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Research Article

An evaluation of CT radiation doses within the Yorkshire Lung Screening Trial

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Abstract

Objectives: To evaluate radiation doses for all low-dose CT scans performed during the first year of a lung screening trial.

Methods: For all lung screening scans that were performed using a CT protocol that delivered image quality meeting the RSNA QIBA criteria, radiation dose metrics, participant height, weight, gender, and age were recorded. Values of volume CT dose index (CTDIvol) and dose length product (DLP) were evaluated as a function of weight in order to assess the performance of the scan protocol across the participant cohort. Calculated effective doses were used to establish the additional lifetime attributable cancer risks arising from trial scans.

Results: Median values of CTDIvol, DLP, and effective dose (IQR) from the 3521 scans were 1.1 mGy (0.70), 42.4 mGycm (24.9), and 1.15 mSv (0.67), whilst for 60-80kg participants the values were 1.0 mGy (0.30), 35.8 mGycm (11.4), and 0.97 mSv (0.31). A statistically significant correlation between CTDIvol and weight was identified for males ($r = 0.9123$, $P < .001$) and females ($r = 0.9052$, $P < .001$), however, the effect of gender on CTDIvol was not statistically significant ($P = .2328$) despite notable differences existing at the extremes of the weight range. The additional lifetime attributable cancer risks from a single scan were in the range 0.001%-0.006%.

Conclusions: Low radiation doses can be achieved across a typical lung screening cohort using scan protocols that have been shown to deliver high levels of image quality. The observed dose levels may be considered as typical values for lung screening scans on similar types of scanners for an equivalent participant cohort.

Advances in knowledge: Presentation of typical radiation dose levels for CT lung screening examinations in a large UK trial. Effective radiation doses can be of the order of 1 mSv for standard sized participants. Lifetime attributable cancer risks resulting from a single low-dose CT scan did not exceed 0.006%.

Keywords: lung cancer screening; CT; dose; low dose.

Introduction

The efficacy of low-dose CT (LDCT) screening for lung cancer has been clearly demonstrated. In two large randomized controlled studies, the National Lung Screening Trial[1] and the NELSON trial,[2] LDCT screening was associated with a reduction in lung cancer mortality of 20% and 26%, respectively. The use of CT for lung cancer screening is now well established and has been the subject of a number of research trials and pilot projects in the United Kingdom along with the NHS England Targeted Lung Health Check (TLHC) programme.[3-7] In September 2022, the UK National Screening Committee recommended that the 4 UK nations move towards implementation of targeted lung cancer screening.[8]

When ionizing radiation is used to screen an asymptomatic population balancing the associated risks and benefits is of prime importance. These risks include the possibility of cancer induction as a result of the radiation exposure, whilst the benefits derive from having a sufficiently high level of image quality to enable confident diagnoses to be made.[9-11]

Thus, when establishing CT scanning protocols for lung cancer screening both the image quality and radiation dose should be carefully considered. Specific, objectively measured metrics of image quality have been provided by the Radiological Society of North America Quantitative Imaging Biomarkers Alliance (QIBA), which has developed a profile for small lung nodule volume assessment and monitoring.[12] Within this profile 6 markers of image quality are presented and it is suggested that each of these need to be met in order for the highest level of volumetric accuracy to be obtained.

Guidance from the American College of Radiology[13] provides suggested maximum dose levels for standard sized individuals—a volume CT dose index (CTDIvol) of <3.0 mGy. The suggested scan protocols provided by the American Association of Physicists in Medicine[14] also include approximate reference values for CTDIvol for 3 different weight ranges. Within the United Kingdom the TLHC Standard Protocol[7] states: "The calculated radiation dose delivered to each individual is below 2 mSv (based on a median standard 70-kg adult)."

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Image quality levels for lung screening CT are mentioned infrequently in the published literature[15-19]; however, there are many articles, which present indications of the patient doses delivered.[4,15-27] There are notable differences in how these doses are presented, with some studies presenting solely values of effective dose,[18,20,22,25,26] some presenting values of CTDIvol or dose length product (DLP) from patient scans[4,20,21,26] whilst others present these same metrics for scans of standardized phantoms.[16,18,19,25]

Lung cancer mortality in the Yorkshire and Humber region is higher that the UK national rate (age standardized mortality per 100 000 persons is 64.7 in Yorkshire and Humber versus 54.7 in England).[28,29] The Yorkshire Lung Screening Trial (YLST)[5] was established in response to these higher rates, and recruitment to the trial started in Leeds in 2018 using community-based screening in mobile units, using a model similar to those successfully used elsewhere in the United Kingdom.[4,30] From the outset of YLST, we planned to develop a CT scan protocol to deliver image quality meeting the QIBA recommendations[12] for accurate and robust automated volumetry measurements for all patient sizes and the ACR dose requirements.[13] The scan protocol for YLST utilized the scanner's automatic exposure control (AEC) system to provide 3D modulation of the X-ray tube current in order to automatically adjust the delivered dose according to the participant attenuation without step changes in dose at the boundaries of any weight categories. The scan protocol and assessment of image quality against the QIBA recommendations has been published previously.[31] This work seeks to evaluate the radiation doses delivered to trial participants examined with this scan protocol. The relationship between dose and participant weight was investigated in order to demonstrate how the scanner's AEC system adjusted dose on a per-participant basis for this specific low-dose scanning protocol. Furthermore, doses were evaluated according to gender in order to identify any gender-specific differences in the dose distribution and to allow calculation of gender specific additional risks of cancer arising from participation in the trial.

Methods

The YLST study was approved by the Greater Manchester West research ethics committee (18-NW-0012) and the Health Research Authority. It was deemed that no additional ethical approval was required for this retrospective review of the radiation doses to trial participants.

The YLST randomized 55- to 80-year olds registered with a general practice in Leeds who had records indicating a current or past smoking history to either normal care, or invitation to risk assessment via telephone for a Lung Health Check. Those evaluated to be at high risk were invited to a community-based Health Check, which incorporates a LDCT scan on a mobile scanner.[5] The YLST has been scanning trial participants since November 2018, using an 80-detector row Canon Aquilion Prime SP scanner (Otawara, Japan). Details of the scan protocol that was developed specifically for this trial have been published previously[31] and are reproduced in Table 1. This scan protocol has been used for all imaging on the trial to date, which includes both prevalence and follow-up scans.

For all study participants, the CT images and associated dose reports were transferred from the scanner to the Picture Archiving and Communication System (PACS) at our institution. Height and weight information was entered into the CT scan console at the time of the scan, and was also available within the CT dose report. In a small number of cases where this information was not included in the dose report, it was possible to extract this from the main trial database.

For each scan performed within the first 12 months of the study, the following data were extracted from the PACS system into a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, WA, United States): date of scan, participant gender, age, height & weight, and the resulting CTDIvol and DLP values. From these data, the body mass index (BMI) and CT scan length were calculated. BMI was calculated as the participant's weight in kilograms divided by the square of the participant's height in metres. Stata Statistical Software Release 17 (College Station, TX, United States) was used for all statistical analysis. Visual inspection of the BMI data histogram was used to assess the normality of the distribution. For these normally distributed data the *t*-test was used to assess for differences in mean BMI between genders, and the chi-squared test was used to test the association between BMI group and gender. The data showing whether each scan was a prevalence scan (T0), first follow-up (FU1) or second follow-up (FU2) were extracted from the main research trial database and were cross matched with the data extracted from PACS.

These data were analysed to identify the relationships between body size and the CT dose metrics, and to establish typical values of CTDIvol and DLP for defined weight ranges, and these were compared with the ACR and AAPM recommended values.[13,14] Dose levels from this study have also been compared with those from previously published studies.[4,18,20,21,25-27] All dose data have been presented as median values in accordance with the recommendations of

Table 1. Details of the scan protocol used on the Canon Aquilion Prime SP.

	YLST scan protocol
Tube voltage (kV)	120
Tube current (mA)	Variable with the SURE Exposure 3D mA modulation system—min.=20 mA, max.=120 mA
Rotation time (s)	0.35
Automatic exposure control (SURE Exposure 3D)	Body standard axial (5-mm target slice), SD=25
Iterative reconstruction (AIDR 3D)[a]	AIDR 3D standard
Beam collimation (mm)	80×0.5
Helical pitch	0.813
Reconstructed slice thicknesses (mm)	2 & 1
Reconstruction algorithms	Body standard axial (FC13) & lung standard axial (FC5)

[a]Adaptive Iterative Dose Reduction 3D (AIDR 3D).

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the International Commission on Radiological Protection.[32] Data from participants with weight in the range 60-80 kg were used to establish a local diagnostic reference level (DRL) according to the methodology presented in Institute of Physics and Engineering in Medicine Report 88.[33]

Data for male and female participants were analysed separately to identify any differences in the dose versus weight relationship. Firstly, the distribution of weight and CTDIvol across the two cohorts was tested for normality using the Kolmogorov-Smirnov test. Since the data were non-normally distributed, the Spearman correlation coefficient was used to evaluate the strength of the relationship between CTDIvol and weight for the separate groups of male and female participants. In order to establish whether there was a statistically significant difference between the two datasets the Fisher r to z transformation was used (http://vassarstats.net/rdiff.html).

Typical effective dose (E [mSv]) values have been calculated using a DLP to effective dose conversion factor of 0.027 mSv/mGycm for a high-resolution chest CT examination, as given by Shrimpton,[34] who noted that the standard deviation in the conversion factor was 4.4% across the range of dose levels that were simulated. Effective doses were also calculated using the NCICT software (v3.0; National Cancer Institute, Maryland, USA)[35] within which there are a range of CT scanner models and phantom sizes, which enabled the calculation of effective doses for the mean male and female sizes observed in the dataset, on the CT scanner used for the lung screening scans.

Tabulated data regarding radiation risk related to both participant age and sex[36] were used to calculate additional lifetime cancer risks for males and females for 4 age ranges based on the calculated effective dose values.

Results

Radiation doses resulting from all scans performed within the first year of a LDCT lung cancer screening research trial have been evaluated with particular focus on the effect of patient size and gender on the delivered doses. Typical dose values for standard sized patients have been calculated and compared with current recommendations and values reported in the published literature.

In the first 12 months of the trial, a total of 3521 scans were performed of which 3222 (91.5%) were initial prevalence screens and 299 (8.5%) were follow-up scans. Of those scanned, 53.5% (1884) were male and 46.5% (1637) female. Further demographics are summarized in Table 2 according to scan type.

Figure 1 shows the distribution of weight in study participants stratified by 10-kg weight categories; 63% weighed between 60 and 90 kg with almost one-quarter between 70 and 80 kg. Data labels show the number in each category. Mean values have been presented for the normally distributed data.

Table 2 shows that males were on average 13 kg heavier and 13 cm taller than females. There was no significant difference in the mean BMI between the male and female groups ($P = .2253$); however, there was strong evidence of association between gender and BMI grouping ($P < .001$).

This shows that in the underweight category, the proportion of females was over 3 times the number of males.

A summary of the dose-related metrics, for each scan type is given in Table 3.

Table 2. Summary of participant demographics by scan type.

	Male	Female	All
Prevalence scan (T0), *n*	1727	1495	3222
Age, mean (SD) (year)	68.5 (7.1)	67.6 (7.0)	68.1 (7.1)
Weight, mean (SD) (kg)	85.3 (17.3)	72.3 (15.4)	79.3 (17.7)
Height, mean (SD) (cm)	171.9 (6.9)	158.9 (6.6)	165.9 (9.3)
Missing, *n*	2 (<0.1)	0	2 (<0.1)
BMI, mean (SD) (kg/m^2)	28.8 (5.2)	28.6 (5.8)	28.7 (5.5)
Missing, *n*	2 (<0.1)	0	2 (<0.1)
BMI group, *n* (%)			
Underweight	8 (0.5)	25 (1.7)	33 (1.0)
Normal weight	394 (22.8)	401 (26.8)	795 (24.7)
Overweight	701 (40.6)	534 (35.7)	1235 (38.3)
Obese	429 (24.8)	335 (22.4)	764 (23.7)
Severe obesity	193 (11.2)	200 (13.4)	393 (12.2)
Missing	2 (0.1)	0	2 (0.1)
Follow-up scan (FU1), *n*	152	135	287
Age (year)	69.0 (7.1)	68.8 (6.3)	68.9 (6.7)
Weight (kg)	81.7 (15.6)	70.9 (16.9)	76.6 (17.1)
Height (cm)	171.3 (6.7)	158.5 (6.4)	165.3 (9.1)
BMI (kg/m^2)	27.8 (4.8)	28.1 (6.3)	28.0 (5.5)
Follow-up scan (FU2), *n*	5	7	12
Age (year)	71 (7.1)	65.7 (6.2)	67.9 (6.8)
Weight (kg)	79.2 (13.2)	66.7 (19.1)	71.9 (17.4)
Height (cm)	173.2 (6.5)	160.8 (6.6)	166.0 (9.0)
BMI (kg/m^2)	26.4 (3.8)	25.5 (6.1)	25.8 (5.0)

Figure 2 demonstrates the relationship between CTDIvol and weight for the full cohort of patients. It can be seen that there is a strong exponential relationship between CTDIvol and participant weight, with an R^2 value of 0.9664 ($P < .001$). What is also clear from this figure is that below ~45 kg, the CTDIvol reaches and remains at a minimum value of 0.5 mGy; and above 135 kg, the CTDIvol value plateaus at ~2.5 mGy.

The traditional methodology for LDRL calculation[32] utilizes data from a specific weight range, usually 60-80 kg. The mean weight, and median values of CTDIvol and DLP for the 60-80 kg patients were 71.0 kg, 1.0 mGy, and 35.8 mGycm, respectively. These CTDIvol and DLP values were adopted as local DRLs for the study.

The data were further broken down into 10-kg weight ranges, and for each of the ranges that contained at least 30 individuals, the median values of CTDIvol and DLP are shown in Table 4. It is anticipated that these values could be used as weight-based DRLs in order to provide the scanning staff with a guide to typical doses for participants within these weight categories.

Figure 3 shows the variation in CTDIvol with weight for both males and females. There was a strong correlation between CTDIvol and weight for both patient groups: male $r = 0.9123$ ($P < .001$); female $r = 0.9052$ ($P < .001$). The Fisher r to z transformation showed that there was no statistically significant difference between the Spearman correlation coefficients for the male and female datasets: $z = 1.19$ ($P = .2328$).

Table 5 shows how the median CTDIvol values from this trial compare with those specified in the AAPM protocols.[13] These data show that the YLST CTDIvol values are towards the lower end of those from the AAPM protocol document for all patient weight ranges, whilst also remaining below the 3 mGy maximum value given by ACR.[13] The median value of effective dose calculated using the Shrimpton[34] conversion factors was 1.15 mSv, with a range of 0.38-3.11 mSv. The

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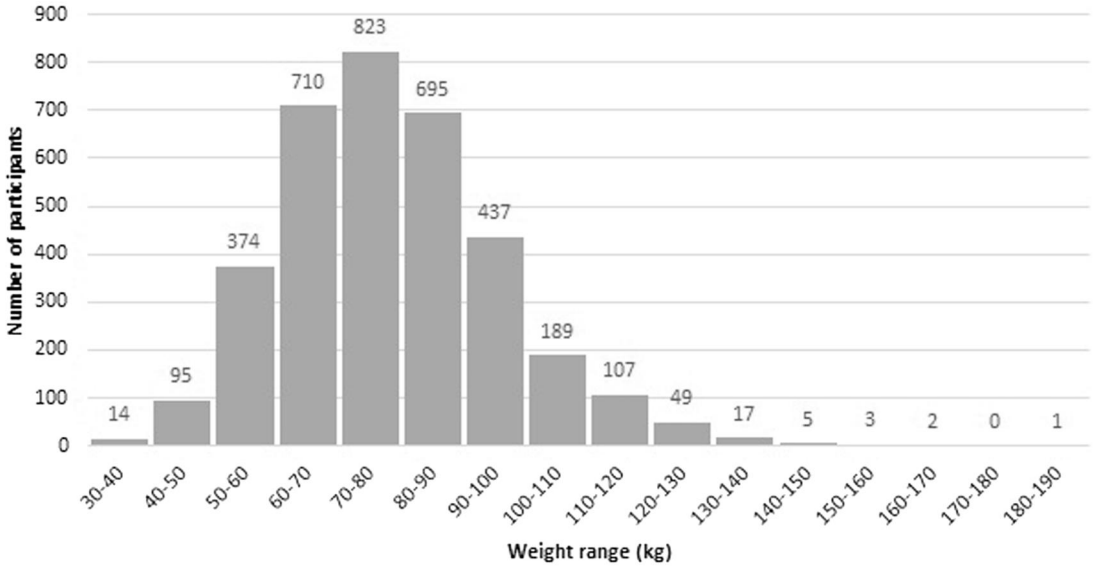

Figure 1. Distribution of participants scanned according to 10-kg weight categories.

Table 3. Summary of dose metrics for prevalence and follow-up scans.

	Prevalence scan (T0)	Follow-up scan (FU1)	Follow-up scan (FU2)
Sample size, *n*	3222	287	12
CTDIvol (mGy), median (IQR)	1.10 (0.70)	1.10 (0.60)	1.00 (0.50)
Missing, *n*	17	1	0
DLP (mGycm), median (IQR)	42.6 (25.20)	40.35 (22.65)	40.40 (16.38)
Missing, *n*	17	1	0
Scan length (cm), median (IQR)	37.5 (4.12)	37.5 (3.81)	36.7 (4.66)
Missing, *n*	17	1	0

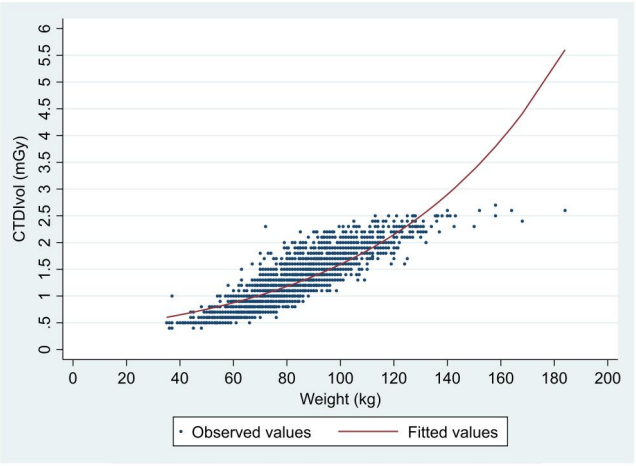

Figure 2. The variation in CTDIvol as a function of weight for all trial participants.

median DLP of 35.8 mGycm for a 60-80 kg patient equates to an effective dose of 0.97 mSv.

It should be noted that the effective dose values presented above have been calculated using a DLP to effective dose conversion factor of 0.027 mSv/mGycm.[34] This is in contrast to many previously published studies[18,20,25,26] in which factors of ~0.014 mSv/mGycm have been used.

The mean values of weight and height, and median values of CTDIvol and DLP for male and female participants, respectively, were used within the NCICT software (v3.0) to calculate gender-specific values of effective dose, which were 1.14 and 1.08 mSv, respectively.

These values show good agreement with those calculated with the Shrimpton factor based on the median DLP for each gender ($M = 1.29$ mSv, $F = 0.95$ mSv). The additional lifetime risks of cancer arising from a single CT scan within the trial are shown in Table 6 broken down by both age and gender.

Discussion

The population data presented in Table 2 demonstrate a 13-kg difference in weight and a 13-cm difference in height for male and female participants with males being both heavier and taller. This is entirely consistent with the data presented by Taylor in an analysis of the dependence of sex on regional fat distribution in a post puberty population.[37] Taylor also demonstrated negligible difference in average BMI between genders, and the same trend is found in this study with no statistically significant difference in mean BMI between gender ($P = .2253$). Our study did however demonstrate a strong association between BMI group and gender ($P < .001$) with 20% more females than males in the severe obesity category. Kanter[38] reported that the prevalence of overweight and obesity among men and women is related to a country's income level, and our findings are in line with those presented by Kanter for high income countries.

The dose data presented above demonstrate that the scan protocol developed specifically for this study[31] delivers radiation doses, in terms of CTDIvol and DLP, that are in line

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Table 4. Median values of CTDIvol and DLP for each weight category. Rounded values could be used as weight-specific DRLs.

Weight category (kg)	Number	Median CTDIvol (mGy)	Median DLP (mGycm)
40-50	95	0.53	19.58
51-60	374	0.66	24.24
61-70	710	0.86	31.85
71-80	823	1.10	40.81
81-90	695	1.37	51.33
91-100	437	1.62	60.50
101-110	189	1.85	69.82
111-120	107	2.04	77.63
121-130	49	2.22	85.71

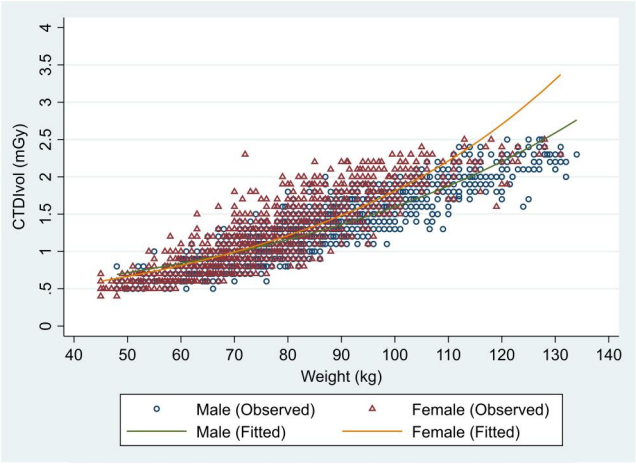

Figure 3. Showing the relationship between CTDI and weight separately for male and female patients within the 45-135 kg weight range. Male: $y = 0.3201106 * e^{0.0160815}x$ ($R^2 = 0.9818$), female: $y = 0.2442019 * e^{0.0200376}x$ ($R^2 = 0.9627$).

Table 5. Median CTDIvol values compared with those from the AAPM protocols.[36]

	Weight (kg)	AAPM CTDIvol (mGy)	YLST CTDIvol (mGy)
Small	50-70	0.25-2.8	0.70
Average	70-90	0.5-4.3	1.20
Large	90-120	1.0-5.6	1.70

Table 6. Additional percentage lifetime risk of cancer resulting from a single scan within YLST, based on median effective dose values.

	Additional lifetime risk of cancer (%)	
Age	Male	Female
50-59	0.004	0.006
60-69	0.003	0.004
70-79	0.002	0.002
80-89	0.001	0.001

with or lower than those for many previously published studies.[4,20,21,26] Furthermore, we show that for the clinical scan protocol the variation of CTDIvol with patient weight is exponential over the weight range 45-135 kg, which included 98.9% of the participants scanned in the first year of the trial. As such, the protocol is providing effective adjustment of dose across a wide weight range. The range of doses delivered to participants of a given weight reflects variations in body mass distribution and also the accuracy of patient positioning within the CT scanner and the scan length chosen by the Radiographers. Habibzadeh[39] identified that any individual patient may be positioned between 7 cm below and 4.5 cm above the scanner's isocentre, and that an average offset of 2.2 cm resulted in a 23% increase in patient dose. Variation in the accuracy of participant positioning will be a contributory factor to the range of doses observed in our study.

The exponential variation in dose within the 45-135 kg range demonstrates that there is effective adjustment of the X-ray tube current for the vast majority of the cohort. This further shows that the protocol developed previously[31] achieves the stated objectives in terms of automatically adjusting dose for participant size. The plateauing of CTDIvol above ~135 kg, as a result of the maximum mA setting in the protocol being reached for the duration of the scan, will mean that for participants above this weight there will be a general increase in image noise compared with those in the 45-135 kg range within which the AEC functions well. Within the first year of scanning only 19 people weighing over 135 kg have been scanned, and there have been no reported issues with image quality in this group. Although an increase in image noise could be considered problematic, some CT manufacturers have designed their AEC systems to allow increased noise levels in larger patients; the rational being that the presence of additional internal fat helps with differentiation of adjacent tissues.[40] It should also be remembered that lung screening is primarily a high contrast task—visualizing soft tissue against an air filled background—which is unlikely to be deleteriously affected by small amounts of additional noise. It would be ideal to have available phantoms of varying size in order to objectively assess the increase in image noise associated with scanning those weighing over 135 kg. Ideally a variable size version of the Accumetra CTLX1 phantom would be available as this would allow the user to understand how increases in CTDIvol and/or image noise affected the objective measurements of image quality identified within the QIBA profile.[12] A similar plateauing of the CTDIvol can be observed below 45 kg where the minimum mA level was reached for the duration of these participants' scans.

The Fisher *r* to *z* test of the data in Figure 3 demonstrated no statistically significant difference between the male and female datasets, however, the trendlines fitted to the data show that differences do exist at the lower and upper ends of the clinically encountered weight range. This implies that the percentage of the total body mass that is contained within the thorax region shows a greater weight dependency for females than males. The relative attenuation of a patient can be described in terms of the water equivalent diameter (WED) and based on the data in Figure 3 it would be expected that there

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would be demonstrable difference on WED as a function of weight between the male and female patients. For the patients scanned in the first year of YLST the WED was not available, but this could be investigated in future work.

The median value of CTDIvol across the whole participant cohort was 1.1 mGy. Previously published data by Demb et al[20] showed a median CTDIvol of 2.1 mGy, whilst Fujii, Larke, and Crosbie[4,21,25] showed mean CTDIvol of 2.9, 2.5, and 2.1 mGy from their respective studies. In addition, Jacobs and Jafari[26] showed mean CTDIvol values of 2.8 and 2.5 mGy for male and female patients, respectively. The data presented by Field as part of the UK Lung Screening Trial[27] yielded CTDIvol values of 1.6 mGy, which are the closest to the values shown in this study. It should be noted that there is variation in the exact nature of the CTDIvol values in the above articles, with some calculated from patient scans, some from phantom scans, some presented as the mean, and some as the median. Of the previously published studies both mean and median doses have only been presented by Demb,[20] with the mean (2.4 mGy) being 14% higher than the median (2.1 mGy). We identified a similar difference in our study with the mean exceeding the median by 6%. It may therefore be the case that reducing the mean values reported by other studies[4,21,25,27] by 14% would enable a more direct comparison with the median values from our data. In this case, the lowest median dose[27] would be ~1.38 mGy, which remains 25% higher than our reported values. It is therefore clear that the doses from this study are lower than those from many of the other major screening trials.

Typical values of DLP are scarce in the published literature, with Fujii[21] stating a mean value of 74 mGycm and Jacobs and Jafari[26] showing 102.9 and 85.2mGycm for males and females, respectively. The median value of 42.6 mGycm in this study is again notably lower than these previously published values.

As noted in the "Results" section, effective dose values are highly dependent on the methodology used in the calculation. The DLP to effective dose conversion factor used in this study, which is taken from a 2016 publication, is almost double the conversion factor used in the majority of publications on CT lung screening doses.[18,20,25,26] In order to avoid confusion arising from the variation in effective dose values quoted in published articles, we recommend that comparisons of CT doses between lung screening datasets should be limited to values of CTDIvol and DLP, preferably arising from participant scans, and set alongside weight information. The authors acknowledge that this "ideal" may be difficult to achieve. The effective dose values calculated using the Shrimpton methodology are 13% higher for males and 12% lower for females when compared with the NCICT calculated values. This is to be expected as the Shrimpton factor is based on the ICRP 110 hermaphrodite phantom.[41] The calculated effective dose of 0.97 mSv for a 70-kg patient was lower than the 2 mSv requirement in the UK TLHC standard protocol.[7]

As part of the Italian COSMOS study, Rampinelli[22] presented lifetime attributable risks of cancer arising from 10 years of annual screening of 8.1-2.6 per 10 000 people screened. The additional lifetime risk values presented in Table 6 are for a single CT scan within YLST. If patients had 10 years of annual scanning at the dose levels used in this study, then, the lifetime attributable risks of cancer would be 5.9-0.8 per 10 000 people screened, which are in broad agreement with Rampinelli's estimates, especially considering that different sources of risk data were used.[36,42] Screening within YLST is biennial, and as such the risks to trial participants are half of those stated above. Given the significant reductions in mortality associated with CT lung screening,[1,2] these levels of radiation risk, which would be considered to be "very low" or "minimal"[43] should be considered to be acceptable and concerns about radiation risk at this level should not be a barrier to implementation of a UK-wide CT lung cancer screening programme.

The typical dose values presented in this study could be used as a guide for other lung screening research trials or pilot screening studies within the United Kingdom although it is recognized that scan protocols and therefore dose levels may vary significantly between scanners. However, the values presented here should make a notable contribution to the assessment of typical patient doses from CT lung screening in the United Kingdom.

Limitations

The study relates specifically to one model of scanner and as such the reported doses may not be typical of, or optimal for scanners from different manufacturers. However, since the study was performed using a CT scanner for which the technical specification exceeds that specified in the UK TLHC standard protocol[7] and with a large cohort of patients it is anticipated that the results of the study are relevant to contemporary lung screening practice. Further collaborative work is required to evaluate doses for a range of CT manufacturers and scanners, which could be undertaken as part of the UK TLHC programme.

Clinical image quality was not evaluated as part of this study. In our previous work[31] we objectively evaluated the image quality yielded by this scan protocol in order to ensure high levels of accuracy for volumetric assessment of small lung nodules. It is suggested that an audit of clinical image quality across a number of UK lung screening trials would yield valuable information for a future lung screening programme.

In conclusion, CT doses have been assessed for a lung cancer screening scan protocol, which has previously been shown to yield objectively measured image quality levels that exceed those specified in the RSNA QIBA profile.[12] Doses showed a strong correlation with the weight of the participants and also some variation with gender. For standard sized participants, typical values of CTDIvol, DLP, and effective dose were 1.0 mGy, 35.8 mGycm, and 0.97 mSv, respectively. These dose levels may be considered as typical values for CT lung screening on broadly similar types of scanners.

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Conflicts of interest

None declared.

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