Clinical Oncology 31 (2019) e67–e74

Contents lists available at ScienceDirect

Clinical Oncology

journal homepage: www.clinicaloncologyonline.net

Original Article

# An Audit for Radiotherapy Planning and Treatment Errors From a Low–Middle-Income Country Centre

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Received 6 May 2018; received in revised form 21 August 2018; accepted 24 August 2018

## Abstract

*Aims:* To report the findings of an audit for radiotherapy errors from a low–middle-income country (LMICs) centre. This would serve as baseline data for radiotherapy error rates, their severity and causes, in such centres where modern error reporting and learning processes still do not exist.
*Materials and methods:* A planned cross-sectional weekly audit of electronic radiotherapy charts at the radiotherapy planning and delivery step for all patients treated with curative intent was conducted. Detailed analysis was carried out to determine the step of origin of error, time and contributing factors. They were graded as per indigenous institutional (TMC) radiotherapy error grading (TREG) system and the contributing factors identified were prioritised using the product of frequency, severity and ease of detection.
*Results:* In total, 1005 consecutive radically treated patients' charts were audited, 67 radiotherapy errors affecting 60 patients, including 42 incidents and 25 near-misses were identified. Transcriptional errors (29%) were the most common type. Most errors occurred at the time of treatment planning (59.7%), with "plan information transfer to the radiation oncology information system" being the most frequently affected sub-step of the radiotherapy process (47.8%). More errors were noted at cobalt units (52/67; 77.6%) than at linear accelerators. Trend analysis showed an increased number of radiotherapy incidents on Fridays and near-misses on Mondays. Trend for increased radiotherapy errors noted in the evening over other shifts. On severity grading, most of the errors (54/60; 90%) were clinically insignificant (grade I/II). Inadequacies and non-adherence towards standard operating procedures, poor documentation and lack of continuing education were the three most prominent causes.
*Conclusion:* Preliminary data suggest a vulnerability of LMIC set-up to radiotherapy errors and emphasises the need for the development of longitudinal prospective processes, such as voluntary reporting and a continued education system, to ensure robust and comprehensive safe practises on par with centres in developed countries.


*Key words:* Audit; incident; low–middle-income country; near-miss; radiotherapy errors

## Introduction

Over the last 30 years, attempts have been made to apply aviation safety-related concepts to healthcare [1]. Contrary to the contemporary healthcare specialities, radiation treatment is a multistep complicated process with the involvement of multiple professionals in the different manual and automated procedures interplaying and relying heavily on complex datasets, their interpretation, transfer and handoffs between staff and systems, making it prone to various errors [2]. Over the last decade, there have been several reports resulting in guidelines from various high-income countries, such as the UK, France and Australia [3–5]. Several international collaborative groups have also started radiation incident reporting programmes, such as the Radiation Oncology Safety Information System (ROSIS) from the European Society of Therapeutic Radiology and Oncology (ESTRO), the Radiation Oncology Incident

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https://doi.org/10.1016/j.clon.2018.09.008
0936-6555/

Learning System (RO-ILS) from the American Society of Therapeutic Radiation Oncology (ASTRO), SAFety in Radiation ONcology (SAFRON) from the International Atomic Energy Agency (IAEA), to name a few, to develop a continuous collective learning process [6–9].

As per World Health Organization (WHO) estimates in 2008, radiation incidents affected 3125 patients, resulting in 38 deaths (1976–2007) in middle and high-income countries from the USA, Latin America, Europe and Asia and almost certainly underestimated the number of deaths [10]. No such detailed reports are available from low–middle-income countries (LMIC). One dosimetric audit in developing countries by the WHO and IAEA estimated that an acceptable range of radiation dose was delivered for only 84% of patients. The critical reasons cited were lack of proper staffing, training and equipment at these centres [11]. Another external audit of the oncology practice at an LMIC in Asia suggested suboptimal radiotherapy treatment in almost 52% of the audited patients [12].

India is an LMIC and accounts for 17.9% of the world's population, with 7.8% of the global cancer burden [13,14]. Unfortunately, the current understanding of the incidence and types radiotherapy error or causality relationship in the background of a low resource, high throughput setting is mostly unknown. It would be more appropriate to develop an indigenous system of learning and formulations of guidelines, keeping in mind the local needs, than overlaying recommendations directly from a very different work environment of developed countries. To understand those local needs, an audit of the current situation regarding radiotherapy errors would be ideal. It will be valuable to understand our strengths and challenges for the improvement of existing radiotherapy practises.

Our centre is one of the largest tertiary multidisciplinary cancer care centre in Southeast Asia and faces some of the similar challenges as any other high throughput LMIC centre. As per the published annual report 2015–2016, 6235 patients received about 100,000 radiotherapy external beam fractionations and 3590 brachytherapy fractions in the year 2015 [15]. The external beam radiotherapy (EBRT) techniques used range from conventional cobalt teletherapy machines to specialised techniques, such as rotational intensity-modulated radiotherapy, image-guided radiotherapy, adaptive and stereotactic radiotherapy using high-end linear accelerators. In this preliminary cross-sectional study, we conducted a planned audit for our teletherapy planning and delivery step of the radiotherapy process. The number and type of radiotherapy errors (radiotherapy incidents and near-misses), their severity and causes would serve as baseline information and may also be beneficial to other similar LMIC set-ups.

## Materials and Methods

An approved departmental team (ADT) reviewed the departmental process map for EBRT. After approval from the Institutional Ethics Committee (Clinical Trial Registry of India: CTRI/2015/01/005382), a weekly audit was conducted from 17 May 2015 to 8 August 2015 to detect and analyse errors in the radiotherapy treatment planning and execution steps for all patients undergoing curative-intent EBRT.

### *Terminology*

The standard recommended terminologies adapted from 'Towards Safer Radiotherapy' [3] for radiotherapy errors, radiotherapy incidents and near-misses were used to identify and classify the deviations.

The detailed EBRT process map suggested by AAPM consensus guidelines [17] was reviewed. Several alterations relevant to current work practices in our department were recognised, and so a modified departmental EBRT process map was formulated. There are a few noteworthy examples that have not been explored in the consensus document mentioned above and needed additional modifications [17]. Most patients treated on a telecobalt machine were planned using conventional simulation (orthogonal X-ray based), with dose calculation carried out as per standard dose tables. Several palliative patients were planned based on clinical marking and calculations based on standard tables or using direct phantom-based plan calculations on a treatment planning system (TPS). The head and neck cancer patients treated radically on a telecobalt machine were planned with tissue compensators and so forth. Hence, being a very heterogeneous department regarding available and practised technologies that are still relevant and quite prevalent in LMIC countries, a detailed modified process map was necessary and was created. Further discussion of the full map and all the differences with Western literature is beyond the scope of this paper. Table 1 shows the existing steps of checks and audits in treatment planning and during treatment.

For the study, ADT reviewed most of the prominent and available radiotherapy error severity scoring guidelines, such as ASN-FSRO, Towards Safer Radiotherapy and AAPM medical and dosimetric scales [3,16,17]. Due to a lack of uniform direction of severity scoring and nomenclature, a simplified institutional (TMC) radiotherapy error grading system (TREG) was developed denoting possible severity. The supplementary material describes TREG in detail, which was used for grading the possible severity of errors identified in the study.

### *Auditing*

The e-RT charts (electronic radiation treatment charts) of the patients on curative EBRT were collected from all treatment units (four telecobalt, six linear accelerators including one tomotherapy unit) over the weekends. They were reviewed for the treatment plan parameters. A comparison was made for the planning record and e-RT charts on the machine. The planning record comprised of treatment plan parameters obtained from the final approved plans on either TPS or simulator portal films printouts/screenshots when conventional planning was done. Both manual physics calculations and TPS calculations were also verified. The delivery details were also verified from the electronic records of the patients.

**Table 1**
Existing checks and audits in the treatment planning and treatment delivery

| Checks/audits | Responsibility of the step | Checks/audits by | Scope of Checks/Audits |
|---|---|---|---|
| Pre-planning audits | Charts prepared by Junior and Senior Residents | Consultant | 1. Diagnostic/staging work-up.<br>2. Need for any additional information/investigation.<br>3. Intent of treatment, technique and suitable machine, dose, fractionation.<br>4. Simulation set-up details decided. |
| Contouring | Junior and Senior Registrar | 1. Senior Registrar and Consultant<br>2. Physicist | 1. Image fusion, organs at risk and planning target volumes contoured as needed.<br>2. Contours as needed for desired planning endpoints defined in the chart. |
| Plan evaluation | Physicist, Registrars | 1. Consultants<br>2. Physicist cross-check | 1. The plan meets the desired clinical and dosimetric endpoints.<br>2. Two-dimensional simulation records and thermoplastic marks review. |
| Plan transcription | Registrar | Registrar/Consultant and Physicist | 1. Machine, set-up and treatment plan parameters. |
| Plan Implementation | Junior or Senior Registrar | Senior Registrar or Consultant | 1. Proper isocentre shifts are applied. |
| Physics cross-check | Junior Physicist | Senior Physicist | 1. Quality assurance tests as applicable.<br>2. Manual calculations cross-check.<br>3. Calculation transcription review. |
| Set-up check | Resident and Technologist | Resident and Technologist | 1. Before the first fraction, on the machine: review the chart, patient information, devices, plan, plan implementation and review set-up at the machine. In case of discrepancies, review with a consultant. |
| Third fraction review/audits | - | 1. Residents and Consultant<br>2. Physicist | 1. Chart review and medical records for any errors.<br>2. Calculation cross-checks, quality assurance review, transcription of calculations. |
| Weekly chart review/audits | | Resident and Consultants | 1. Chart review and medical records for any errors.<br>2. Treatment compliance, toxicity etc. |

At the time of the first audit of any given patient, the e-RT paper was checked for errors/discrepancies in various treatment plan parameters. These included treatment machine/unit, time dose fractionation, technique used (conventional, conformal etc), immobilisation techniques, source to skin distance/source to axis distance (type and value), radiotherapy field information (number, orientation, dimensions, weightage, collimation, depth of the point of prescription for each field, treatment time calculations for each field), additional beam modification devices (bolus, tissue compensator, block and template for marking field block, wedge, asymmetric jaws). Further information in e-RT charts regarding clinical protocols (concurrent chemotherapy, such as capecitabine, temozolomide, cisplatin; bladder filling, rectal preparations, etc.) were reviewed for any discrepancies. On the identification of radiotherapy errors, the day and time of occurrence of the error were also noted to determine any correlation of timing with the frequency of radiotherapy errors (radiotherapy incident/near-miss).

During the following weeks, reviews were carried out to verify delivery details (machine records) to see any discrepancy from the planned treatment or any change of plan and plan parameters and further error(s). In cases of undue treatment breaks or severe acute toxicity, repeat complete auditing of e-RT papers was carried out.

In case of any deviations found, the discordant parameters and other details were reviewed with the team of treating physicians, physicists and technologists, to identify if it was a planned deviation or an error. Appropriate corrections were made by the treating physician for the remaining treatment as deemed necessary. Furthermore, the identified radiotherapy errors were classified as radiotherapy incidents or near-misses, as defined previously. The step of the radiotherapy process, at which the radiotherapy error started, was identified and categorised as per the departmental process map.

The root-cause analysis was carried out for each radiotherapy error detected to identify all possible causes contributing to the occurrence of a particular radiotherapy incident or near-miss in accordance with AAPM guideline, appendix D [17]. For the purpose of policy making, prioritisation of root causes was decided based on a cause severity priority index calculated as the product of frequency, severity (TREG) and the ease of detection of the cause of the radiotherapy error. Based on this information, the future policy was suggested by the ADT.

### *Statistical Methods*

Data were collected on the Statistical Package for the Social Sciences (SPSS) version 21, and simple descriptive statistic calculations were carried out, such as rates, ratios, and percentages.

## Results

During the study period of 12 weeks, the e-RT chart of all 1005 patients radically treated patients (532 men, 472

women) equating to 25,430 fractions were reviewed. In total, 67 (6.7%) radiotherapy errors (25 near-misses [37.3%] and 42 radiotherapy incidents [62.7%]) were identified, amounting to 0.075 near-misses per 100 fractions and 0.16 radiotherapy incidents per 100 fractions (4.1 radiotherapy incidents/100 patients). Twenty-five near-misses involved 19 patients, whereas 42 radiotherapy incidents involved 41 patients (Table 2). Radiation incidents were more common than near-misses (42 versus 25, respectively). The transcriptional type was the most common error (35/67; 52.2%) followed by an act of commission (24/67; 35.8%) and the act of omission (8/67; 12%). The most errors affected patients treated on cobalt machines (52/67; 77.6%), as detailed in Table 2.

Table 3 shows the steps of the radiotherapy process at which various errors originated. The maximum number of errors originated at the time of treatment planning (40/67; 59.7%) followed by pre-treatment review and verification, treatment delivery, imaging for radiotherapy planning, on-treatment quality management and patient assessment in decreasing order. Overall, the most critical sub-step of the whole process was detected to be plan information transfer to a radiation oncology information system, with a total of 32 (47.8%) errors (17 near-misses [68%] and 15 radiotherapy incidents [35.7%]). This sub-step is most prone to the transcriptional type of error, where manual entry of planned information from the simulation record or TPS is transferred to the treatment unit, especially for cobalt units. Critical information comprising individualised patient set-up details is also error-prone because of the manual entry leading to transcriptional errors, which are not restricted to the type of treatment unit (cobalt or linear accelerator) and automation of TPS.

On reviewing the trend of timing for the occurrence of various radiotherapy errors, it was noticed that overall the numbers of errors on each day of the week (Monday to Friday) remained almost constant, there was a steady increase in the number of radiotherapy incidents from Monday to Friday (almost doubling), whereas there was a decrease in

**Table 2**
Details of various radiotherapy errors

| Details | Near-misses Number (%) | Incidents Number (%) |
|---|---|---|
| Type of error | | |
| • Transcription | 13 (52) | 22 (52.4) |
| • Commission* | 8 (32) | 16 (38.1) |
| • Omission* | 4 (16) | 4 (9.5) |
| Total number of errors | 25 | 42 |
| Total number of patients affected | 19 | 41 |
| Number of patients affected by a single error | 13 (68.4) | 40 (97.6) |
| Number of patients affected by two errors | 6 (31.6) | 1 (2.4) |
| Machine | | |
| • Tele-cobalt | 21 (84) | 31 (73.8) |
| • Linear accelerator | 4 (16) | 11 (26.2) |

* Omission is when one fails to do what is desired; commission is when one does what is not required and causes error [3].

**Table 3**
Errors at various steps of the radiotherapy process

| Step of radiotherapy process where the error originated | Near-misses Number (%) | Incidents Number (%) |
|---|---|---|
| 1. Patient assessment | 0 | 1 (2.4) |
| • Patient education | 0 | 1 |
| 2. Imaging for radiotherapy planning | 3 (12) | 3 (7.1) |
| • Documentation (positioning/immobilisation/ancillary devices) | 2 | 3 |
| • Transfer of images to the planning system | 1 | 0 |
| 3.Treatment planning | 18 (72) | 22 (52.4) |
| • Preliminary prescription parameters, constraints and technique | 1 | 1 |
| • Appropriate field parameters selection | 0 | 1 |
| • Dose distribution optimisation | 0 | 1 |
| • Final plan and prescription approval by a physician | 0 | 4 |
| • Plan information transfer to radiation oncology information system | 17 | 15 |
| 4. Pre-treatment review and verification | 3 (12) | 6 (14.3) |
| • Plan implementation with the application of shifts and final marking | 3 | 6 |
| 5. Treatment delivery | 0 | 7 (16.6) |
| • Patient preparation | 0 | 1 |
| • Selection of intended field | 0 | 1 |
| • Setting treatment accessories and treatment unit parameters | 0 | 2 |
| • Set-up | 0 | 3 |
| 6. On-treatment quality management | 1 (4) | 3 (7.2) |
| • Physician chart review and plan modification | 1 | 2 |
| • Therapist chart check | 0 | 1 |
| Total | 25 | 42 |
| Step propagation (propagation of error from one step to next one without detection) | 17 (68) | 38 (90.5) |

the number of near-misses in that order. Similarly, when each day was divided by technologist working shifts of three (9:30 am to 12:00 noon, 12:00 noon to 3:00 pm and after 3:00 pm), we noticed a definitive trend of increasing radiotherapy errors from morning to evening, but no trend was noticed for radiotherapy incidents or near-misses.

*Possible Severity of Radiotherapy Errors and Root-Cause Analysis*

The severity scoring was carried out cumulatively per patient based on worst case possible severity due to error. Most of the radiotherapy errors (54/60; 90%) were either grade I or grade II; whereas only three radiotherapy errors were grade III and grade IV each (Table 4). There were two grade III radiotherapy incidents. The first one was a significant set-up variation due to seroma collection in a post-lumpectomy breast cancer patient leading to an estimated under dosage of 15%. This was picked up as an SSD (source to skin distance) mismatch during the audit, which was very well documented on e-RT charts but ignored by the treating technologist and missed by the physician on routine review. The treating physician contemplated no dosimetric correction after detection. The patient is doing well with no evidence of recurrent disease at 15 months. The second one was the omission of concurrent oral capecitabine with radiotherapy in a rectal cancer patient. The patient had defaulted further treatment and follow-up after radiotherapy. The single grade IV radiotherapy incident included omission of planned tumour boost treatment in an anal canal cancer patient. He was reviewed at first follow-up after treatment (at 2 months) with residual disease and was given a boost radiotherapy dose at that time. He is doing well with no evidence of recurrence at 12 months of follow-up.

After root-cause analysis for all errors by ADT, the most common and recurrent contributing factors for radiotherapy errors were determined. They included inadequacy and non-adherence to relevant policy (standard operating procedure; SOPs), poor documentation and verbal instructions not supported by written documentation, lack of continuing education and training; in order of decreasing frequency and CPSI scoring (Cause-Severity-Priority index).

ADT conducted several brainstorming sessions within the committee as well as with the departmental groups of technologists, physicist and clinicians to decide the policies for the future quality improvement. The existing checks and audits were reviewed in the workflow. It was felt that the most important and critical steps of checks or audits already exist in the department. There was a systematic lack of proper documentation of these checks or audits. Regular rotations of registrars and juniors in all teams of physicians, physicists and technologists make it challenging to maintain the verbal understanding of reviews and checks. It was suggested to develop in detail written SOP documents for various steps and to start a regular education programme. This will help to improve education and sensitisation towards the relevance of various steps leading to improved implementation with proper documentation. It was also recommended to renew the impetus to a patient safety culture in the department, which is guided by a formal programme for voluntary online incident reporting. Over time we will know better how to balance the existing checks, introduce new ones or reduce the redundant ones.

The incident reporting committee would encourage enhanced reporting with the vision of being 'anonymous, non-punitive and just' and to oversee all steps of radiotherapy processes for improvement. They would provide regular detailed analysis of the errors noted and suggestions based on them as a continuous learning process in the department. Urgent need for formulating and strengthening official written SOPs with stress on error-prone areas was noted. Their implementation of regular updating and an education programme would lead to safety sensitisation of all the staff.

**Table 4**
Severity of radiotherapy errors as per TMC Radiotherapy Error Grading System (TREG)

| Grading | Definition | Number of patients affected (%) | |
|---|---|---|---|
| | | Near-misses | Incidents |
| Grade I | Event with dosimetric consequences with mean dose variation to target $\leq$5% of planned; no expected clinical consequences (neither symptomatic due to the varied dose to organs at risk nor affecting the tumour control rate) | 11 (57.9) | 33 (80.5) |
| Grade II | Event with dosimetric consequences with mean dose variation to target >5% but $\leq$10% of planned; mild to moderate clinical consequence (symptomatic but neither affecting the activities of daily living due to varied dose to the organs at risk nor affecting tumour control rate) | 5 (26.3) | 5 (12.2) |
| Grade III | Event with dosimetric consequences with mean dose variation to target >10% but $\leq$20% of planned; severe clinical consequence (either affecting the activities of daily living due to varied dose to the organs at risk or affecting tumour control rate) | 1 (5.3) | 2 (4.9) |
| Grade IV | Event with dosimetric consequences with mean dose variation to target >20% of planned; very severe clinical consequence (severely disabled, requires hospital admission for care) | 2 (10.5) | 1 (2.4) |
| Grade V | Death | 0 | 0 |

## Discussion

A large number of reports on radiotherapy errors and recommendations aimed at minimising errors have been published from developed countries [3–8,16–22]. To date, only one dosimetric audit and another external audit report from an LMIC have been published, suggesting suboptimal treatment to up to 52% of the audited patients. This was mainly attributed to the lack of proper training, absence of any quality assurance and excessive workload [10,11]. Adoption of the guidelines from the developed nations for direct application in LMIC centres like ours with probably similar deficiencies of other LMIC, as cited previously, would be imprudent due to poorly known and understood impracticalities in our settings [23]. In this preliminary pilot study, we presented an audit report of the radiotherapy planning and delivery process steps. We dissected in detail the pattern, types and severity of radiotherapy errors seen in our setting. The most significant findings are discussed below in the context of known literature.

First, a higher error rate (4.1/100 patients or 0.16/100 fractions) was noted as compared with previously published studies from developed countries, e.g. the error rate of 1.97/100 patients seen in Canada and 0.06/100 fractions seen in the USA [2,24–29]. Arguably, an audit may pick up more errors due to reporting bias in the voluntary reporting system, but they may be higher as this was the first audit in our place, where people are not conditioned by the presence of error reporting and a learning system, suggesting the need for developing one in the future.

Second, contrary to previous reports from Western countries, we found that the frequency of radiotherapy incidents was much higher than near-misses (0.16 incidents/100 fractions versus 0.075 near-misses/100 fractions) [30,31]. Conducting weekend audits on Saturdays, when a treatment has already been started, would lead to the detection of more radiotherapy incidents than near-misses if proper checkpoints are lacking or non-functional.

Third, as seen in previous studies, the most common step at which radiotherapy errors initiated was at the time of treatment data transfer from the TPS to the treatment unit due to transcriptions errors [32,33]. The audit was limited to a small part of the whole radiotherapy process, mainly planning and delivery by comparing e-RT charts with planning and treatment records. This would more efficiently discover transcriptional errors in the prior steps as compared with other types of error possible at previous steps of the whole process. As transcription requires human-machine-interface and is prone to increased errors, even previously in the United States Nuclear Regulatory Commission large database report, human involvement lead to an increased risk of error in radiotherapy administration (60%) [34].

The cobalt units are not networked with the TPS and require complete manual entries on e-RT charts, making it more prone to the translation of transcriptional errors as compared with the typical modern linear accelerators, where most of the information is auto-transferred directly via the planning system. The electronic medical records may not be commonly present in most LMIC centres, requiring manual entry, which we feel would be similarly prone to a high number of errors as our telecobalt machines. It might be easier to capture, audit and correct errors in small isolated linear departments as compared with us due to less heterogeneity and working patterns, and more availability of direct supervision and intervention. We feel massive and diverse technology set-ups like ours are more complicated and prone to errors as compared with the small isolated linear, thinner and easier to supervise departments.

This study, for the first time, documents more errors in cobalt units (48/60) than linear accelerators (12/60). This issue is unaddressed in Western data as most cobalt units have already been replaced by linear accelerators. In LMIC even today, 48% of teletherapy machines are cobalt units [35]. Again, the individualised patient set-up details need to be entered manually at the time of treatment planning for both types of treatment unit and so if not done prudently, will lead to radiotherapy incidents irrespective of technology.

Fourth, a distinct trend in the timing of radiation errors was seen with almost a doubling of numbers of radiotherapy incidents from Monday to Friday and conversely for near-misses. This might be due to the rejuvenated staff being more alert on Mondays and picking up more errors before delivery while delivering treatment in haste or fatigue on Fridays. In a study by Chang *et al.* [25], more incidents were observed in the afternoons compared with mornings, suggesting a role of circadian rhythm dips as well. This may also be related to the variability in the number of staff available throughout the day during various shifts, needing further investigation. Analysis of more substantial numbers of radiotherapy errors and correlating with other factors of importance, like duty roster, individual or group work patterns, absenteeism, patient loads and other deviations in work environment, may bring newer insights.

Finally, in concurrence with Western data, most of our radiotherapy errors were clinically insignificant (grade I or II) [25,30]. As presented in the results, several recommendations based on the findings were charted to be implemented. On priority, a formal programme for a voluntary online incident reporting system with the theme of 'anonymous, non-punitive and just' was envisioned in October 2016 [36]. This has been fully functional since January 2017 as Tata Memorial Centre (T) Radiation Incident Programme (TRIP) with committee members from all groups (clinicians, physicists, technologists). We encourage reporting by use of technology enablement, and so our radiation oncology information system has been upgraded to allow direct reporting to the committee members by the users through any computer system in the hospital with intranet facility. Regular sensitisation sessions are organised for all groups regarding radiation patient safety, with examples of reported errors to create a renewed impetus towards patient safety culture in the department. Written SOPs are being

formulated in consultation with various groups in light of known errors. Their implementation with a formal education and training programme with regular proficiency testing and prospective audits to overview adherence is being proposed. The continued process of learning from errors leading to systemic improvements is expected over time. The results of voluntary reporting and other developments are out of the scope of the preliminary work presented here.

Several limitations of this study are recognised. This was a preliminary study with a snapshot of a part of the whole radiotherapy treatment process. The audit step mainly focused on checking the transcription information from pre-planning, planning and delivery. This would have missed errors in the preceding steps such as clinical decision making, errors in quality assurance; or later steps such as errors during treatment delivery, image-guided radiotherapy implementation and on reviews during the treatment duration. The audit did not study the brachytherapy part. The audit was carried out for a limited time period with no intention to study the impact on errors by the single intervention of audit.

## Conclusion

Despite its limitations, this preliminary study suggests that LMIC radiotherapy set-ups are quite vulnerable to radiotherapy errors and have their share of similarities and dissimilarities with Western countries. There is a further need to study indigenous systems in more detail and develop robust and comprehensive safe practises with continuous processes of learning from voluntary reporting and education as per local needs.

## Conflicts of interest

The authors declare no conflict of interest.

### Acknowledgement

This study was supported by a Tata Memorial Centre, Institutional Research Grant. CTRI/2015/01/005382.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clon.2018.09.008.

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