Reducing Instances of Staff Exposure to Ionizing Radiation in the PACU

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Reducing Instances of Staff Exposure to Ionizing Radiation in the PACU

Christina McAuliffe

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Abstract

Background

On the Post Anesthesia Care Unit mobile X-Rays were necessary on site for confirmation of medical device placement. There was an unofficial procedure in place which consisted of announcing when an X-Ray was to be taken, and which bay it was taken in.

Local Problem

Upon observation it was noted that the mobile X-Ray unofficial procedure was only being adhered to for approximately 25% mobile X-Rays taken on the PACU, unnecessarily exposing staff to ionizing radiation. There was also no written procedure or standardized training policy available at the facility.

Methods

Baseline ionizing radiation knowledge was assessed using a pre-assessment which consisted of five multiple choice and five true or false questions. Participants then viewed an educational powerpoint, and were administered a post-assessment to gather data on whether learning occurred. The scores on the assessments were averaged and the standard deviation was calculated to determine if the interventions were successful.

Results

Participants in the radiology department averaged 74% on the pre-assessment and 92% on the post-assessment. Participants in the PACU averaged 80% on the pre-assessment and 93% on the post-assessment. All participants completed the knowledge checkoff for the standardized procedure.
Conclusions

While the interventions in this quality improvement project were successful the results are not sustainable due to the facility not instituting a standardized safety training policy at onboarding, not including safety protocols in yearly education, and not having a written safety policy available for staff to access. In a future quality improvement project these deficiencies could be addressed for sustainability.
Reducing Instances of Staff Exposure to Ionizing Radiation in the PACU

Problem Description

The primary focus of this problem was the presence of radiology, and specifically X-Ray technicians, on the Post Anesthesia Care Unit (PACU). There was a procedure in place for notifying the nurses of when an X-Ray is being taken. This was due to the fact that the Post Anesthesia Care Unit is one open room with no opportunity to shield from the X-Rays other than moving far away from the radiation source while in use.

The procedure that existed was for the X-Ray team to audibly say “X-Ray” as well as the bay they were in before taking the X-Ray; this step was either missed or inaudible, resulting in staff being unknowingly exposed to harmful radiation on a regular basis. Staff safety was therefore being compromised, and this was a problem to be addressed to help ensure that staff were able to work in an environment that they can trust to be safe.

There was an average of one to two X-Rays observed being taken on the floor per day, totaling about seven per week, though this could be variable depending on the surgical cases performed. Through observation it was noted X-Rays were only audibly announced 25% of the time, resulting in staff members being exposed to approximately 75% of the X-Rays taken on the unit. This was an unacceptable and unsafe frequency. The existence of a verbal procedure to mitigate risks to the staff was a clear acknowledgement of the safety risks of having X-Ray come to the unit. This illustrated an attempt to lessen the risk to staff, though with an unofficial protocol that regularly failed to be followed an opportunity for procedural change was presented. Revision of the procedure introduced a system in which adherence could become standardized and eliminate non-adherence and staff exposure. The X-Rays could not be eliminated from the floor as they are essential to confirmation of surgical outcomes and are time sensitive, needing to
be completed before the patient is discharged from the PACU by the surgeon. Ensuring there was instead an effective safety procedure introduced to the unit helped improve staff safety. This was a necessary proposed change because participants reported that their lack of understanding of how X-Rays impact the body led them to be less concerned with adhering to X-Ray safety procedures.

Available Knowledge

After conducting a literature review of current available knowledge it was found that in studies conducted on exposure to radiation, typically the only available information focused specifically on surgeons. This was because of the frequent use of radiation during surgery and due to this, surgeons and those in the operating room are at risk of exposure more often than those in other settings. There was also limited information on the long term effects of repeated exposure to ionizing radiation. This was due to the fact that the effects of this exposure would reveal themselves long after the exposure, and as such, would be difficult to study over decades. However, there were some useful articles identified pertaining specifically to staff knowledge, education, and radiation exposure that were compiled and detailed below.

In the article by Alghamdi et al. (2020) the purpose was to identify areas for improvement in staff education pertaining to the current knowledge of the staff regarding the risk for ionizing radiation exposure and knowledge of techniques used to mitigate risk of exposure to healthcare workers and patients. In the article it was reported that while staff were found to be aware of the possibility of increase in cancer risk in the future for patients with regular radiation exposure, they were lacking in knowledge regarding best ways to reduce exposure to radiation, as well as the exact radiation dose received by an x-ray, incorrectly reporting the belief that abdominal ultrasounds and MRI’s resulted in higher radiation exposure than x-rays. The findings
of Alghamdi et al. (2020) are that there was a need for improvement in education regarding ionizing radiation risk for healthcare staff.

In the article by Behzadmehr et al. (2020) there was also a focus on evaluating healthcare worker’s knowledge levels in regard to radiation exposure. This article is a systematic review which included 1,848 articles and 41 studies on healthcare workers knowledge and attitude toward radiation protection. Behzadmehr et al. (2020) reported that approximately 50% of the studies found that healthcare workers had an average knowledge, and 60% had a positive attitude toward radiation protection. The authors suggested that there be an inclusion of radiation protection standards in the curriculum for students to enhance knowledge and awareness of radiation exposure risks and radiation protection measures.

In the article by Frane & Bitterman (2023) the point was made that fluoroscopic procedures pose the greatest risk to healthcare workers in terms of radiation exposure; the authors also noted that any radiation exposure poses a risk to both healthcare workers and patients. The authors discussed the three basic principles of radiation protection, listing them as justification, optimization, and dose limitation. The authors also noted that the key factors in reducing exposure are distance from the radiation source, duration of the exposure, and shielding methods. The authors conclusion regarding enhancing outcomes for the healthcare team was that there needs to be protocol development as well as education for staff on radiation best practices.

In the article by Hussain et al. (2022) there was an emphasis on discussing that imaging techniques are a vital diagnostic tool, and in the United States 50% of total ionizing radiation exposure is a result of exposure to medical imaging radiation. In the remainder of the article the authors focus on describing each different medical imaging source of ionizing radiation, exploring uses and risks for each of these different medical imaging technologies, and recognize
that while there is risk posed in utilizing these medical imaging technologies, they are essential to diagnostic medicine. The conclusions reached in this article pertain to the benefit and improvement of diagnostic technology and understanding of the disease process rather than discussing the safety of these medical imaging devices. This article was included due to the in-depth explanation of each medical imaging device and information on radiation despite the fact that the authors did not focus on the impact of the exposure to ionizing radiation. The article provided pertinent background information necessary to understand the function and uses of these technologies.

In the article by Matityahu et al. (2017) the focus was on fluoroscopic imaging and the impact of this technique on radiation exposure to surgeons. The article is a systematic review on radiation exposure to orthopedic surgeons. The databases utilized were PubMed and Cochrane, and the years were limited to 2000 through 2014. The authors included clinical studies and systematic literature reviews, and the authors had a specific focus on surgical specialty, procedure type, imaging used, radiation measurement methods, fluoroscopy time, radiation exposure, the use of protective equipment, and references to specific safety guidelines. The authors noted that when wearing a thyroid collar and lead apron radiation exposure was reduced by 96.9% and 94.2% respectively. The authors concluded that due to the increase in use of intraoperative imaging it is necessary to ensure radiation awareness of the surgeon. There was an emphasis on the importance of strict adherence to radiation protection for surgeons in training.

In the article by Pennington et al. (2019) there is also a focus on intraoperative imaging resulting in radiation exposure to healthcare workers. This article is a systematic review which reviewed English medical literature to “identify all articles reporting patient and/or surgeon radiation exposure in patients undergoing image-guided thoracolumbar instrumentation”
(Pennington et al., 2019). The authors noted that 85 articles met inclusion/exclusion criteria, of which 41 articles were included for analysis. The authors concluded that all image guiding modalities result in surgeon radiation exposure well below current safety limits.

In the article by Salama et al. (2016) a study was conducted which aimed to assess occupational radiation exposure and safety among healthcare workers, specifically in Saudi Arabia. For the study four healthcare facilities with radiological imaging were selected at random, and the study was conducted through measuring the radiation in the X-Ray and CT scan rooms as well as the diagnostic, imaging, and waiting rooms throughout the different hospitals. The authors noted that the results were “alarming” due to finding that there is a significant association between the levels of radiation exposure in all hospitals concerning imaging. The authors also noted that while thyroid shields and lead aprons are available, only about 50% of the hospitals had lead eyeglasses and lead shields, and that radiation dosimeters were only utilized between 57.7% and 68.9% of the time. The authors concluded that the staff and patients in Saudi Arabia were being exposed to radiation levels above standard guidelines, and there was a lack of safety equipment available in healthcare facilities to mitigate these exposure risks.

In the article by Shah et al. (2020) the use of intraoperative fluoroscopy was the focus of the article. The authors conducted a systematic review, with a specific focus on fluoroscopy used during hip arthroscopy procedures. The authors noted that fluoroscopy may place surgeons and patients at greater risk of radiation exposure. They noted that the review included nine studies with a mean subject age of 38.6 years. The mean time of fluoroscopy exposure was 0.58 seconds. The authors noted that the higher the BMI of the patient the greater occupational exposure there was due to the need for a higher effective dose, and they also noted that surgeons with more experience had shorter fluoroscopy times, reducing exposure. The authors concluded that annual
exposure to surgeons and patients is within acceptable limits, and key strategies to reducing unnecessary exposure include the proper use of protective equipment, specifically noting use of lead eyeglasses as essential, carefully selecting the correct imaging modality, and C-arm positioning.

In the article by Thaker et al. (2015) a systematic review was conducted to study the efficacy of policies and structural-level interventions on reducing radiation dose and risk of cancer. The authors noted that there were a total of 1,543 unique sources, which were then narrowed down to 16 sources to include in the systematic review. Fifty percent of the studies were focused on CT scans, and 50% of the studies were focused on x-rays or fluoroscopy. The authors reported that all studies included in the systematic review were successful in reducing radiation dose, exam frequency, or both. They also found that the programs that were multipronged were superior compared to the other four program types, which were policy or structural intervention, dose-feedback system, provision of training, and quality control audit. The authors also noted that there were significant limitations in these studies, including lack of proper controls, the fact that one article was rated as moderate for quality of evidence while all others were rated as low, and the wide variability regarding measurement of radiation exposure. The authors also noted that there was a general scarcity of studies available on this subject, leading to the necessary use of low evidence and limited studies, as those were the only ones available.

Lastly, in the article by Xie et al. (2016) radiation exposure to healthcare workers in the ICU due to use of a portable CT scanner was studied. The authors noted that while there were many studies on radiation exposure in the operating room, there was a lack of data available on radiation exposure in the ICU, and none included information on radiation exposure due to the
use of portable CT scanners. They also reported that while there is no data available on radiation dose range from both x-rays and CT scanners to ICU staff, they found that most healthcare professionals are aware that they should be as far away from the machine as possible when in use, and any level of radiation exposure is harmful. The authors reported in their findings that while most staff were below the standard levels for radiation exposure, eight doctors and one nurse received a dose exceeding the limit in a three month period; the authors concluded that it is still unlikely that the staff would be exposed over the annual limit. The authors concluded that while ICU staff do not receive high doses of ionizing radiation, it is highly recommended to monitor a small number of professionals for measures to protect pregnant staff in case of radiation overdose.

Originally the intent of the conducted literature review was to recognize the strengths and limitations of each individual article being reviewed; throughout summarizing the articles it became apparent that the limitations were universal across all 10 articles included. In each systematic review the authors specifically noted a lack of available, high quality evidence regarding radiation exposure to healthcare workers. There was also a lack of education in place for staff regarding the acceptable dosage of radiation and protective methods to minimize radiation exposure in the workplace.

Through summarizing the articles it also became apparent that, while the information is pertinent, there was an absence of strong data on this topic, leading to the conclusion that these articles, while providing insight into this problem, did not have strengths. The authors of these articles reported a lack of good quality evidence and studies, and due to the low quality of evidence presented there needed to be further studies conducted to help understand this potential safety risk. Many of the findings in the articles were similar to observations made on the PACU,
such as no formal staff safety education and a paucity of adhering to protocol regarding mobile imaging. Therefore, there was a need for further studies, as there was a scarcity of strong data as well as a gap in practice of the understanding of radiation exposure.

Rationale

In the hospital setting healthcare workers frequently encounter possible exposure to harmful substances, such as chemicals, radiation, and biological hazards. Therefore, hospitals have policies and procedures in place in order to mitigate risks for workers; these procedures can only be successful when adhered to by healthcare staff. When policies are not followed unnecessary exposure to health hazards is inevitable. In order to keep staff safe, it was necessary to review adherence to these policies and to amend the policies when it was found that these measures were not being followed. It was also essential to ensure educational programs are given to staff to increase understanding and awareness of the necessity of following protective procedures, as the facility’s yearly educational programs did not encompass the impacts of ionizing radiation on the body and the risks incurred by repeated exposure.

Specific Aims

The purpose of this quality improvement project was to increase staff safety within the PACU during the use of portable X-Ray machines on the unit. These X-Ray machines were frequently brought to the patient's bedside following surgical procedures, before the patient was admitted to their respective unit, to ensure that the placement of medical devices during surgery was successful.

The specific aim of this project was to reduce instances of non-adherence with the X-Ray safety procedure from 75% to 10% within three months. To measure adherence X-Ray
technicians would be observed demonstrating the procedure and giving a ten second waiting period before taking the X-Ray. Nurses would demonstrate acknowledgement of the announcement by moving a safe distance away from the X-Ray area. There would also be an educational intervention in which staff are given a pre-assessment and a post-assessment which would establish a baseline for their knowledge preceding the educational intervention. These assessments would measure the effectiveness of the educational intervention. The goal for the post-assessment was for staff to pass with an 80% or higher. The purpose of the educational intervention was to ensure that staff members understood the risks of repeated exposure to ionizing radiation and understand why this quality improvement project was being implemented.

The global aim of this intervention was to increase staff safety and decrease unnecessary staff exposure to X-Rays through increasing verbalization of when an X-Ray is about to be taken and ensuring nearby staff had adequate time to move to a safe distance. This project was implemented utilizing a PDSA cycle. The planning component of this project included meeting with X-Ray technicians, nurses, and the nurse manager to ensure that the proposed improvement measures were possible to carry out and test. The do stage involved administering the educational intervention to the X-Ray technicians and PACU nurses. The study stage involved compiling the data that was collected during the intervention, recognizing patterns, and carrying out informal interviews with both nursing staff and X-Ray technicians about their perceived benefits and concerns with the intervention. The act stage consisted of taking information gathered from the data and interviews to adjust the policy if necessary. The PDSA cycle was completed once within the first thirty days.
Methods

Context

In the PACU at CMC when X-Ray technicians came to the patient bedside there was a consistent issue with alerting the staff when an X-Ray was about to be taken so they could move away from the area. Within the PACU there were a variety of professionals working together.

Table 1

*PACU Nursing Staff Characteristics*

<table>
<thead>
<tr>
<th>Role</th>
<th>FTE %</th>
<th>Part-time %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursing Director (1)</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Charge Nurses (4)</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Nursing Staff (30)</td>
<td>66%</td>
<td>33%</td>
</tr>
<tr>
<td>Licensed Nursing Assistants (5)</td>
<td>100%</td>
<td>0%</td>
</tr>
</tbody>
</table>

As illustrated in Table 1, the nursing staff in the PACU included one full-time nursing director, two full-time charge nurses, two part-time (evening) charge nurses, approximately twenty full-time nurses, approximately ten part-time (evening) nurses, one lead licensed nursing assistant, and four licensed nursing assistants. Professionals who briefly visited the unit to give handoff reports and to check on patients when requested included the certified registered nurse anesthetists, surgeons, anesthesiologists, physicians assistants, and operating room nurses. This intervention solely focused on the radiology technicians and the nursing staff on the PACU working directly with post-surgical patients.

The intervention provided education to both the PACU staff and the radiology staff about the adverse effects of repeated unnecessary exposure to ionizing radiation, and included
instituting a standardized alert procedure to ensure that staff are given adequate time to put distance between themselves and the radiation source. While there was no immediate cost-benefit with this intervention, it was possible that this intervention could have helped prevent high medical costs for staff members later in life that could be incurred if they had continued to be exposed to unnecessary radiation. Staff do not wear radiation exposure meters and therefore it was not possible to measure how much radiation a staff member was exposed to over time. The education was provided to the hospital for no cost, and was delivered to staff members while they were not with patients rather than requiring payment for overtime hours for a formal educational seminar. Therefore, there was no cost for this intervention. There was the existing cost of the exposure to radiation as a total health detriment to staff, and the benefit of the education was to help prevent unnecessary exposure to ionizing radiation, minimizing the cost to the health of the staff as well as reduce potential medical expenses incurred by the staff later in life should they experience adverse health outcomes due to repeated radiation exposure.

**Interventions**

This intervention consisted of two parts: providing staff education about the effects of unnecessary exposure to ionizing radiation, and updating the current policy about how X-Ray technicians were to alert staff members to their presence while giving them time to move away from the X-Ray area. For the educational component a short staff education course was created consisting of a six slide powerpoint, and there was a knowledge checklist to be completed during the training. The knowledge of the staff was assessed with both a pre-assessment and a post-assessment, which measured effectiveness of the educational intervention by providing data about how much knowledge the staff gained when contrasted to their prior scores on the pre-assessment.
The policy about how to alert staff members to the taking of an X-Ray also needed to be updated and standardized. Some X-Ray technicians did not alert staff at all. Some inaudibly announced that an X-Ray was being taken. Some followed policy and audibly alerted staff and stated which patient bay the X-Ray is being taken in; did not give time for staff members to move from the area. The original policy was to state “X-Ray, PACU Bay (#),” and the update to the policy was to allow ten seconds between the announcement of the X-Ray and the taking of the X-Ray for the staff to move a safe distance away. Instituting this policy was part of the educational intervention, and both PACU staff and X-Ray staff needed to demonstrate understanding of this procedure before being checked off for knowledge in this area.

**Study of the Interventions**

Assessment of the impact of this intervention was completed in two parts: assessing the effectiveness of the educational component, and assessing knowledge in the standardized policy. To assess the educational interventions effectiveness there was a pre-assessment, which established the staff’s baseline knowledge about exposure to ionizing radiation, and a post-assessment which measured effectiveness of the intervention by seeing how the staff performed compared to the pre-assessment.

To study the effectiveness of the implementation of the standardized procedure for announcing X-Rays it was necessary to ensure demonstrating the procedure was part of the knowledge checklist for the staff. Before staff could be checked off as knowledgeable they needed to pass the post-assessment with a score of 80% or higher, verbalize the mobile X-Ray safety procedure, and demonstrate the procedure.
**Measures**

For this intervention a knowledge assessment tool was used to study the processes and outcomes of the intervention. An Ionizing Radiation Knowledge Assessment Tool (IRKAT) was developed through utilizing facility competency tools and tailoring them to the desired outcomes of the educational intervention. It consisted of a 10 question multiple choice and true or false pre-assessment to establish a baseline of the staff’s understanding of ionizing radiation, and a 10 question multiple choice and true or false post-assessment which measured the impact of the educational intervention on the staff’s knowledge. The use of a knowledge assessment tool is frequent in healthcare educational programs, and demonstrating knowledge in both the subject matter and the policy intervention was the best way to measure success of the intervention.

**Analysis**

The data collected for these interventions was discrete quantitative data. There were a finite number of questions on the pre-assessment and post-assessment. Descriptive statistical analysis was utilized when reporting and analyzing the data. Individual scores on the pre- and post-assessments were used to calculate the average percentage scored on the tests. The average was calculated to illustrate the improvement in knowledge after the post-assessment. By analyzing the average in both of these cases it helped to illustrate how well the staff understood the information and how effective the educational intervention was for the unit overall rather than on an individual basis.

After collecting and analyzing the data to get the average, standard deviation was also used to provide a more in depth analysis of the effectiveness of the intervention. This illustrated the amount of variability in the staff’s scores, which helped assess the overall knowledge of
those who have taken the tests. Before the intervention the expectation was that there will be a higher standard deviation, and the ideal outcome was that after the educational intervention the standard deviation will lower, illustrating a smaller gap in knowledge between staff members.

**Ethical Considerations**

Due to the fact that this quality improvement project was focused on staff knowledge rather than patients, the ethical considerations were different than they would have been if this was a project relying on the participation of patients. The biggest ethical consideration in this case was timeliness; the educational component of this project should not impinge on the staff’s time or take away from their ability to care for patients while on shift. Therefore, the education was structured to have flexible timing, and was shortened as much as possible to still achieve knowledge goals while being brief for the staff. This led into the consideration of efficiency; the educational intervention was structured to maximize efficiency and cut down on waste. Lastly, equity was an ethical consideration for this project. All staff members had equitable access to the interventions, meaning there was more than one offering of the education. There was flexibility in providing the education at times that were best for the staff so each staff member had equal access to the education.

**Results**

The educational intervention and policy intervention was implemented on both the PACU and the radiology units, with onsite visits and data collection occurring in each department. The goals of the interventions were explained and the assessments, education, and demonstrations were administered to staff. Seven staff members on the radiology unit consented to participation, and five staff members on the PACU consented to participation in the first round of implementation. Due to staffing limitations and patient needs, the first round of implementation
was the only round able to be completed. Staff participants were selected based on availability (having no patients assigned) and their willingness to participate, thus constituting a convenience sample.

**Figure 1**

*Educational Intervention Process*
A pre-assessment was given to each staff member, and consisted of ten questions (five multiple choice and five true or false questions) regarding ionizing radiation and the impact of and damage caused by X-Rays on the cellular level. The results of the assessments are illustrated in Table 2. The assessments were not scored until completion of both the pre-assessment and post-assessment. On the radiology unit the average of the pre-assessment scores was 74%. On the PACU the average of the pre-assessment scores was 80%. An educational powerpoint was then presented to the participant, and the information presented in the powerpoint was specifically relevant to the questions on the pre-assessment, and also presented the new proposed procedure for mobile X-Ray safety on the PACU.

Table 2

*Individual Staff Pre- and Post-Assessment Scores*

<table>
<thead>
<tr>
<th>PACU Department</th>
<th>Pre &amp; Post Assessments</th>
<th>Average Scores</th>
<th>SD</th>
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<tbody>
<tr>
<td>Pre</td>
<td>Pre</td>
<td>80</td>
<td>12.25</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>93</td>
<td>8.37</td>
</tr>
</tbody>
</table>

![PACU Knowledge Scores](chart.png)
A post-assessment was then given to the participants which consisted of the same questions as the pre-assessment in order to most accurately ascertain that learning occurred during the educational intervention. The pre- and post- assessments were scored at the same time, after the participant completed both assessments, so as to not reveal the answers prematurely and skew results. The average of the post-assessment scores in the radiology department was 92% and in the PACU 93%, indicating success of the educational intervention and knowledge in mobile X-Ray safety following the interventions.

The last step of the intervention was to complete a knowledge checkoff, which required that all participants take both the pre- and post- assessment, passing the post-assessment with a score of 80% or higher, received the education on mobile X-Ray safety, verbalized the new procedure, and watched a live demonstration as well as demonstrated the proper procedure themselves. All participants completed 100% of the knowledge checkoff.
The expectation when administering the pre-assessments was that the radiology department would score higher than the PACU nurses due to their education and licensing requirements. Due to the unexpectedly low pre-assessment scores in the radiology department compared to the nurses in the PACU the test was reviewed with feedback from participants to edit for clarity. Materials and feedback were analyzed to establish a root cause for the pre-intervention gap in knowledge between the radiology department staff and the PACU staff. During these discussions with radiology staff it was established that the gaps in knowledge may be due to a lack of continuing education on theory learned during their initial radiology education. Staff who had been working for a year or more noted that they had “forgotten” much of what had been learned during formal education, leading to low scores on the pre-assessment, rather than the problem being with the materials used in the intervention. This indicates a lack of yearly education that includes theory rather than a focus on hospital policies, and should be investigated further as there was a fundamental gap in knowledge about what X-Rays are and how they impact cells biologically. This gap in biological knowledge was not present on the PACU among the nurses.

Participants in radiology also noted the unit’s lack of a written policy in regard to mobile X-Ray safety, resulting in a lack of standardization in each radiology technician's approach to alerting PACU staff of X-Rays. The policy is not part of on-boarding competencies, and their understanding of procedure is dependent on their trainer rather than on unit policies. This shed light on the discrepancies noted in the mobile X-Ray procedure, and led to a conclusion that this safety intervention was necessary to standardize practices and ensure staff safety.
Discussion

Summary

In order to increase mobile X-Ray safety procedure compliance an educational program for mobile X-Ray safety was introduced both in the radiology department and the PACU, and all participants were required to fulfill a knowledge checkoff to ensure they had the knowledge and tools necessary to comply with the procedure. The procedure entails the radiology technician audibly announcing X-Ray and the specific PACU bay they are in, and providing ten seconds for the staff members to move at least six feet away from the bay where the X-Ray will be taken.

Key Findings

When data collection began, staff self-reported confusion in regard to mobile X-Ray safety procedures due to a lack of both a written procedure and standardized training procedures while onboarding in both the radiology department and in the PACU. The pre-intervention scores for the radiology technicians averaged 74%, while the PACU nurses averaged 80%. The questions on the assessment were designed to identify the staff’s knowledge regarding the impact of ionizing radiation on the body. The educational presentation addressed these topics for the purposes of ensuring the staff understand the medical complications that could occur after long-term repeated exposure to ionizing radiation, and was successful in increasing knowledge both for the radiology technicians and the PACU nurses, bringing their post-intervention assessment score averages to 92% and 93%, respectively.

This project incorporated both a standardized policy and a knowledge checkoff, so while the specific aim was met in the short term there is low likelihood that observed changes will be permanent. Without the introduction of a written, standardized safety policy that includes
onboarding knowledge assessments at the microsystem level, adherence to mobile X-Ray safety procedures will return to pre-intervention rates.

**Root Cause**

The specific aim for this project was not met. Knowledge increased for all staff members after the educational intervention; during data collection staff members shared frustrations with a lack of written policy on mobile X-Ray safety. There is also no mobile X-Ray safety knowledge checkoff when onboarding new radiology technicians. The technician’s safety practices are not regulated by the microsystem, leading to disorganization and non-standardized practices. Another key finding that must be noted is the lack of continuing education for the radiology technicians to ensure they remain competent in safety practices. This can be addressed on a microsystem level by including the impact of ionizing radiation on the cellular level in continuing education provided by the hospital.

**Interpretations**

Alghamdi et al. (2020) published an article which had a focus on identifying areas for improvement in educating staff on the risk of ionizing radiation exposure, and the results were similar to those seen in this quality improvement project. According to Alghamdi et al. (2020) staff were aware of the increased cancer risk when exposed to ionizing radiation; staff had a knowledge deficit regarding protecting oneself from ionizing radiation. A systematic review by Behzadmehr et al. (2020) also corroborates the findings of this quality improvement project as well as Alghamdi et al. (2020), and the authors suggested an inclusion of radiation protection education to enhance knowledge of the risks of radiation exposure as well as methods of protection.
Staff directly benefit from these safety procedures. When working with exposure to ionizing radiation on a regular basis adverse health outcomes, such as a higher probability of developing cancer, can result. Therefore, it was necessary for staff to be aware of this risk, as well as be trained in how to minimize exposure to ionizing radiation.

The expectation at the commencement of this project was that the staff would be aware of the increased cancer risk associated with repeated exposure to ionizing radiation. There was also an expectation of a written policy for mobile X-Ray safety, and of formal safety training when onboarding. The outcome of this quality improvement project was the discovery of no written policy and no formal safety training in the radiology department and the PACU. The facility had no available written safety policy when a search of their policy database was conducted. On the pre-assessment there was a question regarding the increased probability of cancer directly resulting from repeated exposure to ionizing radiation, and this question was answered correctly by 7 out of 12 participants. The expectation was that at least 10 of the participants would be able to correctly answer this question during the pre-assessment. On the post-assessment this question was answered correctly by all 12 participants, illustrating that the knowledge deficit was addressed by the intervention.

An opportunity cost of this project was implementing an educational intervention and knowledge checkoff rather than implementing a standardized written safety policy for the facility. The results of this project are not sustainable, therefore putting the staff at potential risk of repeated exposure to ionizing radiation which increases the probability of developing cancer. This can result in direct healthcare costs for the employees, as well as the potential loss of life due to illness. While the knowledge deficit was addressed for the participants, future employees
and staff who were unable to participate may have the same knowledge deficit and therefore will be at increased risk of non-adherence, which can result in adverse long-term health effects.

**Limitations**

This project is not generalizable. The sample is a convenience sample due to administering the interventions to employees who were available, and those who were willing to participate. Due to this, the sample of staff who received the educational intervention is not representative of the entire hospital system, nor is it representative of the same departments in other hospital systems.

Factors that may have impacted validity are the methods of data collection. Data collection was conducted via the pre-assessment and post-assessment, and analysis was conducted based on the results of these assessments as well as participant feedback. Participant feedback was not collected formally through a survey. The feedback was substantial and necessary to include in the analysis. However, because a formal survey was not utilized the validity of the feedback was reduced.

Actions were taken to minimize limitations, primarily reviewing the pre- and post-assessment tools for quality and clarity. The pre-assessments were not scored until after the completion of the educational intervention and the post-assessment. This choice was made to ensure that the impact of the educational intervention could be measured, rather than participants memorizing answers and artificially inflating scores. The results of the post assessment were then representative of the learning that occurred during the educational intervention.
Conclusion

Usefulness

This quality improvement project helped to identify potential root causes of non-adherence to mobile X-Ray safety on the PACU. Through conducting a literature review this project also recognized the scarcity of information available on the long term impacts of ionizing radiation exposure on healthcare staff. It was also recognized through current literature as well as this project that there is a missed opportunity for yearly education for healthcare staff pertaining to radiation safety. These results can help inform healthcare policy to create more sustainable procedures and practices dedicated to staff safety.

Sustainability

Without addressing the root cause, the specific aim of reducing non-compliance from 75% to 10% is unsustainable, and therefore the root cause of having no written hospital policy or knowledge assessment at onboarding is an issue that can be addressed in a future project to offer more sustainable change. Implementation of new continuing education as well as written, standardized procedures are both topics that can be addressed in future quality improvement projects, and are necessary to address in order to achieve this project’s specific aim permanently.

Potential for Spread to Other Contexts

This quality improvement project corroborated other literature findings concerning current issues in healthcare facilities in regard to safety practices when utilizing ionizing radiation. Due to the scarcity of evidence of long term impacts of ionizing radiation on the body, this project can help inform further research of the impacts of the paucity of this information.
Implications for Practice

The results of this quality improvement project suggest that it is necessary to include radiation safety training when onboarding staff who will frequently encounter ionizing radiation. Units should also institute yearly continuing education to ensure staff remain aware of the risks of continued radiation exposure. Staff should also be able to demonstrate safety procedures, and these procedures should be written policies that staff are trained formally on during orientation. This formal training will ensure standardized safety procedures that adhere to the written safety policies.

Suggested Next Steps

A future project dedicated to instituting a written radiation safety policy for mobile X-Ray use, both at this and other healthcare facilities, is suggested. It is also suggested to ensure staff are informed of the potential risks of long-term ionizing radiation exposure, and are knowledgeable in methods to mitigate that risk. Further studies on the long-term impacts of ionizing radiation on the body should be conducted to address the scarcity of current literature.
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