Evaluation of the Type and Frequency of Errors Discovered During Routine Secondary Patient Chart Review

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Abstract: *Purpose*: Desire to improve efficiency and throughput inspired a review of the frequency and scope of our physics chart check procedures. Departmental policy mandates review of a patient's treatment plan prior to port-filming, after first treatment and "weekly" every 3-5 fractions. This study examined the effectiveness of the "after-first" physics check with respect to improving patient safety and clinical efficiency.

Methods and Materials: A shared spreadsheet was created to record errors discovered during patient-specific chart review following the first fraction of treatment and before the second fraction. First, entries were recorded and categorized from August 2014 through February 2015. Frequencies were assessed month-to-month. Next, utilizing these results, a continuous quality improvement (CQI) process following Deming's Plan-Do-Study-Act (PDSA) methodology was generated. The first iteration of this PDSA was adding a dose tracking checklist item in the pre-treatment plan check assessment. A two-sided Fisher's exact test was used to determine if there was a nonrandom association between the checklist implementation and incidence of dose tracking errors.

Results: Analysis of recorded errors indicated an overall error rate of 3.4% over the 13 month period. The majority of errors related to discrepancies in documentation, followed by prescription, plan deficiency, and dose tracking-related errors. A two-sided Fisher's exact test revealed a statistically significant decrease in dose tracking-related errors after implementing the checklist item ($p = 0.0322$, significance level = 0.05).

Conclusions: This work indicates that this redundant secondary check is an effective QA process in our department. The first month spike in rates could be due to the Hawthorne/observer effect, but the consistent 3% error rate suggests the need for continuous quality improvement and periodical re-training on errors noted as frequent to improve awareness and quality of the initial chart review process, which may lead to improved treatment quality, patient safety and increased clinical efficiency.

Keywords: Error analysis, chart checks, continuous quality improvement.

I. INTRODUCTION

Identifying and reducing the incidence of medical errors has been a topic of great interest across all medical disciplines including radiation oncology [1, 2] The continual development and integration of new technology and sophistication of modern treatment plans creates a process of care that is subject to mishaps, and effort should be made to reduce the likelihood of these mishaps propagating through the treatment chain [3-6]. In fact, international societies such as American Association of Physicists in Medicine (AAPM), European Society for Radiotherapy & Oncology (ESTRO), American Society for Radiation Oncology (ASTRO), and International Atomic Energy Agency (IAEA) have published recommendations and guidelines for quality assurance (QA) in radiation oncology to help mitigate potential deviations from intended treatment [7-11]. Additionally, publications such as *Safety is No Accident* strive to address the particular needs of safely operating radiation oncology departments [12].

Among the safety procedures recommended by AAPM and mandated through state and national regulations, a thorough and independent review of each patient's chart by a qualified medical physicist (QMP) remains an important part of the treatment process [9, 13-15]. It is documented that independent secondary checks may reduce the incidence of errors [13, 16].

In fact, quality chart checking is an expressly defined requirement for accreditation from bodies such as the American College of Radiology (ACR), American College of Radiation Oncology (ACRO), and ASTRO [10, 17-19].

At our institution, a QMP performs plan and chart documentation review prior to initiation of port filming, after the first fraction of radiotherapy ("after-first" checks), and "weekly" every 3-5 days, based on prescribed frequency of treatment. A desire to improve

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PACS number: 87.55Qr

physicist clinical efficiency without compromising patient safety inspired us to examine the frequency and purpose of our chart checking procedures in order to validate the effectiveness of the secondary chart review in our clinic and improve workflow. To do this, the type and frequency of errors discovered during this redundant secondary review was examined and quantitatively analyzed.

II. METHODS AND MATERIALS

A shared spreadsheet was created and linked through the electronic medical record (EMR) making it easily accessible to all physicists responsible for completing patient-specific chart reviews. Each physicist was instructed to log an entry of any errors, documentation issues or "variations" discovered within a patient's chart during the after-first check in the spreadsheet after patients completed the first fraction of treatment. There were no specified categories; each individual physicist could free-text a description of the discovery. Initially, entries were recorded from August 2014 through February 2015, amounting to 43 recorded errors out of 906 after-first checks.

The recorded errors were divided into the five categories listed in Table **1**, and likewise assigned occupational-specific identifiers to better ascertain at what stage errors tend to present themselves. For example, dosimetrists are responsible for creating a patient's treatment plan, which includes normalizing the plan according to institutional policy and procedure. If an error was discovered in the plan normalization, this type of error would be classified under "plan deficiency" and as "dosimetrist-related". Furthermore, if this same error was not detected during the after first check by the physicist, it would be classified as both "dosimetrist-related" and "physicist-related". Ultimately, all errors were determined to be therapist, dosimetrist, physicist, and/or physician-related. As mentioned previously, this classification is used solely for identifying where errors present themselves in the treatment process, and was not used for punitive action.

Additionally, each error was classified as either consequential or non-consequential. Consequential errors were defined as those which impacted patient treatment in any way. Further, non-consequential errors were subdivided into major and minor categories. Table **2** lists this categorization. A univariate descriptive analysis was performed with the recorded data.

Following this analysis it was decided to supplement this research by implementing a continuous quality improvement (CQI) project following Deming's Plan-Do-Study-Act (PDSA) methodology [20]. PDSA methodology involves a series of systematic steps to gain valuable information and knowledge in order to continue improving or optimizing a process or product.

Table 1: Categorization of Recorded Errors by Type with Examples

Category of Error	Example
Documentation	Omission of or errors in digitally reconstructed radiographs, setup photos, secondary dose verification documentation, patient notes, table parameters, etc.
Plan Deficiency	Setup field isocenter differs from treatment isocenter, wrong table shifts, wrong cutout factor, poor coverage, high dose to sensitive structures, etc.
Revenue	Secondary dose verification document not imported.
Dose Tracking	Dose per field not set up in record & verify system.
Prescription	Wrong energy or prescribed isodose line, wrong or changed prescribed dose, density corrections not specified.

The errors listed in Tables **1** and **2** are polychotomous; they may belong to more than one category. For example, not importing the secondary dose verification document into the record and verify system would be categorized under revenue and documentation.

Table 2: Categorization of Recorded Errors by Consequence with Examples

Category of Error	Example
Minor Non-Consequential	Any error listed in Table **1** that does not fall under the category of major non-consequential.
Major Non-Consequential	Wrong setup shifts, setup field isocenter differs from treatment isocenter, patient treated without after first check, any error in the prescription (see Table **1**).
Consequential	Wrong energy treated for one fraction, wrong electron cutout factor used for one fraction.

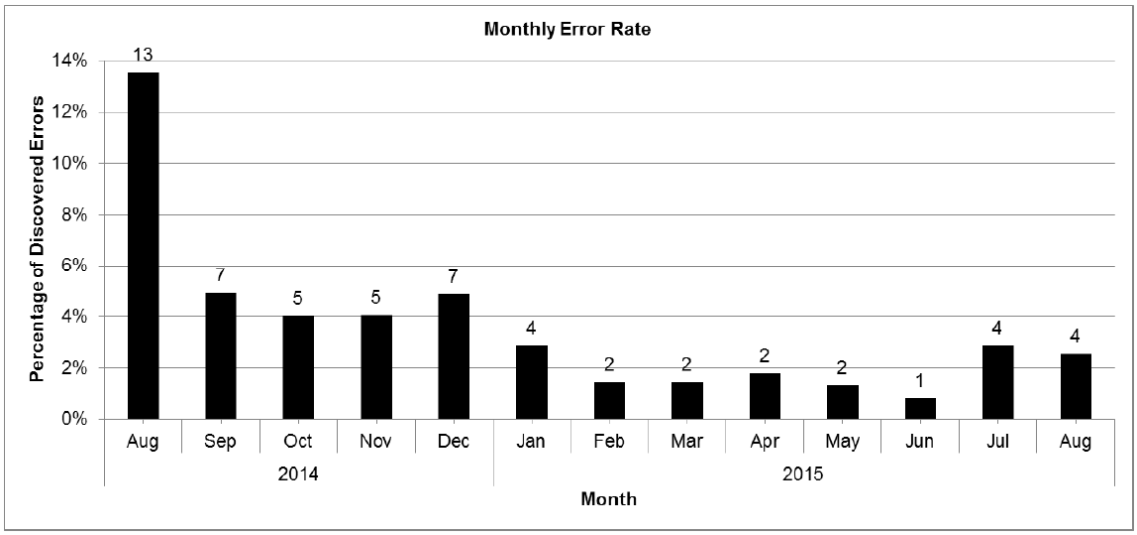

Figure 1: Percentage of discovered errors month-to-month over the 13 month span is presented. A specific dose tracking checklist item was introduced toward the end of February 2015. Raw number of recorded errors is shown above each bar.

This methodology starts with a *plan* step followed by a *do* step, which introduces a change to current process. Then, a *study* step will monitor and analyze the validity of the plan. The *act* step incorporates information or knowledge gained during the process to current practice.

In this study, the first step was formulating the hypothesis that adding a specific checklist item addressing a commonly occurring error in the existing pre-treatment physics plan check quality checklist would reduce the occurrence of the error. In this case, a dose tracking checklist item was added due to the relatively large number of dose tracking errors that were recorded during this study (see results). This checklist item was added toward the end of February 2015. Additional data was collected from March 2015 through August 2015, amounting to 17 recorded errors out of 820 after-first checks, to test our hypothesis. A two-sided Fisher's exact test was used to determine if there was a non-random association between the introduction of this checklist item and the incidence of dose tracking errors.

III. RESULTS

Figure **1** depicts the percentage of discovered errors by month from August 2014 through August 2015. Percentage error by month was determined as the ratio of recorded errors in a particular month to the number of after first checks performed in that month. Analysis of the recorded data from August 2014 through February 2015 (pre-checklist implementation) revealed an overall error rate of 4.7% over the seven month span. The initial rate was 13.5%; months 2-7 averaged 3.7% per month. The number of after-first checks performed per month averaged 129 with a standard deviation of 17. Analysis of the recorded data from March 2015 through August 2015 (post-checklist implementation) revealed an overall error rate of 1.8% over the six month span. The number of after-first checks performed per month averaged 136 with a standard deviation of 17.

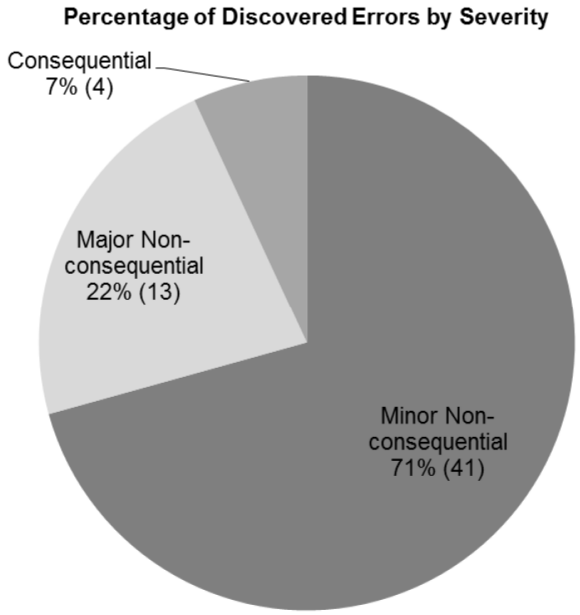

Figure 2: Percentage of discovered errors sorted by category before the implementation of a specific dose tracking checklist item (August 2014 through February 2015) is shown. The data is normalized to 100%. Raw number of recorded errors is shown in parentheses.

Charts depicting the percentage of discovered errors by category from August 2014 through February

2015 (pre-checklist implementation) are shown in Figures **2** and **3**[1]. The majority of errors were classified as minor non-consequential (74.4%) and related to discrepancies in documentation at 42.5%, followed by prescription, plan deficiency, dose tracking, and revenue-related errors at 25.5%, 12.8%, 12.8%, and 6.4% respectively. Only two consequential errors were found. In addition, the majority of discovered errors were physicist-related at 46.5%, followed by dosimetry, physician, and therapist-related at 22.5%, 16.9%, and 14.1% respectively.

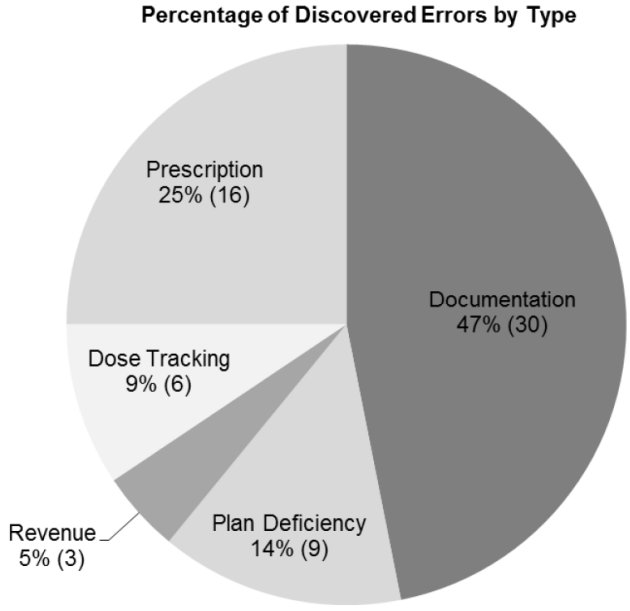

Figure 3: Percentage of discovered errors pre- and post-checklist implementation is shown for each category. The data is normalized to 100%. The raw number of recorded errors is shown in parentheses.

Additionally, charts depicting the percentage of discovered errors by category from March 2015 through August 2015 (post-checklist implementation) are shown in Figures **3** and **4**. The majority of recorded errors in this second set of data were classified as minor non-consequential (60.0%) and related to discrepancies in documentation at 58.8%, followed by prescription and plan deficiency-related errors at 23.5% and 17.7% respectively. There were no recorded errors relating to dose tracking or revenue. Similar to the initial seven month's data, the majority of discovered errors were physicist-related at 44.8%, followed by dosimetry, physician, and therapist-related at 31.0%, 17.3%, and 6.9% respectively.

[1]All reported data is normalized to 100%.

Statistical software package R (Version 3.2.2) was used to perform a two-sided Fisher's exact test and revealed a statistically significant association between the introduction of the checklist item and the incidence of dose tracking errors ($p = 0.0322$, significance level = 0.05) [21].

IV. DISCUSSION

This work indicates that current departmental policy requiring a secondary check immediately after the first treatment is an effective quality assurance tool. The first month spike in rates could be due to the Hawthorne effect, but the average 3% error rate over the course of one year highlights the importance of implementing the PDSA CQI process, and suggests the need for periodical retraining on variations in care noted as frequent to improve awareness and quality of the initial chart review process [22]. Moreover, as procedures evolve additional items may be identified through this type of study.

The observation that the majority of discovered errors were categorized as "physicist-related" is expected since all plans are checked once by a physicist prior to receiving the after-first check; theoretically, the physicist should catch almost all variations from intended treatment at the time of the initial chart check. However, some errors, such as missing setup photos, will only present themselves during the after-first check since setup photos become available between the initial check and after-first check. It should be stressed that most errors are associated with more than one group; this nomenclature is more to define where in the treatment process an event occurs or is discovered rather than to place blame on team divisions. We support a Culture of Safety and acknowledge that no one division is usually responsible for a discovered error and encourage all team members to participate in reporting errors and improving the care process [23].

A comparison of the data recorded before and after the implementation of the dose tracking checklist item revealed a statistically significant decrease in the incidence of dose tracking errors ($p = 0.0322$, significance level = 0.05). This suggests that the use of checklists in mitigating minor variations in patients' treatments is effective, which is in alignment with AAPM's Medical Physics Practice Guideline 4.a [24, 25]. Similarly, a decrease in the other types of errors was noted in the data recorded after the

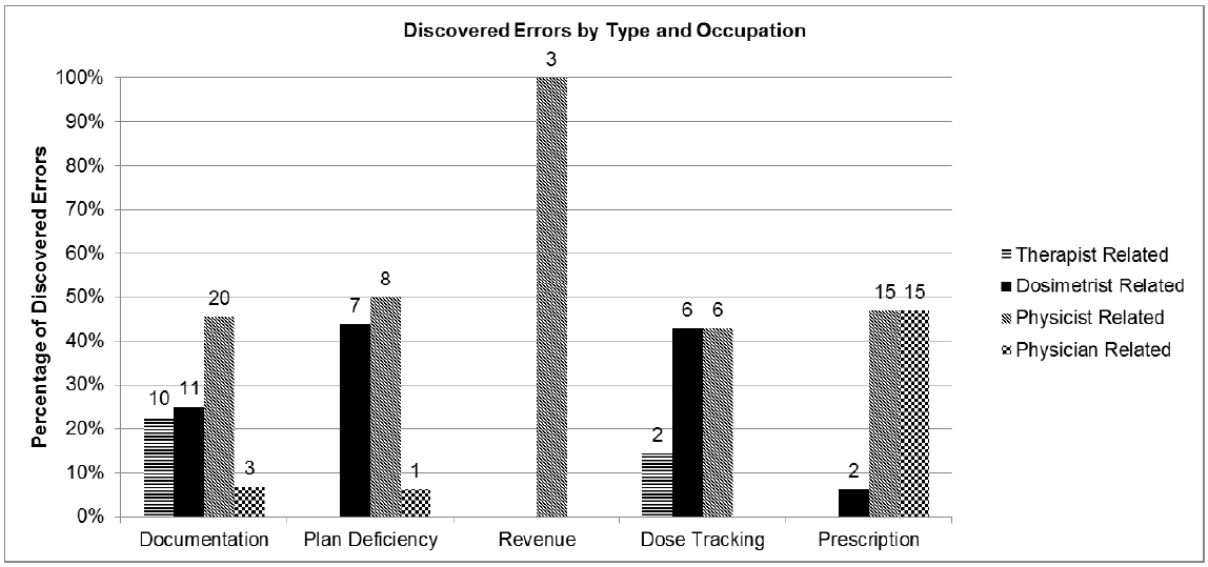

Figure 4: Percentage of discovered errors sorted by category after the implementation of a specific dose tracking checklist item (March 2015 through August 2015) is shown. The data is normalized to 100%. The raw number of recorded errors is shown above each bar.

implementation of the checklist item, but these were not statistically significant.

V. CONCLUSIONS

Our current protocol for performing independent secondary patient chart checks is effective. The unexpected utility of this after-first check proved that we could not eliminate this workflow process and that we needed to implement a quality improvement process to limit these errors. An average error rate of 3% suggests the need for continuous quality improvement, and periodical retraining, which may lead to improved treatment quality, patient safety, and increased clinical efficiency. The statistically significant drop in dose tracking errors following the implementation of a specific dose tracking checklist item in the pre-treatment plan check assessment demonstrates the efficacy of this method in the first iteration our PDSA cycle. With these results, the next step in our CQI process will be to address other errors noted to occur frequently, such as prescription errors, with another PDSA cycle involving modification to the dosimetrist's existing checklist and repeating the same analysis.

As a final note, our physics team submitted this work for the American Board of Radiology Maintenance of Certification Practice Quality Improvement, which incentivized full team member participation and unified the physics team towards the goal of quality care and helped commit individuals to this process.

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Received on 22-12-2016 Accepted on 18-01-2017 Published on 16-02-2017

DOI: https://doi.org/10.6000/1929-2279.2017.06.01.3