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Basic Original Report

Evaluation of near-miss and adverse events in radiation oncology using a comprehensive causal factor taxonomy

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Abstract

Purpose: Incident learning systems (ILSs) are a popular strategy for improving safety in radiation oncology (RO) clinics, but few reports focus on the causes of errors in RO. The goal of this study was to test a causal factor taxonomy developed in 2012 by the American Association of Physicists in Medicine and adopted for use in the RO: Incident Learning System (RO-ILS).

Methods and materials: Three hundred event reports were randomly selected from an institutional ILS database and Safety in Radiation Oncology (SAFRON), an international ILS. The reports were split into 3 groups of 100 events each: low-risk institutional, high-risk institutional, and SAFRON. Three raters retrospectively analyzed each event for contributing factors using the American Association of Physicists in Medicine taxonomy.

Results: No events were described by a single causal factor (median, 7). The causal factor taxonomy was found to be applicable for all events, but 4 causal factors were not described in the taxonomy: linear accelerator failure (n = 3), hardware/equipment failure (n = 2), failure to follow through with a quality improvement intervention (n = 1), and workflow documentation was misleading (n = 1). The most common causal factor categories contributing to events were similar in all event types. The most common specific causal factor to contribute to events was a "slip causing physical error." Poor human factors engineering was the only causal factor found to contribute more frequently to high-risk institutional versus low-risk institutional events.

Conclusions: The taxonomy in the study was found to be applicable for all events and may be useful in root cause analyses and future studies. Communication and human behaviors were the most common errors affecting all types of events. Poor human factors engineering was found to specifically contribute to high-risk more than low-risk institutional events, and may represent a strategy for reducing errors in all types of events.

Note—Earn CME credit by taking a brief online assessment at https://academy.astro.org.

Conflicts of interest: None.

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Introduction

Efforts to improve patient safety in radiation oncology (RO) have accelerated in recent years. One strategy for improving safety in RO clinics is to implement an incident learning system (ILS).[1-3] Incident learning refers to the process of reporting a patient safety near-miss or adverse event, analyzing it in detail, and developing interventions to prevent it from happening again.[1,4] Numerous prior publications have recommended the use of ILS in RO clinics,[1,5-8] and ILS has now become a requirement for practice accreditation through the American Society for Radiation Oncology (ASTRO; https://www.astro.org/Accreditation.aspx). There have also been efforts to implement multicenter ILS to more broadly address patient safety in RO, such as the Radiation Oncology Incident Learning System (RO-ILS) from ASTRO and the American Association for Physicists in Medicine (AAPM)[9] and the Radiotherapy Incident Reporting and Analysis System from the Center for Assessment in the Radiological Sciences patient safety organization (www.cars-pso.org).

With increased reporting into ILS, there have been efforts to develop standardized operational frameworks, metrics, and terminologies to learn from errors in RO,[1,10-14] and prior works have described many features of errors in radiation therapy, such as where they originate in the RO workflow,[15] which clinical features predict event reporting,[16] and the frequencies at which different RO team members report events.[17,18]

Although there is a substantial and growing literature on incident learning in the RO context, few reports specifically focus on causes of errors in RO.[19-21] This is arguably the most important aspect of incident learning, because understanding the underlying causes may lead to the prevention or mitigation of errors. A thorough understanding of factors contributing to errors also supports improvement of radiation therapy equipment and practices through strategies such as human factors engineering (HFE). This requires a deeper analysis of the causal factors that drive error beyond reductionist assignments such as "human error."[22] The reports published in the RO literature thus far do not present a deep analysis of this type and are highly variable in their use of causal factors. In 2012, a standardized taxonomy of potential causes of RO errors was proposed by an AAPM workgroup,[1] and this system was adopted for use in the RO-ILS system. There has been no report to date that systematically tests or validates this causal factor schema in the RO context. The goal of this study therefore was to systematically test the causal factor taxonomy to better understand the causes of patient safety events in RO through a retrospective analysis of casual factors leading to near-miss and adverse events in both a departmental ILS and multicenter ILS.

Methods

Three hundred event reports were randomly selected for analysis from our institutional ILS, entered between February 2011 and September 2015, and from Safety in Radiation Oncology (SAFRON), an international RO incident reporting system maintained by the International Atomic Energy Agency (https://rpop.iaea.org/SAFRON). The institutional incident reports were events that did not affect the patient but were deemed to be potentially important safety indicators. The reports were split into 3 groups: low-risk institutional, high-risk institutional, and SAFRON. The low- and high-risk institutional groups contained 100 reports each with low (0-2) and high (3-4) near-miss risk index (NMRI) scores, respectively. The NMRI has been described previously.[14] The third group (eg, SAFRON) contained 100 reports from SAFRON. An attempt was made to randomly select reports from SAFRON, but the final dataset was drawn largely from more recent reports because earlier reports often had insufficient information required for causal factors analysis.

Each event was classified as a near-miss, an incident, or "other," consistent with the definitions used in the current version of RO-ILS (circa 2017). A near-miss is defined as a safety event that did not reach the patient. An incident is defined as an event that reached the patient with or without harm. Incidents include events in which radiation dose was not delivered as intended and events not involving radiation dose (eg, collision, fall). For instance, an error leading to a repeat computed tomography (CT) simulation scan would be considered an incident in this analysis. Events classified as "other" are of 2 types: unsafe conditions (eg, conditions that increase the probability of a safety event) or operational/process improvements (eg, nonsafety event). Examples of events classified as "other" include a report concerning an unclear policy on isocenter localization procedures (considered an "unsafe condition") or a problem scheduling a patient's initial treatment because of unclear assignment of duties (considered a "process improvement").

Three raters (MS, RF, OG) were trained in the interpretation of the causal factor table and causal factors were scored by consensus. The raters retrospectively analyzed each event for contributing factors using a custom data collection tool created using REDCap.[23] The data collection tool allowed each rater to enter the event date, index number, NMRI, and to select potential factors contributing to the event. The potential contributing factors used in this study were identical to those proposed in the AAPM consensus report on incident learning (Appendix D[1]). This causal factor taxonomy was created collaboratively with input from representatives from radiation therapy professional societies (eg, ASTRO, American College of Radiology) and a core developer of Radiation Oncology Safety Information System and SAFRON. The taxonomy was specifically designed to be robust and specific to radiation therapy, easy to use, and mappable to other taxonomies. This specific taxonomy was chosen because the same 19 categories were used in the RO-ILS system. Of note, the casual factors tables in RO-ILS were updated and modified in October 2016 after