Individual QI projects from single institutions

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Decreasing Radiograph Errors in Pediatric Sports Medicine Clinic

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ABSTRACT

Background: Radiographs are frequently ordered for general musculoskeletal complaints in the outpatient setting. However, incorrect laterality, incorrect location, or unnecessary radiographs have been reported as errors in our clinics. This quality improvement (QI) project aimed to reduce incorrect duplicate radiographs in outpatient pediatric sports medicine clinic. The overall global goal was to stop unnecessary radiation exposure in our pediatric patients. **Methods:** Using QI methodology, we evaluated the current clinic flow, the process of ordering radiographs, and the completion of radiographs at the main sports medicine outpatient clinic. Staff communication, staff education, and patient participation were identified as the prominent gaps in our clinic process. We implemented interventions using progressive biweekly Plan-Do-Study-Act (PDSA) cycles to promote change and to reduce our radiographic errors. **Results:** Retrospective baseline data demonstrated baseline errors of 9% (10/106) in the main outpatient clinic. After 6 months of PDSA cycles, we found no duplicate errors. Highly successful interventions included radiograph screening survey for families, staff education, and improved staff communication. The project was expanded to a second outpatient clinic with baseline errors of 6% (4/64). After 2 months of PDSA cycles, no duplicate errors were found. **Conclusion:** Our goal was to reduce incorrect duplicate radiographs in outpatient sports medicine clinic and limit unnecessary radiation exposure in our pediatric patients. A reduction in duplicate errors at 2 clinics occurred using the Institute for Healthcare Improvement model to facilitate change. Effective communication between physicians, clinical athletic trainers, radiology technologists, patients, and families drove the success of this quality improvement initiative. *(Pediatr Qual Saf 2018;3:e089; doi: 10.1097/pq9.0000000000000089; Published online July 13, 2018.)*

INTRODUCTION

Background Knowledge

Incident data on radiographic error reporting has increased in the literature and spanned health care systems and continents. The Radiology Events Registrar was first established by Royal Australian and New Zealand College of Radiologists in 2006 to report adverse events within radiology department and to define, analyze, and decrease radiology incidents.[1] The initial data from the Australian patient safety reporting system confirmed clinical management as the most common error when computed tomography, radiographs, and ultrasounds were performed.[2]

Moreover, in the United States, evaluation of near misses and latent safety events in 18 pediatric emergency departments confirmed radiology errors as the third most common event in pediatric emergency research network.[3] Human factors were attributed to 87% of the incident reports rather than equipment issues.[3] Furthermore, a subanalysis classified the incidents into subtypes: test delays, result delays, report changes, wrong patient, wrong site, or other.[4] Systems issues and human errors were a common thread causing excess radiation exposure in 54% of the incidents and indirectly increasing medical morbidity for the pediatric patient.[4]

Where could potential failures occur when radiographs are ordered? The imaging care cycle can be categorized into 4 phases: preprocedural, procedural, postprocedural, and clinical action.[1] Preprocedural phase solely relies on the clinician asking a clinical question and placing the order. The procedural phase encompasses patient preparation, the reliable performance by radiology technologists and the presentation of the images in the system. The postprocedural phase relies on the radiologist for interpretation of the study and communication of the diagnosis. The clinical action phase is undertaken once the clinician receives the results and all phases of the imaging care

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cycle are completed. Rubio and Hogan[5] successfully initiated a 2-person verification system, Rad Check, to tackle preprocedural and procedural errors throughout a tertiary pediatric hospital. They demonstrated a statistically significant decrease in error incidence with Rad Check verification for radiology studies completed throughout this hospital system.[5]

Local Significance

Pediatric sports medicine is an outpatient subspecialty service at Nationwide Children's Hospital serving Columbus, Ohio, and the surrounding area with 8 outpatient locations. In 2015, the pediatric sports medicine division evaluated more than 15,000 patients and completed 5,800 radiographs during these encounters. In this busy clinical service, radiographs are often necessary for diagnostic evaluation of a musculoskeletal complaint and are preordered by the clinical athletic trainers before physician evaluation. In 2015, a total of 12 children had radiographic errors reported during the sports medicine visit in our internal reporting system.

Although an error incidence of < 1% (12/5,800) is low, incorrect radiograph errors are not benign and do have consequences for our young patients. First, the estimated lifetime cancer risk is not zero from radiation exposure from unnecessary radiographs; specifically, the spine and pelvis carry the most significant radiation risk compared with extremity radiographs.[6–11] Second, the estimated cost of extra musculoskeletal radiographic views ranges from $150 to $300 at our institution, which is incurred by the patient's insurance or the hospital due to the initial error. Third, incorrect radiographic errors slow clinical flow in the ambulatory setting, thereby, increasing patient wait times downstream.

Albeit incorrect radiographs are a rare event in our outpatient setting, errors still occurred. Given the significance of unnecessary radiation for our pediatric patients, we developed a quality improvement (QI) initiative to evaluate and reduce the radiographic errors during the preprocedural and procedural phase in our pediatric sports medicine division. The goal of this QI initiative was to decrease incorrect duplicate radiographs at our main outpatient location from a baseline of 9% (10/106) to zero duplicate errors by June 2016 and sustain for 1 year. The QI initiative focused on patient and family awareness, clinical staff training, and improved team communication to achieve the aim. Subsequently, the project was expanded to a second outpatient location to impact further pediatric patients seen within sports medicine division.

METHODS

Ethical Consideration

This QI work involved retrospective chart reviews in evaluating for radiographic errors and prospective Plan-Do-Study-Act (PDSA) cycles to reduce radiographic errors on current patients. Per policy, the project did not qualify as research involving human subjects. Therefore, approval by the Institutional Review Board at Nationwide Children's Hospital was not required.

Setting

Pediatric sports medicine is an outpatient subspecialty service with 8 locations in Columbus, Ohio, and the surrounding area. In 2015, the division completed over 15,000 patient visits with 5,000 patient visits completed at the main location in Westerville, Ohio. This location served the highest patient volume and was chosen as the initial site for the QI initiative. Once this project reached sustain mode, we selected the second busiest outpatient location for initiative expansion.

Data Collection and Definitions

We established a baseline of radiographic errors by retrospective chart review over a 14-month period for both locations. Patient charts were evaluated for duplicate radiographs completed in a single patient visit. We identified 106 duplicate studies at the main clinic location. At the second clinic, we detected 68 charts meeting these criteria. Each encounter was analyzed retrospectively and classified into 4 categories by a single sports medicine attending physician. The categories were no error, incorrect location, incorrect laterality, or an unnecessary radiograph.

Charts classified as no error, for example, had duplicate radiographs with stress views, special fracture views, multiple joint views due to trauma, and comparison views correlating with the chief complaint. We identified incorrect location errors when the patient complaint and initial radiograph completed did not match. The patient was then subsequently sent for a second radiograph as documented in the chart. For example, an initial foot radiograph was completed instead of an ankle radiograph based on the patient's chief complaint. Incorrect laterality errors were classified when the initial radiograph did not match the laterality of the chief complaint. The patient was then subsequently sent for a second radiograph to address the correct laterality. Additionally, the documentation in the chart supported the error rather than true comparison views.

Radiographs classified as unnecessary were based on a known contributing factor after discussion with the QI team. In our clinical flow, multiple radiographs could be preordered by a clinical athletic trainer and completed before the physician evaluation and assessment. At times, the clinical athletic trainers in our clinic noted uncertainty of the radiograph type needed for evaluation. Therefore, multiple radiographs were preordered and completed. Furthermore, the documentation by the physician did not acknowledge, evaluate, or incorporate the multiple radiographs for clinical management. Per the QI team discussion, classification of these instances in this category was inherent in our clinical process and a known error.

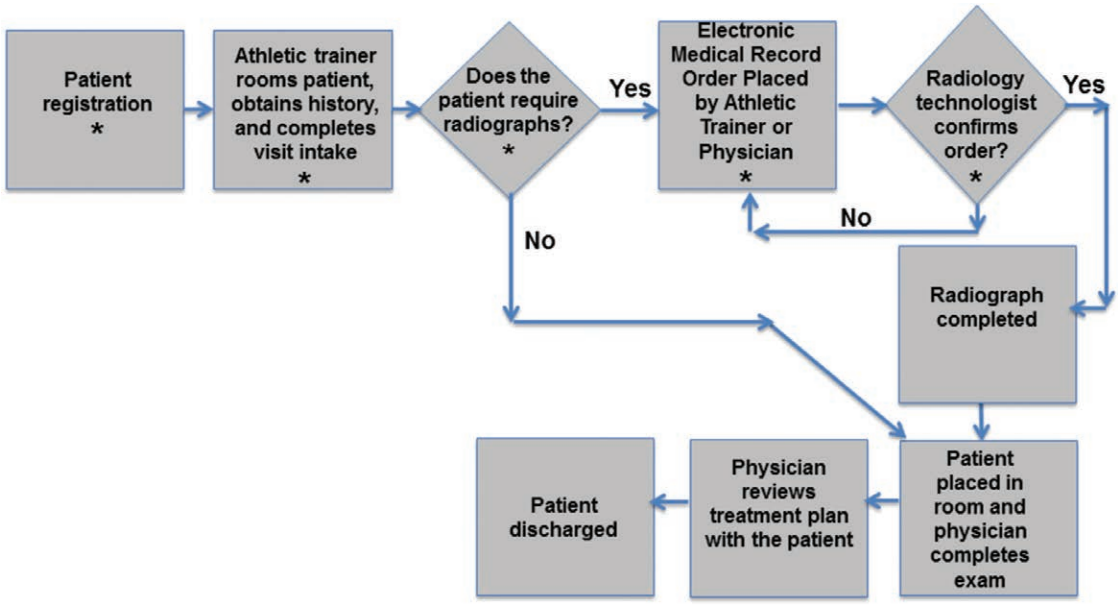

Fig. 1. Clinic patient flow and radiographic decision making. Process map outlines the clinical flow for patient from registration to discharge in pediatric sports medicine. The entire top row of this map was identified as a potential source of error and could lead to an incorrect radiograph (*). The QI team used this process map to identify key drivers and formulate initiatives to reach the aim of this QI project.

Interventions

We established a multidisciplinary QI team and included those involved in the preprocedural and procedural phases of the imaging care cycle. Specifically, the team was composed of attending pediatric sports medicine physicians, clinical athletic trainers, radiology technologists, and clinic assistants. The clinic assistants represent various educational backgrounds and play a role in rooming patients as well. All team members primarily worked at the main clinical location chosen for the QI initiative.

The team met initially and constructed a process map of typical patient flow from intake to discharge during a patient visit (Fig. 1) The process map allowed the team to identify potential preprocedural and procedural error points in our clinical flow. Next, the team formulated reasons for the known radiographic errors and developed a key driver diagram with the following 5 drivers: patient and family participation, clinic staff education, physician participation, team communication, and radiograph verification (Fig. 2).

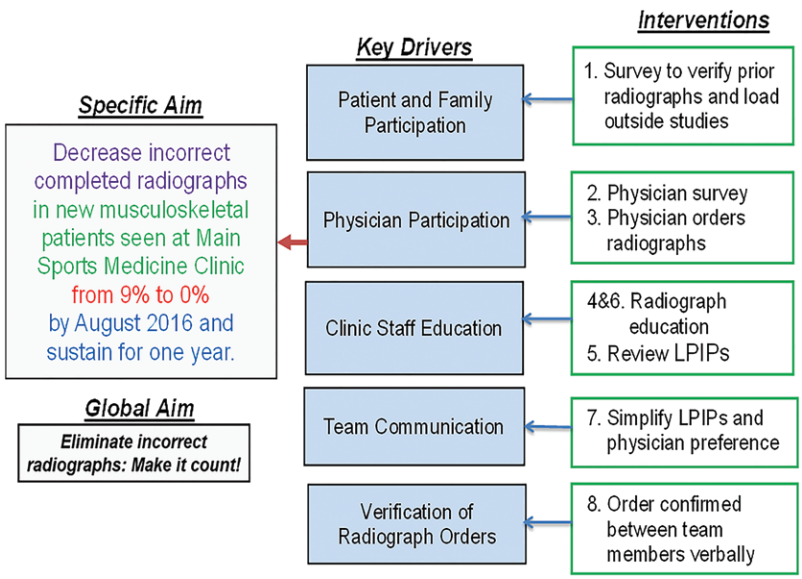

Fig. 2. Key driver diagram. The key driver diagram demonstrates the drivers identified by the team for this QI initiative: patient and family participation, physician participation, clinical staff education, team communication, and verification of radiograph orders. The interventions are labeled according to the PDSA cycles for initial clinical location.

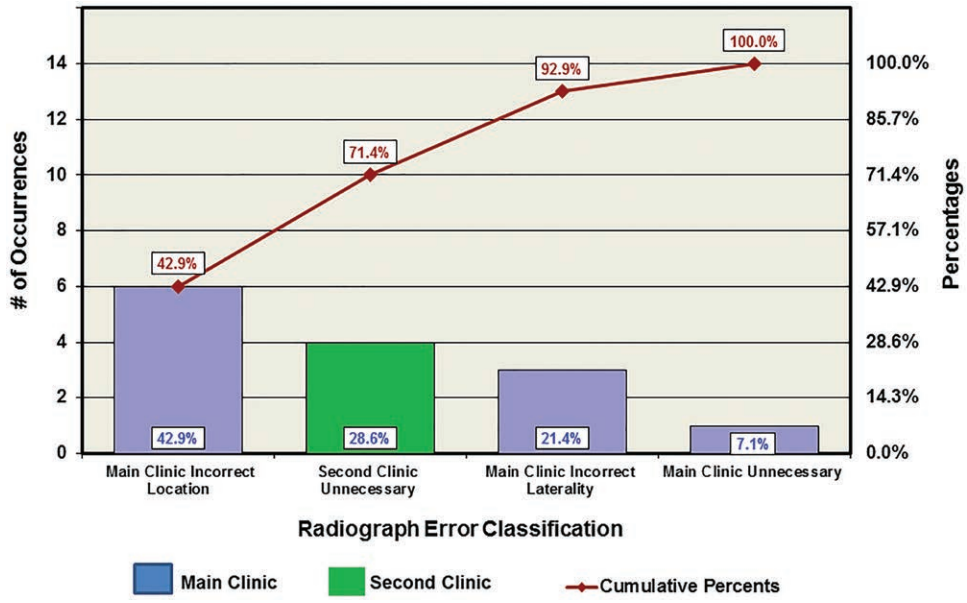

Fig. 3. Radiograph error classification at both pediatric sports medicine clinics. Baseline of classified errors at both pediatric sports medicine clinics represented on a Pareto chart. Radiographs were retrospectively classified as incorrect location, incorrect laterality, or unnecessary.

We established the radiographic error baseline by retrospective chart review for each outpatient location. At the initial outpatient site, 106 duplicate radiographs were analyzed in the prior 14 months; 10 errors were categorized. The error frequency was stratified using a Pareto chart. The Pareto chart demonstrated the most common radiograph error: incorrect location (Fig. 3). This finding also correlated with the QI team's perception of radiographic errors at the initial outpatient location. At the second location, 68 duplicate radiographs revealed 4 radiograph errors in the prior 14 months. These errors were all classified as unnecessary radiographs, displaying a different error distribution compared with the main clinic (Fig. 3).

We developed interventions related to each key driver, and serial PDSA cycles began the end of February 2016 to decrease duplicate radiographs at our main outpatient location (Table 1). First, we distributed a survey to patients and families at clinic registration. The survey addressed chief complaint, laterality, outside evaluation, and prior outside radiographs. Second, we surveyed the attending physicians in real-time to assess if errors were missed by our retrospective review or internal reporting system. Third, attending physicians placed their radiograph orders instead of clinical athletic trainers in the Electronic Medical Record (EMR). Over the next 2 months, a radiograph educational session, which was developed by sports medicine, was presented to all clinical athletic trainers. From these sessions, a review of the Licensed Provider Initiated Protocols (LPIPs) generated discussions within entire sports medicine division. The LPIPs guide clinical athletic trainers on the type of radiograph to preorder under preset clinical circumstances; yet, staff felt the LPIPs were complicated and difficult to follow. We simplified the LPIPs to streamline the protocols for the clinical athletic trainers. The radiograph educational sessions for the clinical athletic trainers were then repeated and updated to reflect simplified LPIPs. Additionally, the order sets for radiographs were changed in EMR to reflect simplified LPIPs. Any radiographs outside of the LPIPs needed to be placed by the attending physician. Throughout the initiative, verbal radiographic verification occurred between the radiology technologist, ordering team, patient, and family.

Subsequently, in March 2017, the QI project was expanded to a second location. The PDSA cycles were

Table 1. Interventions Implemented in Progressive PDSAs at Both Clinical Locations

Date Initiated at Clinical Location #1	PDSAs at Clinical Location #1
February 2016	1. Radiograph patient survey
March 2016	2. Physician survey to identify real time errors in clinic
March 2016	3. Physicians order radiographs in EMR
April and May 2016	4. Radiograph education to athletic trainers
June 2016	5. Review LPIPs
August 2016	6. Repeat radiograph education to athletic trainers
November 2016	7. Simplify EMR order sets in EPIC
*Continuous throughout project	8. Order confirmed between team members verbally
Date Initiated at Clinical Location #2	**PDSAs at Clinical Location #2**
March 2017	1. Radiograph education to athletic trainers
April 2017	2. Radiograph patient survey
April 2017	3. Physician survey to identify real time errors
May 2017	4. Team huddle before clinic to determine if radiographs are necessary
*Continuous throughout project	5. Order confirmed between team members verbally

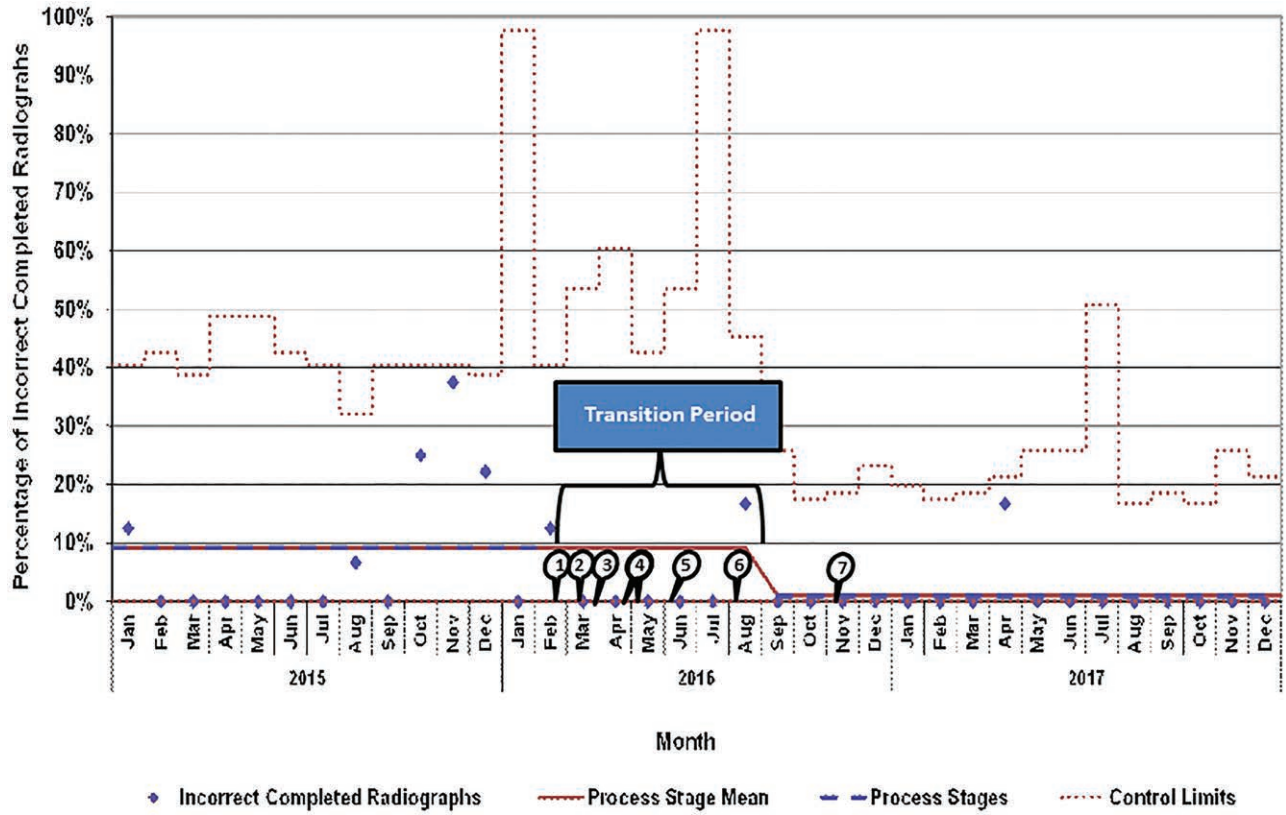

Fig. 4. Incorrect completed radiographs in main pediatric sports medicine clinic represented on a control chart (p-chart). Blue diamond represents incorrectly completed radiographs as a percentage of the total completed duplicate radiographs per month evaluated. The transition period represents the majority of the PDSA cycles. The PDSA cycles are labeled on the graph as points 1–7. At point 1, patients and families were given a radiology intake survey to complete related to chief complaint. At point 2, physician survey was completed to identify real-time errors. At point 3, physicians entered their own orders in EMR. At point 4, all athletic trainers and clinical staff were educated on radiographs—types, sets, locations, indications for ordering. At point 5, the LPIPs were simplified. At point 6, all athletic trainers were reeducated on radiographs—types, sets, locations, indications for ordering according to simplified LPIPs. At point 7, the EMR radiograph order sets were simplified and matched the current LPIPs.

adjusted for highest impact factor and the different error distribution (Table 1). First, radiograph educational sessions were presented to clinical athletic trainers. Next, patient surveys were employed to engage patients and families. Third, attending physicians were surveyed to identify real-time errors were missed by our retrospective review or internal reporting system. Our final PDSA at the second location had the biggest impact: a "team huddle" before the clinic session. The huddle specifically addressed unnecessary radiograph orders placed during the preprocedural phase. Throughout the initiative, a verbal radiographic verification occurred between the radiology technologist, ordering team, patient, and family.

Data Analysis

The radiograph errors were evaluated using a statistical process control chart, along with statistical testing of the pre- and postintervention error levels. Because we implemented the interventions over a period of several months, and these months are neither preintervention nor postintervention, they were excluded from the statistical tests, which consisted of Fisher's exact tests, performed using Minitab v17.1.

RESULTS

We achieved the goal to decrease incorrect duplicate radiographs in pediatric sports medicine from 9% over 6 months. After a statistical shift occurred, incorrect radiograph errors stayed within the control limits while the project was sustained for 16 months (Fig. 4). During the sustain mode, we evaluated 121 charts with duplicate radiographs, and 2 errors were identified. In August of 2016, the error was categorized as an unnecessary radiograph; the physician did not use the multiple radiographs preordered for evaluation, assessment, or the plan of care. The clinical athletic trainer ordered multiple radiographs without discussing with the physician; the physician did not feel the radiographs were warranted. In April 2017, we classified the error as incorrect location, and subsequently, another radiograph was ordered to address the chief complaint. Both instances led to a team discussion, a review of radiograph education, and the simplified LPIP. Most importantly, the lack of communication was the root cause of both errors.

When we spread the QI initiative to a second clinical location, we achieved our goal to decrease incorrect

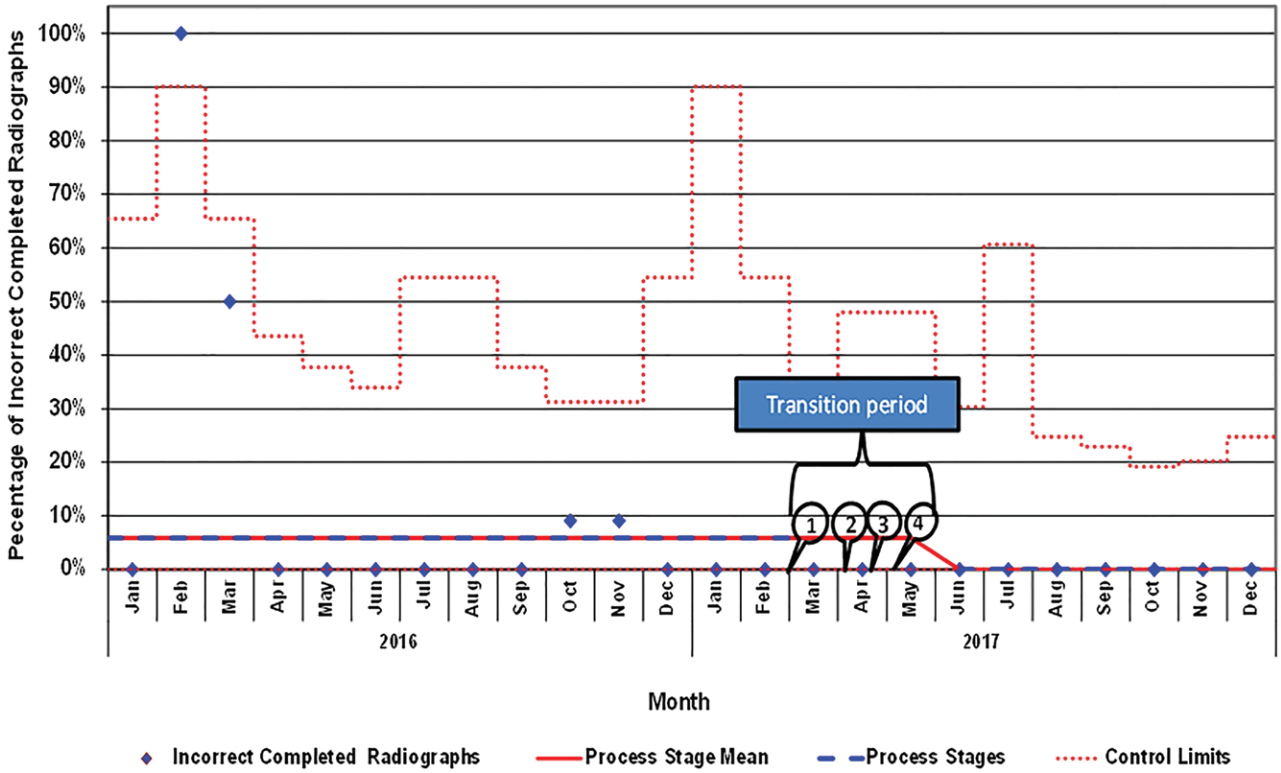

Fig. 5. Incorrect completed radiographs in the second pediatric sports medicine clinic represented on a control chart (p-chart). The blue diamond represents incorrectly completed radiographs as a percentage of the total completed duplicate radiographs per month evaluated. The transition period represents the PDSA cycles. The PDSA cycles are labeled on the graph as points 1–4. At point 1, all athletic trainers and clinical staff were educated on radiographs—types, sets, locations, indications for ordering. At point 2, patients and families were given a radiology intake survey to complete related to the chief complaint. At point 3, physician survey was given to identify real-time errors. At point 4, team huddles were done to discuss radiographs necessary before physician examination.

duplicate radiographs from 6% to no duplicate errors in 2 months. Incorrect radiograph errors stayed within the control limits while the project was sustained for 7 months (Fig. 5). During the sustain mode, we evaluated a total of 47 charts with duplicate radiographs, and no errors were identified.

DISCUSSION

Reduction of incorrect duplicate radiographs during clinic visits proved to be an effective and attainable goal in this fast-paced pediatric subspecialty clinic. The QI initiative focused on patient and family awareness, clinical staff training, and improved team communication to achieve the aim. This QI initiative did not have a detrimental effect on workflow. Rather, the initiative proved to be a forum for discussion between patients, families, clinical athletic trainers, and physicians. The verbal verification of radiographs by ordering staff, radiology technologist, families, and patients empowered those involved in the preprocedural and procedural phases. This verification differed from Rad Check by Rubio and Hogan,[5] which involved only health care workers in the verification process. We specifically believed involvement of the ordering staff member, radiology technologist, patient, and family in the verbal verification was critical to our initiative. This verbal communication was sustained throughout the PDSA cycles in both clinical locations.

Next, patient and family awareness was cultivated with the patient radiograph survey at clinic registration. This brief survey encouraged patients and families to participate. The survey reviewed the chief complaint, laterality, prior evaluation, prior studies, pending studies, and opened the conversation regarding outside radiographs. The clinical athletic trainer took a more focused intake to prevent any possible errors and needlessly repeating radiographs. This tactic specifically aimed to prevent unnecessary duplicate errors.

Also, clinical athletic trainers became invested to stop before ordering unnecessary radiographs. Education within our sports medicine division was essential to achieve the aim. In the early stages of the initiative, an obvious disconnect existed between clinical athletic trainers and physicians about radiograph orders. Feedback from an anonymous survey distributed to all the athletic trainers within the division drove the discussion and led to change. The survey revealed the gaps in radiograph education and complicated LPIPs as a cause for concern. The survey results also opened a division discussion to improve communication between the clinical athletic trainers and attending physicians.

Furthermore, radiograph education was necessary from the clinical athletic trainer survey results. Athletic trainers voiced a knowledge gap regarding radiograph indications, radiograph views, and the utility of radiographs when assessing a general pediatric musculoskeletal complaint. This gap was directly addressed threefold. First, a radiograph educational session was developed reviewing radiograph types, indications, and views ordered in the clinic. Second, the LPIP was simplified, and physicians now needed to directly order the stress views, special views, and comparison views in our clinical process. Physicians accepted responsibility to order radiographs outside of the simplified LPIP. Third, changes were made to radiograph ordering sets in EMR. The changes matched the simplified LPIPs further streamlining our radiograph ordering process for clinical athletic trainers.

Finally, the radiology technologists at each clinical location were vital to the success. From project initiation, they were included in this QI initiative. In our clinical flow, the radiology technologists were positioned as the last stop to prevent preprocedural and procedural errors. The technologists acknowledged that verbal communication with the patient, family, and team was essential. This enhanced verbal communication within all parties. If a discrepancy existed in the radiograph order, the technologists requested team clarification. Although simple, communication again proved pivotal to the project success.

Limitations

Several limitations were identified during this QI initiative. In our hospital system, an internal error reporting system currently exists. We found that errors were not always reported within the internal reporting system. Staff acknowledged that error reporting could be a tedious process. Therefore, the physician survey aimed to catch real-time errors missed in the retrospective review or the internal reporting system. Moreover, this project focused on a retrospective chart review evaluating errors; thereby, the project was prone to observer bias if the charts were not analyzed correctly. To minimize inherent bias, the QI team established strict definitions of radiograph error types for the initiative.

Charts with duplicate radiographs completed in a single patient visit were utilized to evaluate errors. This approach theoretically could miss single radiograph errors in a patient visit, a glitch we could not overcome for this project. Given the large volume of radiographs ordered in the sports medicine division, it was not feasible to retrospectively review every patient who had a radiograph completed. Therefore, using duplicate radiographs in a single patient visit served as a starting point to identify errors.

Prior outside radiographs not permanently uploaded in the radiology system also could be missed. Outside radiographs need to be uploaded in the radiology viewing system from the main hospital. Our division locations are all offsite. When patients bring outside radiology studies, the discs are viewed in real-time by the attending physician and are typically not sent for permanent uploading. The patient intake survey specifically aimed to prevent duplicate errors and inadvertently repeating radiographs.

CONCLUSIONS

Our goal was to reduce incorrect duplicate radiographs in outpatient sports medicine clinic and limit unnecessary radiation exposure in our pediatric patients. Between August 2016 and December 2017, the baseline errors were reduced from 9% to no identifiable duplicate errors using the Institute for Healthcare Improvement model to facilitate change. The most impactful PDSA cycles were patient surveys, radiographic education for clinical athletic trainers, LPIP simplification, and verbal team verification. Six months after a sustained change, the QI initiative was expanded to a second clinical location. Previous high impact PDSA cycles were employed driving the baseline error rate from 6% to no identifiable duplicate errors.

Communication between patients, families, and the health care team is paramount to quality and safety. Prior studies have evaluated near misses and errors in pediatric emergency departments.[3,4] Our work addressed a clinical problem of preprocedural and procedural radiograph errors using QI methodology in 2 outpatient clinic locations, which has not been reported in the literature. We intend to continue the QI initiative within our division, enhancing communication within the team, and expanding to our other clinical locations.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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