Purpose
Delivered radiotherapy dose may be compared between clinics due to the traceability of dose to Primary Standards Laboratories (PSL). Uncertainties arise at each point in the calibration chain and thus the actual delivered dose can deviate from that desired. These uncertainties were quantified for each step:
- calibration transfer to a secondary standard instrument
- transfer to field instruments
- subsequent QA measurement tolerances

Radiobiological modelling was used to predict the clinical impact of these uncertainties for individuals and populations of patients. The variation in delivered dose due to the dosimetric chain has been put into perspective by comparing with dose ranges in 3D conformal and IMRT techniques.

Results
Linac calibration uncertainty: Uncertainty in the initial transfer of the calibration from PSL to the clinic was determined from on-site audits performed by the National Physical Laboratory (NPL) over 2 decades and is normally distributed with a SD of 0.7% [3]. Uncertainty reduced over time, from 0.8% to 0.4% between 1995 and 2015 respectively.

Beam output uncertainty: Data from over 24,000 multi-centre beam output measurements was used as a basis of the uncertainty following calibration and had a 0.7% SD [4] due to output drift. Daily fluctuations were 0.2% SD.

Summary of uncertainties (SD): Linac calibration (overall mean) 0.7%
Output variation due to drift 0.7%
Daily fluctuations 0.2%
Total (calibration + output + daily) 1.0%

Impact of systematic shift in delivered dose:

Table 1 shows simulated change in clinical outcome caused by a systematic deviation in dose throughout the treatment for a variety of modelled cases for individuals and patient populations using commonly accepted parameter values fitted to clinical trial data.

Comparison of conformal and IMRT dose variation: There is a greater variation in the planned dose to the target volume for a population of patients planned using conformal techniques than with IMRT. Values are compared in Figure 2.

Conclusions
This analysis highlights the increased importance of accurate dosimetry particularly in the advent of greater treatment planning accuracy and consistency. It may be desirable to review routine tolerances and reduce these below the common 2% used. Changes of this magnitude are readily detected; however this information is seldom used routinely even though easily available with data recorded electronically. Clinical trials may benefit from reducing uncertainty in delivered dose to provide more robust assessments of response between treatment arms.

References:

Acknowledgements:
Funding was provided by the National Measurement System (NMS) as part of the larger NPL QUASAR project (quantifying the impact of dosimetry quality assurance on clinical outcomes of radiotherapy). Thanks to those in each centre who collated and provided data for this work.

Abstract number: PO-0947