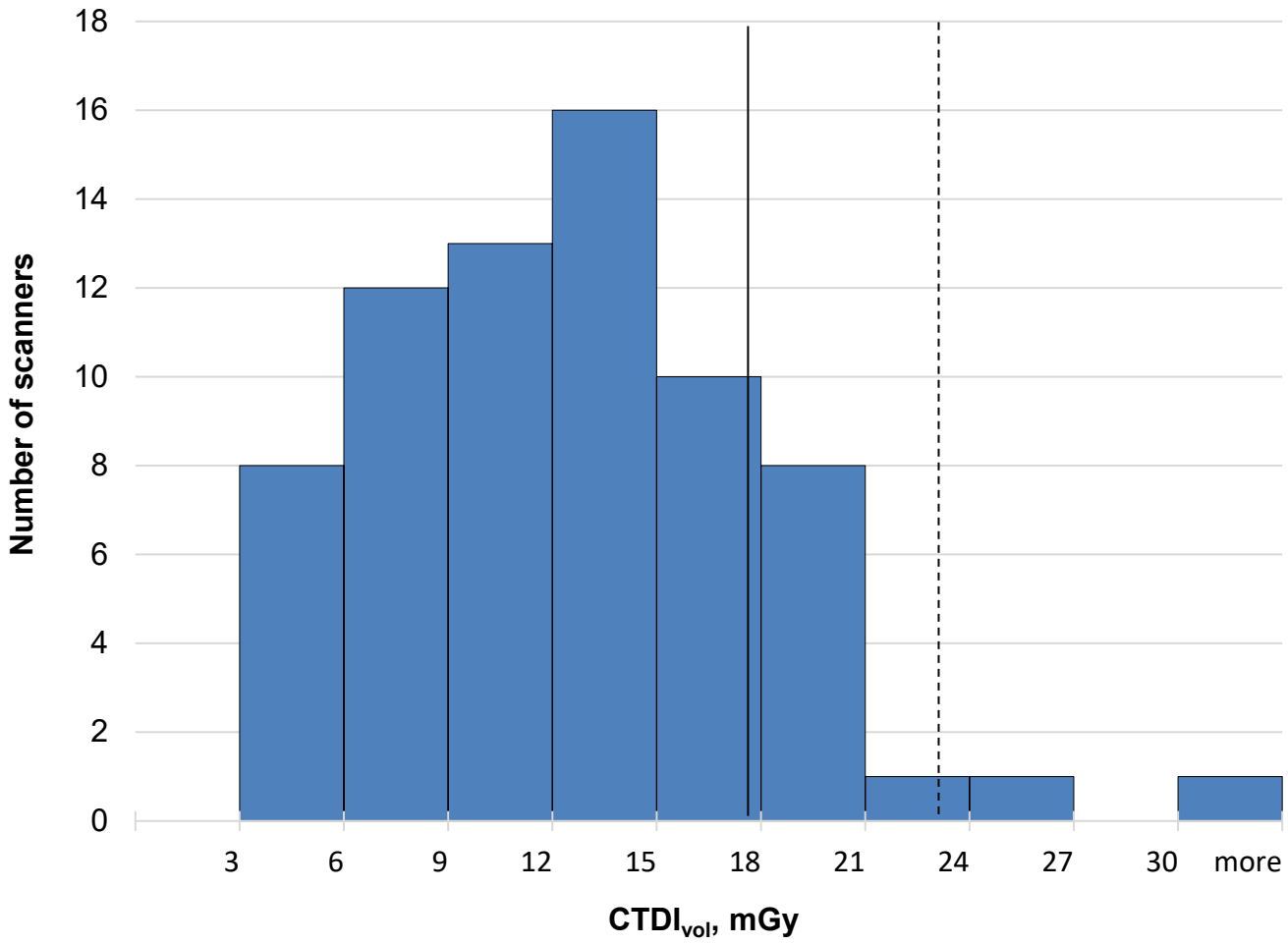
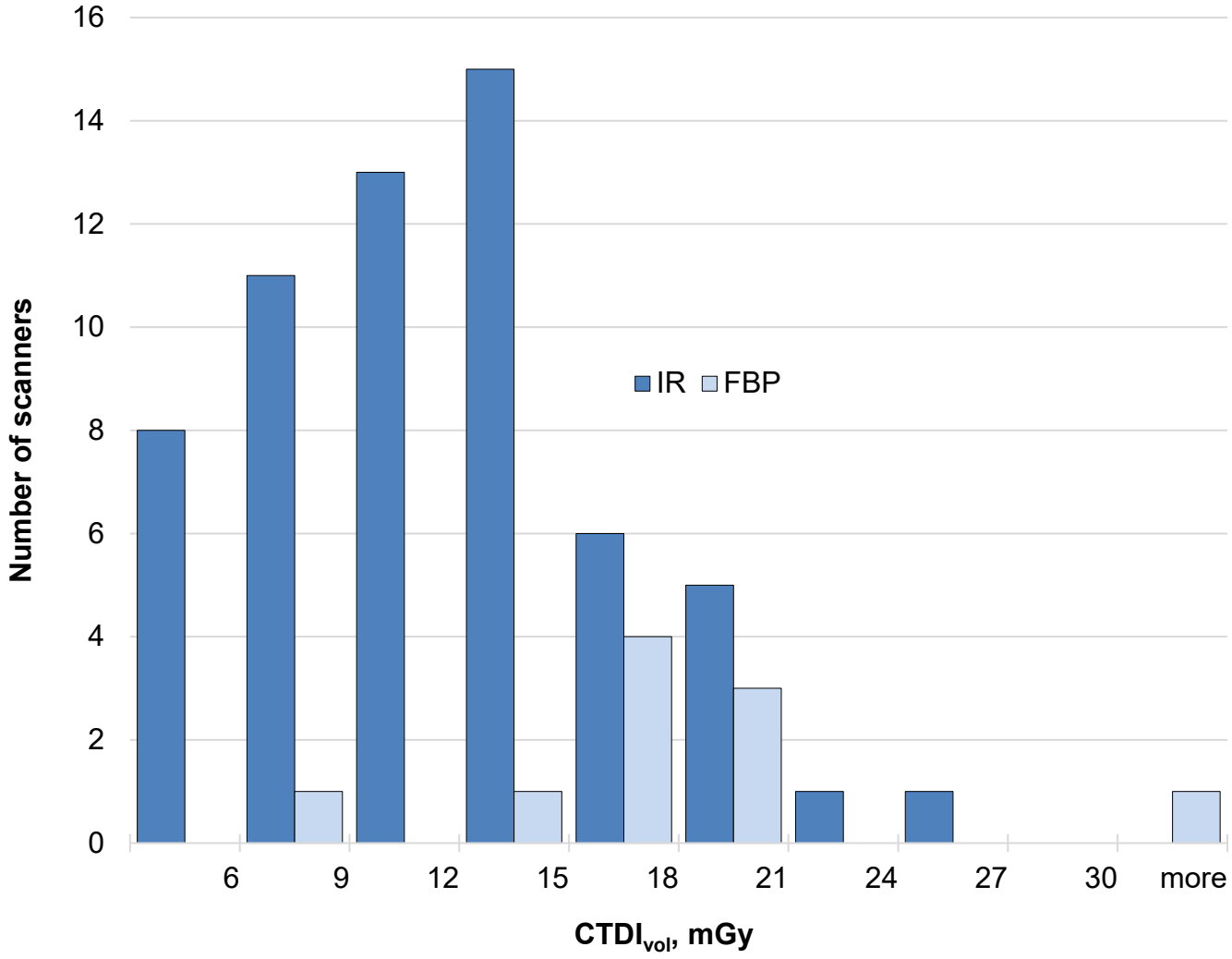


Figure 13. Histogram of scanner median $CTDI_{vol}$ values for cervical spine (c-spine) (fracture) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Chest (Lung cancer)

Figure 14. Histogram of scanner median $CTDI_{vol}$ values for chest (lung cancer) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

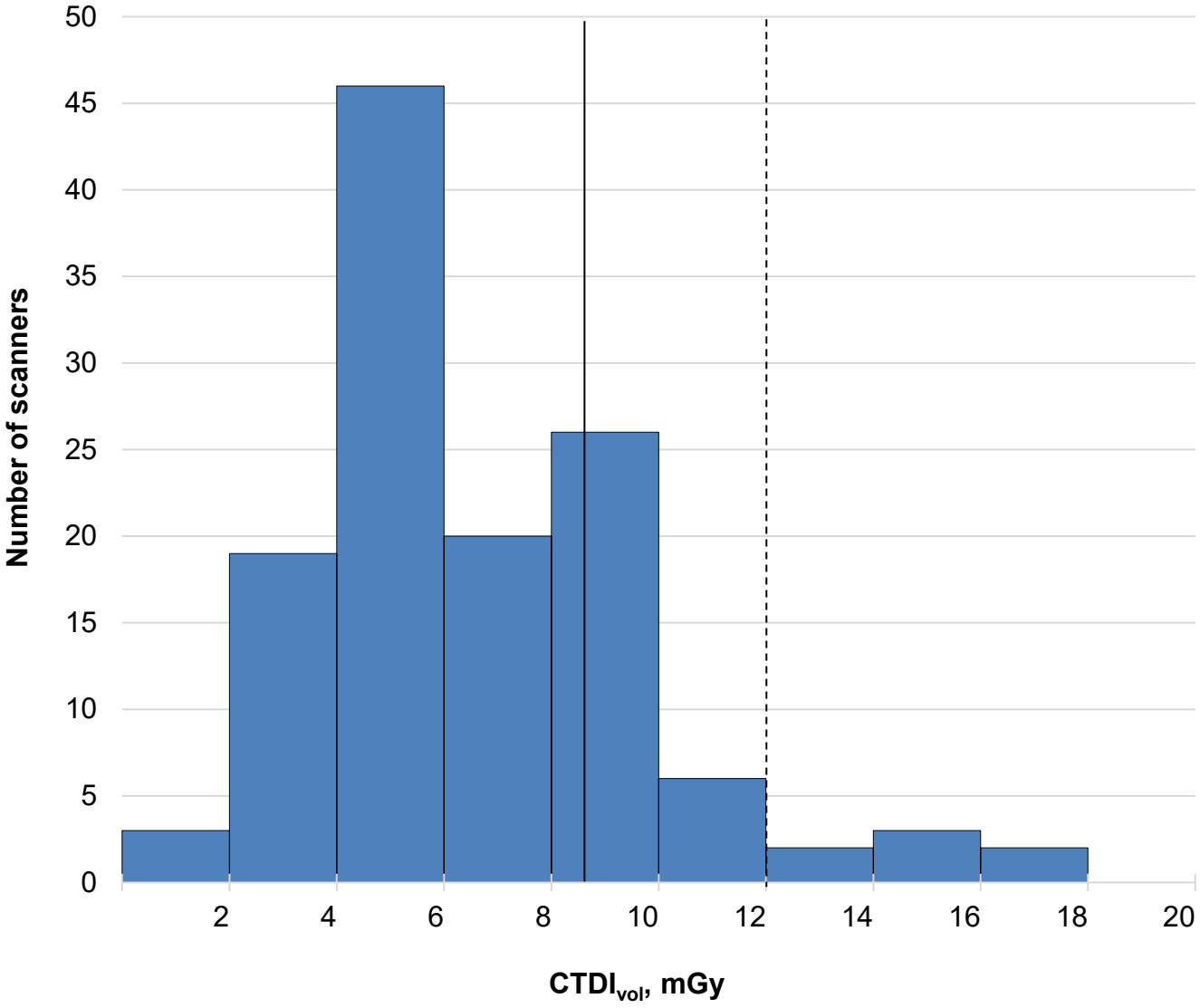
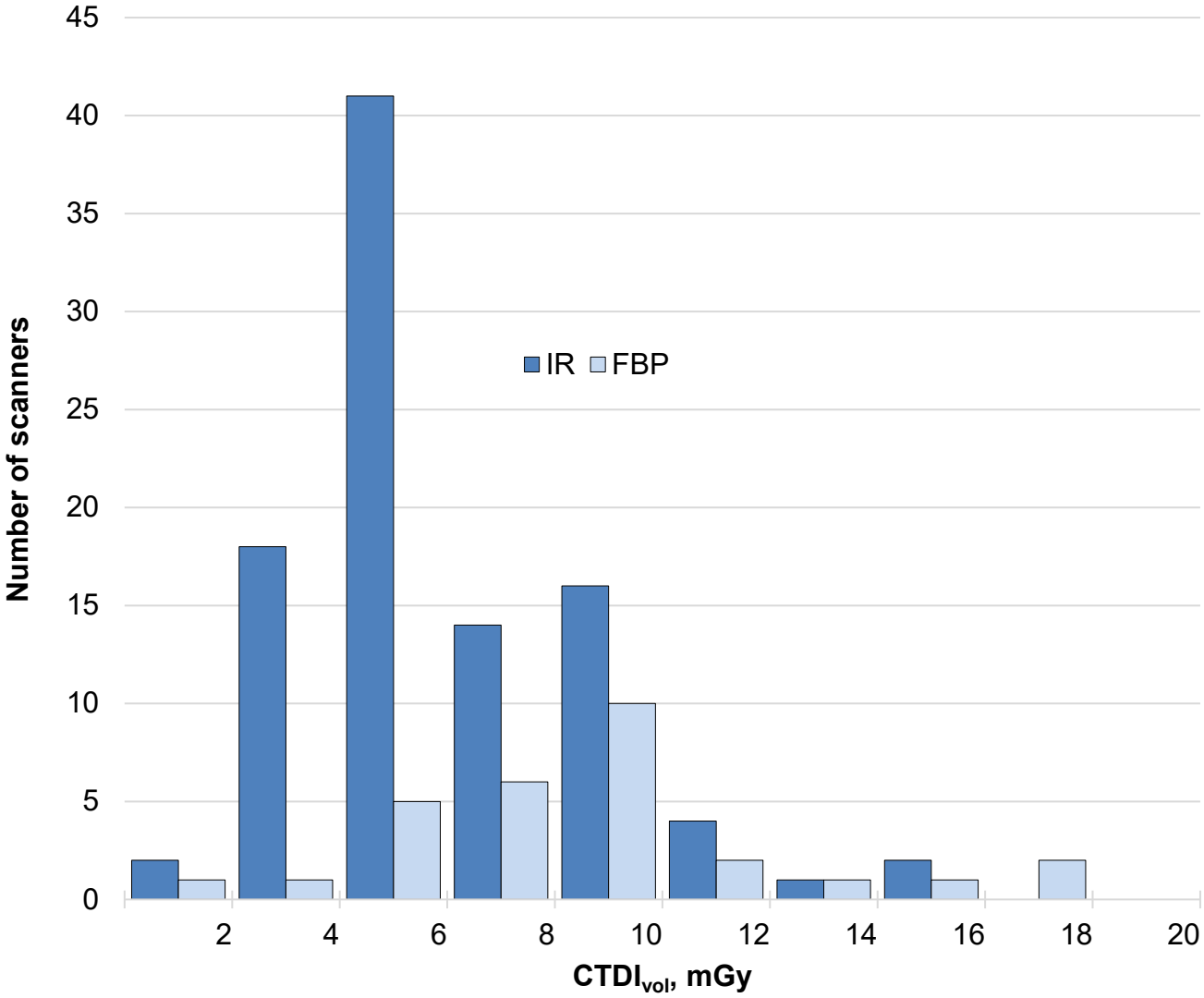


Figure 15. Histogram of scanner median $CTDI_{vol}$ values for chest (lung cancer) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



CT pulmonary angiography (CTPA) (Pulmonary embolism)

Figure 16. Histogram of scanner median $CTDI_{vol}$ values for CT pulmonary angiography (CTPA) (Pulmonary embolism) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

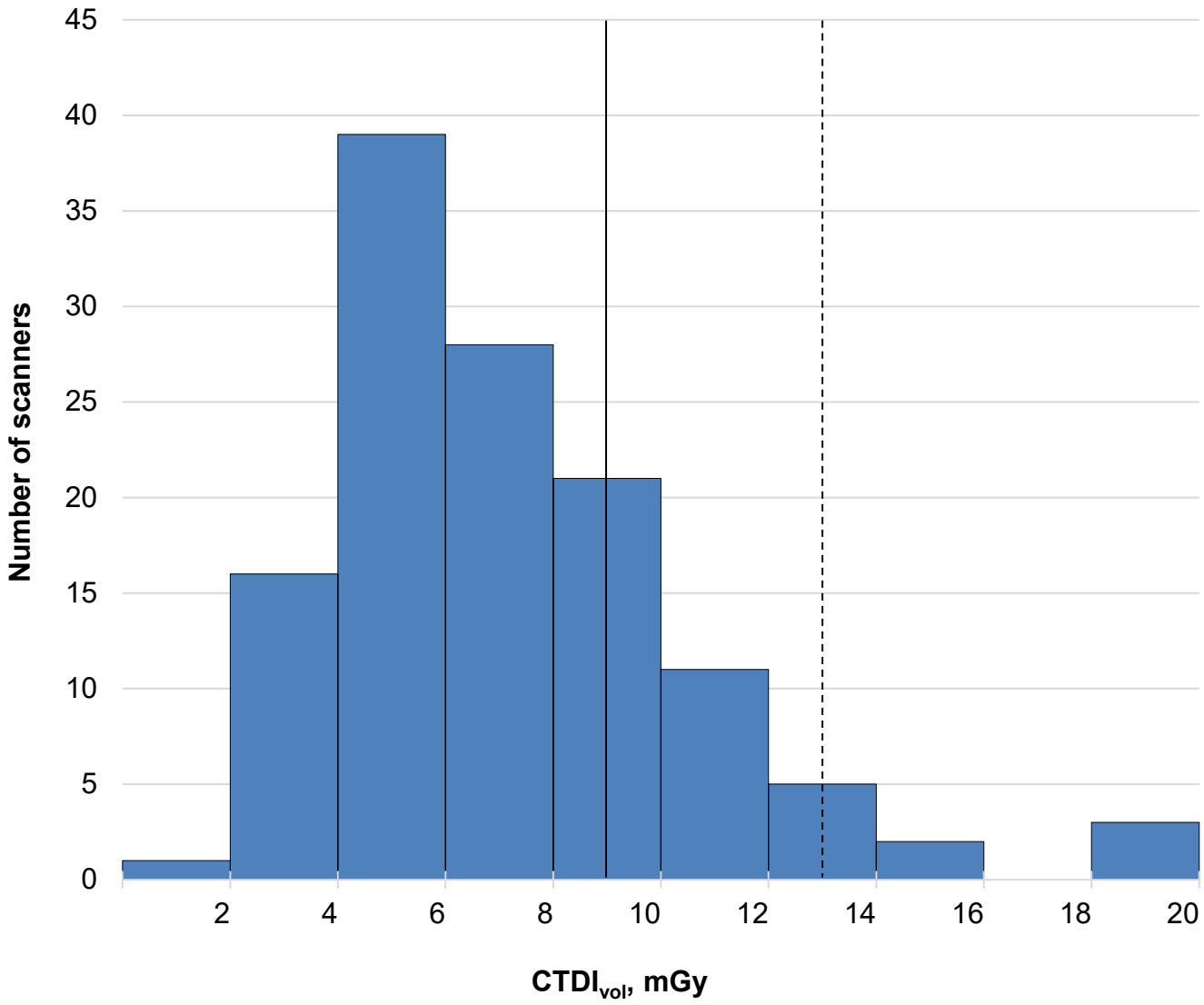
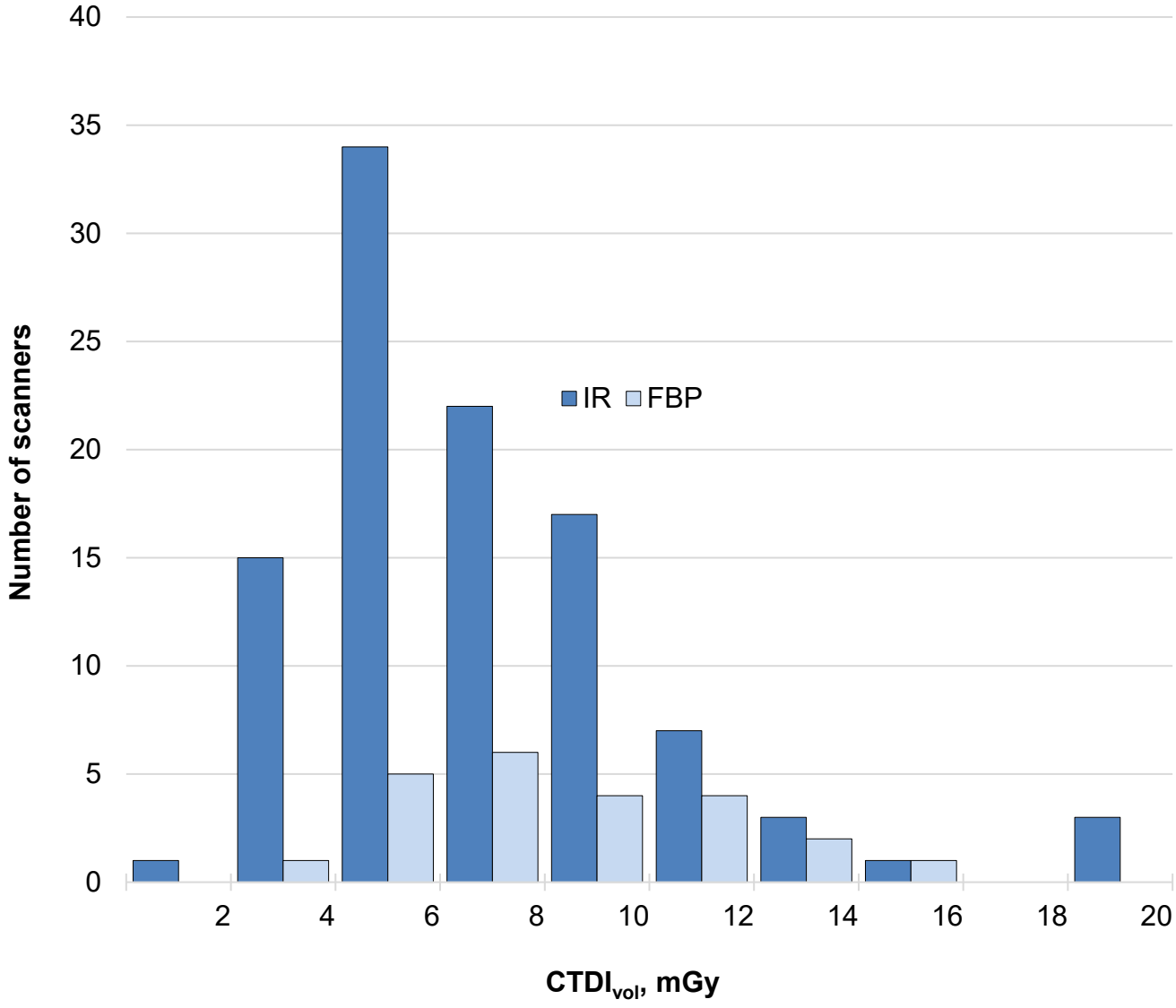


Figure 17. Histogram of scanner median $CTDI_{vol}$ values for CT pulmonary angiography (CTPA) (Pulmonary embolism) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Abdomen and pelvis (Abscess)

Figure 18. Histogram of scanner median $CTDI_{vol}$ values for abdomen and pelvis (abscess) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

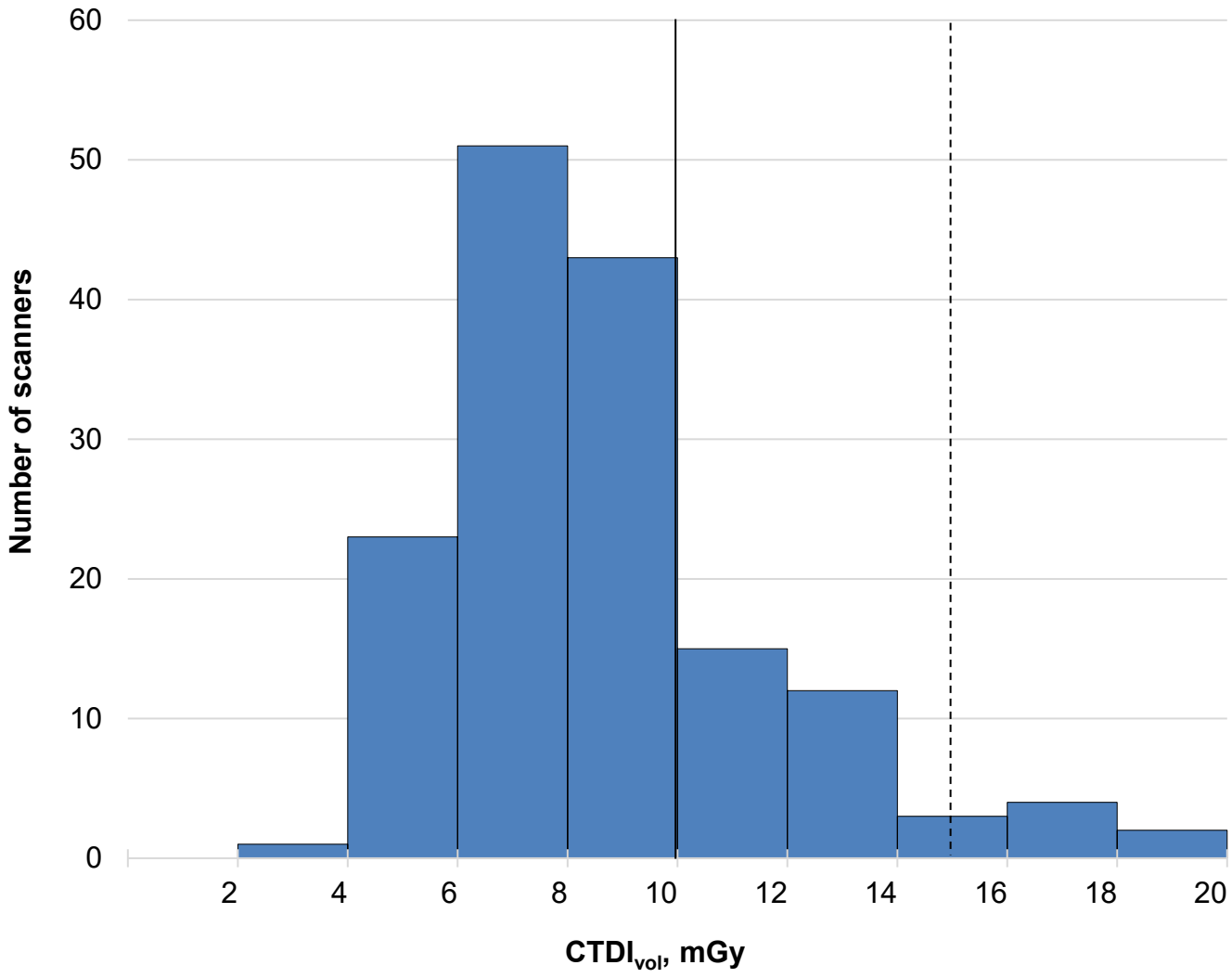
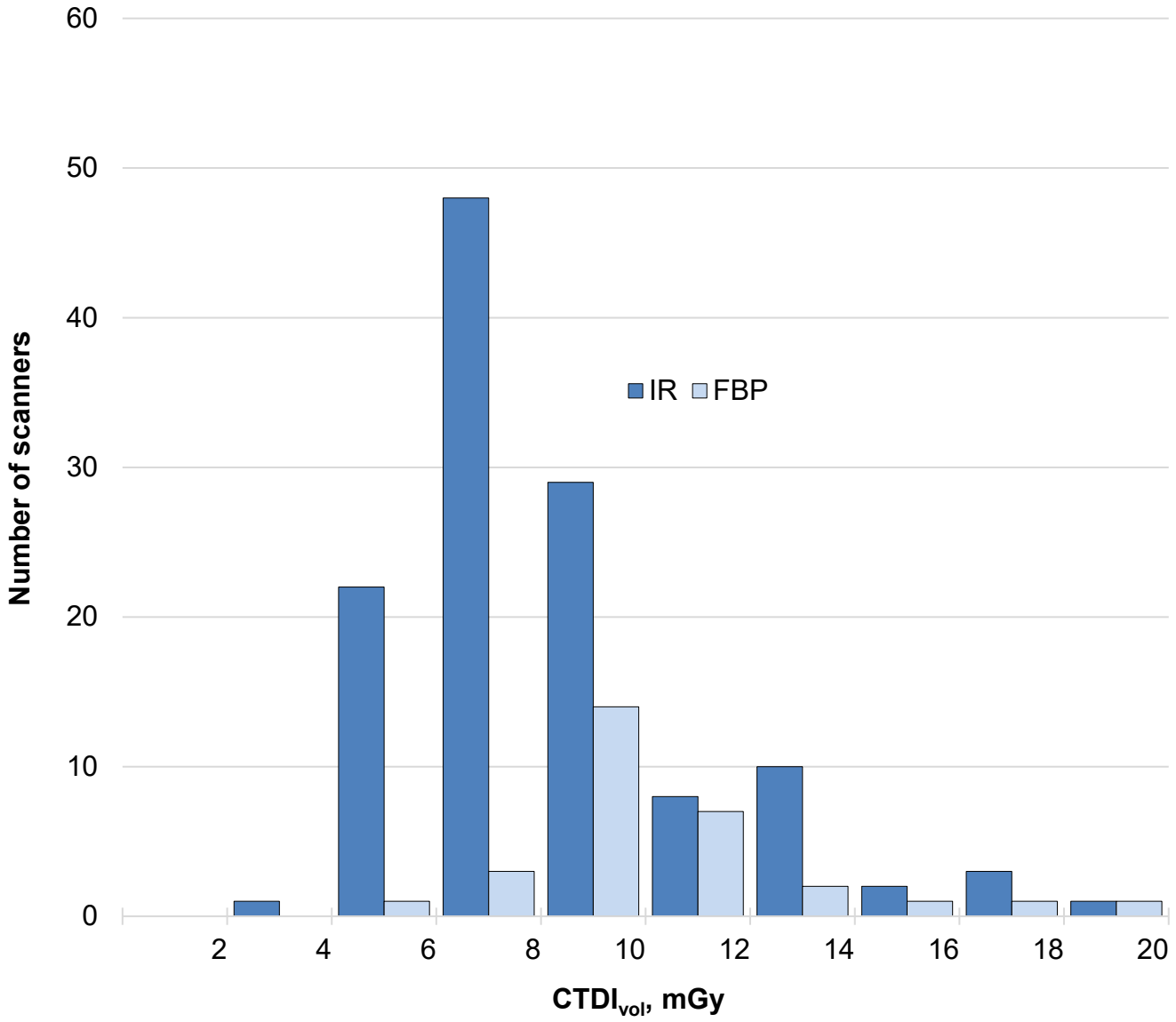


Figure 19. Histogram of scanner median $CTDI_{vol}$ values for abdomen and pelvis (abscess) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Kidney-ureters-bladder (KUB) (Stones/colic)

Figure 20. Histogram of scanner median $CTDI_{vol}$ values for kidney-ureters-bladder (KUB) (Stones/colic) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

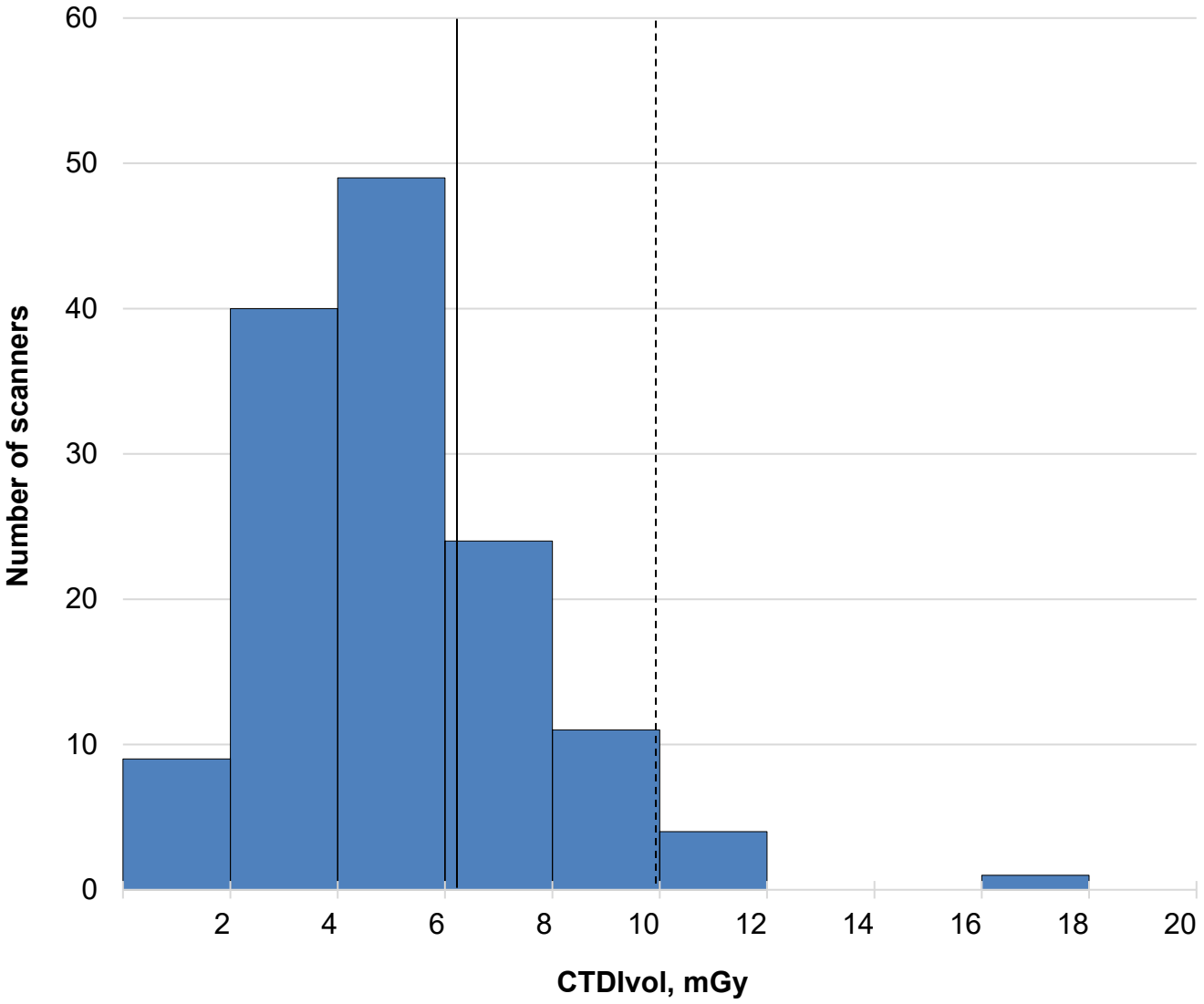
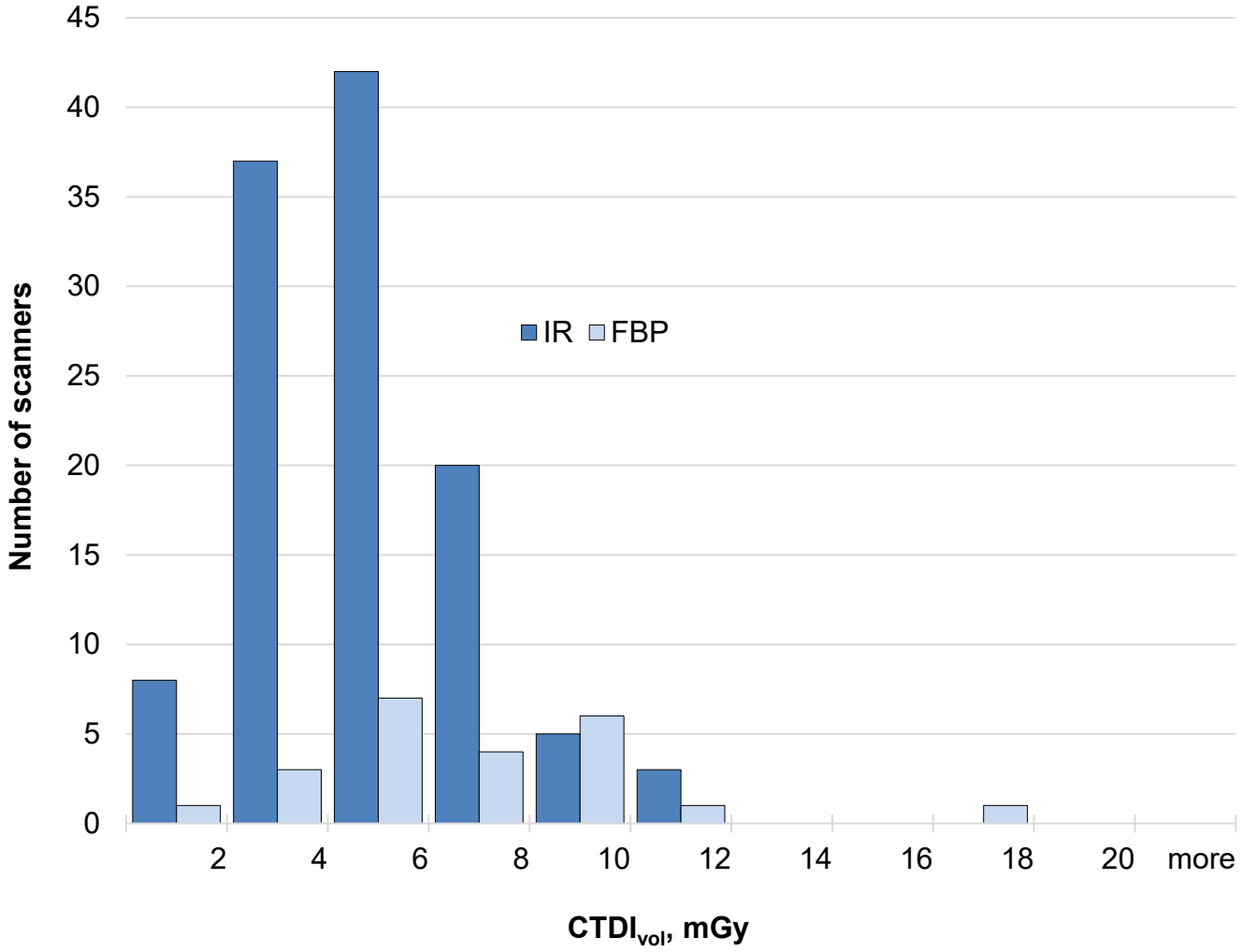


Figure 21. Histogram of scanner median $CTDI_{vol}$ values for kidney-ureters-bladder (KUB) (stones/colic) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Chest – high resolution (Interstitial lung disease) single helical protocol

Figure 22. Histogram of scanner median $CTDI_{vol}$ values for chest high resolution (Interstitial lung disease) exams performed as a single helical sequence. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

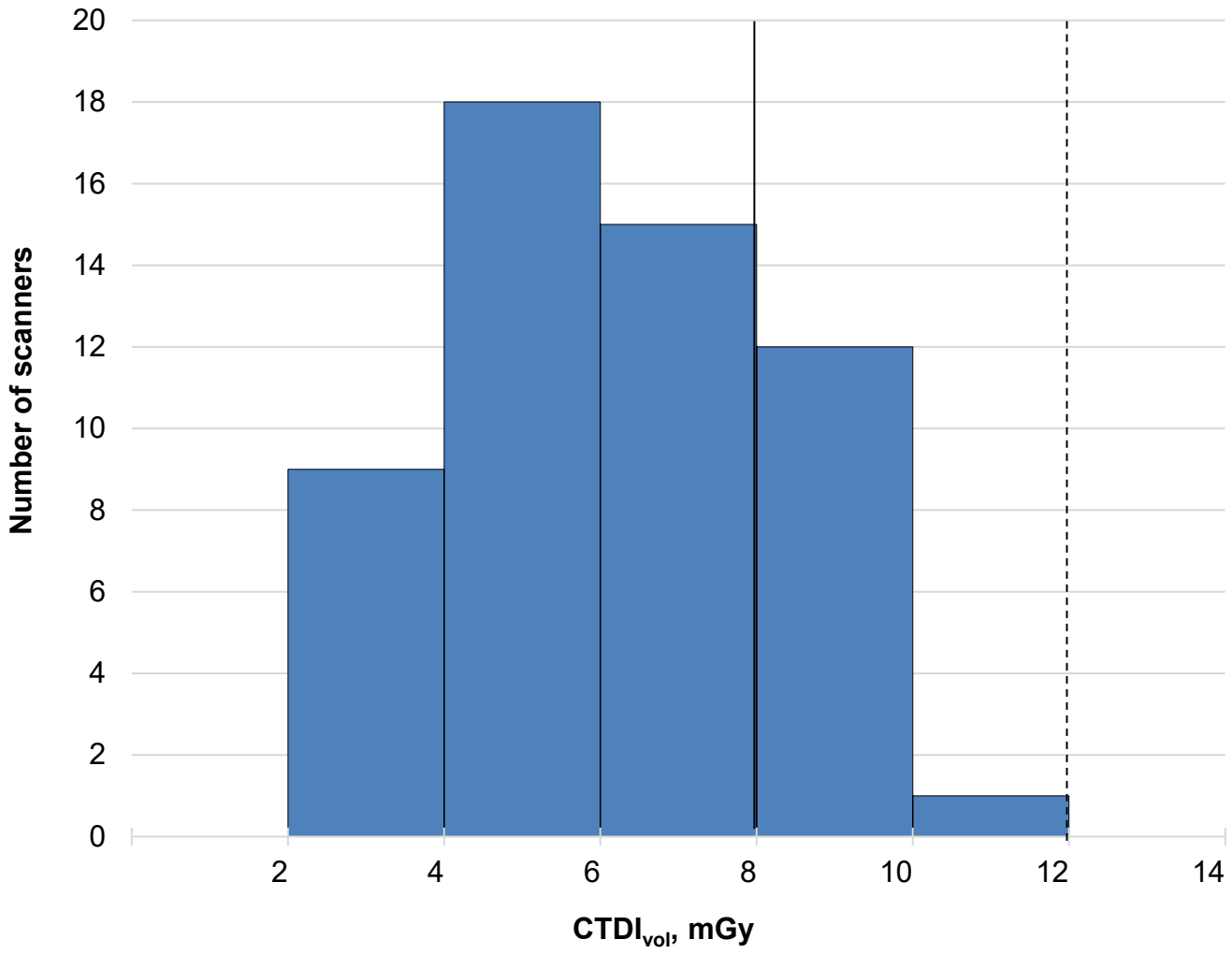
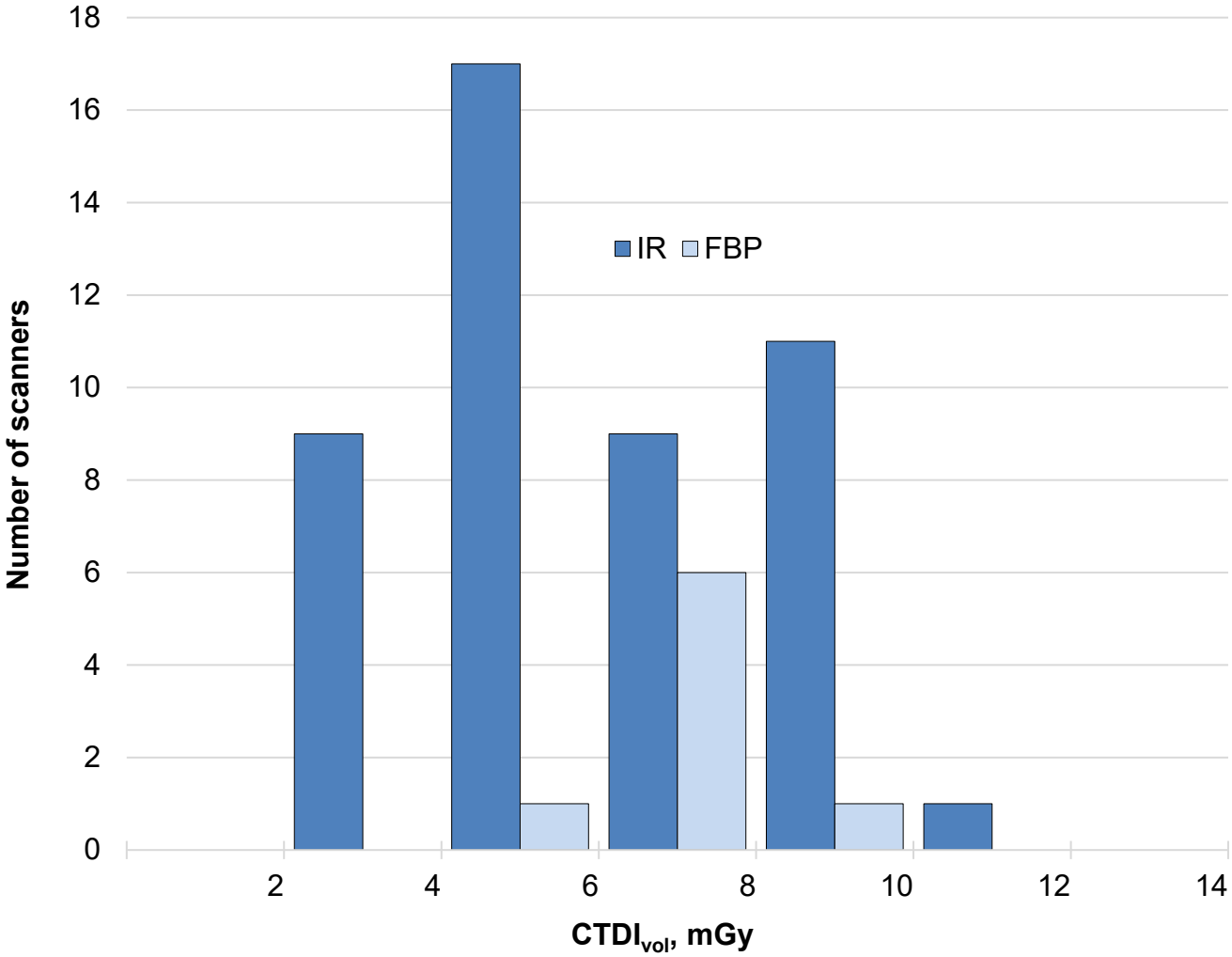


Figure 23. Histogram of scanner median $CTDI_{vol}$ values for chest high resolution (Interstitial lung disease) exams performed as a single helical sequence separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Appendix B. Histograms for distributions of DLP results

The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL where one exists.

Head exam

Figure 24. Histogram of scanner median DLP values for head (acute stroke) exams. Doses refer to the 16cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

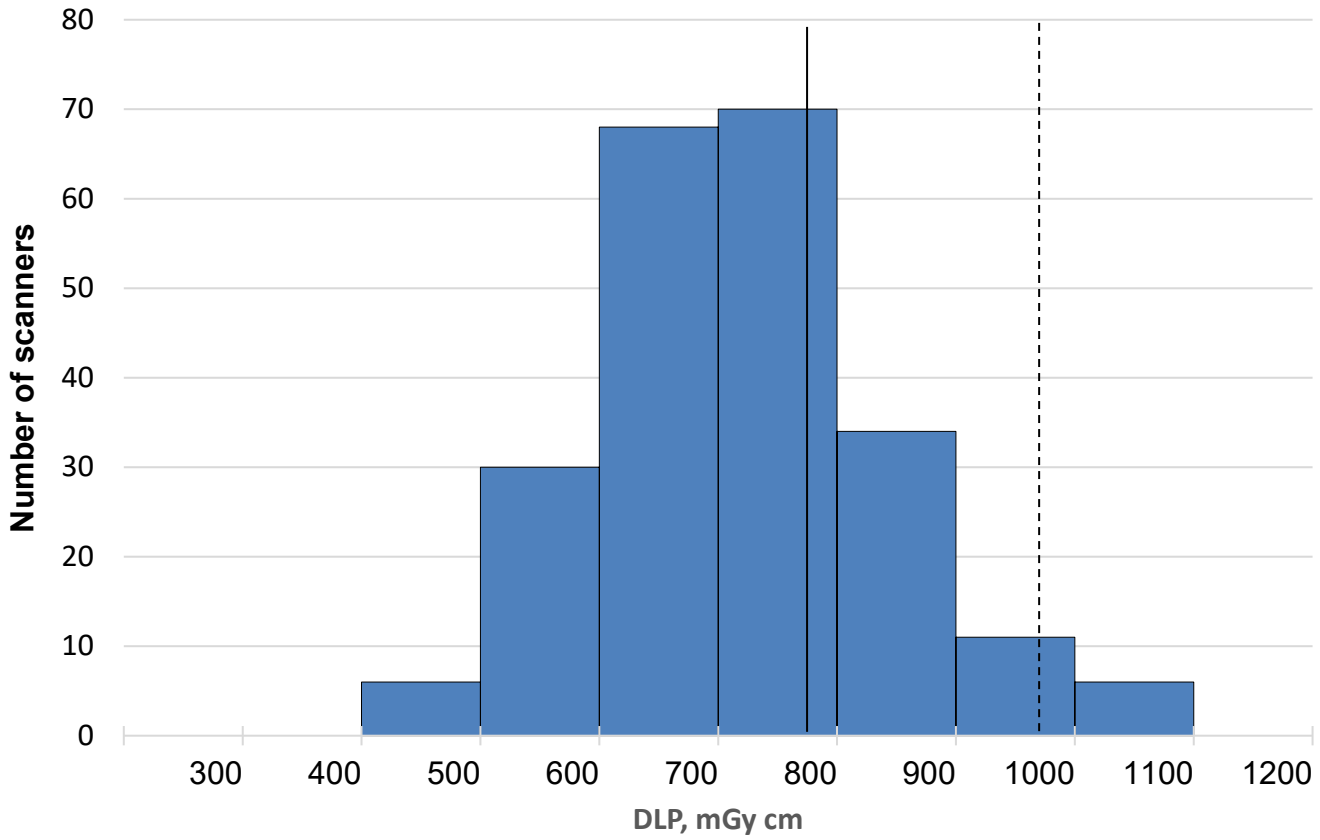
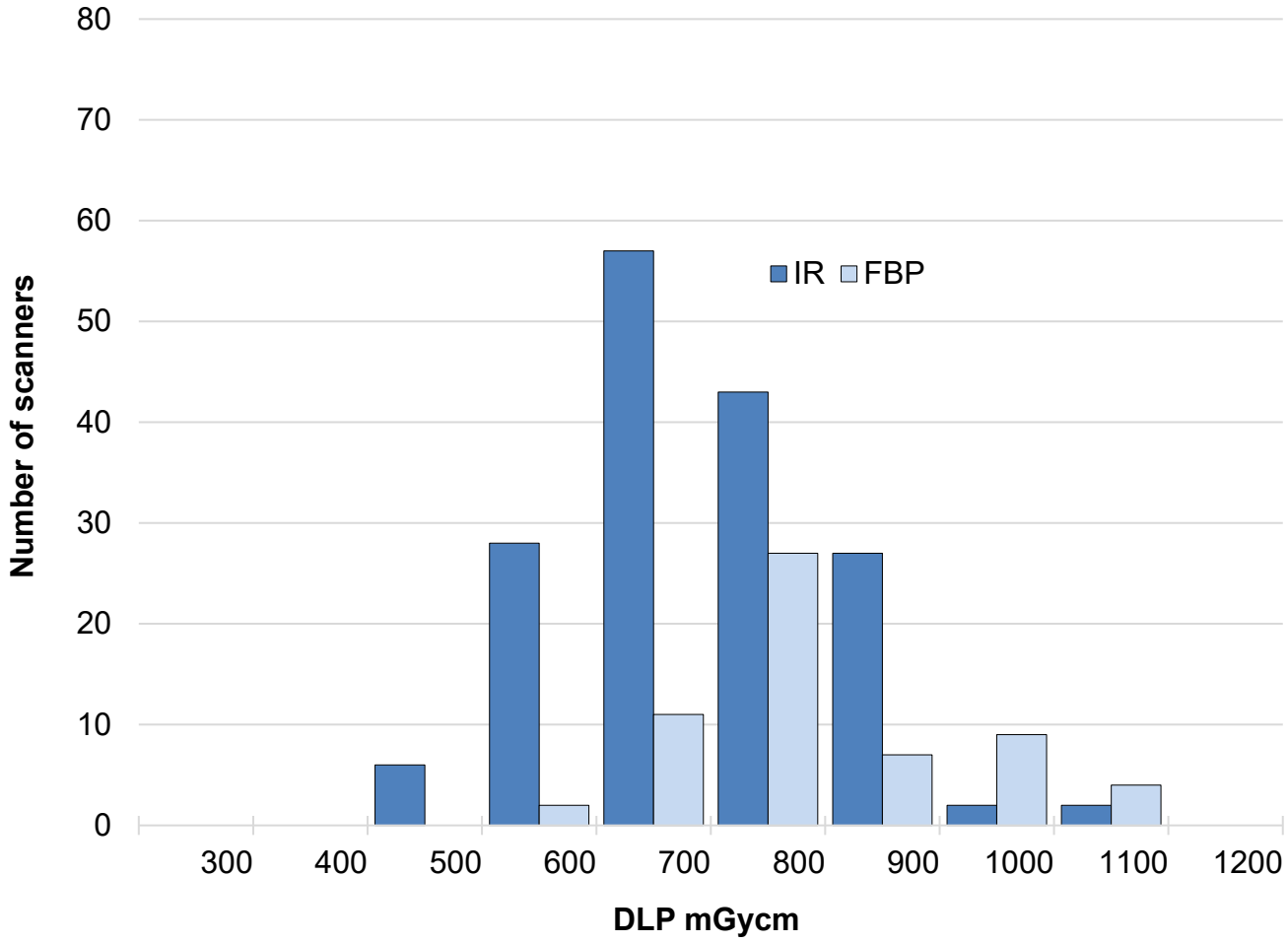


Figure 25. Histogram of scanner median DLP values for head (acute stroke) exams separated by reconstruction technique. Doses refer to the 16cm standard CT dosimetry phantom



Sinuses

Figure 26. Histogram of scanner median DLP values for paranasal sinuses (sinus disease) exams. Doses refer to the 16cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey

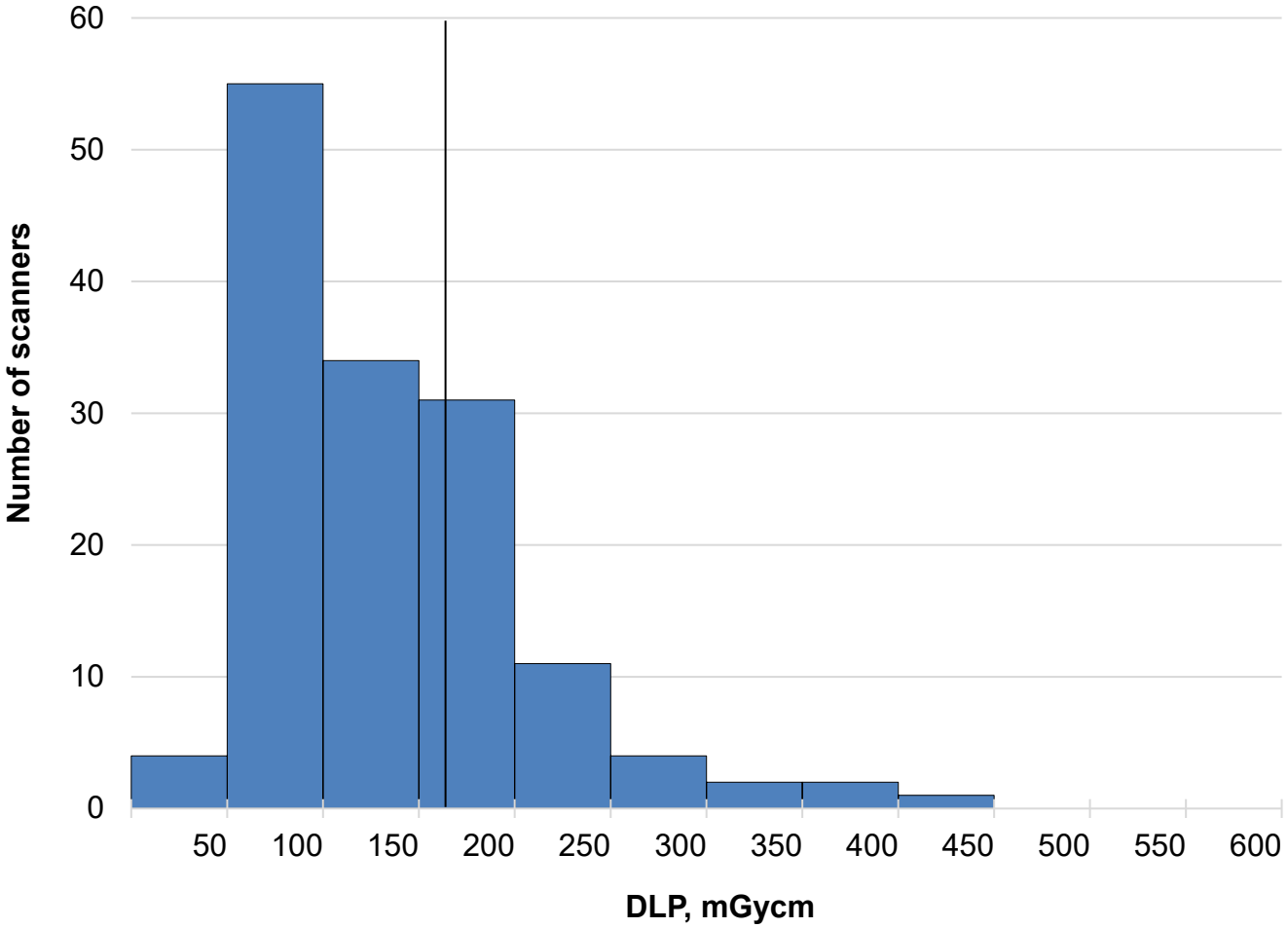
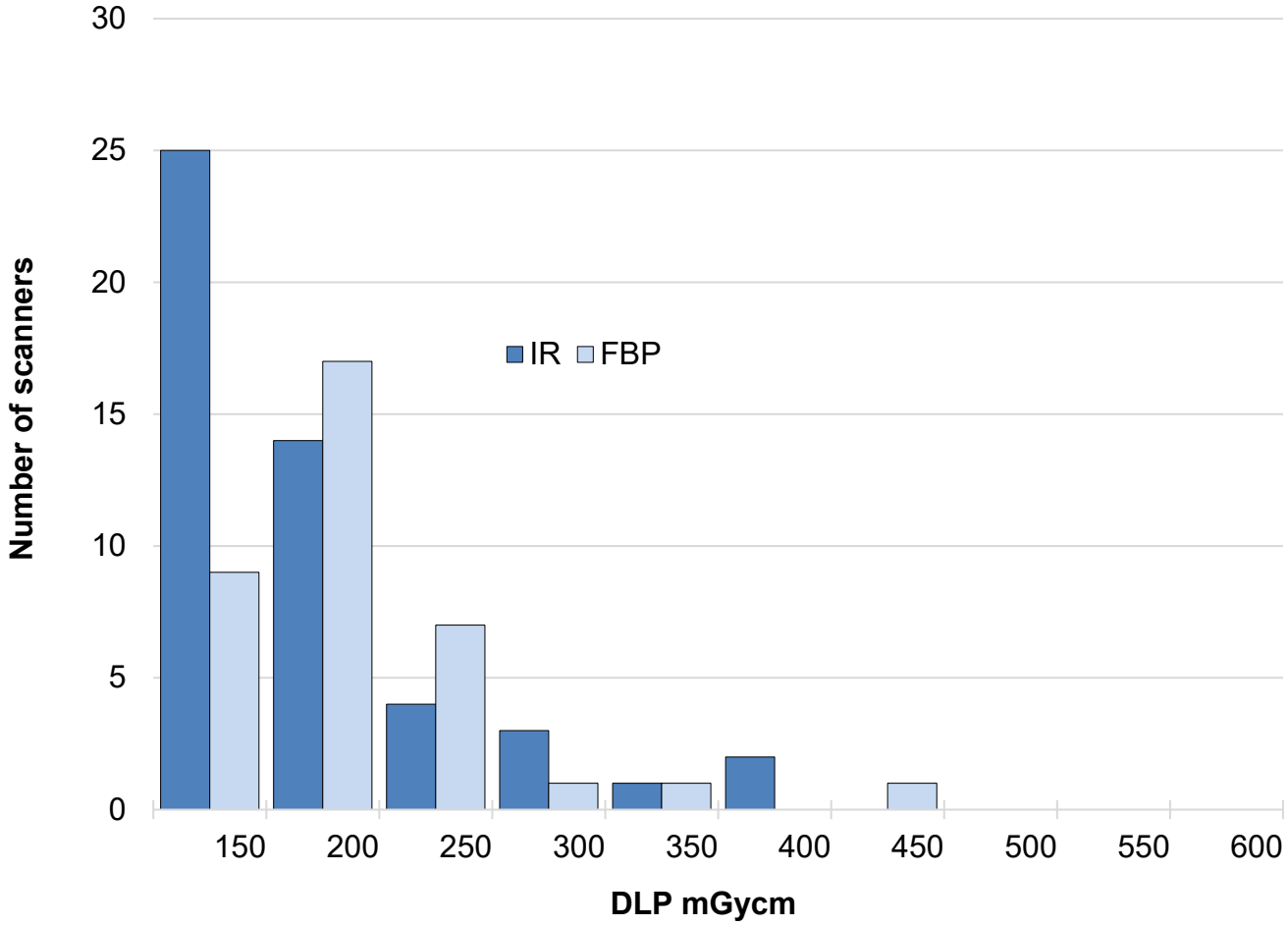


Figure 27. Histogram of scanner median DLP values for paranasal sinuses (sinus disease) exams separated by reconstruction technique. Doses refer to the 16cm standard CT dosimetry phantom



Cervical spine (C-spine) (Fracture)

Figure 28. Histogram of scanner median DLP values for cervical spine (c-spine) (fracture) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

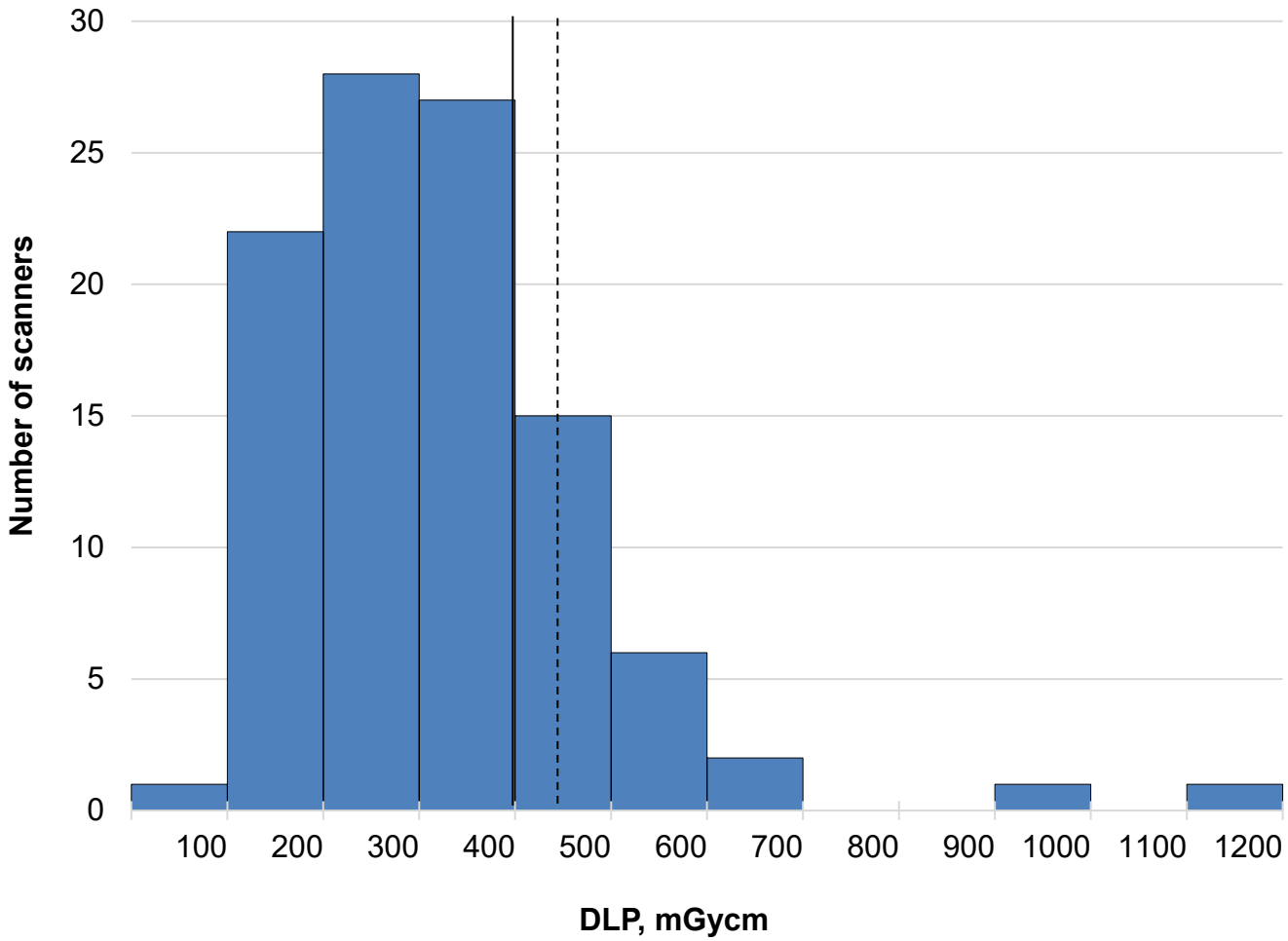
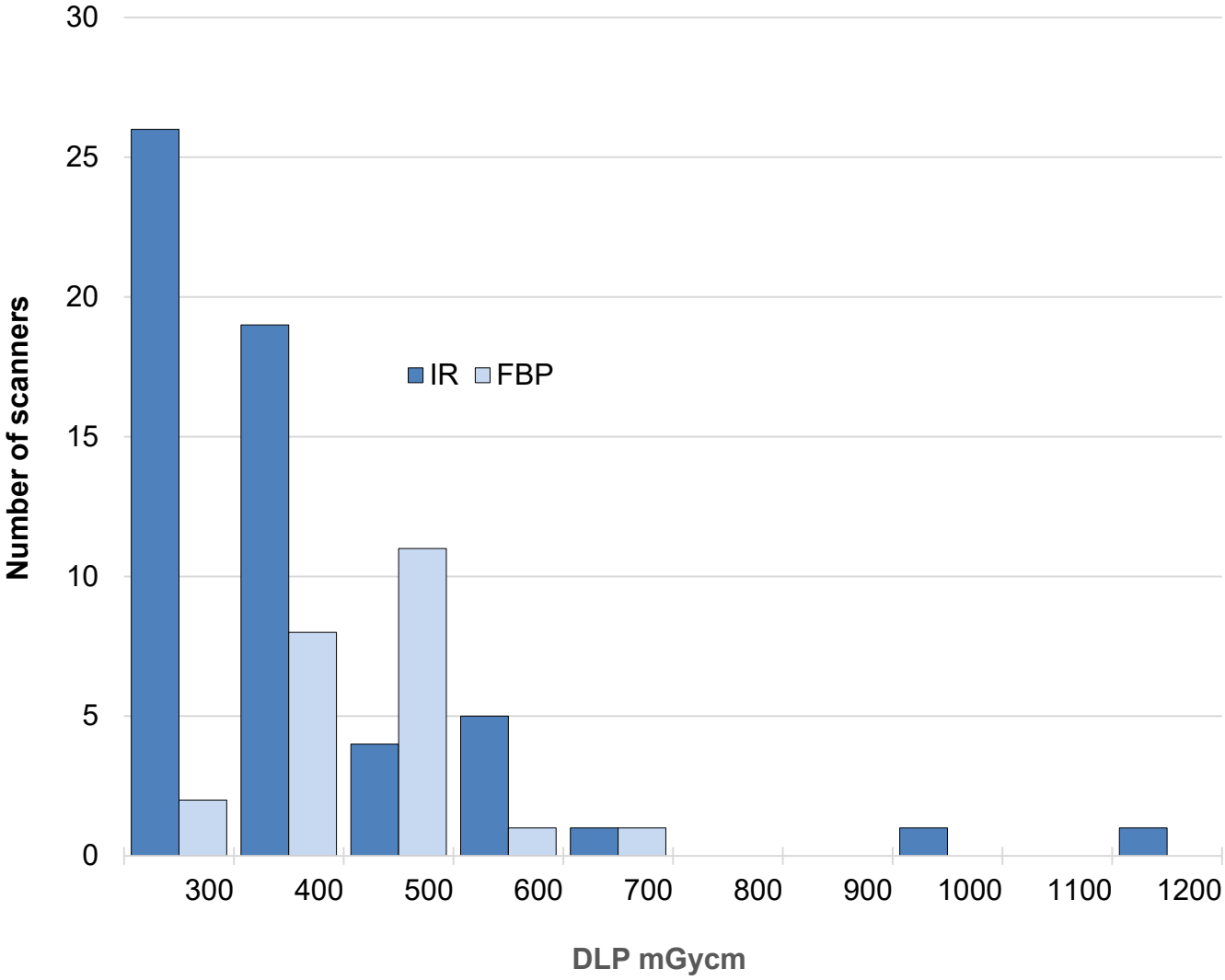


Figure 29. Histogram of scanner median DLP values for cervical spine (c-spine) (fracture) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Chest (Lung cancer)

Figure 30. Histogram of scanner median DLP values for chest (lung cancer) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

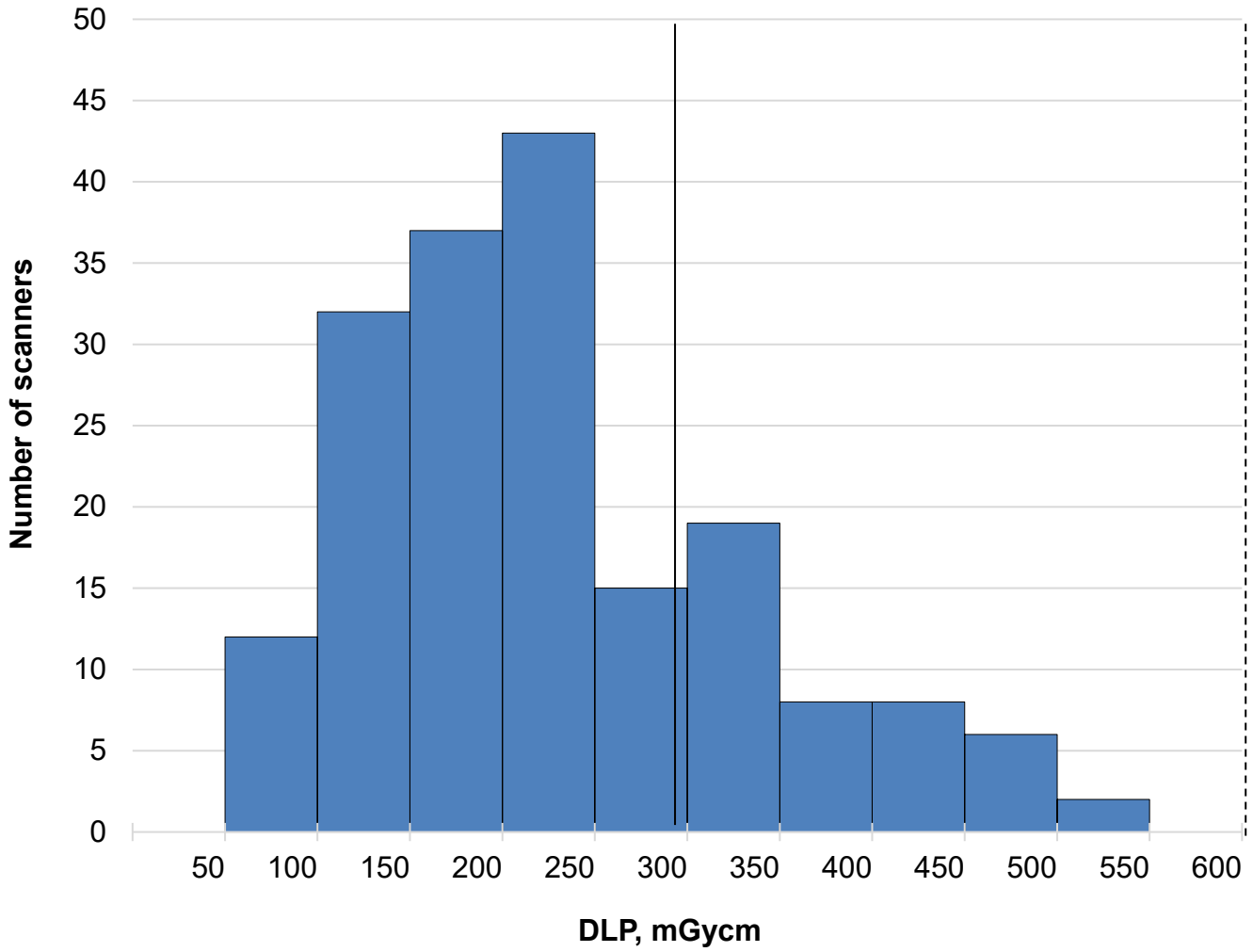
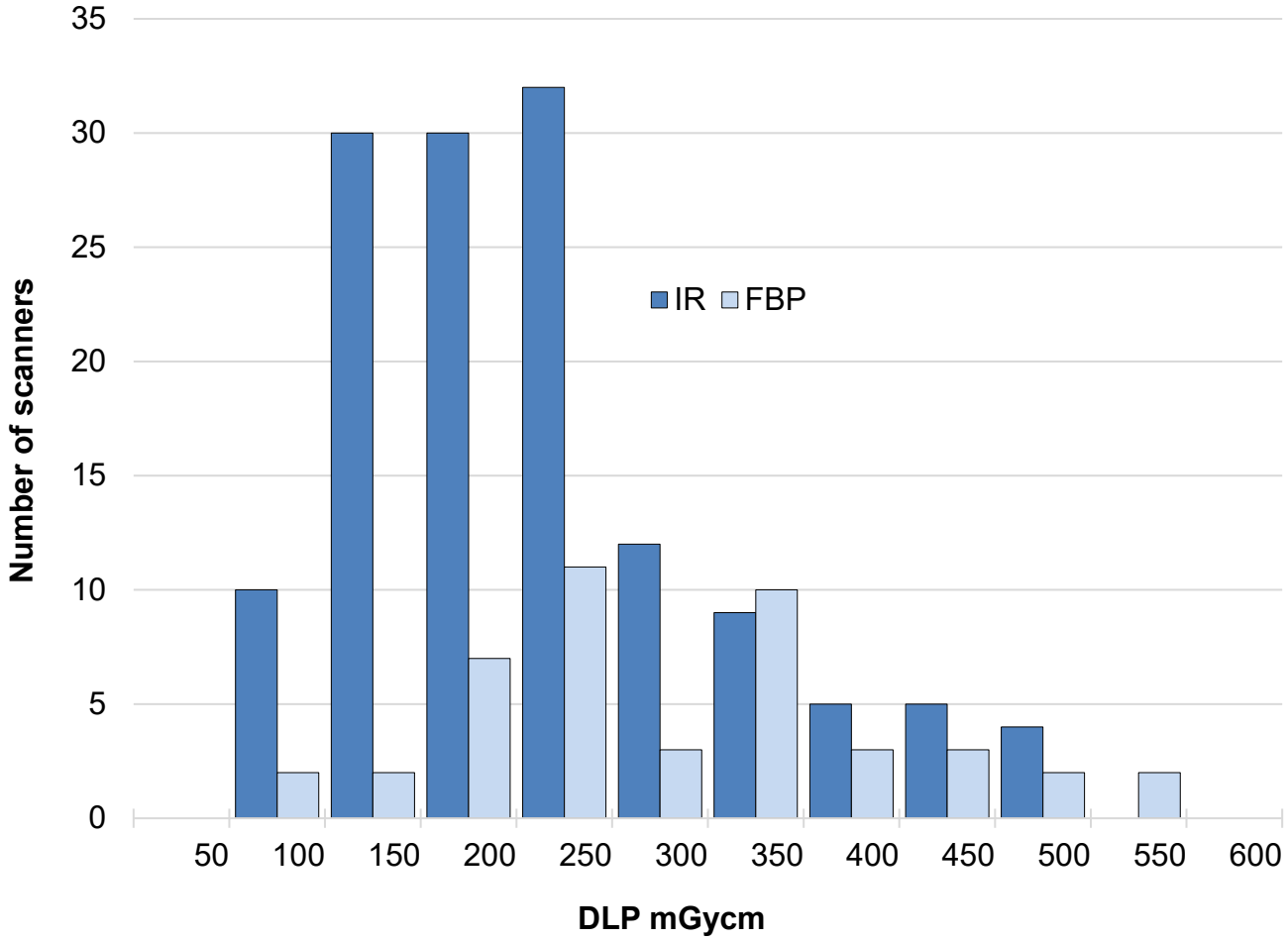


Figure 31. Histogram of scanner median DLP values for chest (lung cancer) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



CT pulmonary angiography (CTPA) (Pulmonary embolism)

Figure 32. Histogram of scanner median DLP values for CT pulmonary angiography (CTPA) (Pulmonary embolism) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

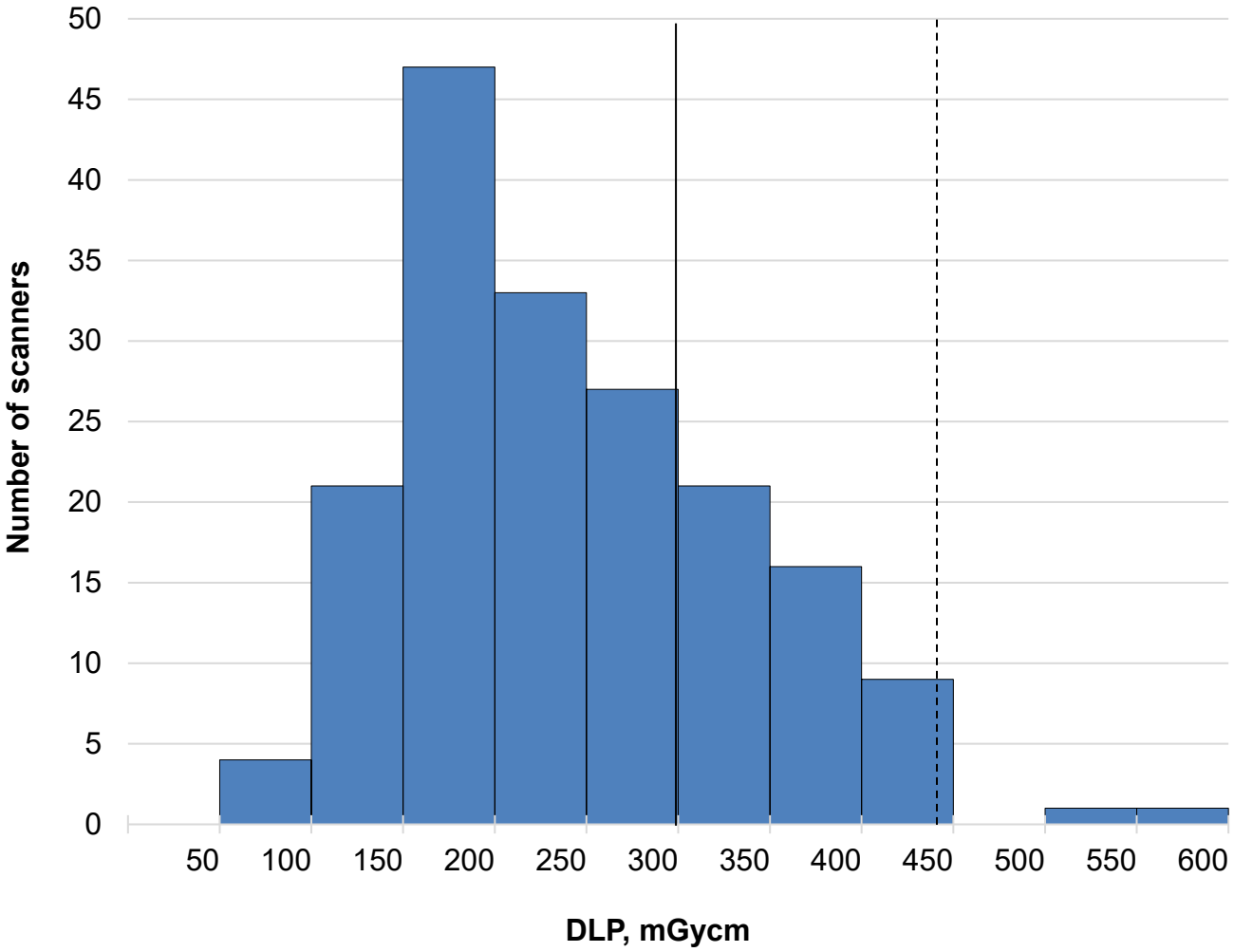
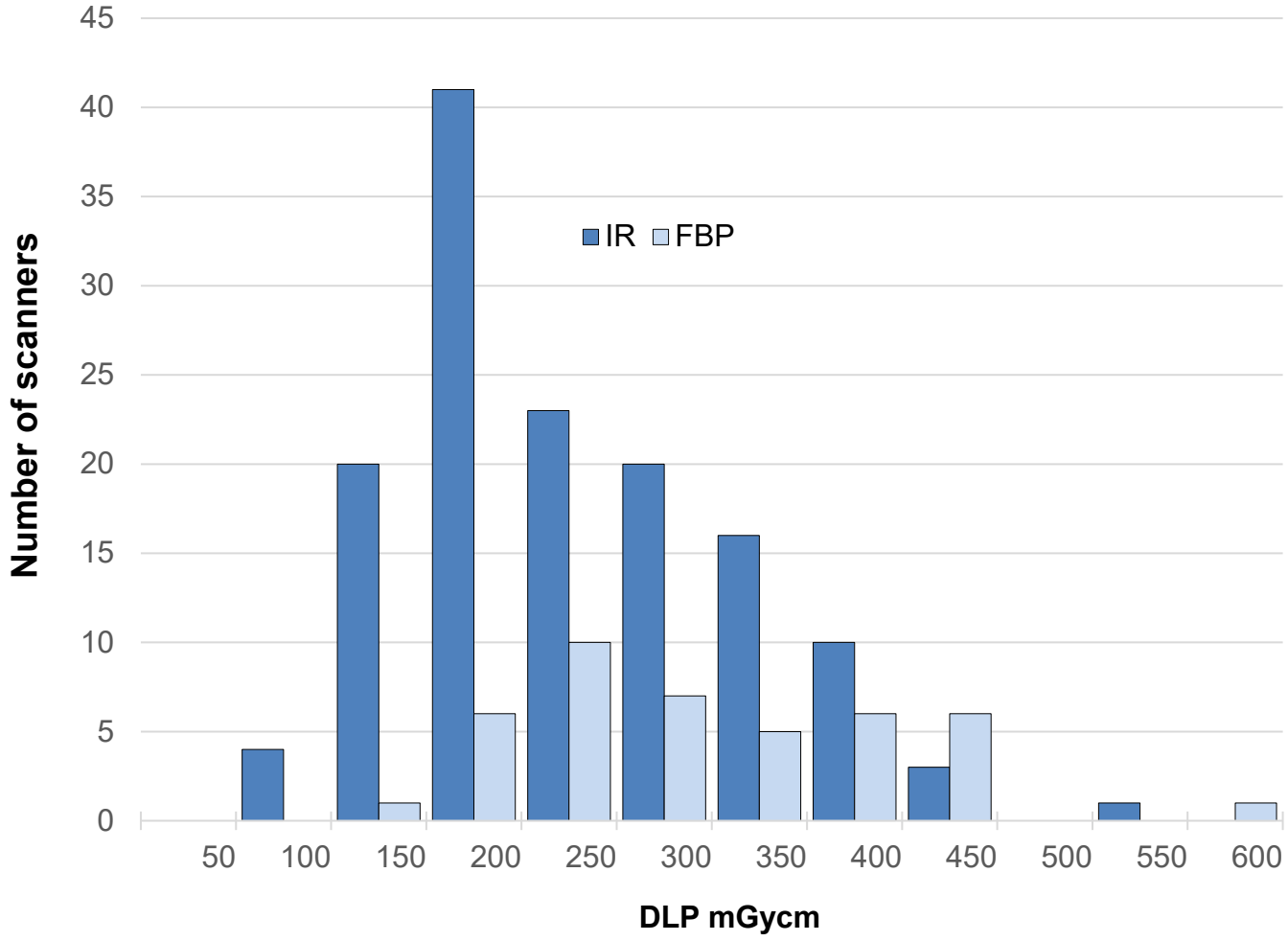


Figure 33. Histogram of scanner median DLP values for CT pulmonary angiography (CTPA) (Pulmonary embolism) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Abdomen and pelvis (Abscess)

Figure 34. Histogram of scanner median DLP values for abdomen and pelvis (abscess) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

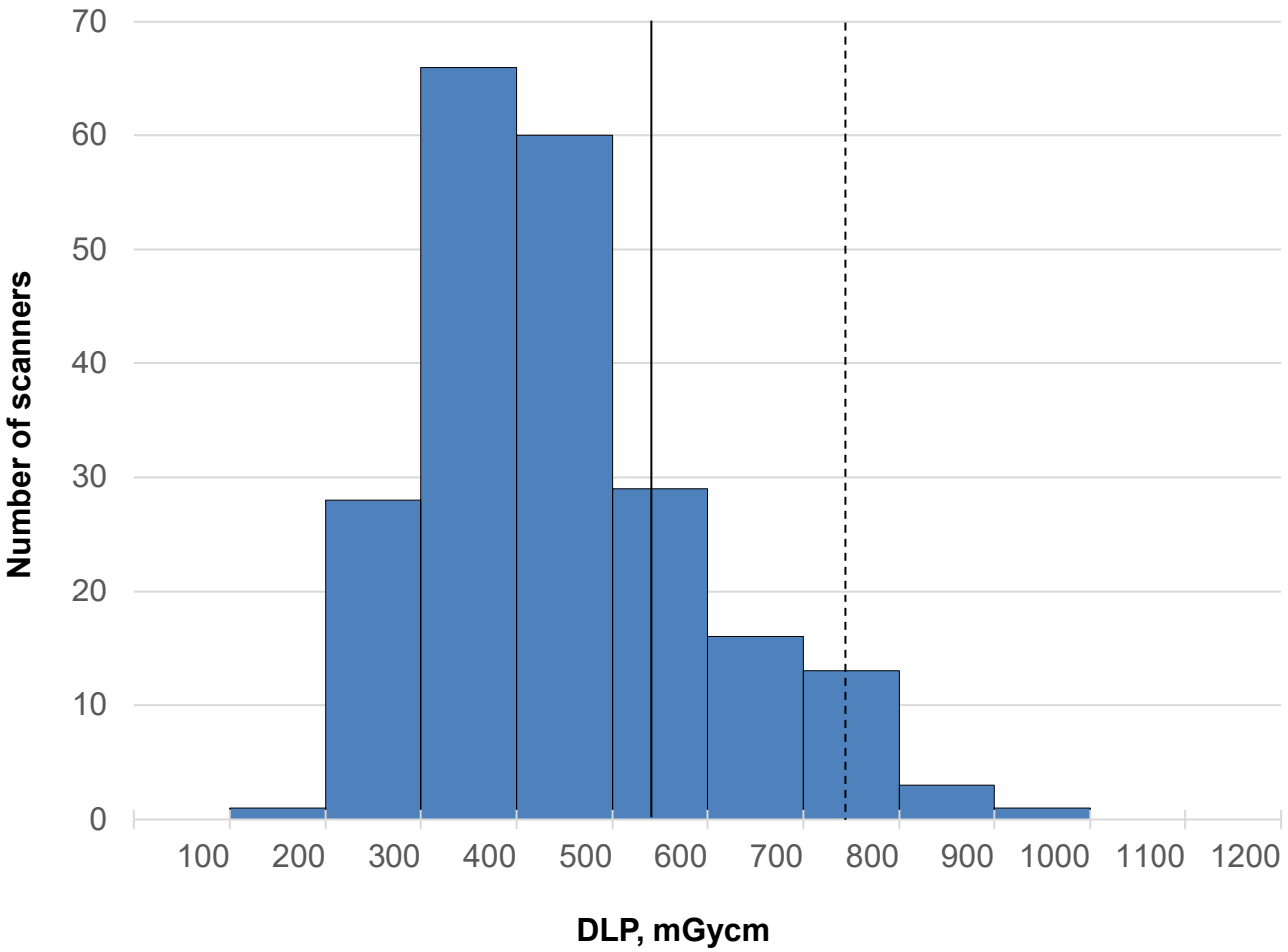
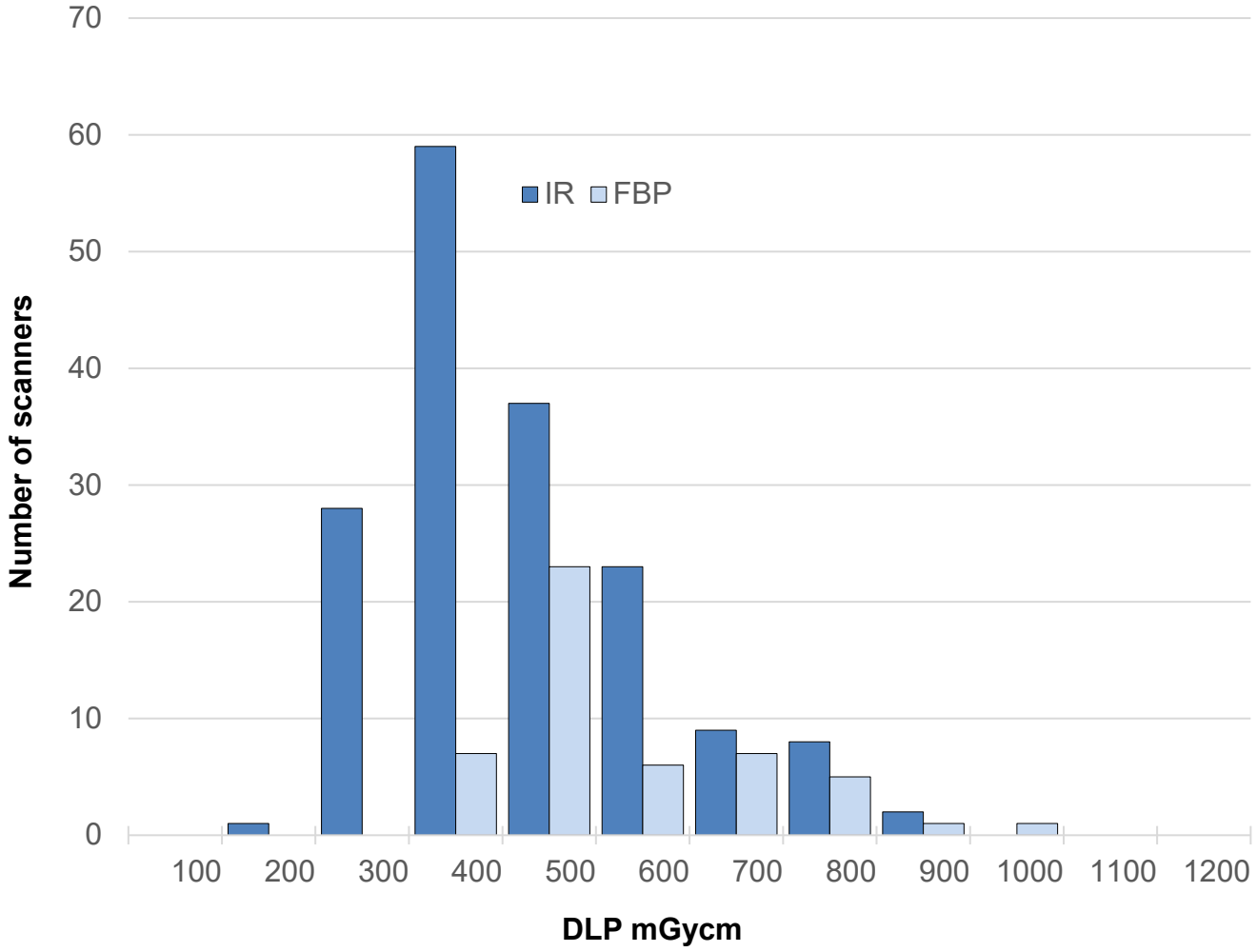


Figure 35. Histogram of scanner median DLP values for abdomen and pelvis (abscess) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Kidney-ureters-bladder (KUB) (Stones/colic)

Figure 36. Histogram of scanner median DLP values for kidney-ureters-bladder (KUB) (stones/colic) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

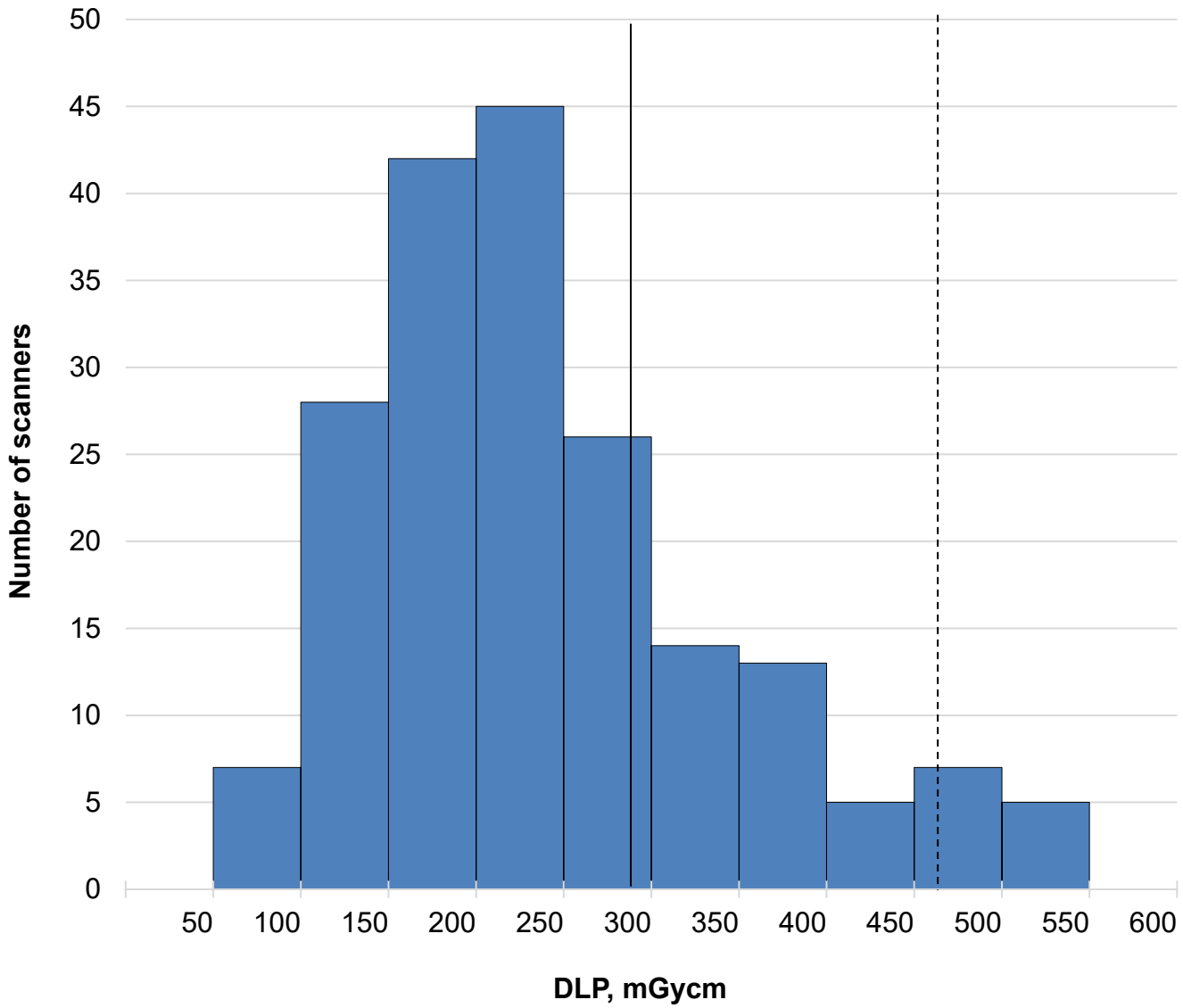
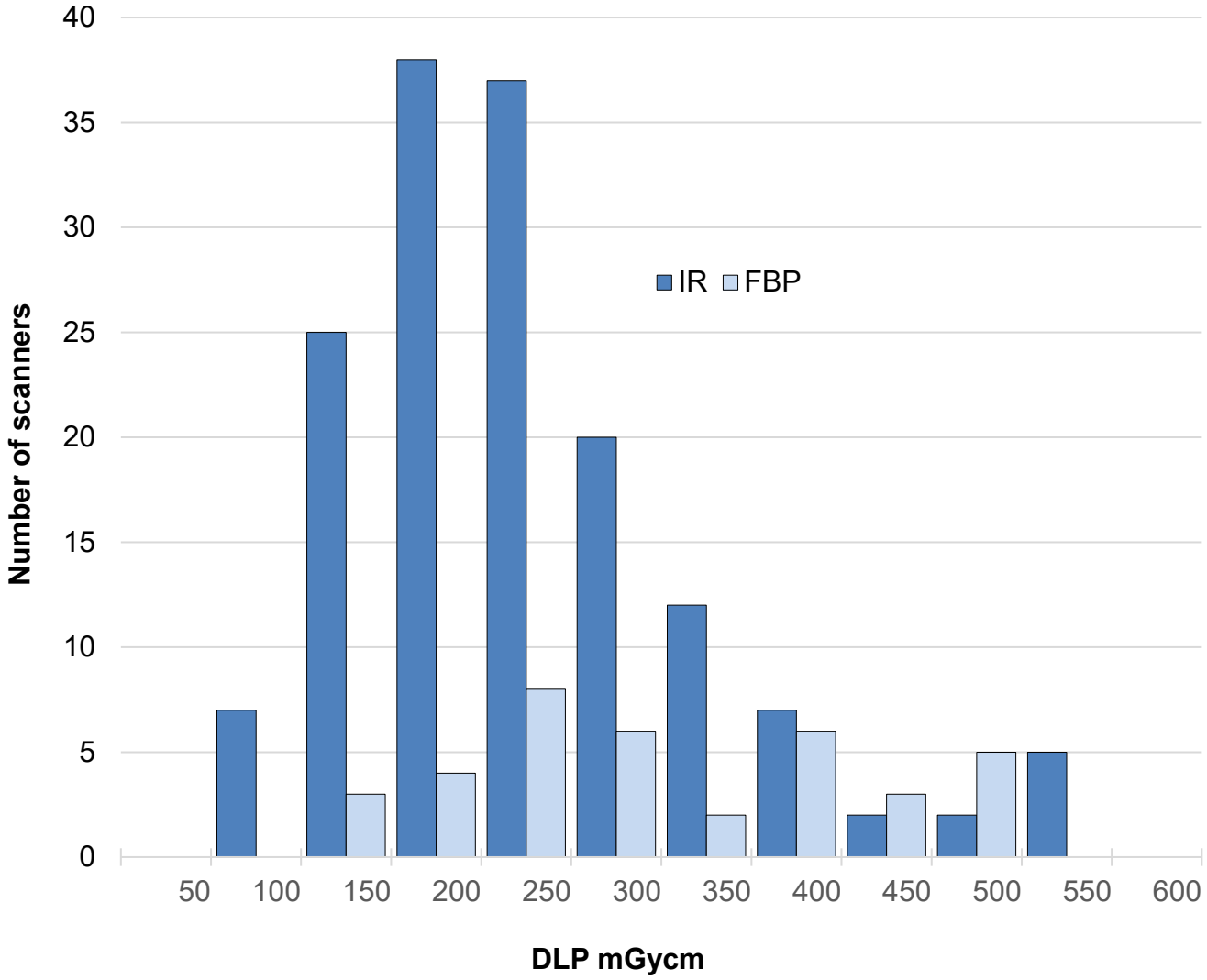


Figure 37. Histogram of scanner median DLP values for kidney-ureters-bladder (KUB) (stones/colic) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Neck, chest, abdomen and pelvis (Cancer)

Figure 38. Histogram of scanner median DLP values for neck, chest, abdomen and pelvis (cancer) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey

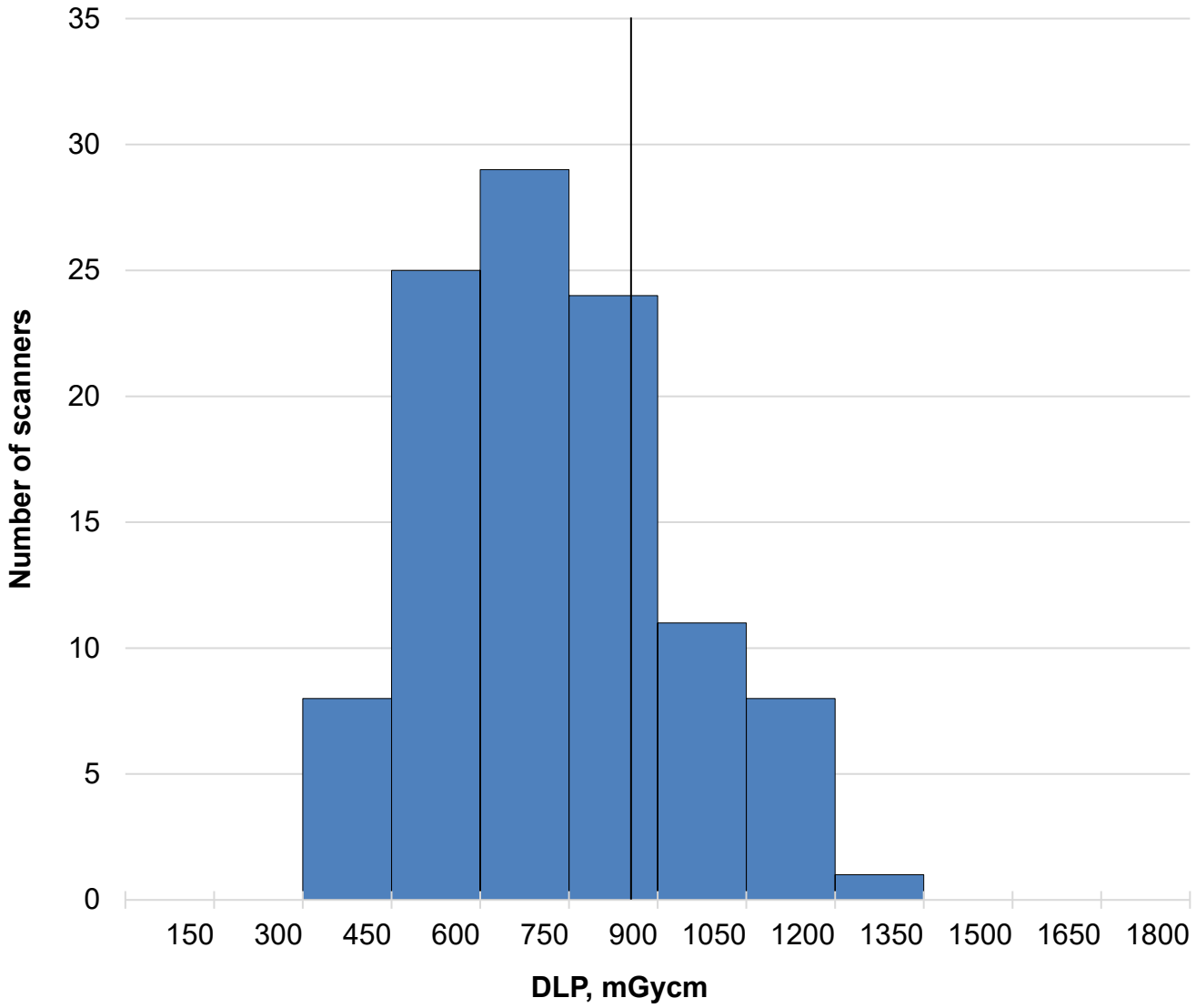
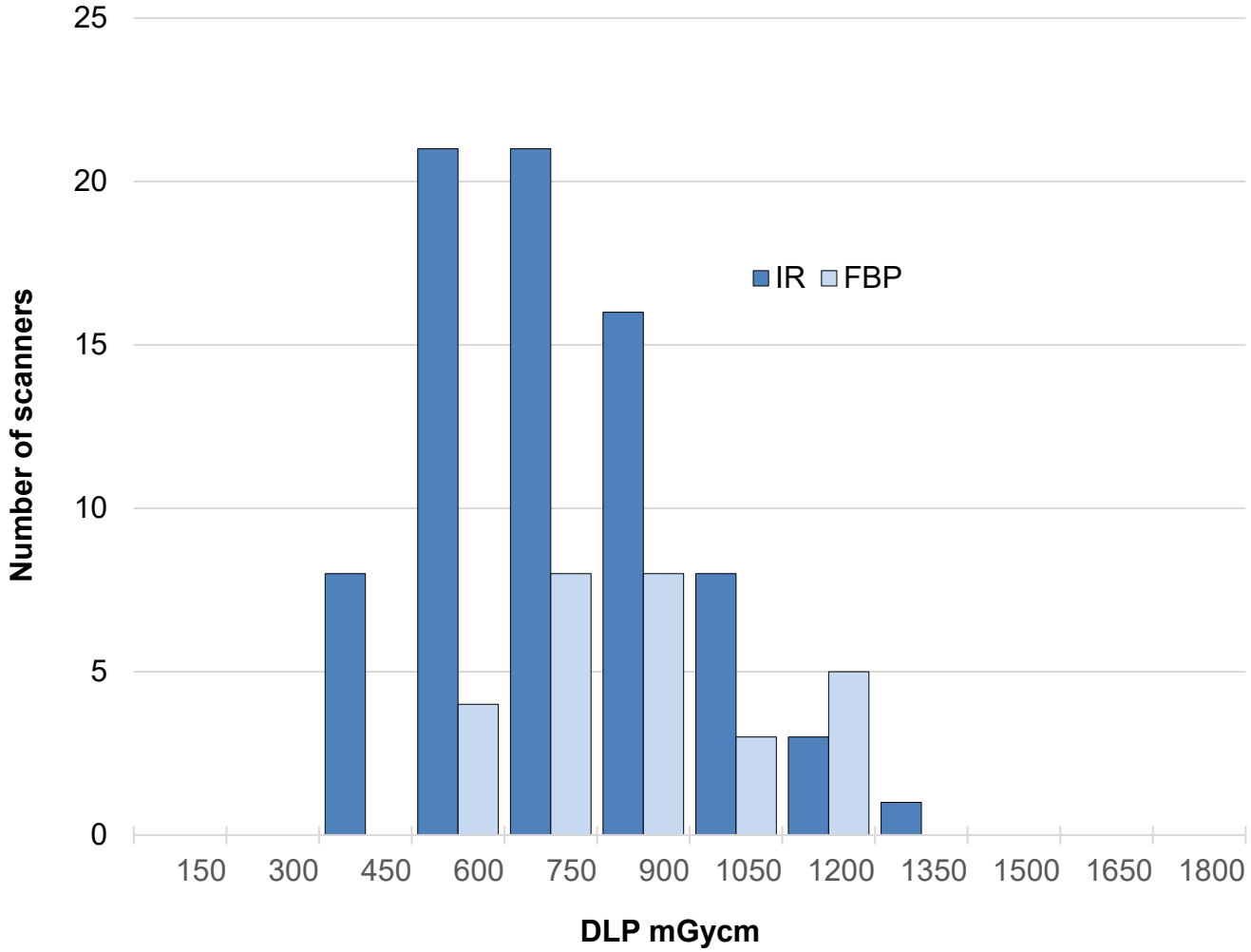


Figure 39. Histogram of scanner median DLP values for neck, chest, abdomen and pelvis (cancer) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Chest and abdomen (Lung cancer)

Figure 40. Histogram of scanner median DLP values for chest and abdomen (lung cancer) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey

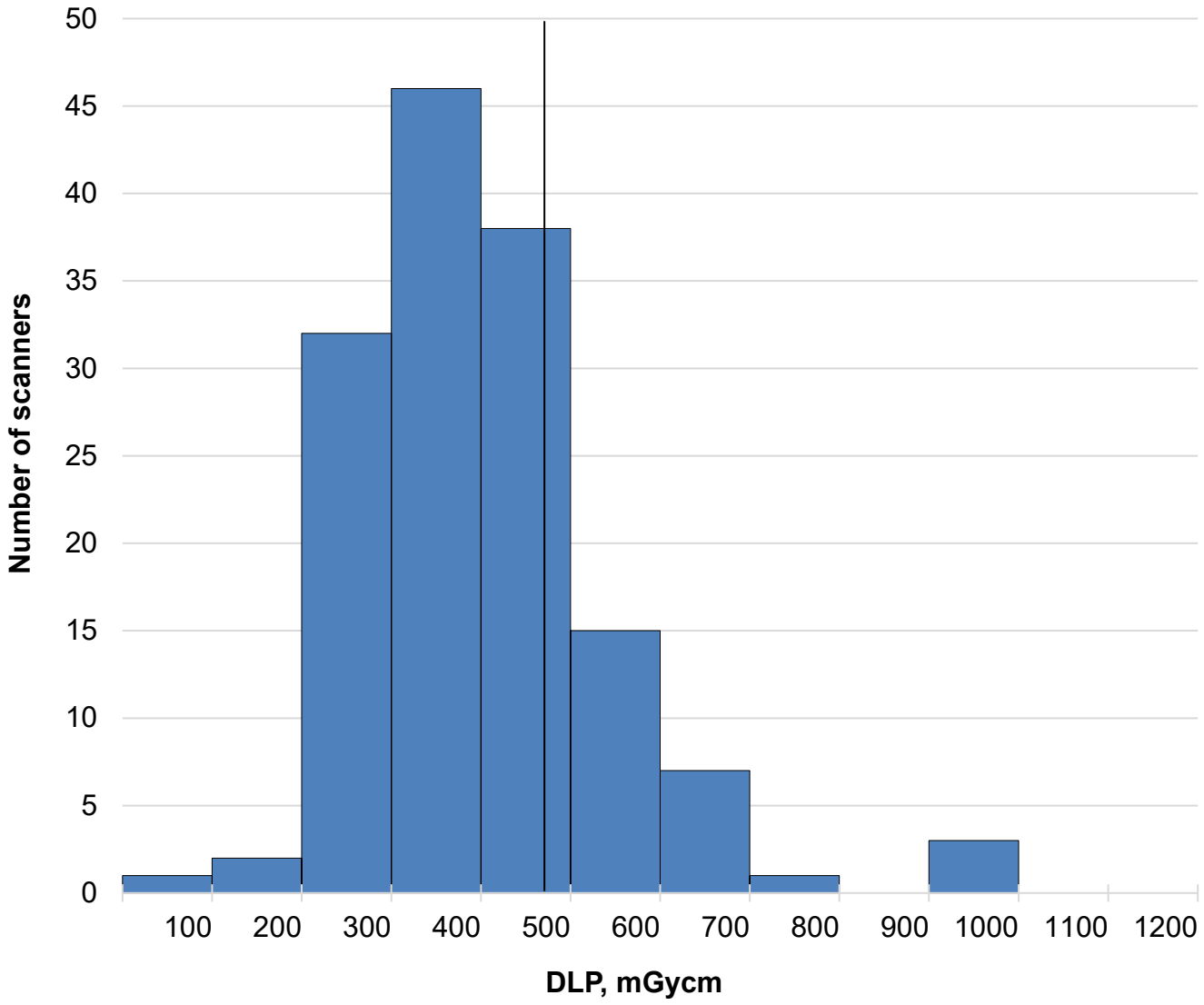
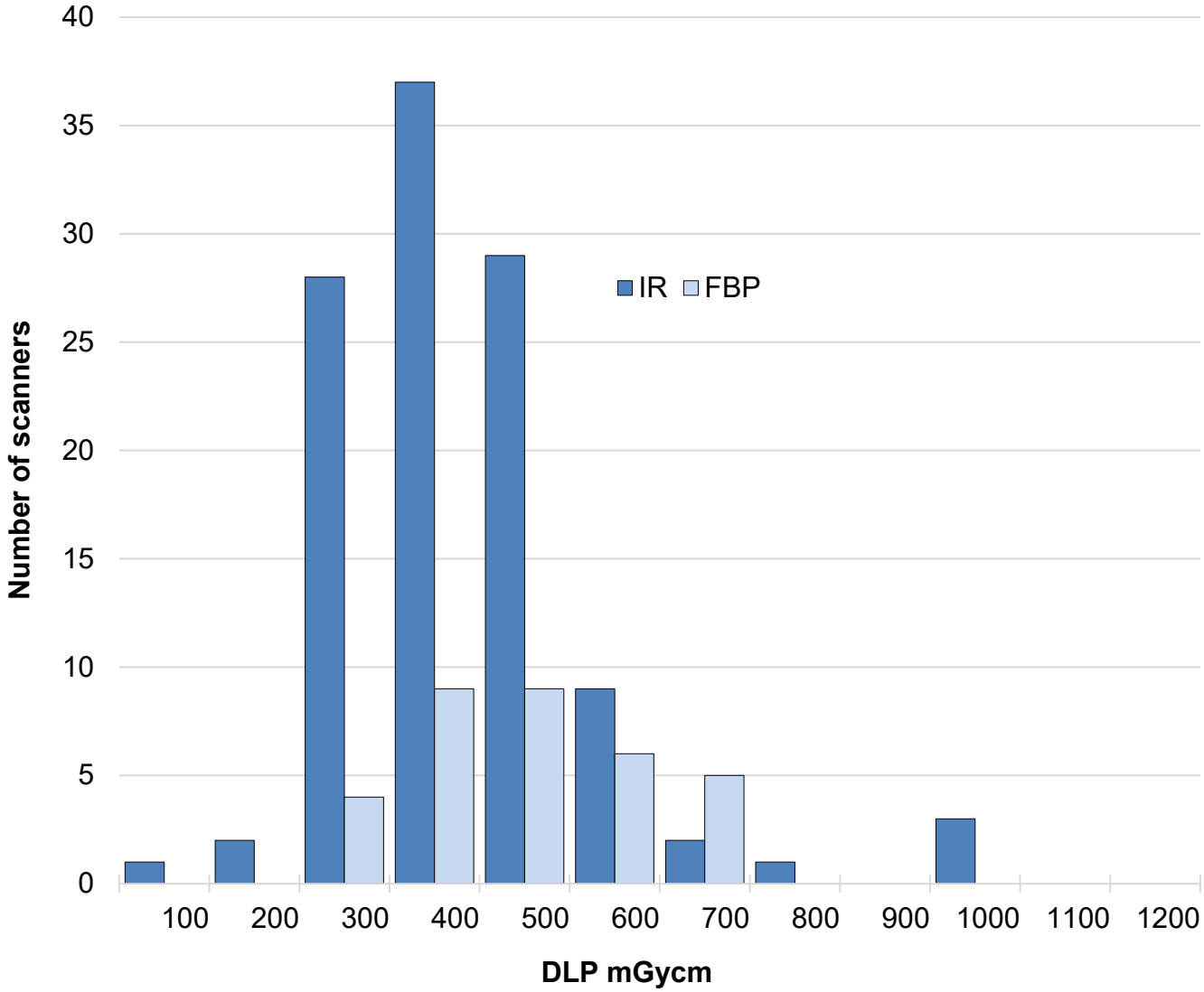


Figure 41. Histogram of scanner median DLP values for chest and abdomen (lung cancer) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Chest-abdomen-pelvis (CAP) (Cancer)

Figure 42. Histogram of scanner median DLP values for chest-abdomen-pelvis (CAP) (cancer) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

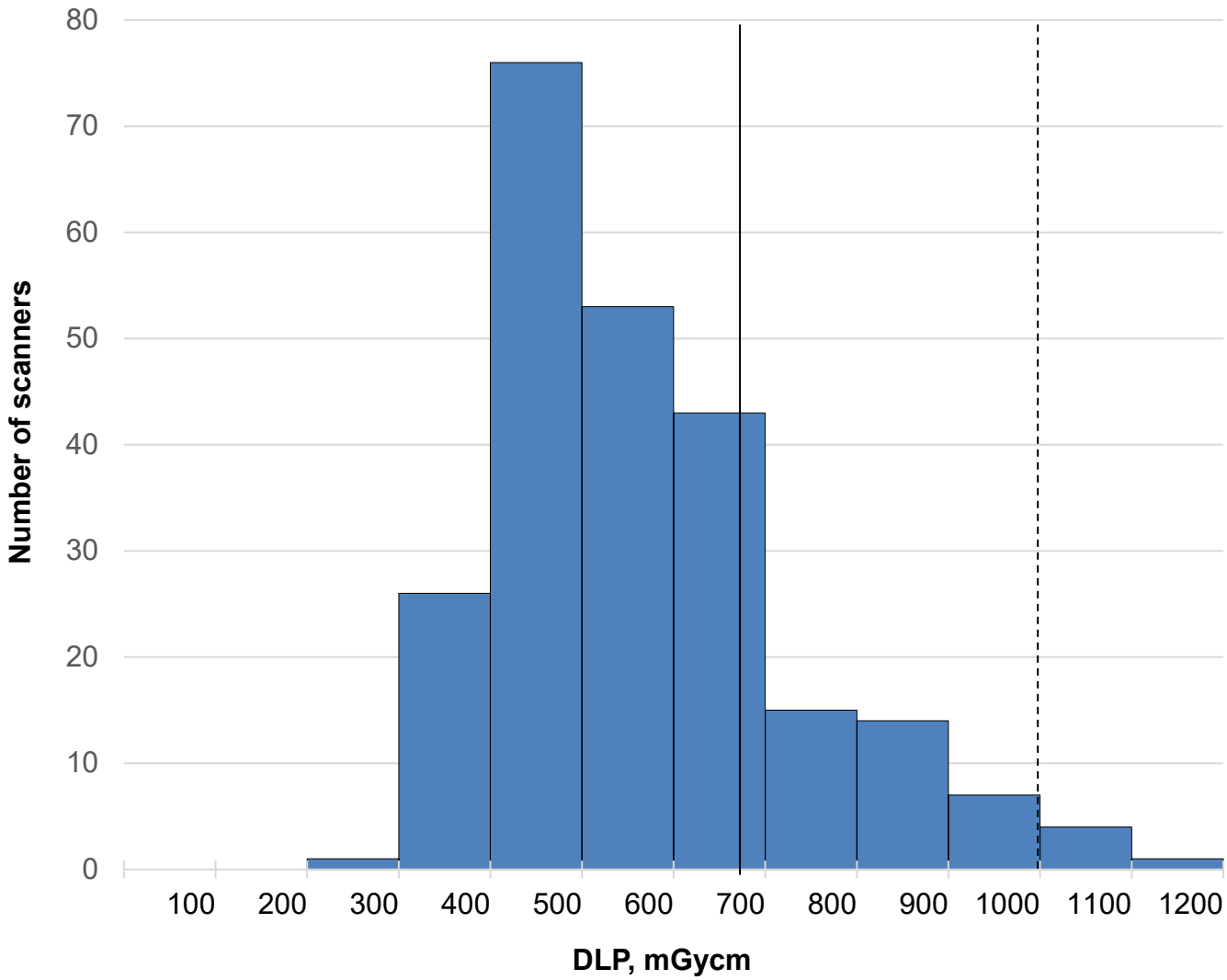
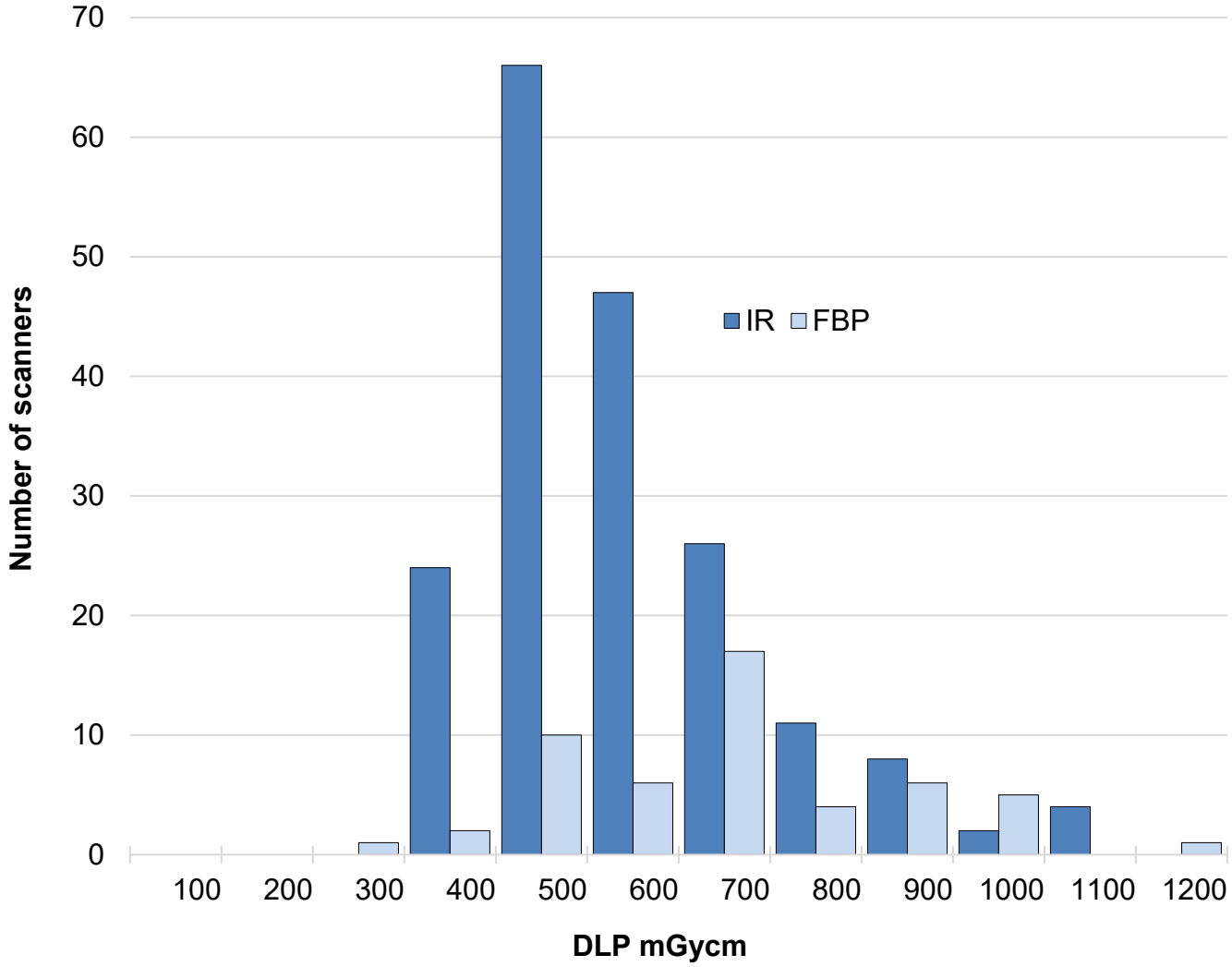


Figure 43. Histogram of scanner median DLP values for chest-abdomen-pelvis (CAP) (cancer) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Colonography/Virtual colonoscopy (VC) (Polyps/tumour)

Figure 44. Histogram of scanner median DLP values for colonography/virtual colonoscopy (VC) (polyps/tumour) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

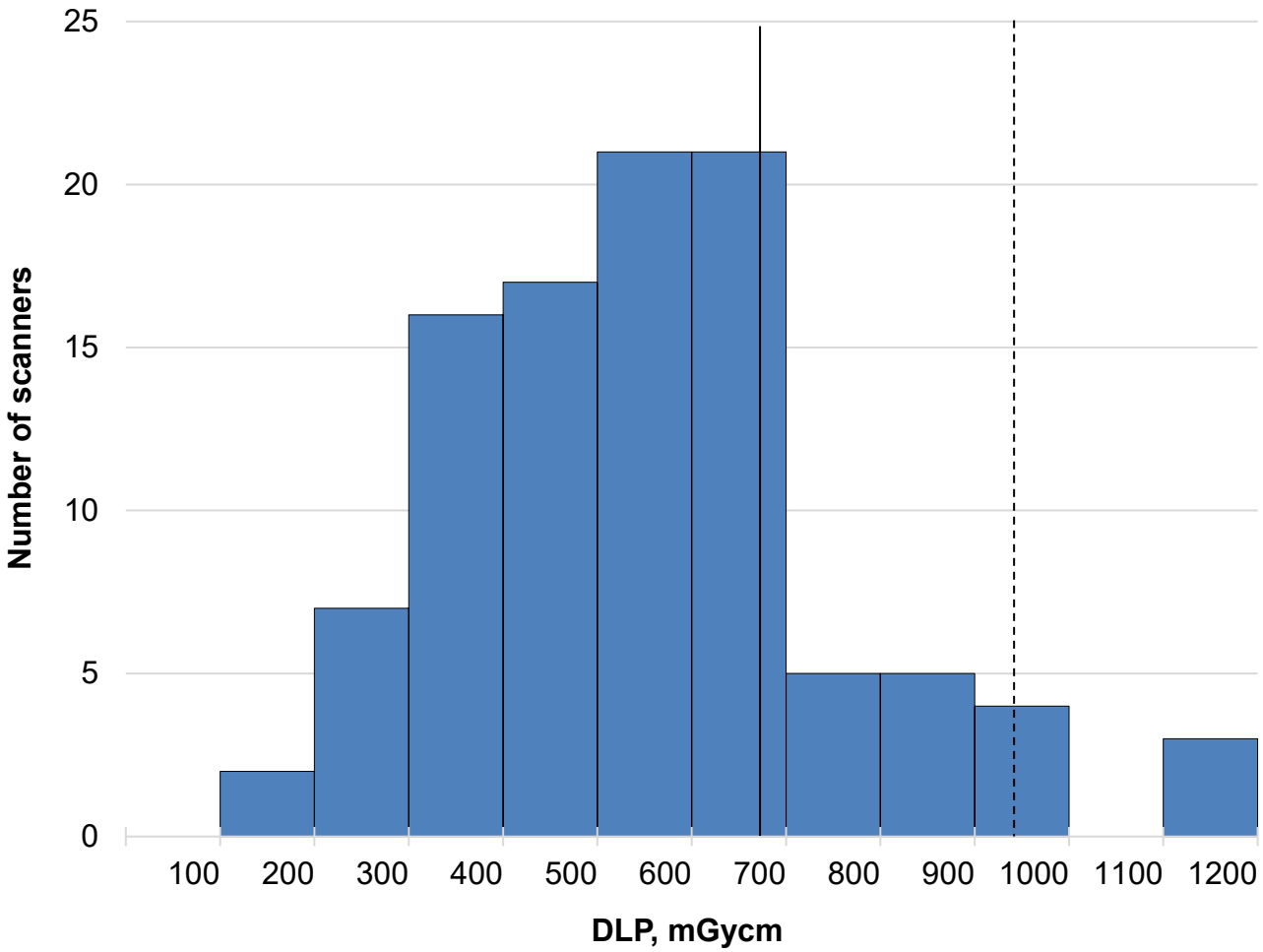
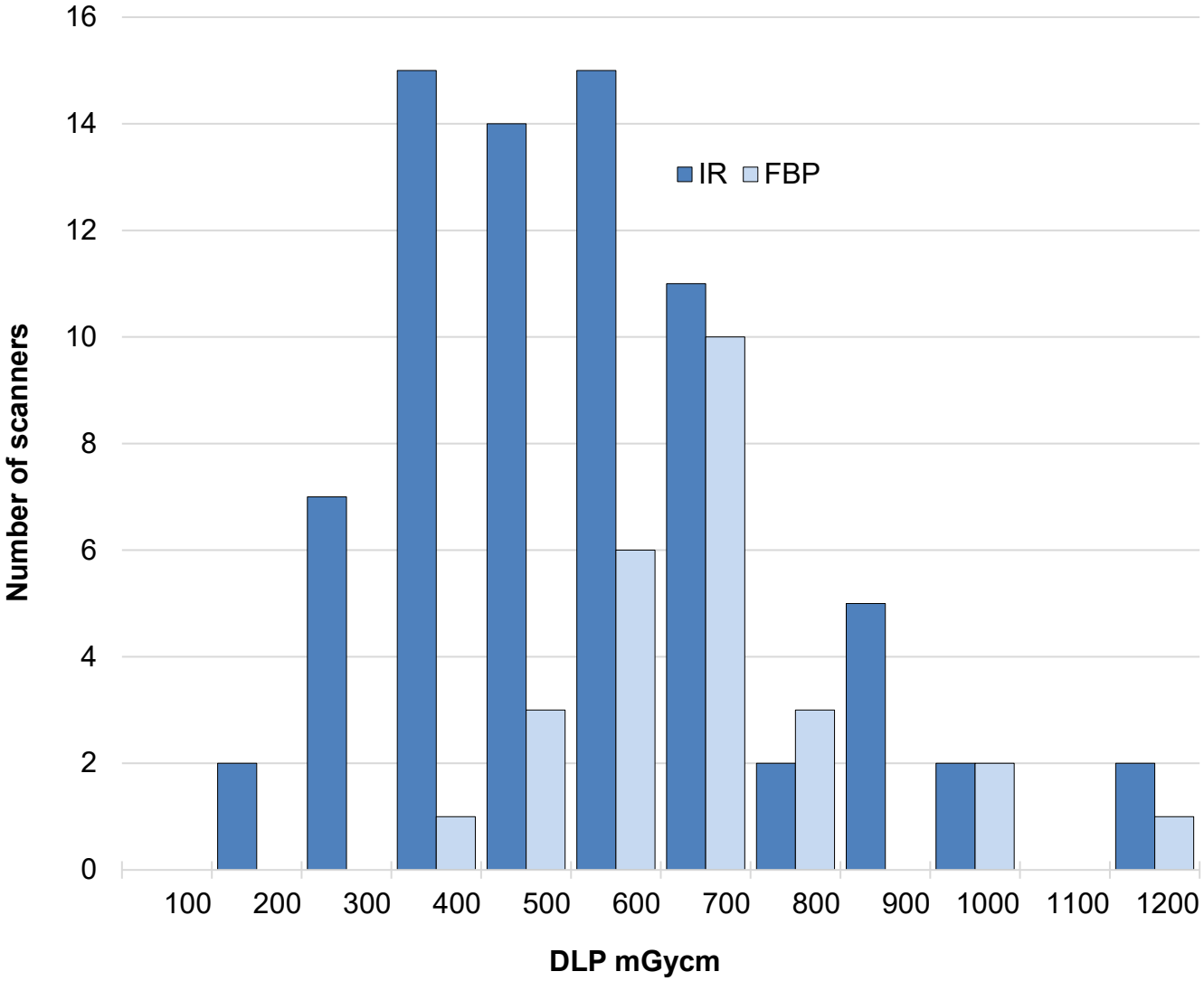


Figure 45. Histogram of scanner median DLP values for colonography/virtual colonoscopy (VC) (polyps/tumour) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Urogram (Stones/colic or tumour)

Figure 46. Histogram of scanner median DLP values for urogram (stones/colic or tumour) exams. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

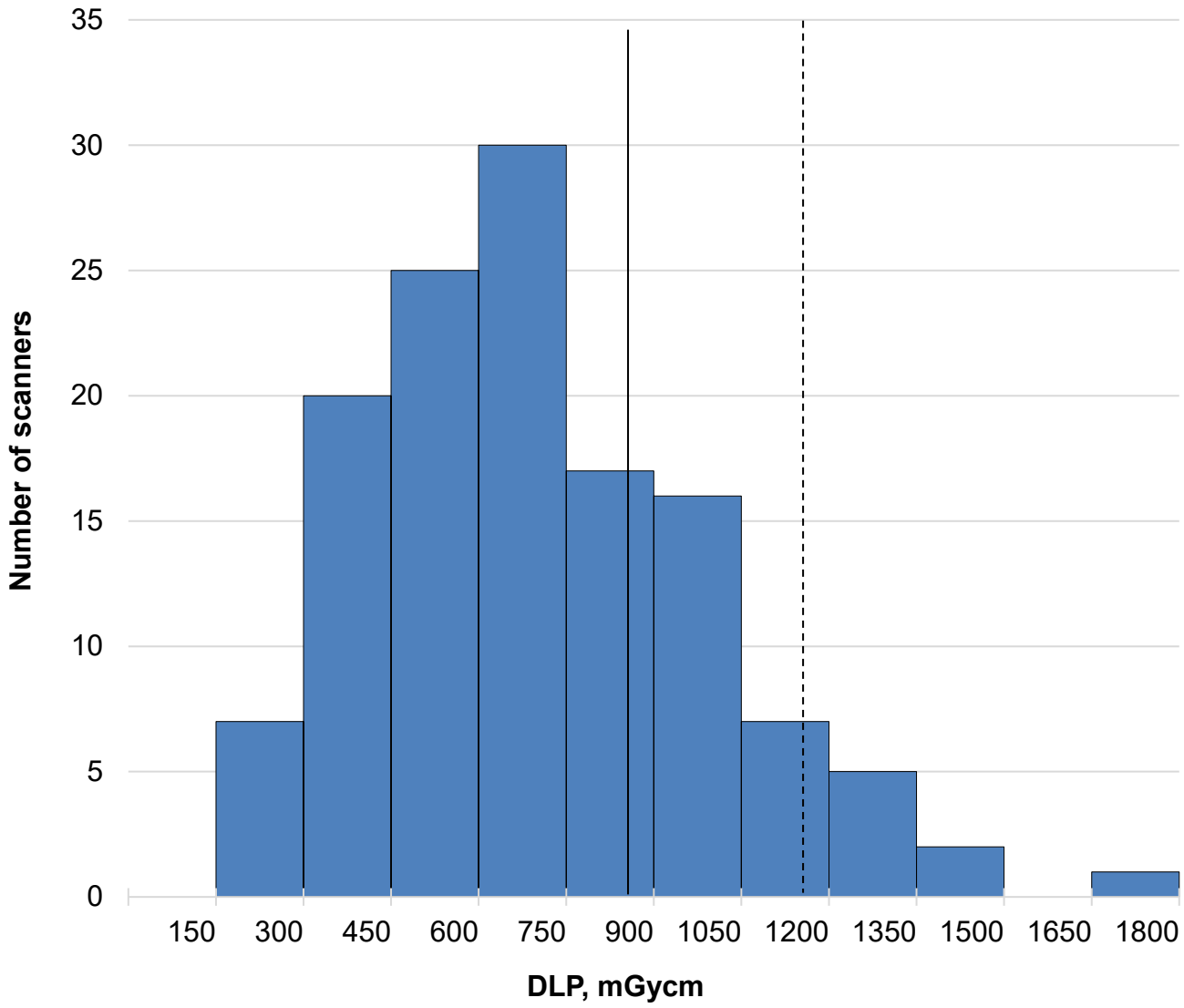
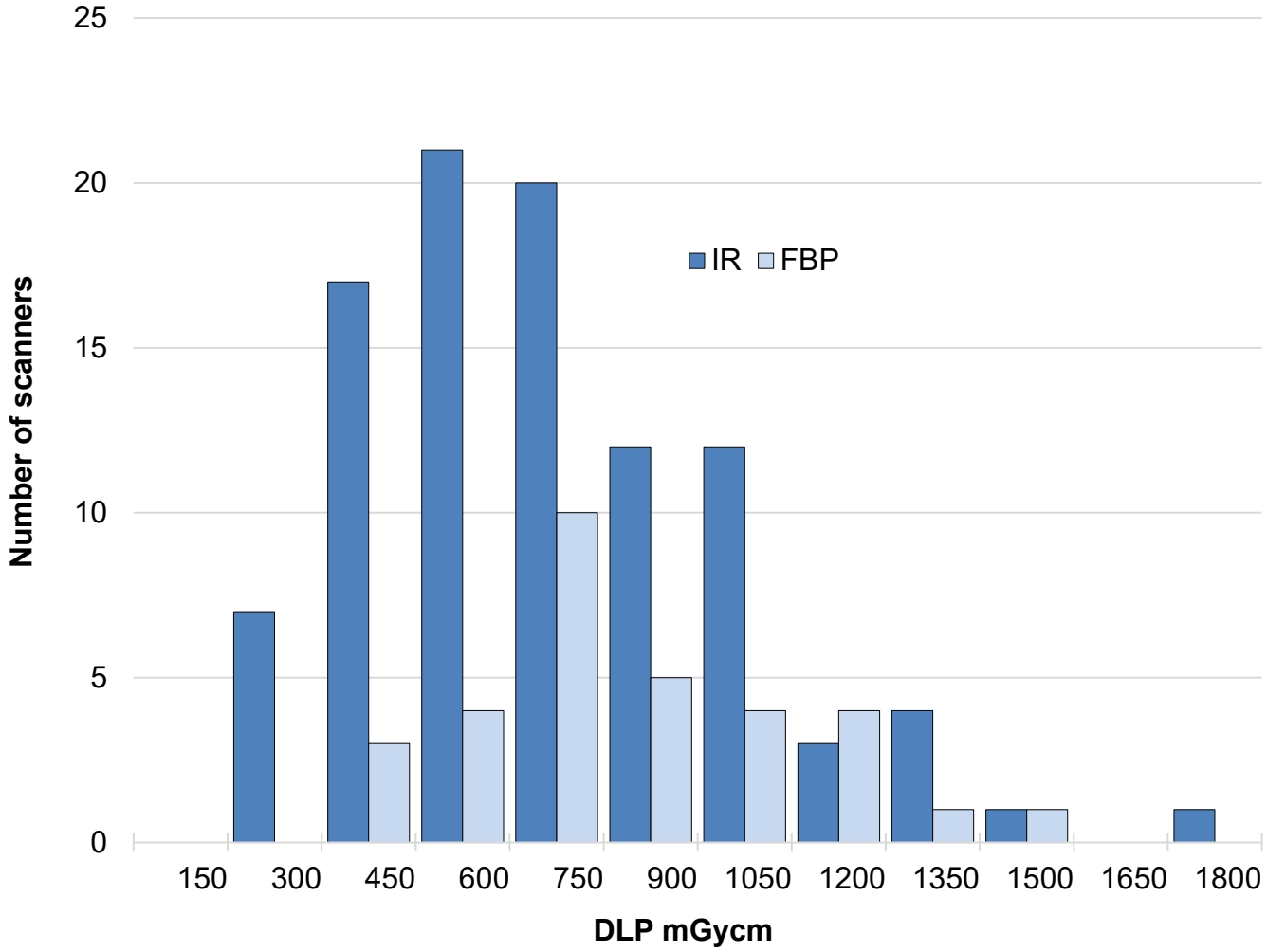


Figure 47. Histogram of scanner median DLP values for urogram (stones/colic or tumour) exams separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Chest – high resolution (Interstitial lung disease) - single helical protocol

Figure 48. Histogram of scanner median DLP values for chest high resolution (Interstitial lung disease) exams performed as a single helical sequence. Doses refer to the 32cm standard CT dosimetry phantom. The solid line represents the third quartile value from this survey and the dashed line represents the current UK NDRL

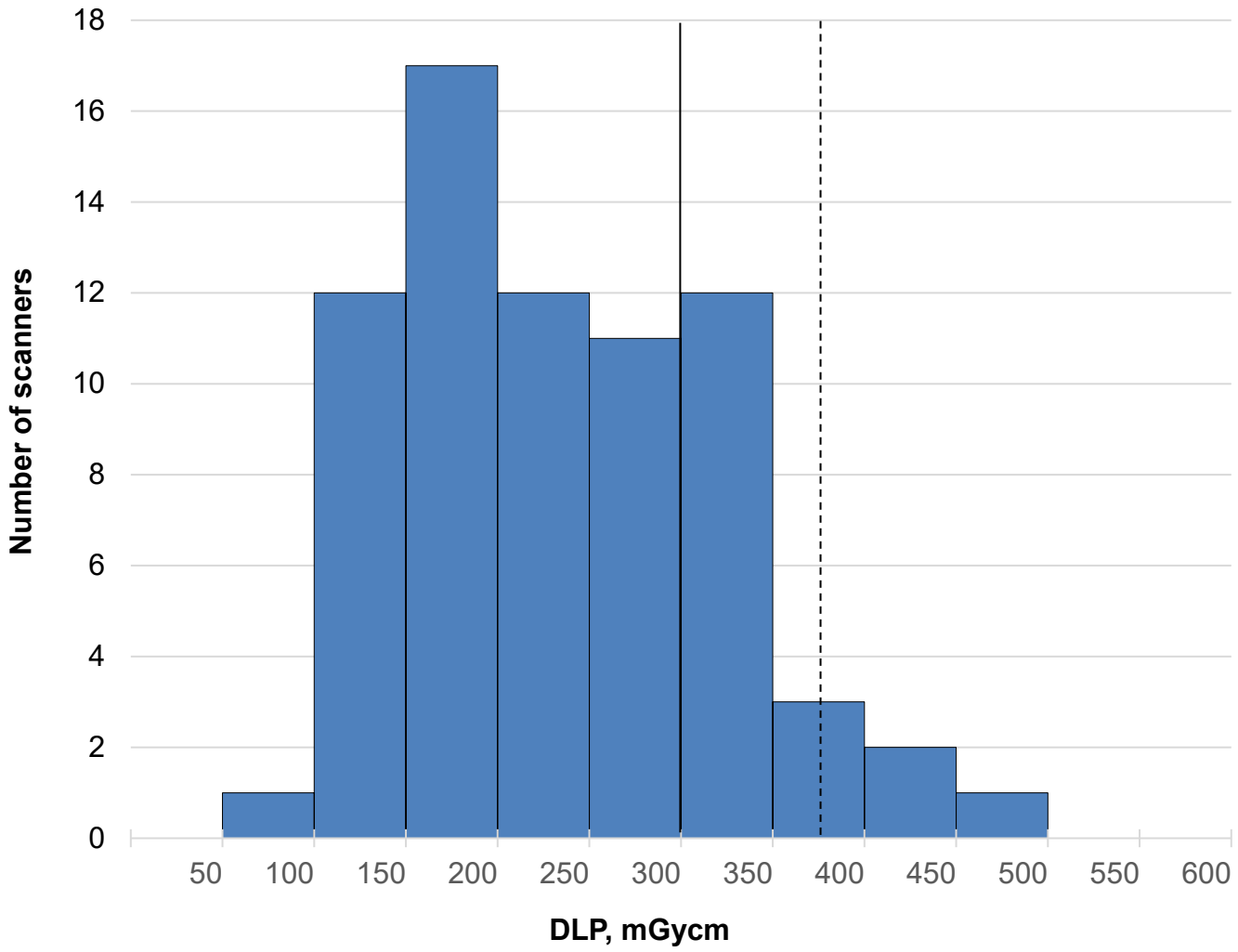
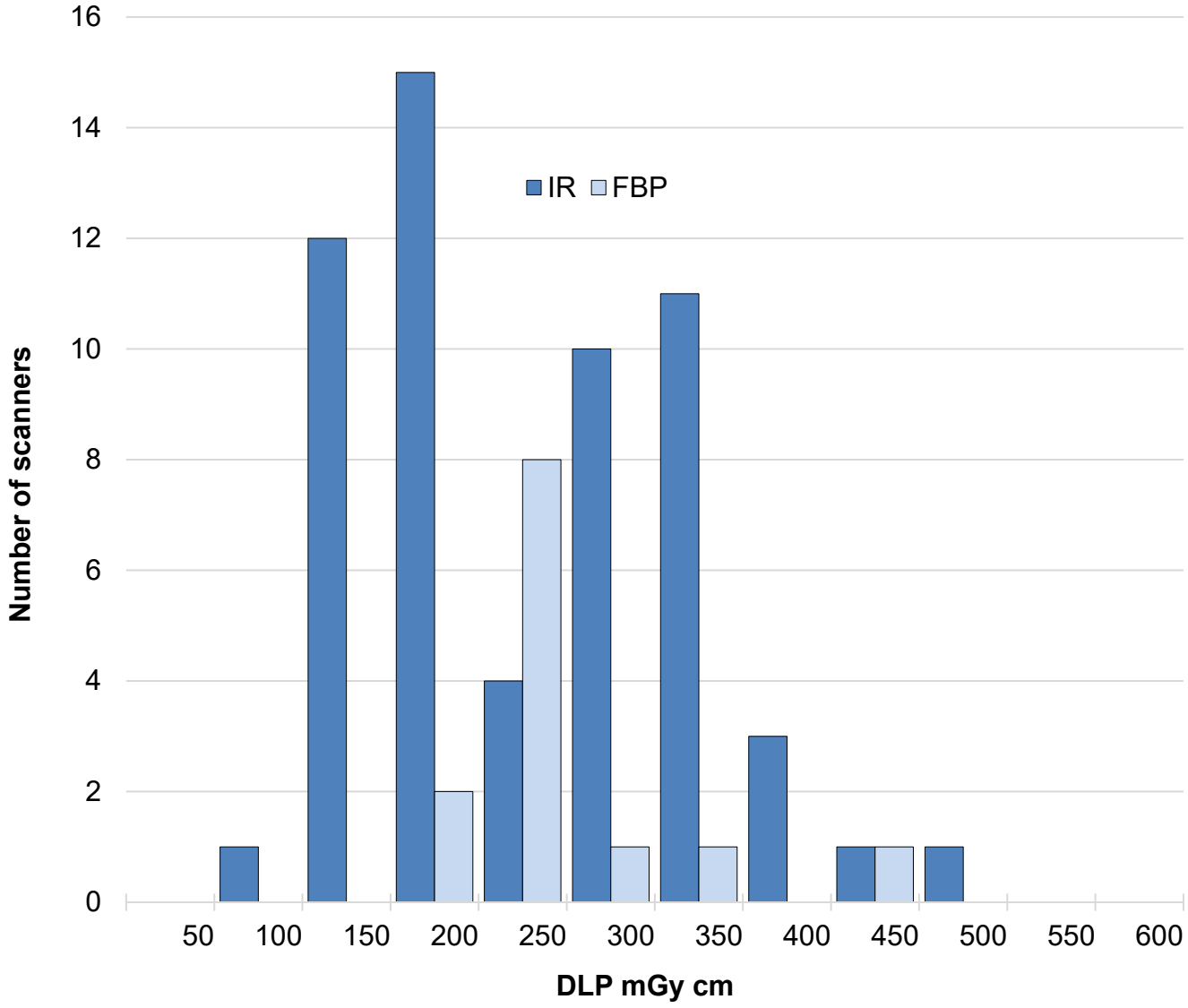
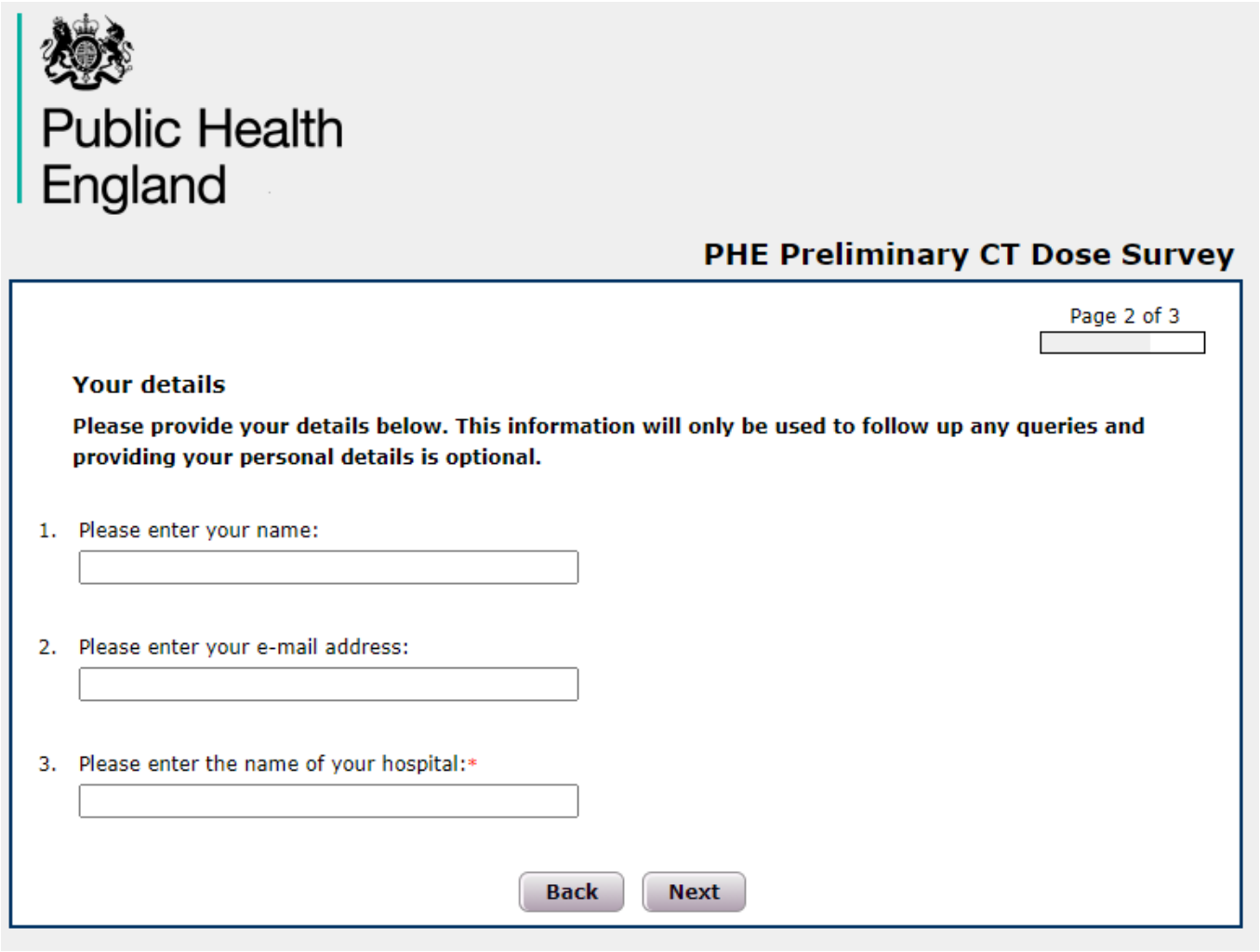


Figure 49. Histogram of scanner median DLP values for chest high resolution (Interstitial lung disease) exams performed as a single helical sequence separated by reconstruction technique. Doses refer to the 32cm standard CT dosimetry phantom



Appendix C. Preliminary survey

The following are 3 screenshots of the online survey.



Public Health England

PHE Preliminary CT Dose Survey

CT examinations

4. The examinations proposed for inclusion in this survey are listed below. These are some of the most frequent exams carried out as indicated in the NHS England Diagnostic Imaging Dataset. For each of the exams and clinical indications listed below, please indicate if you could provide patient data for at least 100 adult patients for at least one scanner over the past year. This could either be individual patient data, or the summary results of a local dose audit.

	Yes	No
Abdomen (Liver metastases)	○	○
Abdomen and pelvis (Abscess)	○	○
Cervical spine (C-spine) (Fracture)	○	○
Chest (Lung cancer)	○	○
Chest – high resolution (Interstitial lung disease)	○	○
Chest-abdomen-pelvis (CAP) (Cancer)	○	○
CT angiography (CTA) (Abdominal aorta/blood vessels)	○	○
CT pulmonary angiography (CTPA) (Pulmonary embolism)	○	○
Enteroclysis (Crohn's disease)	○	○
Head (Acute stroke)	○	○
Kidney-ureters-bladder (KUB) (Stones/colic)	○	○
Urogram (Stones/colic or tumour)	○	○
Colonography/Virtual colonoscopy (VC) (Polyps/tumour)	○	○
Chest and abdomen (Lung cancer)	○	○
Paranasal sinuses (sinus disease)	○	○
Neck, chest, abdomen and pelvis (Cancer)	○	○
Pelvis (Fracture)	○	○
CT angiography of lower limb artery (ischaemic limb, claudication)	○	○

5. Please list any CT examinations not listed above that are the most frequently carried out at your hospital or give the highest patient doses. At least 100 procedures should have been carried out in the past year for an examination and for which you could submit patient dose data for. Please also list any exams you believe should be included in this survey and why.

Exam 1: _____

Exam 2: _____

Exam 3: _____

Exam 4: _____

Exam 5: _____

6. Are you able to provide the following additional patient details automatically from your electronic records/systems (ie. without any manual processing):

	Yes	No
Patient age	○	○
Patient height	○	○
Patient weight	○	○
Patient diameter (or AP/Lat dimensions)	○	○
Water Equivalent Diameter (Dw)	○	○
Size Specific Dose Estimate (SSDE)	○	○

7. For those items listed above where you cannot automatically provide data, would you be willing to provide manually collected data for:

	Yes	No
Patient age	○	○
Patient height	○	○
Patient weight	○	○
Patient diameter (or AP/Lat dimensions)	○	○
Water Equivalent Diameter (Dw)	○	○
Size Specific Dose Estimate (SSDE)	○	○
Perceived patient size (eg. small, medium, large)	○	○

8. Are you able to provide the following additional parameters for your typical protocols for the examinations listed above:

	Yes	No
Automatic Exposure Control (AEC) used or not	○	○
Automatic Exposure Control (AEC) setting (eg. SD 7.5, ref mAs 200, etc.)	○	○
Iterative reconstruction (IR) used or not	○	○
Iterative reconstruction (IR) setting (eg. ASIR 40%, SAFIRE 3, iDose level 4, etc.)	○	○

9. Where will you get the data from to submit to the survey?

- ☐ Dose Management System
- ☐ RIS system
- ☐ Custom built dose data system
- ☐ Per patient from the scanner console
- ☐ Recent local dose audit
- ☐ Other, please give details:

10. Please provide any further comments you wish to make below:

Back Submit

Appendix D. List of participating hospitals and organisations

Aberdeen Royal Infirmary
Aintree University Hospital
Alliance Medical Limited
Barnet Hospital
Basingstoke and North Hampshire Hospital
Bedford Hospital
Belford Hospital, Fort William
Borders General Hospital
Bristol Royal Infirmary
Bronglais General Hospital
Burnley General Hospital
Caithness General Hospital Wick
Calderdale Royal Hospital
Castle Hill Hospital
Charing Cross Hospital
Chase Farm Hospital
Churchill Hospital
City Hospital, Nottingham
Clatterbridge Cancer Centre
Colchester Hospital
Countess of Chester NHS Foundation Trust
County Hospital, Stafford
Darent Valley Hospital
Dewsbury District Hospital
Dorset County Hospital
Downe Hospital
Dumfries & Galloway Royal Infirmary
Forth Valley Royal Hospital
Freeman Hospital
Galloway Community Hospital
Gartnavel General Hospital
George Eliot Hospital NHS Trust
Glan Clwyd Hospital
Glangwili General Hospital
Glasgow Royal Infirmary
Glenfield Hospital
Gloucestershire Hospitals NHS Foundation Trust
Grantham Hospital
Gwynedd Hospital

Hadley Wood Hospital
Hairmyres Hospital
Hammersmith Hospital
Harefield Hospital
Harrogate District Hospital
Hemel Hempstead General Hospital
Hillingdon Hospital
Horton General Hospital
Hospital of St Cross
Hull Royal Infirmary
Hurstwood Park Neurological Centre
InHealth
Inverclyde Royal Hospital
James Paget University Hospital Trust
John Radcliffe Hospital
Kent and Canterbury Hospital
King's Mill Hospital
Lagan Valley Hospital
Leeds General Infirmary
Leicester General Hospital
Leicester Royal Infirmary
Lincoln County Hospital
Luton & Dunstable University Hospital
Macclesfield District General Hospital
Monklands Hospital
Morriston Hospital, Swansea
National Hospital for Neurology and Neurosurgery
Neath Port Talbot Hospital
New Victoria Hospital
Newham University Hospital
Ninewells Hospital
Norfolk and Norwich University Hospitals NHS Foundation Trust
North Middlesex University Hospital
Paul Strickland Scanner Centre
Perth Royal Infirmary
Pilgrim Hospital
Pontefact General Infirmary
Prince Philip Hospital, Llanelli
Princess of Wales Hospital, Bridgend
Princess Royal Hospital, West Sussex
Princess Royal Hospital, Shropshire
Queen Alexandra Hospital
Queen Elizabeth Hospital, King's Lynn
Queen Elizabeth Hospital, Woolwich

Queen Elizabeth University Hospital
Queen Margaret Hospital
Queen's Medical Centre, Nottingham
Raigmore Hospital, Inverness
Royal Alexandra Hospital
Royal Berkshire Hospital
Royal Blackburn Hospital
Royal Cornwall Hospital
Royal Devon and Exeter NHS Foundation Trust
Royal Free Hospital
Royal Hampshire County Hospital
Royal Infirmary of Edinburgh
Royal Shrewsbury Hospital
Royal Stoke University Hospital
Royal Sussex County Hospital
Royal United Hospital, Bath
Royal Victoria Infirmary
Saint Bartholomew's Hospital
Salford Royal Hospital
Scarborough Hospital
Singleton Hospital, Swansea
Southampton General Hospital
Southmead Hospital
Spire Bristol Hospital
St James's University Hospital
St John's Hospital
St Mary's Hospital
St Richard's Hospital
St Helens Hospital
Stepping Hill Hospital
Stobhill Hospital
Stoke Mandeville Hospital
Stracathro Hospital
The Montefiore Hospital
The Royal Brompton
The Royal London Hospital
The Royal Marsden NHSFT
Ulster Hospital
University Hospital Ayr
University Hospital Coventry and Warwickshire
University Hospital Crosshouse
University Hospital Llandough
University Hospital of Wales
University Hospitals Bristol

University Hospitals of Derby and Burton NHS Foundation Trust
Vale of Leven Hospital
Velindre Cancer Centre
Victoria Hospital, Kirkcaldy
Walton Centre
Watford General Hospital
West Berkshire Community Hospital
West Cornwall Hospital
West Suffolk Hospital
Western General Hospital
Weston General Hospital
Whipps Cross University Hospital
Whiston Hospital
William Harvey Hospital
Wishaw General Hospital
Withybush General Hospital
Worthing Hospital
Wrexham Maelor Hospital
Wycombe Hospital
York District Hospital

About the UK Health Security Agency

UKHSA is responsible for protecting every member of every community from the impact of infectious diseases, chemical, biological, radiological and nuclear incidents and other health threats. We provide intellectual, scientific and operational leadership at national and local level, as well as on the global stage, to make the nation heath secure.

UKHSA is an executive agency, sponsored by the Department of Health and Social Care.

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