Validation of a large scale audit technique for CT dose optimisation

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13th CT Users Group
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Great Staff - Great Care - Great Future

Hull and East Yorkshire Hospitals NHS Trust

Overview

- Introduction
  - RIS, dose audits and DRLs
- Method
  - Dosalyzer© and data filtering
  - The 3rd UK CT Survey
- Results & Discussion
  - A comparison of the large scale audit with the 3rd UK CT Survey data
- Dosalyzer© in action – a practical example
  - CT Head optimisation (Toshiba Aquillion 64 slice)
- Conclusions

Introduction

- It is a requirement of IR(ME)R that we perform dose audits for the purposes of optimisation and checking protocols against DRLs (national and local).
- The traditional ‘paper-based’ audit exercise is time-consuming and very limited in scope (~20 standard (70 kg) patients per room per examination).
- The Radiology Information System (RIS) should contain dose information already – so why not use this?
- Is this sounding familiar?...

Large Scale CT Dose Audit Through Radiology Information Systems (RIS)

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[1] Integrated Radiological Services Limited, Liverpool, England

Paul Charnock - Scientific Officer, IRS ltd

CT Users Group Meeting, Hammersmith Hospital, London. October 2010

Patient dose audit using RIS data

- In principle there are many advantages to using the RIS data for patient dose audit
  - Much bigger sample size (e.g. 3400 head CT scans from RIS compared with 20 for the 3rd UK CT Survey)
  - Lessens the burden on often very busy CT departments
  - Much quicker and easier to analyse data
  - Allows routine and long-term monitoring of patient dose and CT protocol changes
  - Readily available local dose data, including the rarer examination types e.g. IR(ME)R incidents, ethics, etc.

The concerns…

- As was raised at last years meeting, there are potential problems:
  - Incorrect data entry
  - Zeroes and blank entries
  - Multiple exposures assigned to a single exam (linked to zeroes and blanks)
  - Non-standard practice
  - ‘Abnormal’ patients e.g. bariatric
- The results of the dose audit will only be as good as the quality of the data that goes into it!

The ‘Hull’ solution – Data entry

- Talk to the Radiographers
  - Establish what the problems are with data entry, and come up with mutually agreeable solutions
  - Establish what the examination names mean e.g. what’s the difference between a CT chest and a CT chest with contrast? Are they all unique?
- Simple adaptations to the RIS (Radcentre)
  - Flags were added to identify multiple and ‘abnormal’ exposures e.g. non-standard practice, bariatric patients, etc
- Training, training & training
  - Make sure all Radiographers know how important it is to enter data correctly, and when to use the multiple/abnormal flags

The ‘Hull’ solution - Dosalyzer©

- Data is extracted from the RIS in .csv format and uploaded onto a central database every month
- Individual systems, date ranges, examination types (codes) and age groups can be analysed
- Filters can be applied to the data to remove blanks, zeroes and multiple/abnormal exposures (as identified by the Radiographers)
- An additional ‘outlier’ filter can also be applied using sliders on the dose distribution to set the limits for analysis (exclude anything ridiculous)
- Summary dose statistics are then produced, which are exported to Excel for further analysis

DRL Dosalyzer

Dosalyzer

Load Data

Analyze

Reports

Administration

Analysis Dates

From: 01 Jul 2010

To: 31 Jul 2011

Analysis Options

Site: HRI (RCT)

Room: HRI CT RM1

Exam: CT CHEST WITH CONTRAST

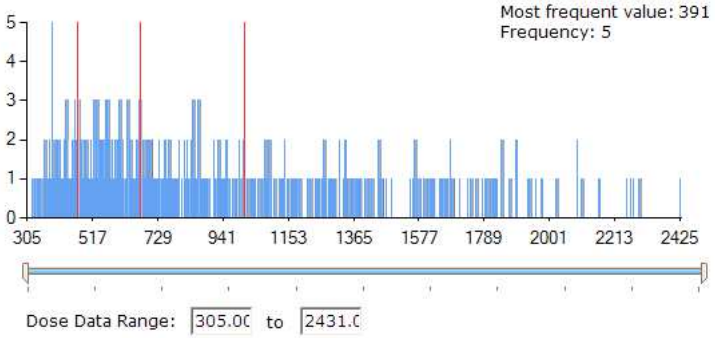
Age Range: 16 to 150

Analyze

Select Filters

- Remove 0s
- Remove Blanks
- Remove Abnormal Exposures
- Remove Outliers

Apply Filters



Dose Data Range: 305.0 to 2431.0

View Raw Data | View Analysis Results | Min Samples: 1 | Save to Excel

ExamName	RoomName	ExamMonth	NumSamples	NDRL	AverageD (Gy.cm)²	MedianDc (Gy.cm)²	SEM (Gy.cm)²	MinDose (Gy.cm)²	MaxDose (Gy.cm)²	StandardI (Gy.cm)²	Quartile1 (Gy.cm)²	Quartile3 (Gy.cm)²
CT CHEST WITH CONTRAST	HRI CT RM1	January	51	580	834.91	674.00	70.07	305.00	2431.00	500.41	470.00	1012.00
CT CHEST WITH CONTRAST	HRI CT RM1	February	49	580	863.51	739.00	70.85	290.00	2172.00	495.98	528.00	1019.00
CT CHEST WITH CONTRAST	HRI CT RM1	March	76	580	892.50	710.00	60.36	160.00	2873.00	526.17	538.00	1181.00
CT CHEST WITH CONTRAST	HRI CT RM1	April	48	580	871.54	641.50	77.50	299.00	2539.00	536.93	488.00	1132.80
CT CHEST WITH CONTRAST	HRI CT RM1	May	49	580	859.42	701.00	73.69	223.00	2924.00	515.83	460.00	1052.00
CT CHEST WITH CONTRAST	HRI CT RM1	June	50	580	954.90	674.50	87.88	116.00	2914.00	621.41	579.00	1348.00
CT CHEST WITH CONTRAST	HRI CT RM1	July	39	580	1026.55	788.00	113.29	351.00	3410.00	707.47	582.00	1176.00
CT CHEST WITH CONTRAST	HRI CT RM1	August	23	580	1008.91	832.00	106.94	422.00	2098.00	512.88	632.00	1377.00
CT CHEST WITH CONTRAST	HRI CT RM1	September	51	580	1014.22	759.00	88.49	240.00	2891.00	631.98	577.00	1299.00
CT CHEST WITH CONTRAST	HRI CT RM1	October	38	580	864.31	695.50	70.30	337.00	1852.00	433.37	498.00	1324.00
CT CHEST WITH CONTRAST	HRI CT RM1	November	47	580	952.85	917.00	62.53	260.00	1901.00	428.66	598.00	1309.00
CT CHEST WITH CONTRAST	HRI CT RM1	December	33	580	808.45	705.00	75.71	288.70	2098.00	434.90	463.00	1115.00

Ready

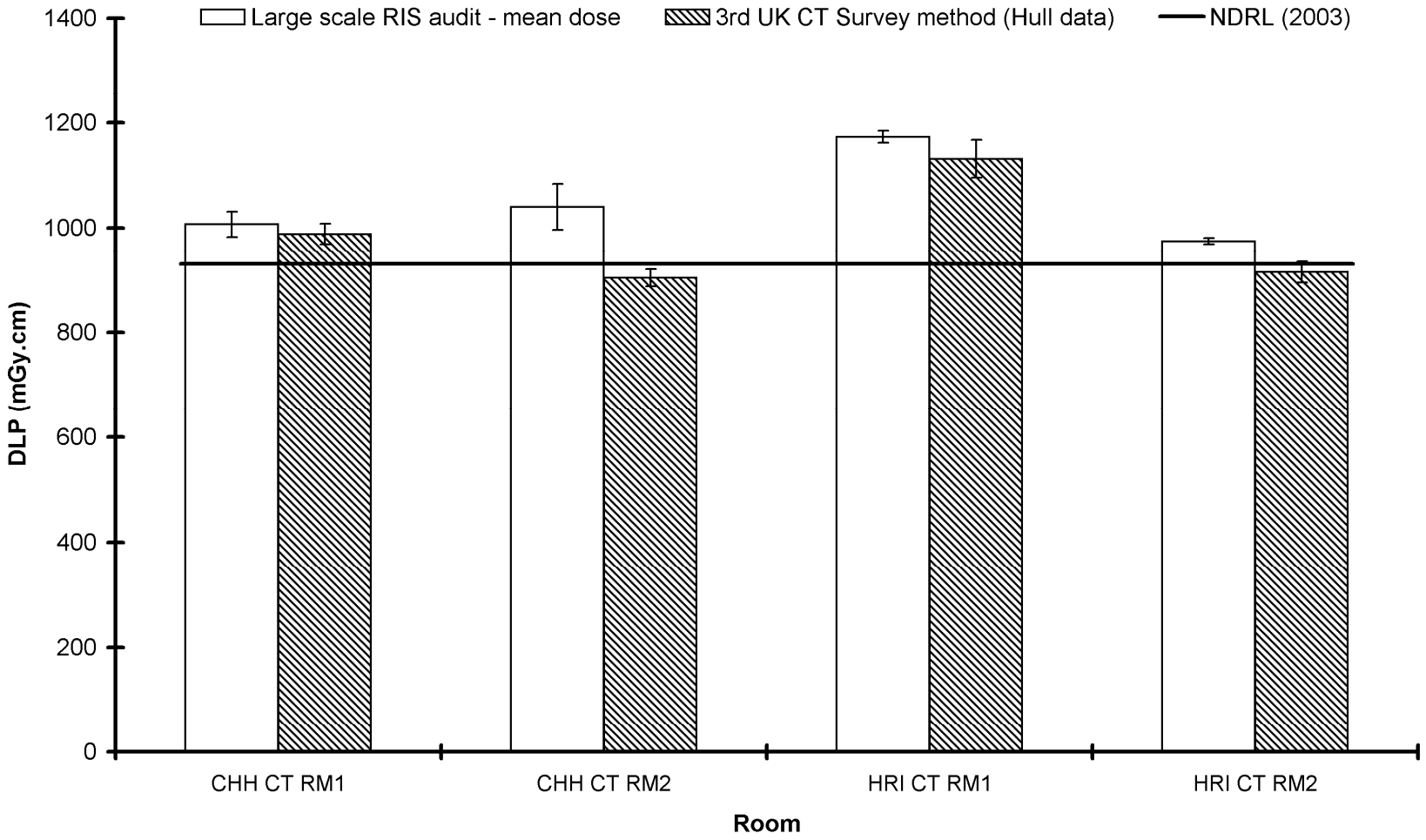
Method - Dosalyzer©

- Summary dose statistics were generated for CT heads, chests, hi-res chests, CTPAs, abdo/pelvis, C-spines and virtual colonoscopies for up to four CT scanners (three Philips, one Toshiba)
- 6 month period between July 2010 and December 2010
- Only adult exposures considered (age range set between 16 and 150)
- All blanks, zeroes and multiple/abnormal exposures were filtered out of the data set

Method – 3rd UK CT Survey

- This data was taken as the ‘gold-standard’
  - It will be the basis for future revisions of national DRLs(?)
- Data was acquired for 20 patients per examination per room
- The data collection was complete in just a few days for the most frequent exams (very much a snap-shot of doses compared with Dosalyzer©), and up to a month for the less frequent
- Mean DLPs and SEMs determined from data
- The patient dimensions of the patients in this study suggested no particularly large or small patients were included (standard patient?)

Results – CT Head

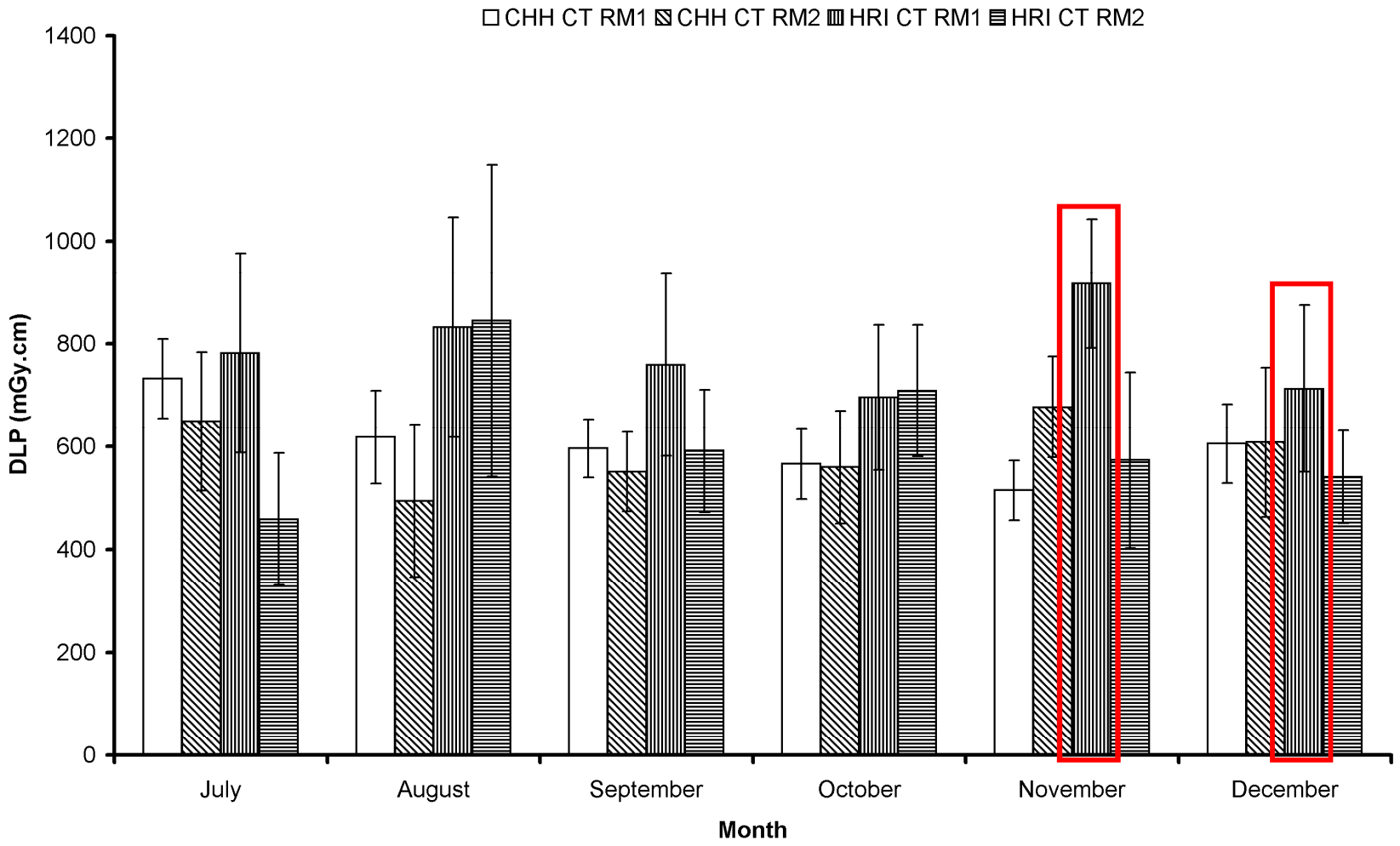


Results

- Overall, good level of agreement between RIS audit and 3rd UK CT survey data for all examinations considered
  - Generally (but not always) agree within the limits of the error bars (2 × SEM)
- Encouraging given the difference in sample size (3400 c.f. 20) and date range
  - Month-to-month variations can be quite significant…

Month-to-month variations

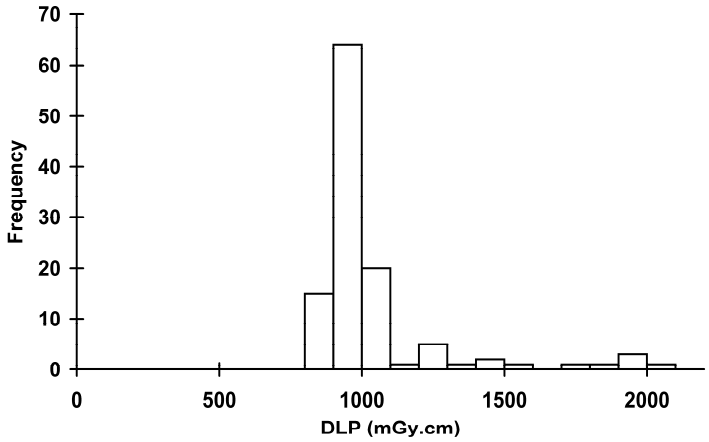
CT chest with contrast

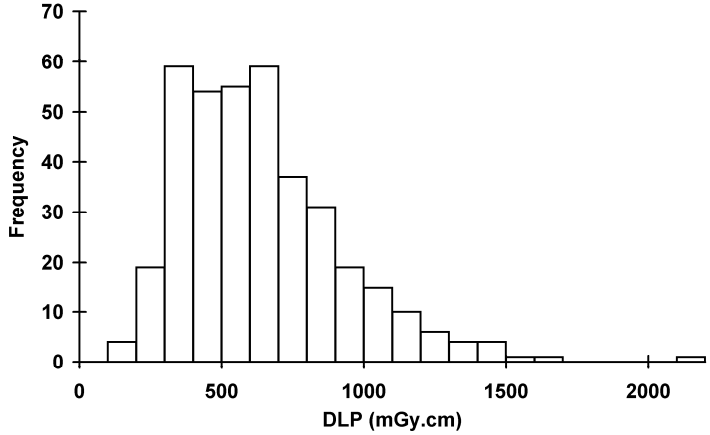


Month-to-month variations

- HRI CT RM1
  - November = 920 mGy cm (N = 47)
  - December = 710 mGy cm (N = 30)
- Whilst not necessarily statistically significant (large error bars), these variations may result in unrepresentative doses being determined
- This may be particularly problematic when setting local DRLs
- However, one trend that has been noted is that the mean dose from RIS is almost always higher than that determined from the 3rd UK CT Survey…

RIS dose distributions

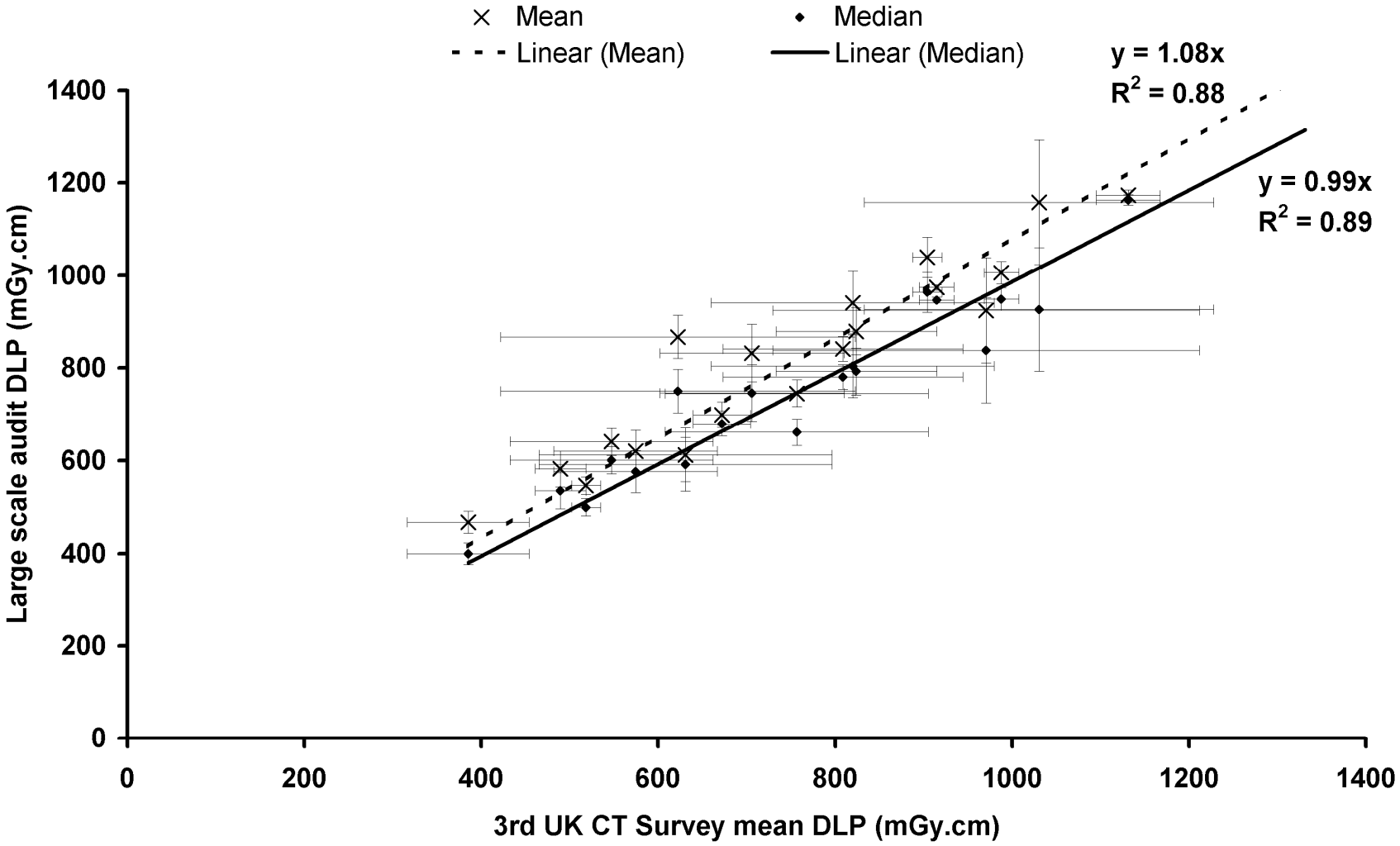




- The dose histograms generated from the RIS data are clearly asymmetric, with an appreciable ‘tail’ extending to the high dose region
  - Due to larger/obese and/or tall (longer scan length) patients i.e. not **standard** patient
- Hence, the **mean** dose is skewed to higher values…

Mean versus median dose

All examinations



Mean versus median dose

- On average, the **mean** dose is 8% higher than that determined from the 3rd UK CT Survey
- The **median** dose is a much better indicator of standard patient dose (on average 1% lower)
  - It will more closely match the peak of the dose distributions and is not skewed significantly by the long high dose ‘tail’
- Only one point does not agree with the 3rd UK CT survey data when the error bars are considered

Dose reporting using RIS data

- The following process is being implemented within the Hull and East Yorkshire Hospitals Trust for routine (quarterly) dose audits:
  - The mean dose is reported as an indicator of overall population dose. This will include obese/tall patients (i.e. non-standard)
  - The median dose is reported to indicate the dose to the ‘standard’ patient, **and for comparison with DRLs**
  - Local DRLs will be set as the mean of the room median doses (i.e. not mean of the room means)

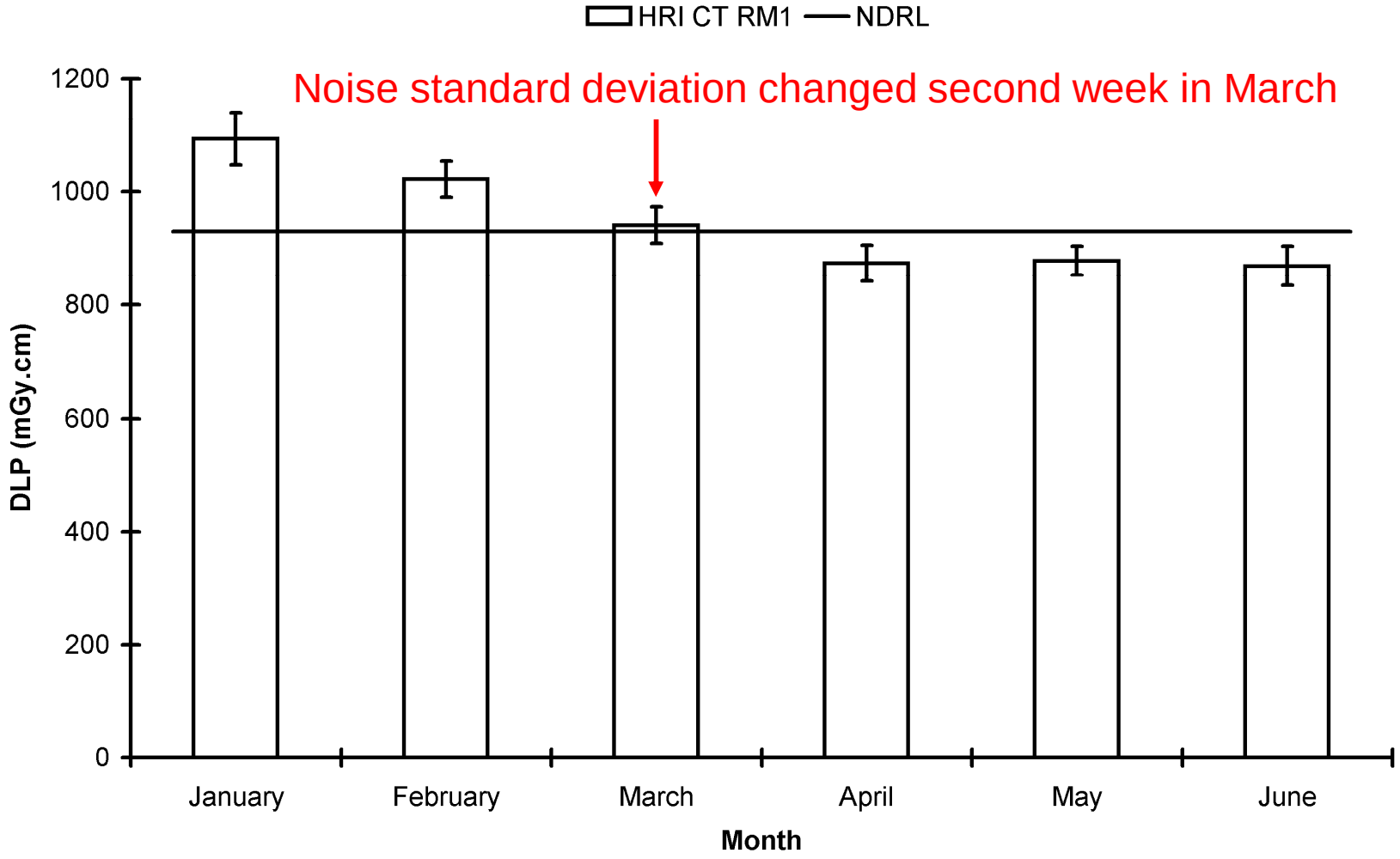
Dosalyzer© in action

A practical example

- CT head exposures on Toshiba scanner above NDRL
  - Median DLP = 1163 ± 11 mGy cm c.f. 930 mGy cm
- Helical protocol using SureExposure AEC system
- Adjusted the noise standard deviation from 2.0 to 2.3
  - Expected ~30% reduction in dose, with a ~15% increase in noise

Dosalyzer© in action

A practical example



Dosalyzer© in action

A practical example

- For the three months following adjustment, consistent dose of 870 mGy cm (now easily below the NDRL)
- 25% dose reduction with no concerns raised over image quality
- Further reductions possible?...

Conclusions

- RIS data can be used for CT dose audits
- It is particularly efficient compared with the ‘traditional’ technique, and allows more routine and long term monitoring of patient doses
- However, caution must be taken to not remove the role of the Radiographer completely
  - As IR(ME)R operators, they have a responsibility to ensure all exposures are optimised
  - They may identify clinical issues that are not obvious from the data present in the RIS system
  - The extra information they ***may*** provide can reveal more about clinical protocols
    - Individual doses for multiple sequence exams e.g. CT chest c.f. CT chest with contrast

Acknowledgements

- The CT Radiographers at Castle Hill Hospital and Hull Royal Infirmary for collecting the 3rd UK CT Survey data
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