Improving Nurse Anesthetist Radiation Safety and Dosimetry Badge Compliance in Endoscopy

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Abstract

Problem: Nurse anesthetists in the Endoscopy unit of a large quaternary academic medical center are exposed to radiation throughout their workday, but noncompliance with wearing their radiation dosimetry badge has been as high as 89.5% - 98.7% of nurse anesthesia staff. Chronic fluoroscopy radiation exposure disproportionately increases the risk of cataracts, unilateral brain cancers, and chromosomal damage of healthcare workers. Dosimetry badge compliance is necessary for fluoroscopy radiation exposure to be properly measured and maintain a safe working environment for nurse anesthetists. **Purpose:** The purpose of this quality improvement project is to increase nurse anesthesia radiation dosimetry badge compliance with the use of a radiation safety timeout over a 15-week period in the Endoscopy unit. **Methods:** A project team consisting of a project leader, nurse anesthesia champion, and Endoscopy nurse champion instituted a radiation safety timeout practice change in the Endoscopy unit. Project strategies included electronic and unit-based education to 25 nurse anesthetists and 15 nurses (emails and in-services), collaboration (weekly site visits and project champions), and evaluation (data collection and analysis). Nurse anesthetists completed an anonymous QR code survey tool, evaluating the frequency of fluoroscopy cases in which the radiation safety timeout was performed, and dosimetry badges were correctly worn. **Results:** Fifteen weeks of data collection showed an average reported compliance of 83.8% with proper display of dosimetry badges and 73% with the radiation safety timeout. Survey response rate was 33.9%. Run charts show a non-random increase in dosimetry badge compliance, but the trend showing increased radiation timeout compliance may be due to reminders from nurse anesthesia staff, and not the intervention itself. Re-education through email and an in-person in-service led to increased compliance reporting during week 3. A change in leadership contributed to absence of data in weeks thirteen through fifteen. **Conclusion:** Dosimetry badge compliance did not reach 100%, but non-significant improvement exists since implementation of the radiation safety timeout and education. Knowledge gaps and opportunities for re-education to increase nurse anesthesia buy-in and compliance will be assessed and ongoing.

Keywords: Dosimetry badge compliance, radiation safety timeout, Nurse Anesthetist (CRNA), fluoroscopy, radiation safety education, endoscopy unit

Improving Nurse Anesthetist Radiation Safety and Dosimetry Badge Compliance in Endoscopy

Problem

Chronic fluoroscopy radiation exposure disproportionately increases the risk of cataracts, same-side brain cancers, and cytogenic markers of chromosomal damage of healthcare workers, such as certified registered nurse anesthetists (CRNAs) (Fazel and Einstein, 2022; Ko et al., 2018). In a recent observational study including 9747 medical staff with occupational exposure to doses of radiation, over 15% had lens dose equivalents great than 20 millisievert (mSv), which is the limit set by the International Committee on Radiological Protection (Borrego et al., 2020; Fazel and Einstein, 2022). More alarming, though, is up to 96% of the medical staff considered for the study failed to wear their assigned dosimetry badges, which monitor radiation safety for both provider and patient (Borrego et al., 2020). It is difficult to quantify the economic burden of increased cancer risk among healthcare radiation workers and their non-compliance with radiation dosimetry badges, but a gross estimations can be made using overall cancer prevalence and X-Ray-associated cancer risk, such that $1.8 million dollars of the $94.8 billion dollars in lost earnings related to cancer deaths in persons aged 16 to 84 years are related to medical radiation exposure (Islami et al., 2019; Moores, 2016).

Low dosimetry badge compliance and high risk of excessive radiation exposure is the current problem within the anesthesia providers working in the Endoscopy unit of a large quaternary care academic medical center in Maryland. Interviews with the CRNA staff found low knowledge regarding proper dosimetry badge display, and no standard check or “time-out” before fluoroscopy procedures. Moreover, 89.5% - 98.7% of CRNA staff in any given month have dosimetry readings of zero. In the month of May 2019, only one CRNA had a dosimetry reading of 131 mrem recorded (Figure 2). Other root causes responsible for this problem are a lack of a radiation safety timeout to ensure availability and proper display of radiation badges (Figure 1). The proposed evidence-based solution for the problem is implementation of a radiation safety timeout during the procedural timeout and radiation safety education.

Available Knowledge

Of the available evidence supporting this intervention, seven articles were selected based on quality and relevance to the proposed project. Behzadmehr et al. (2021) was rated as IIB on the Johns Hopkins Nursing Evidence-Based Practice rating scale, while the remaining six articles were level IIIA-B (Aizer et al., 2019; Brun et al., 2018; Choi et al., 2019; Matsuzaki et al., 2022; Qureshi et al., 2022; Sierra et al., 2022) (see Table 1). The most common recommendations by Behzadmehr et al. (2021) were that some form of formal education on radiation safety is necessary, and there should be sufficient radiation protection devices supplied by the hospital. Healthcare worker knowledge, attitude, and awareness of radiation safety practices is average, positive, and average, respectively. Education and training are essential for improved radiation safety.

In general, studies showed short-term improvement in providers knowledge regarding radiation safety following a radiation safety training program that consisted of either single or multiple education sessions (Aizer et al, 2019; Brun et al, 2018; Choi et al, 2019; Qureshi et al, 2022). Aizer et al (2019), Choi et al (2019), and Matsuzaki et al (2022) showed significantly reduced radiation exposure following radiation education and a radiation safety timeout. However, Sierra et al. (2022) showed that chief residents in vascular surgery had similar radiation dose exposure to high exposure attendings following a radiation safety curriculum that the attendings did not receive. Qureshi et al. (2022) showed significantly improved radiation knowledge, and increased dosimetry badge compliance. Small sample sizes and researcher-made non-validated instruments weakened many of the studies (see Tables 1 and 2 for more detail regarding the evidence review and synthesis).

Rationale

The Promoting Action on Research Implementation in Health Services (PARIHS) theoretical framework (Figure 3) was deemed appropriate for this project site. Capacity for internal facilitation of the practice change, quality of the organizational context, and strength of the evidence supporting practice change are the three tenets of the framework (Kitson et al., 1998). The PARIHS framework is ideal for this quality improvement project (QIP) because there is buy-in from the Endoscopy unit nurses and CRNAs, as well as their leadership. Additionally, the project site has myriad experience in performing research and implementing evidence-based practice. The site's designation as a Magnet hospital also drives active engagement in, and a culture for, research and QIPs at the unit, hospital, organizational, and national levels, as it is a requirement for Magnet certification (ANA, 2023). Lastly, there is sufficient mid-level evidence to support the practice change.

Methods

Context

The culture and climate at this large academic quaternary medical center in Maryland is one that wholly supports research and QIPs. For example, discovery, excellence, healthcare transformation, and high-quality care are phrases that describe the pillars of the institution's values, mission, and vision. Within the hospital's units and policies, QIPs can be found on posters and in enhanced recovery after surgery protocols. The resources of the unit are vast, as it belongs to an institution reported to be at the top third of hospital earners nationally (Cohn and Rector, 2019).

Within the endoscopy unit, there are three procedure rooms, each caring for three to eight patients per day. In every procedure room, there is a fluoroscopy machine, a nurse workstation, an anesthesia work area, an anesthesia machine, and an endoscopy scope cart. The rooms are small, such that anesthesia providers are forced to be within 1-2 meters of an active fluoroscopy machine, even when not manipulating the airway. Nurses, proceduralists, anesthesia providers, and students have access to lead aprons and lead glasses on the unit. Each staff member is assigned a monthly radiation dosimetry badge meant to be worn at the collar and in the midline of the outside of the lead apron for every radiation emitting procedure. Prior to every procedure, there is a procedure time-out, but the timeout does not include radiation safety criteria. Despite the frequent use of fluoroscopy, there is also no regular radiation safety in-service or education for anesthesia provider or endoscopy nurse staff. The institution has a radiation physicist that is responsible for tracking radiation dosimetry data sent from Mirion Technologies for all employees assigned a Mirion optically activated dosimetry badge. Weekly or monthly dosimetry reports can be generated by the radiation physicist, but generally the physicist only notifies radiation workers with radiation exposure doses higher than institutional limits (see Figures 4 and 5 for additional details regarding the current and proposed structures and processes on the unit).

Intervention

The evidence-based radiation safety timeout and education program was implemented over a 15-week period in a large academic quaternary medical center. Adapted from Aizer et al. (2019), a 2-item checklist was used for a radiation safety timeout (Appendix A). Printed and laminated versions of this radiation safety checklist were taped to the nurse workstations as a reminder for the radiation safety timeout. The desired process was that the radiation safety timeout be performed before every endoscopy procedure utilizing fluoroscopy. Ideally, the radiation safety timeout occurs immediately following the procedure timeout and is performed by the endoscopy nurse (see Figure 5 for the desired process).

The educational component of the intervention addresses basic radiation physics principles, how radiation exposure is measured and reported, biological effects of long-term radiation exposure, tactics, and behaviors to reduce radiation exposure, dosimetry badge features and functions, and how to properly wear the radiation dosimetry badge (see Appendix B). A binder version of the education PowerPoint was kept in the endoscopy break room shared by nurses and CRNAs. Education was tracked using a Research Electronic Data Capture (REDCap) survey tool (see Appendix C). Development of educational materials was the collaborative effort of the project lead, the radiation physicist, and the clinical site representative using PowerPoint presentations currently in use at the University of Texas Health Science Center at Houston and the UConn Health Radiation Safety Office. In total, eight CRNAs and endoscopy nurses completed the education tracking survey, but it was discovered many did not know to scan the survey quick response (QR) code at the completion of education. During in-services, the project leader educated 25 CRNAs and 15 endoscopy nurses over the initial four weeks of the QIP.

Education was presented monthly at in-services or through email, along with updates on project progress. The project lead, the charge nurse, and the clinical site representative (CSR) were champions for change and project implementation. Strategies and tactics to achieve the project aims involved accountability, buy-in, collaboration, data, and education by obtaining formal commitments, creating incentive with food and coffee rewards during week 3 of implementation, changing the physical structure with radiation timeout checklists and dosimetry badge reel holders, tracking progress with self-report survey results, and conducting ongoing monthly education, respectively (Bingham, 2010). Weekly chart reviews were performed to identify CRNAs who met inclusion criteria (a CRNA assigned to an endoscopy room with at least one fluoroscopy case during the shift), but did not complete a survey. This allowed for tailored re-education and encouragement to participate.

Measurement

Multiple structure, process, and outcome goals were measured to assess for successful change during implementation of the QIP. Using REDCap, CRNAs self-reported on “yes/no” survey questions addressing badge location on the collar, midline, and outside of the lead apron (yes or no), as well as adherence to radiation safety protocols, frequency of dosimetry badge use, and self-perception of the effect of the intervention (see Appendix D and Appendix E). Initially, survey “yes/no” responses on the were to be cross-references to dosimetry badge data reports to assess for congruency with self-report survey data, but dosimetry data was delayed by 3 months due to new shipping and badge analysis turnaround times. As a result, dosimetry data could not be obtained. Qureshi et al. (2022) demonstrated that as compliance with radiation dosimetry badges increases, radiation dosages on dosimetry reports should also increase. All these tools are reliable, as they will be repeatedly administered throughout the intervention period within the same cohort.

Contextual elements that contributed to success, failure, and efficiency was the unit’s willingness to implement change, despite being in a stressful transitional period with high staff turnover, increased responsibility (pediatric cardiology recovery was combined with endoscopy recovery) and changed in endoscopy leadership. During the intervention period, the unit was being combined with the outpatient cardiac catheterization lab. The added stress may have caused a negative change in the perception of the intervention and lead to failure. Evaluation of this was ongoing with the survey questions and qualitative interviews with CRNAs. Cost was of little significance to this project, as there was no need to hire additional specially trained staff, radiation dosimetry badges were already present at the site, and physical and time resources for implementation and data tracking were minimal.

Ethical Considerations

There were eight steps that were performed before obtaining approval at the project site. First, the project lead collaborated and communicated with the site and school to obtain a student affiliate agreement as well as, provide the information for all project team members. Second, an Approval Form was submitted along with CSR approval of the project. Third, the project sponsor and project specialist reviewed the application and responded with written documentation of project approval or denial. Steps four through seven involved project site and University institutional review board (IRB) review and submission of documentation of the IRB decision to the affiliated point of contact. At this academic medical center, special members of the IRB are present to help address project ethical concerns, if any. Step eight was the final step and signified that the DNP student had been granted permission to proceed with the QIP. There were no foreseen, actual, or potential conflicts of interest regarding the implementation and desired outcomes of this DNP project.

Results

Analysis of quantitative data was achieved with Run Charts. Run charts allow changes in data to be assessed over time with comparison to a median line calculated using all data, or with baseline data. The X-axis is week zero through week 15 of the data collection period from September through December 2023. The Y-axis contains weekly survey data on survey completion rates, dosimetry badge compliance, and radiation safety timeout compliance, respectively (see Figures 6, 7, and 8). Non-random variation in the data that can be assigned a cause is known as special cause variation and denotes a significant change in a process (NHS, 2009). The first three weeks of data collection was used as a baseline, but the median line was calculated using all 15 weeks of implementation and data collection. The target goal line for all CRNAs was to reach 100% compliance with survey completion rates, dosimetry badge compliance, and nurses' compliance with the radiation safety timeout. Originally, mean radiation dosimetry data from Mirion reports for the endoscopy CRNAs was going to be captured using a run chart, but as explained previously, this was not feasible. Of the 109 CRNAs who met eligibility criteria for the QIP, 37 completed REDCap compliance surveys over 15 weeks (Weekly Response Rate Mean = 33.9%) (see Appendix F and Figure 6). Of the 37 completed surveys, radiation safety education and a pre-procedure radiation safety timeout produced a "shift" regarding baseline data, but this did not satisfy a significant "shift" regarding the trend line (six or more consecutive points above the median line) (see Figure 7). In the first 3 weeks of data collection the median dosimetry badge compliance was 33.3% (Figure 7). In week 3 there was a large in-service with coffee and donuts to incentivize project buy-in and compliance. Subsequently, weeks 5, 6, 7, 9, 10, 11, and 12 have 100% dosimetry badge compliance. Given the timing of the intervention with the shift in data, the shift is most likely non-random, and the radiation safety timeout and radiation safety education had an effect on increasing dosimetry badge compliance (NHS, 2009).

Radiation timeout compliance resulted in a "mixture" (where connected data points frequently cross the median line) (see Figure 8). Weeks 3, 5, 7, 11, and 12 had 100% compliance, but this was interspersed with timeout compliance rates ranging from 0% to 60% in weeks 2, 4, 6, 10, 13, 14, and 15, which were below the median line. This indicates that there is either combined data from two different populations, or two processes operating at different levels (NHS, 2009). The phenomenon is likely related to comments on surveys, where CRNAs write, "I have to remind the nurse to do the radiation safety timeout." Weeks 7-10 showed a negative trendline where timeout compliance decreased from 100% to 50%. Additional nurse education and training regarding the radiation timeout is likely needed.

A narrative review and analysis helped fix implementation problems. Data regarding opinions, feelings, perceptions, observations, and problems related to achieving structure, process, and outcome goals were collected through the dosimetry badge and radiation safety compliance survey's comments. Many CRNAs commented, "I do not have lead glasses." This was rectified by sending an education email instructing where CRNAs could find lead glasses available for sign out in a storage closet between two of the endoscopy rooms. Others have helped identify missing surveys commenting, "I did an add-on case that unexpectedly used fluoroscopy, so I didn't remember to wear my dosimetry badge and the timeout was not done."

Discussion

Re-education, reminders, recruitment of junior student champions, and placement of an educational binder in the endoscopy breakroom in Week 2, helped improve compliance to 100% in week 3, but goal attainment was not sustained. At week 12, there was premature termination of the QIP survey and QR codes following nurse anesthesia administrative changes. The impact of this QIP was an improvement in nurse anesthetist radiation dosimetry badge compliance and safety. Secondarily, many of the endoscopy nurse anesthetists who did not have protective lead glasses now know they are available for sign-out in endoscopy since the implementation of this

QIP. Implementation of this QIP did not create additional cost to the site, nor did it interrupt efficient workflow, as the radiation safety timeout was concomitant with the procedural timeout.

The limitations of this QIP included high nurse anesthesia staff turnover and increased per diem staff, which resulted in unawareness of the project. The endoscopy nurses performing the radiation safety timeout faced competing priorities and burnout, as they were short-staffed while being cross trained to recover pediatric cardiac catheterization patients. There was a low overall response rate (33.9%) with a high risk of self-report bias, and lastly, monthly dosimeter badges were not always delivered on time, limiting validation of survey responses.

Conclusion

A radiation safety timeout and providers who are apprised of radiation safety knowledge, protects healthcare workers and patients through increased dosimetry compliance and tracking of radiation exposure. Although 100% radiation dosimetry badge compliance was not achieved following implementation of the radiation safety timeout and radiation safety education curriculum, there was non-siginificant improvement. In the future, a CRNA champion should continue implementation of this QIP in endoscopy, as only continued incentives, education, and leadership will promote the development of a culture preoccupied with, and committed to, radiation safety. Strenghts of this QIP include a site supportive of evidence based practice, staff interested in improving radiation safety, and improved knowledge of radiation yearly limits, radiation safety measures, and actual radiation emission in endoscopy cases. In the Fall of 2024, this QIP is spreading and will be implemented in the interventional radiology department by a student nurse anesthetist. Radiation safety education should be incorporated into the site’s yearly core competencies for clinical staff. The radiation safety timeout should be incorporated into the electronic health record timeout flowsheet, as it will provide a visual cue for the nurse performing the timeout, help improve compliance, mitigate untoward exposure to ionizing radiation, and potentially reduce future healthcare costs related to cataracts and cancer.

References

Aizer, A., Qiu, J. K., Cheng, A. V., Wu, P. B., Holmes, D. S., Wagner, S. R., Bernstein, S. A., Park, D. S., Cartolano, B., Barbhaiya, C. R., & Chinitz, L. A. (2019). Utilization of a Radiation Safety Time-Out Reduces Radiation Exposure During Electrophysiology Procedures. *JACC. Clinical electrophysiology*, *5*(5), 626–634. https://doi.org/10.1016/j.jacep.2018.12.002

American Nurses Association (ANA). (2023). *Magnet recognition program- Eligibility criteria.* Retrieved April 1, 2023, from https://www.nursingworld.org/organizational-programs/magnet/apply/eligibility-criteria/

Behzadmehr, R., Doostkami, M., Sarchahi, Z., Dinparast Saleh, L. & Behzadmehr, R. (2021). Radiation protection among health care workers: knowledge, attitude, practice, and clinical recommendations: a systematic review. *Reviews on Environmental Health*, *36*(2), 223-234. https://doi.org/10.1515/reveh-2020-0063

Bergström, A., Ehrenberg, A., Eldh, A. C., Graham, I. D., Gustafsson, K., Gillian, H., Hunter, S., Kitson, A., Rycroft-Malone, J., & Wallin, L. (2020). The use of the PARIHS framework in implementation research and practice—a citation analysis of the literature. *Implementation Sciene, 15*(68), 1-51. https://doi.org/10.1186/s13012-020-01003

Bingham, D., & Main, E. K. (2010). Effective implementation strategies and tactics for leading change on maternity units. *The Journal of Perinatal & Neonatal Nursing*, *24*(1), 32–42. https://doi.org/10.1097/JPN.0b013e3181c94a24

Borrego, D., Kitahara, C. M., Balter, S., & Yoder, C. (2020). Occupational doses to medical staff performing or assisting with fluoroscopically guided interventional procedures. *Radiology*, *294*(2), 353–359. https://doi.org/10.1148/radiol.2019190018

Cohn, M., & Rector, K. (2019). Given UMMS profits, critics as why it's seeking to raise rates at flagship hospital. *Baltimore Sun.* Retrieved April 1, 2023, from https://www.baltimoresun.com/news/investigations/bs-md-medical-system-profit-20190529-story.html

Fazel, R., & Einstein, A. J. (2022). Radiation risk to healthcare workers from diagnostic and interventional imaging sources. *UpToDate*. Retrieved October 31, 2022, from https://www.uptodate.com/contents/radiation-risk-to-healthcare-workers-from-diagnostic-and-interventional-imaging-procedures

Islami, F., Miller K. D., Siegel R. L., Zheng, Z., Zhao, J., Han, X., Ma, J., Jemal, A., & Yabroff, K. R. (2019). National and State Estimates of Lost Earnings From Cancer Deaths in the United States. *JAMA Oncology, 5*(9):e191460. doi:10.1001/jamaoncol.2019.1460

Karellas A. (2020). Challenges in Dosimetry and Radiation Dose Trends. *Radiology*, *294*(2), 360–361. https://doi.org/10.1148/radiol.2019192414

Kitson, A., Harvey, G., & McCormack, B. (1998). Enabling the implementation of evidence based practice: a conceptual framework. *Quality in Health Care: QHC*, *7*(3), 149–158. https://doi.org/10.1136/qshc.7.3.149

Ko, S., Kang, S., Ha, M., Kim, J., Jun, J. K., Kong, K. A., & Lee, W. J. (2018). Health effects from occupational radiation exposure among fluoroscopy-guided interventional medical workers: A systematic review. *Journal of Vascular and Interventional Radiology*, *29*(3), 353–366. https://doi.org/10.1016/j.jvir.2017.10.008

Moores, B. M. (2016). Cost-risk-benefit analysis in diagnostic radiology: A theoretical and economic basis for radiation protection of the patient. *Radiation Protection Dosimetry*, *169*(1-4), 2–10. https://doi.org/10.1093/rpd/ncv506

National Health Service Institute for Innovation and Improvement (NHS). (2009). *A guide to creating and interpreting run and control charts: Turning data into information for improvement*.

University of Warwick: Coventry, UK. Retrieved April 1, 2023, from https://www.england.nhs.uk/improvement-hub/wp-content/uploads/sites/44/2017/11/A-guide-to-creating-and-interpreting-run-and-control-charts.pdf

Phillips, G., & Monoghan, W. P. (2011). Update for nurse anesthetists: Radiation for anesthesia providers. *AANA Journal*, *79*(3), 257-267.

Qureshi, F., Ramprasad, A., & Derylo, B. (2022) Radiation monitoring using personal dosimeter devices in terms of long-term compliance and creating a culture of safety. *Cureus 14*(8), e27999. doi:10.7759/cureus.27999

Table 1

Evidence Review

Aizer, A., Qiu, J. K., Cheng, A. V., Wu, P. B., Holmes, D. S., Wagner, S. R., Bernstein, S. A., Park, D. S., Cartolano, B., Barbhaiya, C. R., & Chinitz, L. A. (2019). Utilization of a Radiation Safety Time-Out Reduces Radiation Exposure During Electrophysiology Procedures. JACC. Clinical Electrophysiology, 5(5), 626-634. https://doi.org/10.1016/j.jacep.2018.12.002 Level: III-B					
Purpose or Hypothesis	**Type of Evidence and Research Design**	**Sample (population, size, setting)**	**Intervention Procedures**	**Primary Outcome/Measures**	**Results Conclusions**
The purpose of this study was to assess the effects of a radiation safety timeout on radiation exposure during electrophysiology procedures	Although the IRB involved in this study considered it a quality improvement initiative, it was performed as a prospective observational cohort study. Carried out between 2015 and 2017	**Sampling Technique:** Convenience **Eligible Participants:** Patients 18 years of age or older presenting to the EP suite for a procedure. **Setting:** New York University Langone Medical Center EP Lab. **Excluded:** All patients less than 18 years of age. **Accepted:** 1040 EP Lab patient cases were included	**Control Protocol:** Pre-intervention data (dose area product, in Gy * cm^2) was collected prospectively for 6 months without the staff and physicians knowing of the planned intervention. **Intervention protocol:** Prior to beginning each EP Lab procedure and following the procedure	**Dependent Variable:** **Dose Area Product (DAP),** defined as the dose and area of a patient that is irradiated, which is strongly correlated with cancer induction. **DV Measure:** The product of Gray (Gy) (equal to J/kg) and body surface area that is absorbing the radiation (cm^2).	**Statistical Results:** Student's Normal T-test, Chi-Square or Fisher Exact, Mann Whitney U Test, linear regression, and logistic regression were used to compare normal continuous variables, categorical variables, nonparametric data, adjusted analyses of normal distributed data, and adjusted analyses of

		Intervention: Implementation of a 7-point radiation safety checklist/timeout. Nurses, physician assistants, physicians, and fellows in the EP lab were provided with a 10-minute education about the timeout. A physical copy of the radiation safety timeout was attached to the procedure timeout. **Power Analysis:** Not performed **Group homogeneity:** Pre-intervention patient demographics (n=594) were not significantly different from post-intervention patient demographics (n=448)	timeout, a 7-item checklist was used for a radiation safety timeout: 1) Is the lowest acceptable frame rate programmed? 2) Is the bed height elevated as close as is safely possible to the image intensifier? 3) Is the beam collimated? 4) Is the magnification as low as possible? 5) Are all shields and protective drapes in place? 6) Are all physicians and staff members present properly wearing dosimetry badges? 7) Will saving of fluoroscopy images be used if possible rather than fluorography/cine images?		binary data, respectively. Median DAP decreased from 18.7 Gy*cm^2 pre-intervention to 14.7 Gy*cm^2 three months into the intervention period ($p = 0.007$). Even after adjusting for patient demographics and procedure characteristics, there remained a significant decrease in DAP ($p = 0.021$) Twelve months following the 3 month implementation period, the DAP was 13.1 Gy*cm^2, which remained significantly lower than the pre-intervention period of 18.7 Gy*cm^2 ($p<0.001$)

			Treatment Fidelity: All 448 patient cases following implementation of the timeout received the radiation safety timeout.		**Conclusion:** A radiation safety timeout significantly reduces fluoroscopy radiation levels in EP Lab procedures.

Behzadmehr, R., Doostkami, M., Sarchahi, Z., Dinparast Saleh, L. & Behzadmehr, R. (2021). Radiation protection among health care workers: knowledge, attitude, practice, and clinical recommendations: a systematic review. *Reviews on Environmental Health*, *36*(2), 223-234. https://doi.org/10.1515/reveh-2020-0063
Level: III-B

Purpose or Hypothesis	**Type of Evidence and Research Design**	**Sample (population, size, setting)**	**Intervention Procedures**	**Primary Outcome/Measures**	**Results Conclusions**

The purpose of this systematic review was to understand the knowledge, attitude, and practice (KAP) of healthcare workers towards radiation protection.	**Systematic Review:** The international databases Web of Science, PubMed, and Scopus were searched for articles pertaining to the topic using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) checklist	**Search Strategy:** The databases previously described were searched form January 1, 2000 until February 1, 2022. A librarian specialist was utilized. Keywords included Boolean phrases AND, OR, and NOT. MeSH terms and key words consisted of "radiation protection," "healthcare workers," "knowledge," "attitude," "practice," and "KAP." Exclusion criteria included reviews, no quality, non-English, no full text, and qualitative research	**Selection of Studies and Data Extraction:** All results from the three databases were entered into EndNote. Duplicate articles were removed. All remaining results were reviewed by two people, with a third person to decide in the instance that the two reviewers disagreed. Irrelevant articles were removed. Abstracts were then reviewed and articles that did not qualify were removed. The final step of the remaining articles was review of the full text. Extracted data included age, gender,	The primary outcomes were quality of the articles using the Hoy et al. scale, which is a 10-item checklist evaluating the internal and external validity of the studies. Secondary outcomes included instruments used in each study, knowledge about radiation safety, and attitude, practice, and clinical recommendations about radiation safety of the healthcare workers in the 41 studies	40 articles used a researcher-made instrument, while only one used a validated data collection tool. 80.4% of the 41 studies assessed knowledge of healthcare workers. The range of knowledge level was 2% to 95%. Positive attitudes towards radiation safety ranged from 61.2% to 88% of healthcare workers. In most studies the practice of radiation safety was average, but the score was as low as 3.2-13.1%. The most

			target population, author, year, country, sample size, sampling method, method of data collection and risk of bias, outcome measures, knowledge, attitude, practice, and recommendations for improvement. Of the 1848 original articles, 1471 were not duplicated. Of the 1471 remaining studies, 65 met abstract and title criteria. After final full text review, 41 studies met criteria and were included.		common recommendations were that some form of formal education on radiation safety through a curriculum, training courses, or a continuing education program is necessary, and there should be sufficient radiation protection devices supplied by the hospital. **Conclusion:** Healthcare worker knowledge, attitude, and awareness of radiation safety practices is average, positive, and average, respectively. Education and training is essential for improved radiation safety.

Brun, A., Mor, R. A., Bourrelly, M., Dalivoust, G., Gazazian, G., Boufercha, R., Lehucher-Michel, M. P., & Sari-Minodier, I. (2018). Radiation protection for surgeons and anesthetists: practices and knowledge before and after training. ***Journal of radiological protection : official journal of the Society for Radiological Protection*****,** ***38*****(1), 175–188. https://doi.org/10.1088/1361-6498/aa9dbd** **Level: III B**					
Purpose or Hypothesis	**Type of Evidence and Research Design**	**Sample (population, size, setting)**	**Intervention Procedures**	**Primary Outcome/Measures**	**Results Conclusions**
The purpose of this study was to evaluate the occupational practices and knowledge in radiation protection before and after training.	Descriptive pre- and post-intervention study	**Sampling Technique:** Convenience **Eligible Participants:** All surgeons and physician anesthetists at a public hospital center in the South of France **Setting:** Surgical department in a single hospital center in the South of France. **Excluded:** Participants who did not specify their specialty, nurses, and other OR professionals. **Accepted:** Total of 103 physicians	**Control Protocol:** Questionnaire on radiation safety practices and knowledge distributed to 103 physicians prior to radiation safety training to obtain baseline data. **Intervention protocol:** From April through May 2016, six training sessions were administered, as described previously. 23-item questionnaires were given pre-training as a handwritten	**Dependent Variable:** Score on a 23 item questionnaire with 7 questions assessing radiation safety practices and 16 questions assessing radiation safety knowledge **DV Measure:** Points correct out of 23 questions on the radiation safety knowledge and practices questionnaire, defined as 1 point per question correct out of 23.	**Statistical Results:** Data analysis was performed using SPSS Version 20. Chi-square was used to assess comparisons between group demographics. Student's T-test was used to compare age between the respondent groups. The Mac-Nemar statistical test was used for matched groups with regards to pre/post training responses in the before/after population. Differences were considered significant for p <

		Control: Responses of 90 of the physicians before training to a radiation safety questionnaire. **Intervention:** Six training sessions during April and May 2016 that included information on fluoroscopy regulations, annual dose limits for healthcare workers and the public, radiological hazards, and practices to reduce exposure to ionizing radiation. **Power analysis:** Not performed **Group homogeneity:** Mean age of the respondents of the before-training group	response format to encourage high return rate. Post-training questionnaires were emailed within one month of the end of training. **Treatment Fidelity:** All participants received the same training and questionnaires. Response was voluntary, however, and many did not respond to the post-training questionnaire. 61% of the 90 pre-training respondents did not answer the post-training questionnaire.		0.05. Total score on the questionnaire significantly increased after training compared to before training (12.8/23 compared to 8.7/23; $p<0.001$). Knowledge increased significantly in a similar fashion (9.5/23 vs 5.5/23; $p<0.001$). Occupational practices did not change before and after training (3.2/23 vs 3.3/23; $p=0.666$). Significantly more anesthetists (82.9%) than pediatric surgeons (26.7%), surgeons (52%), and surgeons treating adults (62.9%) reported exposure to

		(n=90) was significantly younger than the before/after respondent group (n=35) (43.8 vs 48.5 years old; p<0.001). Otherwise, there was no difference between groups regarding gender, specialty, or status (assistant vs resident vs hospital practitioner, etc.)			radiation several times a week (p<0.05). **Conclusion:** There is a short-term improvement of knowledge after training, but training does not improve provider occupational practices related to radiation safety.

Choi, B. H., Yaya, K., Prabhu, V., Fefferman, N., Mitchell, B., Kuenzler, K. A., Ginsburg, H. B., Fisher, J. C., & Tomita, S. (2019). Simple preoperative radiation safety interventions significantly lower radiation doses during central venous line placement in children. *Journal of pediatric surgery*, *54*(1), 170–173. https://doi.org/10.1016/j.jpedsurg.2018.10.013 Level III-A

Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions

The purpose of this study was to lower radiation exposure during pediatric central venous catheter insertion by implementing a radiation safety process that included a radiation safety briefing, job-instruction model, and a pre-radiation time-out.	Case-control study	**Sampling Technique:** Convenience **Eligible Participants:** All pediatric patients (aged 0-21 years) with valid dose area product (DAP) measurements (59 preintervention and 41 postintervention) who received central lines under fluoroscopy **Setting:** The operating rooms at New York University Langone Health Hospital where pediatric central lines were placed under fluoroscopy by 4 pediatric surgeons. **Excluded:** Patients with limited data on	**Control Protocol:** Chart review of 59 pediatric patient receiving fluoroscopy assisted central line for the 22-month pre-implementation period **Intervention protocol:** 10-month post intervention observation. Intervention had three parts: 1) radiation safety training for staff consisting of information on C-arm beam directions, dose reduction techniques, and proper shielding of patients and staff ; 2) implementation of a mandatory radiation safety time-out prior to C-arm use which	**Dependent Variable:** Total radiation time, defined as the sum of normal dose and low dose modes, or the sum of continuous and pulsed modes. Dose area product (DAP), defined as the estimation of the radiation absorbed by the patient. Specifically, the absorbed dose multiplied by the area irradiated. **DV Measure:** DAP = Rad*cm^2 Total radiation time was measured in seconds (sec).	**Statistical Results:** Analysis of data was done using SPSS. Nonparametric data was analyzed using the two-tailed Mann-Whitney U test. Chi-square was used to determine difference between frequency of post-operative radiograph pre- and post-intervention. P-value of <0.05 was considered statistically significant. DAP decreased significantly: Pre-intervention DAP was 61.44 rad*cm^2 while post intervention DAP was 13.14 rad*cm^2 ($p < 0.001$)

		DAP and fluoroscopy time in the radiology reports. **Accepted:** Total of 100 pediatric patients **Control:** 22 months of baseline fluoroscopy time and DAP data before the intervention **Intervention:** Three parts: 1) radiation safety training for staff consisting of information on C-arm beam directions, dose reduction techniques, and proper shielding of patients and staff ; 2) implementation of a mandatory radiation safety time-out prior to C-arm use which ensured the C-arm was operating in low	ensured the C-arm was operating in low dose and pulsed modes, the fluoroscopy pedal was pressed instead of the exposure pedal, radiation PPE was on all staff and patients, and saving of the last image obtained; and 3) limitation of postprocedural radiographs for asymptomatic patients. **Treatment Fidelity:** The four pediatric surgeons' cases following implementation followed the intervention protocol, but some cases did not record fluoroscopy time and DAP.		Total radiation time decreased significantly: 28.00 sec vs 7.60 sec pre- vs post-intervention ($p < 0.001$) **Conclusion:** Formal training, a radiation safety timeout, and deemphasizing post-procedure X-Ray imaging significantly reduced DAP by almost five-fold.

		dose and pulsed modes, the fluoroscopy pedal was pressed instead of the exposure pedal, radiation PPE was on all staff and patients, and saving of the last image obtained; and 3) limitation of postprocedural radiographs for asymptomatic patients. **Power Analysis:** Not performed **Group homogeneity:** Age, gender, height, weight, and BMI were statistically similar among preintervention and postintervention groups (p>0.16 in all categories)			
Matsuzaki, S., Moritake, T., Sun, L., Morota, K., Nagamoto, K., Nakagami, K., Kuriyama, T., Hitomi, G., Kajiki, S., & Kunugita, N. (2022). The Effect of Pre-Operative Verbal Confirmation for Interventional Radiology Physicians on Their Use of Personal Dosimeters and Personal Protective Equipment. *International journal of environmental research and public health*, *19*(24), 16825. https://doi.org/10.3390/ijerph192416825 Level III-B					

Purpose or Hypothesis	Type of Evidence and Research Design	Sample (population, size, setting)	Intervention Procedures	Primary Outcome/Measures	Results Conclusions
The purpose of this study was to determine if a preoperative briefing prior to radiation emitting fluoroscopy procedures would improve radiation safety by reducing dose exposure.	**Quasi-experimental prospective cohort study**	**Sampling Technique:** Convenience **Eligible Participants:** 14 Interventional radiology physicians known to work in areas with gamma or high-energy beta radiation exposure. **Setting:** The IR unit of a 214-bed acute care hospital in Japan, which sees 300-340 emergency cases per month. April-August 2017 was a pre-intervention baseline data collection period and October 2017 through February 2018 was the intervention	**Control Protocol:** 5 month pre-implementation observation of IR physician dosimeter and PPE use by an inspector. **Intervention protocol:** A preoperative briefing before the start of all fluoroscopy procedures with verbal confirmation of PPE and dosimetry badges, and reinforcement to wear proper PPE or dosimeter if either was missing**.** Data was collected from each of the 415 cases	**Dependent Variable:** 1) Personal Passive Dosimeter defined as the following: **Body:** Double-dosimeter approach with 1 cm personal dose equivalent calibration: $E=0.89 \times D_{main} + 0.11 + D_{additional}$ Single-dosimeter: $E=D_{main}$ **Eye:** Double-dosimeter: $H_{eye} = D_{additional}$ Single-dosimeter: $H_{eye} = D_{main}$ 2) Use rate of PPE, defined as cases wearing dosimeter, lead apron, lead glasses, and thyroid shield per total cases in intervention period. **DV Measure:**	**Statistical results:** BellCurve Excel was used for statistical analysis. Two group comparisons were made with two-tailed Wilcoxon's signed rank test or two-tailed Mann-Whitney U. The significance level was set at $p<0.05$. Main dosimeter use, lead glasses use, and thyroid shield use increased by 50%, 60%, and 45%, respectively ($p=0.002$; $p=.003$; $p=0.008$) Effective body dose rate and lens

		period. **Excluded:** All other hospital staff with risk of radiation exposure (e.g. nurses, nurse anesthetists, radiology techs, endoscopy techs, etc.) **Accepted:** Total of 964 cases (549 pre-intervention and 415 intervention involving the physicians) **Control:** Baseline radiation dosimetry badge data and presence of radiation PPE **Intervention:** A preoperative briefing before the start of all fluoroscopy procedures with verbal confirmation of PPE and dosimetry	**Treatment Fidelity:** All 14 physicians in the study were monitored and observed the same way, and all cases utilized a standardized checklist for the pre-op briefing.	Unit: microsieverts per minute (uSv/min) defined as total radiation dose per time of active fluoroscopy. Mean percentage = mean total cases with proper PPE use/ total cases in intervention period x 100	equivalent dose rate increased by 5 uSv/min and 25 uSv/min, respectively ($p=0.033$; $p=0.003$) **Conclusion:** A pre-procedure briefing significantly increased the use of radiation PPE, as well as, the exposure dose rate. The increase in exposure dose rate was hypothesized to be the result of increased use of dosimetry badges during active fluoroscopy which was previously unseen.

		badges, and reinforcement to wear proper PPE or dosimeter if either was missing. **Power Analysis:** Not performed **Group homogeneity:** Not assessed for statistical significance, but likely homogenous given that all were IR physicians.			
Qureshi, F., Ramprasad, A., & Derylo, B. (2022). Radiation Monitoring Using Personal Dosimeter Devices in Terms of Long-Term Compliance and Creating a Culture of Safety. *Cureus*, *14*(8), e27999. https://doi.org/10.7759/cureus.27999 Level III-B					
Purpose or Hypothesis	**Type of Evidence and Research Design**	**Sample (population, size, setting)**	**Intervention Procedures**	**Primary Outcome/Measures**	**Results Conclusions**

The purpose of this study was to assess the effect of a hospital policy change and radiation education on improving physician compliance with proper use of radiation dosimetry badges	Although the study mentions it is a quality improvement project, the design and data collection are such that it is a quasi-experimental study. The independent variable(s) (monthly radiation education and a change in hospital policy where consequences for physicians with radiation dose readings higher than standardized limits were reduced) were introduced at three separate hospital systems at month six of a twelve-month study period. During phase I (months 1-6) dosimetry badges were handed out to physicians known to work in areas with radiation exposure (this was baseline data collection). The second phase of the study (months 7-12) involved dosimetry badge dose data collection following implementation of the intervention described previously. Data from phase 2 was compared to phase 1 using descriptive statistics	**Sampling Technique:** Convenience **Eligible Participants:** Physicians known to work in areas with gamma or high-energy beta radiation exposure. **Setting:** The units of three hospital systems where X-Ray, fluoroscopy, unsealed and sealed isotopes, and gamma or high energy beta radiation were utilized. **Excluded:** All other hospital staff with risk of radiation exposure (e.g. nurses, nurse anesthetists, radiology techs, endoscopy techs, etc.) **Accepted:** 118	**Control Protocol:** Administration of radiation dosimetry badges and monthly collection of radiation dosimetry readings for baseline analysis during the first 6 months of the twelve-month study period **Intervention protocol:** Monthly radiation safety education and a hospital policy change eliminating penalties for physicians with readings over recommended radiation dose limits**.** **Treatment Fidelity:** All 221 physicians in the	**Dependent Variable:** 1)Dosimetry readings defined as "the cumulative monthly average of all individual physician participants' dosimetry readings at each respective hospital system." 2)Adherence/Compliance defined as "not using the dosimeter at least once or always using the dosimeter before the policy change as compared to after the policy change." 3) Radiation safety test results defined as "the average score on a ten question quiz generated from a question bank on radiation safety of all 221 physicians at 0, 3, and 6 months into phase 2 of the study." **DV Measure:** DV (1) was measured in millisieverts (mSv) using standardized dosimetry badges. Badges were	**Statistical Results:** Run chart comparisons of phase 1 and phase 2 of the study were used for determination of the significance of a change (if any) in the average monthly dosimetry readings for each hospital system. The average cumulative radiation doses were considered significantly increased in Hospital Systems One, Two, and Three, as average doses increased from 3.90 mSv, 2.55 mSv, and 2.02 mSv to 13.9 mSv, 10.9 mSv, and 8.56 mSv, respectively. There was an increase in the "always used

		physicians in hospital system one, 71 in system two, and 32 in system three. Total of 221. **Control:** Baseline radiation dosimetry badge data and radiation knowledge survey data during months 1-6. **Intervention:** 1) Policy change to reduce repercussions towards physicians with radiation doses higher than set limits. 2) Monthly education on sources of radiation, dose limits, and health effects of radiation exposure. **Power Analysis:** Not performed	study were made aware of the policy change at the 6 month mark, and all were provided with monthly radiation education and compliance surveys	stored on site at the different hospital systems to avoid damage from extreme heat, cold, or UV sun exposure. DV (2) was measured as a percentage using proportions from surveys DV (3) was measured as the average percentage of questions answered correctly out of ten for all 221 physicians in the study.	dosimeter" survey response from physicians at each of the three sites following the policy change by as much as 93.8%, but no significance testing was performed. The average score of all 221 physicians on the ten-question radiation safety test increased from 49% at month 0 of the second phase to 84% at month 6 of the second phase. Again, no significance testing was performed. **Conclusions:** The authors concluded that dosimetry compliance and knowledge of radiation safety are improved when unreasonable consequences are

		Group homogeneity: Not assessed for statistical significance			removed, and regular education/training exists.

Sierra, L. A. M., Katsnelson, J. Y., & Pineda, D. M. (2022). Occupational Radiation Exposure Among General Surgery Residents: Should We Be Concerned?. *Journal of surgical education*, *79*(2), 463–468. https://doi.org/10.1016/j.jsurg.2021.10.016 Level III-B

Purpose or Hypothesis	**Type of Evidence and Research Design**	**Sample (population, size, setting)**	**Intervention Procedures**	**Primary Outcome/Measures**	**Results Conclusions**

The purpose of this study was to find typical occupational radiation exposure among a group of general surgery residents before and after introduction of a formal radiation safety curriculum.	This was a single center prospective cohort study	**Sampling Technique:** Convenience **Eligible participants:** All 28 general surgery residents in a 665-bed academic medical center. **Setting:** Residents rotate through vascular surgery 2-3 times per year for 4 week intervals where there is a mounted C-arm used for fluoroscopy in a hybrid vascular suite. Other vascular cases are performed in standard OR rooms with a mobile C-arm.	**Control Protocol:** Measurement of radiation dose via dosimetry badges for all vascular attendings during the study period, as attendings did not receive the training. **Intervention Protocol** All residents and new interns participated in the radiation safety monitoring project and received education on radiation safety during their orientation. Dosimeter badge data was collected bimonthly. All participants were required to wear the dosimeter outside of the lead apron during	**Dependent Variable:** **Monthly Deep Dose Equivalent (DDE) exposure, defined as tissue depths of 0.007 cm (7 mg/cm^2) averaged over a 1 cm^2 area per month.** **DV Measure: millirem (mRem)**	**Statistics:** Student T-tests and one-way analysis of variance (ANOVA) were used to compared mean radiation exposure levels between deep dose equivalents of attendings, interns, chief residents, and residents. Vascular interns had significantly lower DDE than their midlevel , chief resident, and attending (p=0.002). Non vascular residents had significantly lower dose exposures compared to their vascular resident counterparts (p=0.036). Chief resident exposure was not significantly

			fluoroscopy. Residents with high exposure were provided individualized education and training **Fidelity** Nine individual badge readings were excluded because of failure to return the badges bimonthly. Three others did not perform the training as they were at away rotations.		different from attending exposure (p=0.78) **Conclusion:** General surgery residents are routinely exposed to radiation. As training progresses, radiation exposure increases. Despite the radiation safety program, chief resident radiation exposure was similar to the attending.

Table 2
Evidence Synthesis

University of Maryland School of Nursing

Evidence Synthesis Template

Project Title: Improving Radiation Safety and Dosimetry Badge Compliance in the Endoscopy Unit

PICOT: *Among nurse anesthesia providers and nurses participating in fluoroscopy procedures on the Endoscopy Unit, does a program combining formal education and training, as well as, a radiation safety time-out compared to current practice effect nurse anesthetist and nursing outcomes as evidenced by a change in radiation dosimeter badge compliance and monthly dosimeter readings?*

JHNEBP Model Level	Total Number of Sources	Author and Quality Rating of each study	Synthesis of Findings
Level 1 Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis			
Level II Quasi-experimental studies · Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis	1 systematic review of cross-sectional studies without meta-analysis (Behzadmher et al)	Behzadmher et al B	The most common recommendations were that some form of formal education on radiation safety through a curriculum, training courses, or a continuing education program is necessary, and there should be sufficient radiation protection devices supplied by the hospital. Healthcare worker knowledge, attitude, and awareness of radiation safety practices is average, positive, and average, respectively. Education and training is essential for improved radiation safety. Small sample sizes and researcher-made non-validated instruments weaken many of the studies.
Level III Non-experimental study · Systematic review of a combination of RCTs, quasi-experimental, and non-experimental studies, or non-experimental studies only, with or without meta-analysis · Qualitative study or systematic review of qualitative studies	6 single group observational cohort studies pre-intervention/post-	Aizer et al B Brun et al. A Choi et al. B Matsuzaki et al. B	In general, studies showed short-term improvement in providers knowledge regarding radiation safety following a radiation safety training program that consisted of either single or multiple education sessions (Aizer et al, 2019; Brun et al, 2018; Choi

with or without meta-synthesis	intervention (Aizer et al; Brun et al; Choi et al; Matsuzaki et al; Qureshi et al; Sierra et al).	Qureshi et al. B Sierra et al. B	et al, 2019; Qureshi et al, 2022). Aizer et al (2019), Choi et al (2019), and Matsuzaki et al (2022) showed significantly reduced radiation exposure following radiation education and a radiation safety timeout. However, Sierra et al. (2022) showed that chief residents in vascular surgery had similar radiation dose exposure to high exposure attendings following a radiation safety curriculum that the attendings did not receive. Qureshi et al. (2022) showed significantly improved radiation knowledge, increased dosimetry compliance, and increase dose measures on dosimeters following radiation education and a change in hospital policy to no longer punish providers with radiation exposures higher than monthly limits. It was hypothesized that radiation exposure increased because workers previously had falsely low dosimetry reports due to dosimetry badge noncompliance. Despite Brun et al. (2018) showing an increase in radiation safety knowledge following training, occupational practices and radiation safety behaviors increased only slightly and was not statistically significant.
Level IV Opinion of respected authorities and/or reports of nationally recognized expert committees/consensus panels based on scientific evidence			
Level V Evidence obtained from literature reviews, quality improvement, program evaluation, financial evaluation, or case reports · Opinion of nationally recognized expert(s) based on experiential evidence			
Overall Quality Rating w/rational and Recommendation: B: There is good and consistent evidence that a formal radiation safety training and education program combined with a radiation safety timeout before all fluoroscopy procedures increases dosimetry badge compliance, reduces			

radiation exposure over time, and improves radiation safety.
Recommendations Based on Evidence Synthesis • Strong, compelling evidence, consistent results: solid indication for a practice change. • Good and consistent evidence – practice change • Good but conflicting evidence: questionable indication for practice change; consider risk/benefit analysis • Little or no evidence: no indication for practice change

Figure 1

Fishbone Diagram: Radiation Dosimetry Badge Compliance

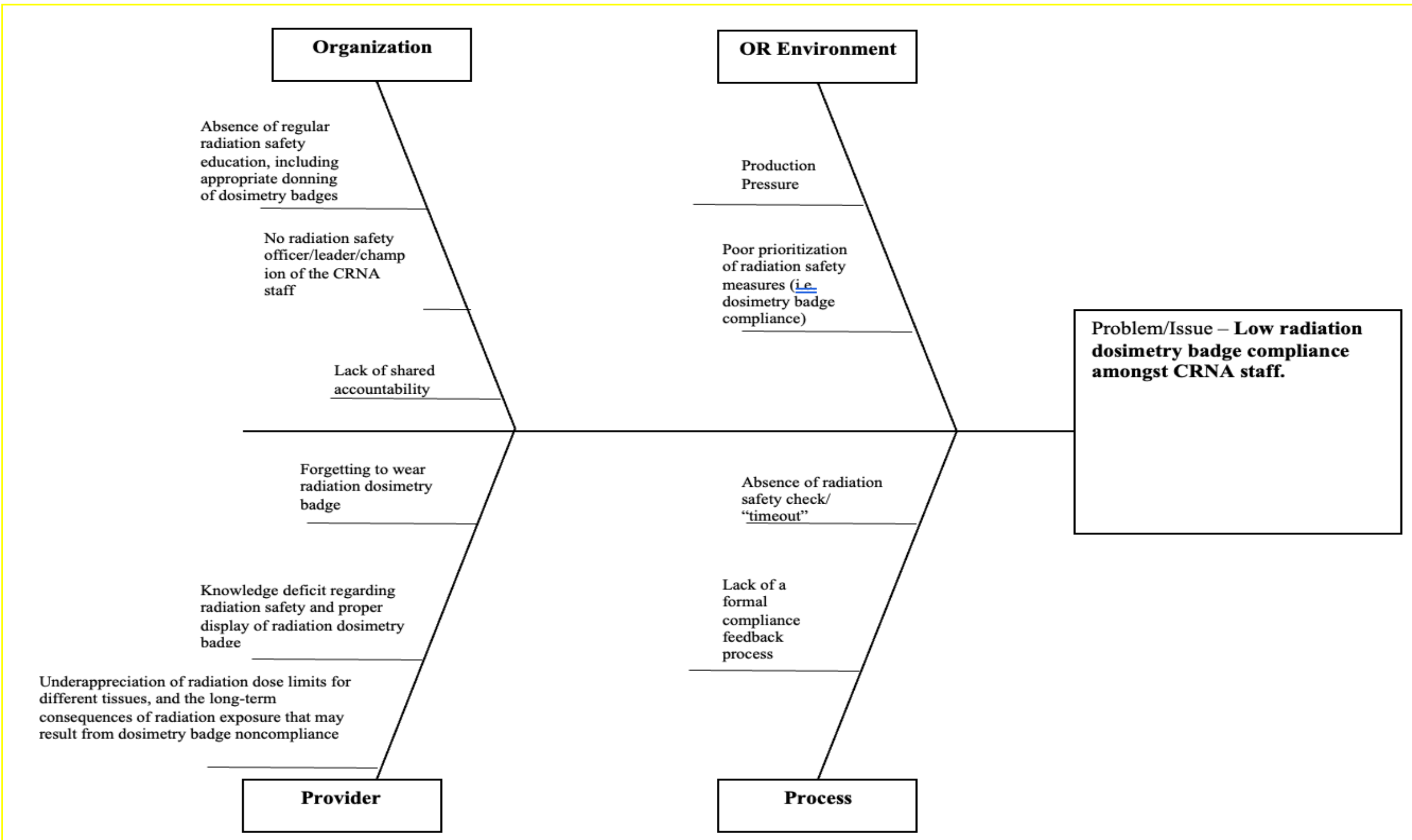


Figure 1. Fishbone diagram of the root cause analysis for low radiation dosimetry badge compliance amongst CRNA staff at a large academic medical center. Absence of a radiation safety timeout as well as, provider knowledge deficits regarding radiation safety and proper display of dosimetry badges are the focus of the intervention.

Figure 2

Internal Badge Compliance Baseline

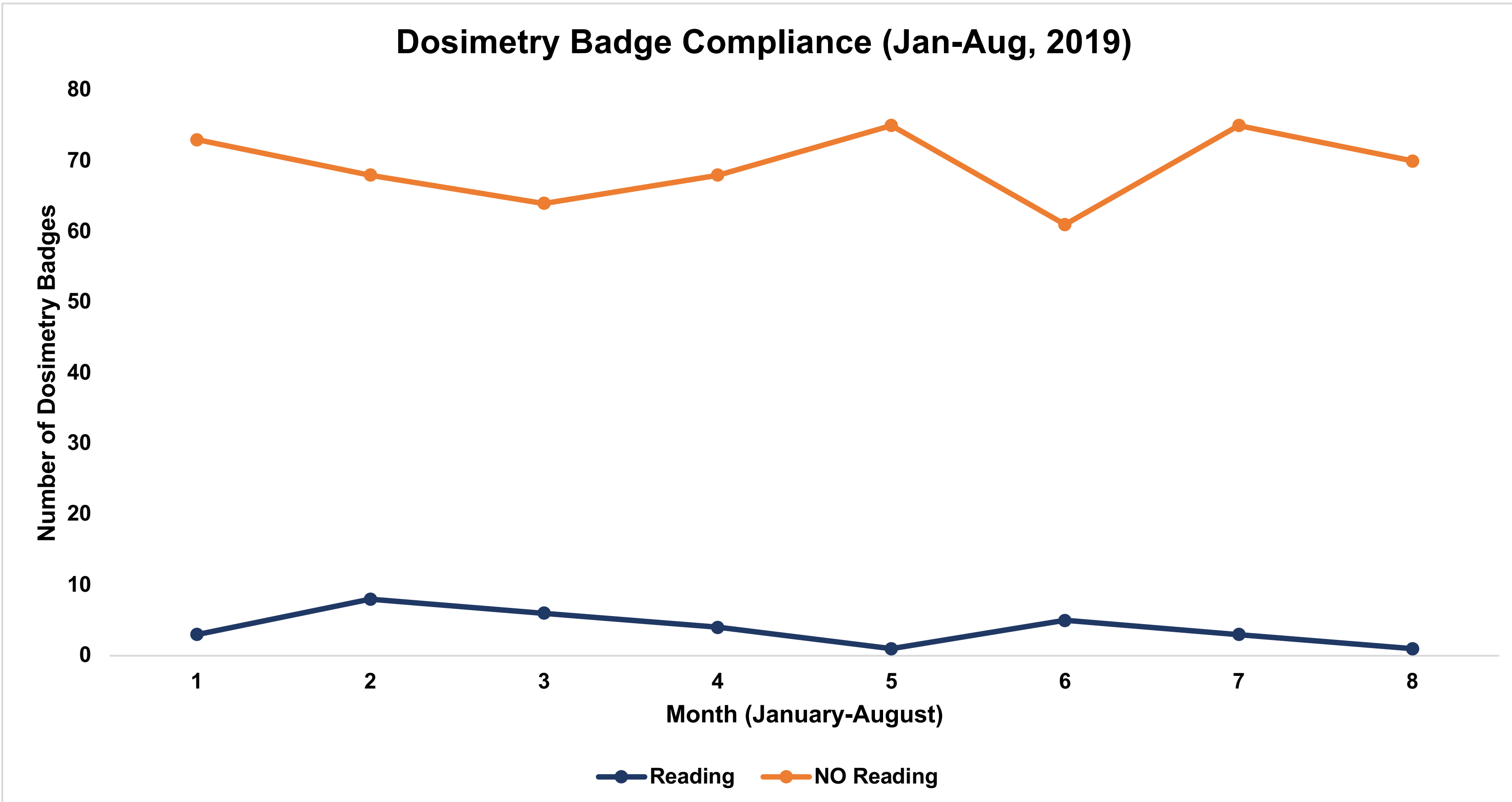
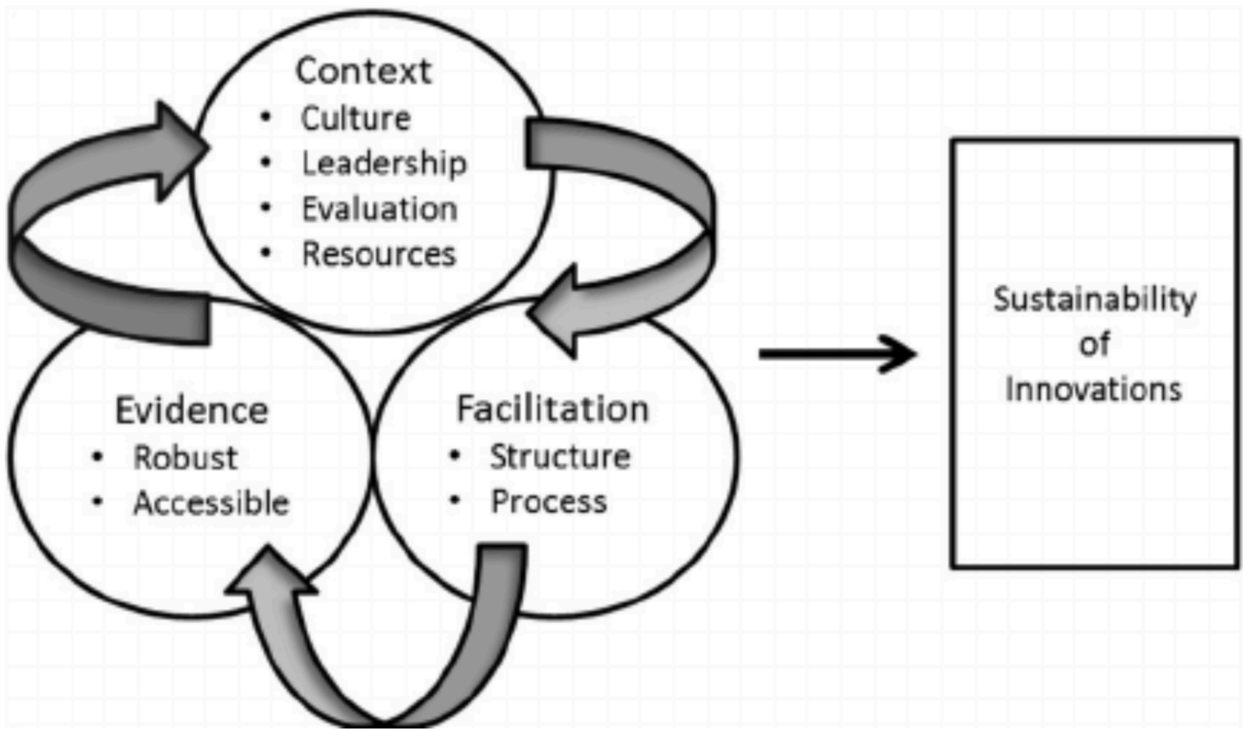


Figure 2. CRNA dosimetry badge compliance for January through August 2019. Reading is a defined as one or more dosimetry readings in a respective month. No reading is defined as missing or absent dosimetry data where there are zero dosimetry readings in a respective month.

Figure 3

Promoting Action on Research Implementation in Health Services (PARIHS) Framework



Note. From University of Maryland School of Nursing NDNP 804, Module 8: Theory, Model or Framework Identification. Rycroft-Malone, J. (2010). Promoting on Research Implementation in Health Services (PARIHS). In J. Rycroft-Malone & T. Bucknall (Eds.), *Models and frameworks for implementing evidence-based practice: Linking evidence to action* (pp. 109-136). Oxford: Wiley-Blackwell. Retrieved April 1, 2023, from https://cf.son.umaryland.edu/NDNP804/module8/subtopic4.htm

Figure 4

Current Process in the Endoscopy Unit

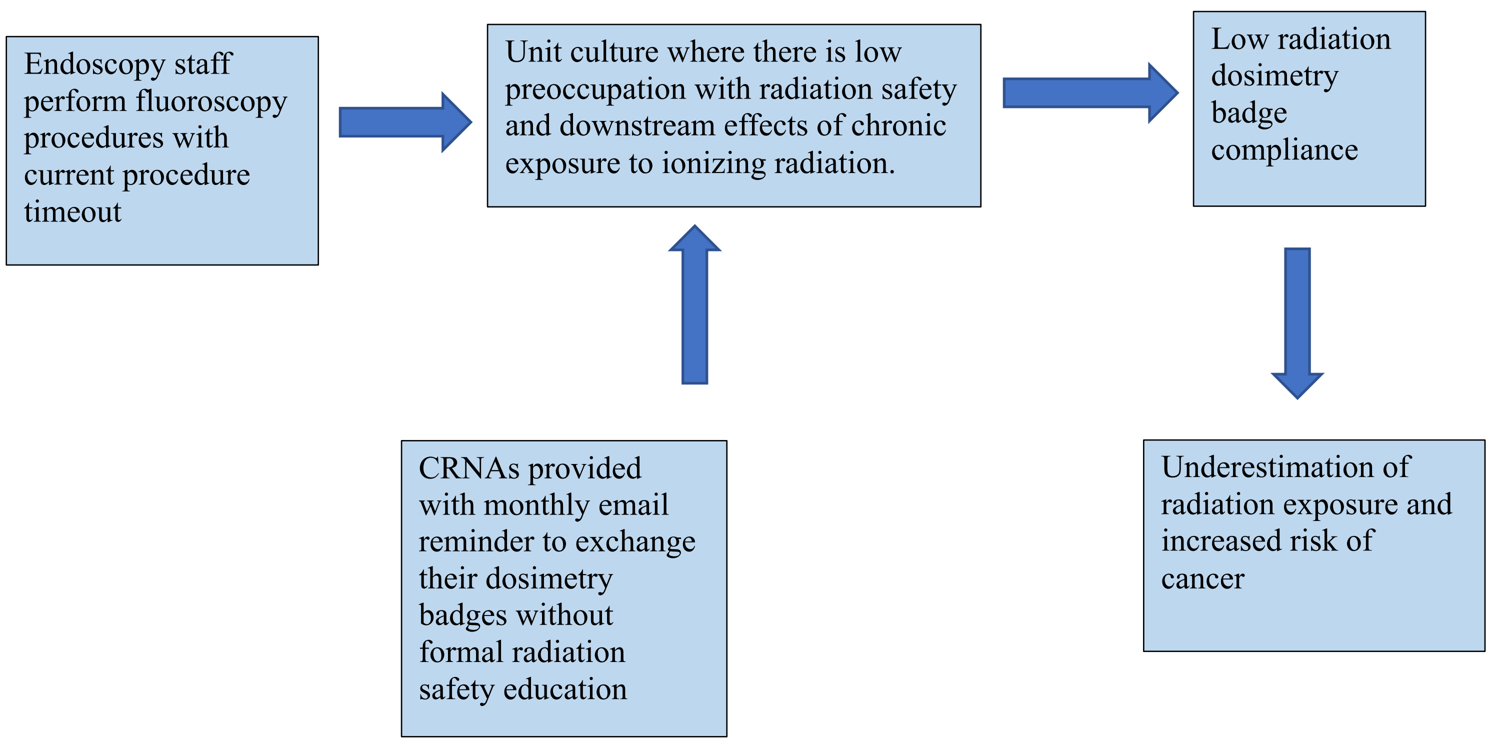


Figure 5

Desired Process in the Endoscopy Unit

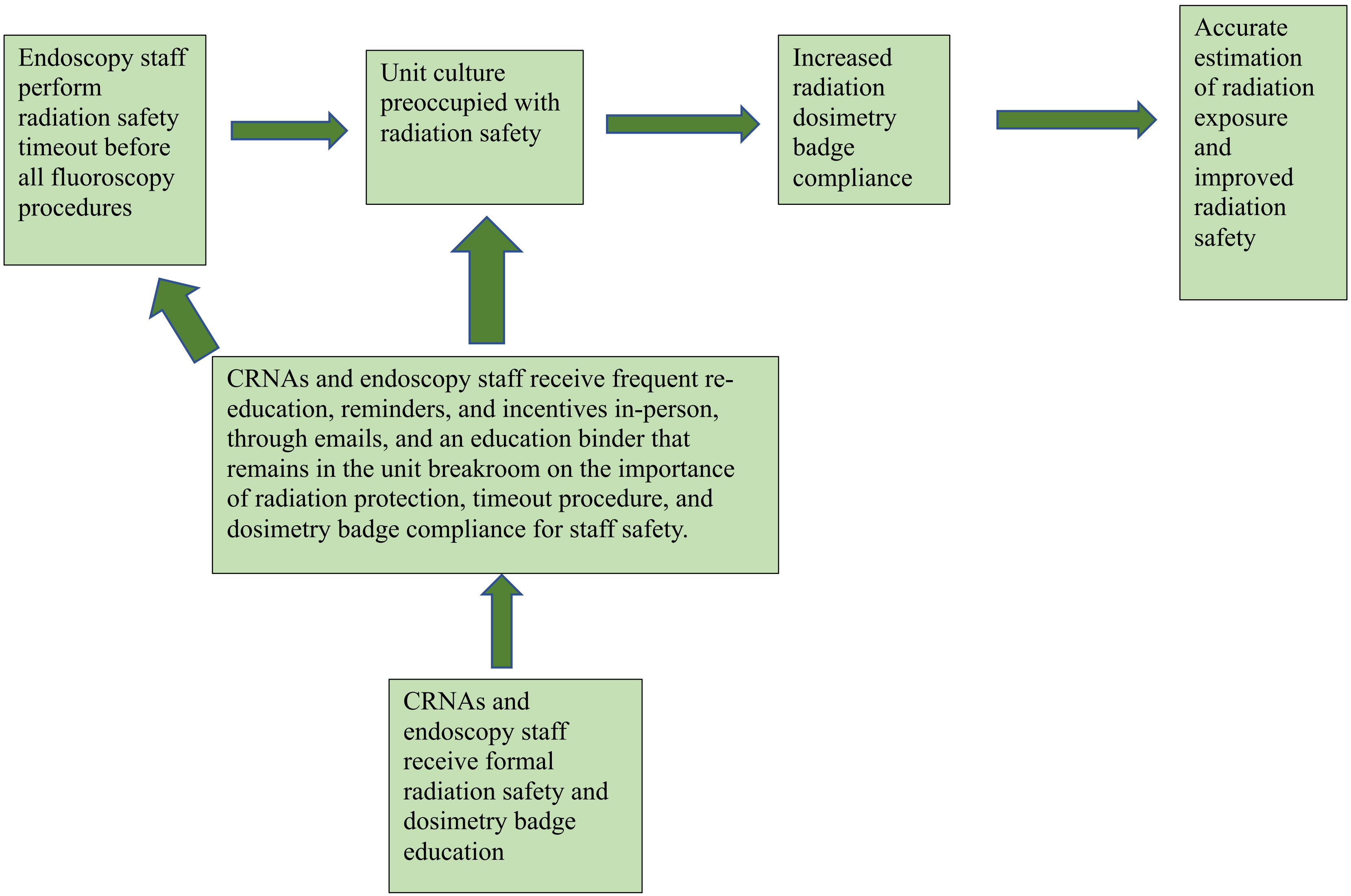


Figure 6

Survey Response Rate

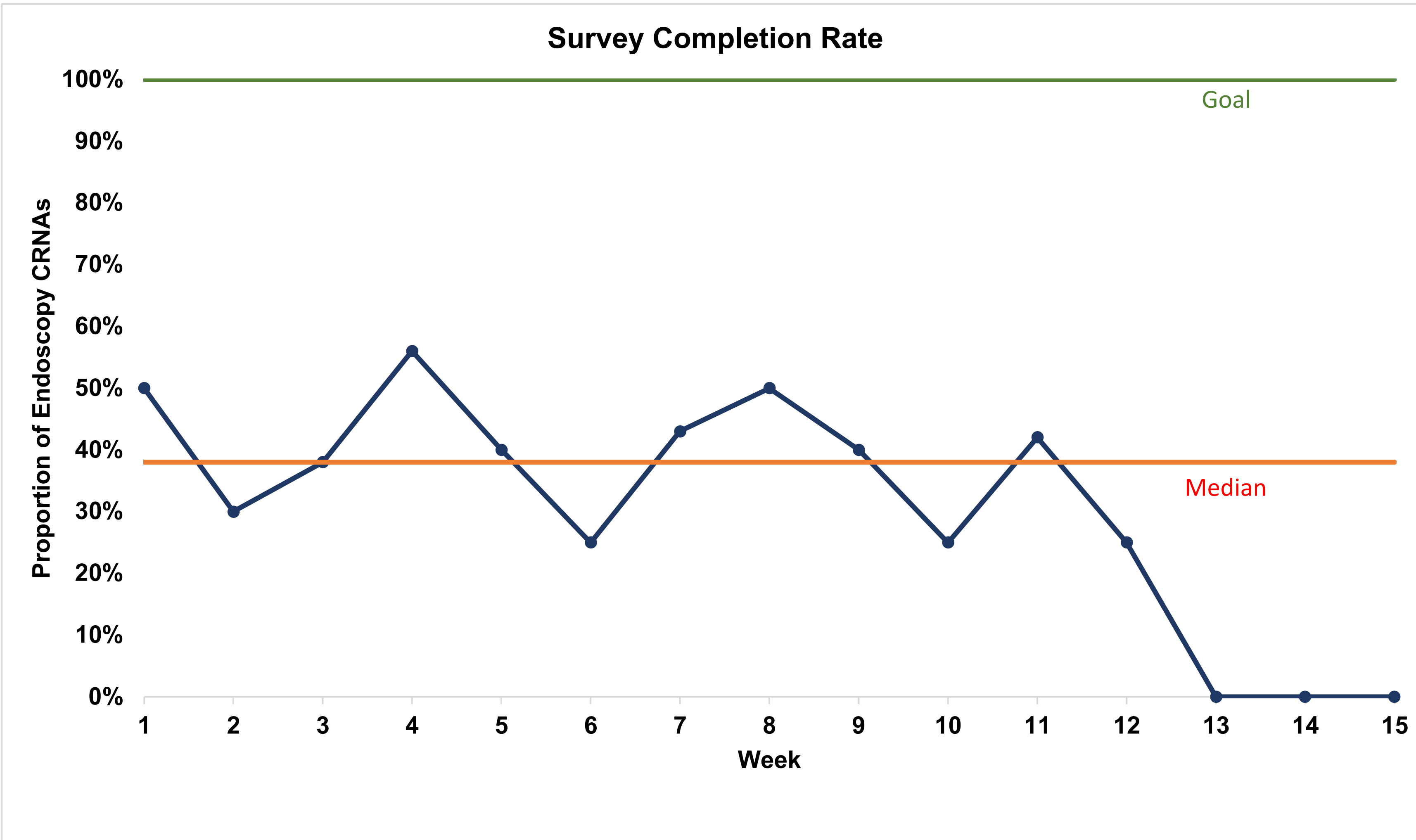


Figure 7

Dosimetry Badge Compliance Rate

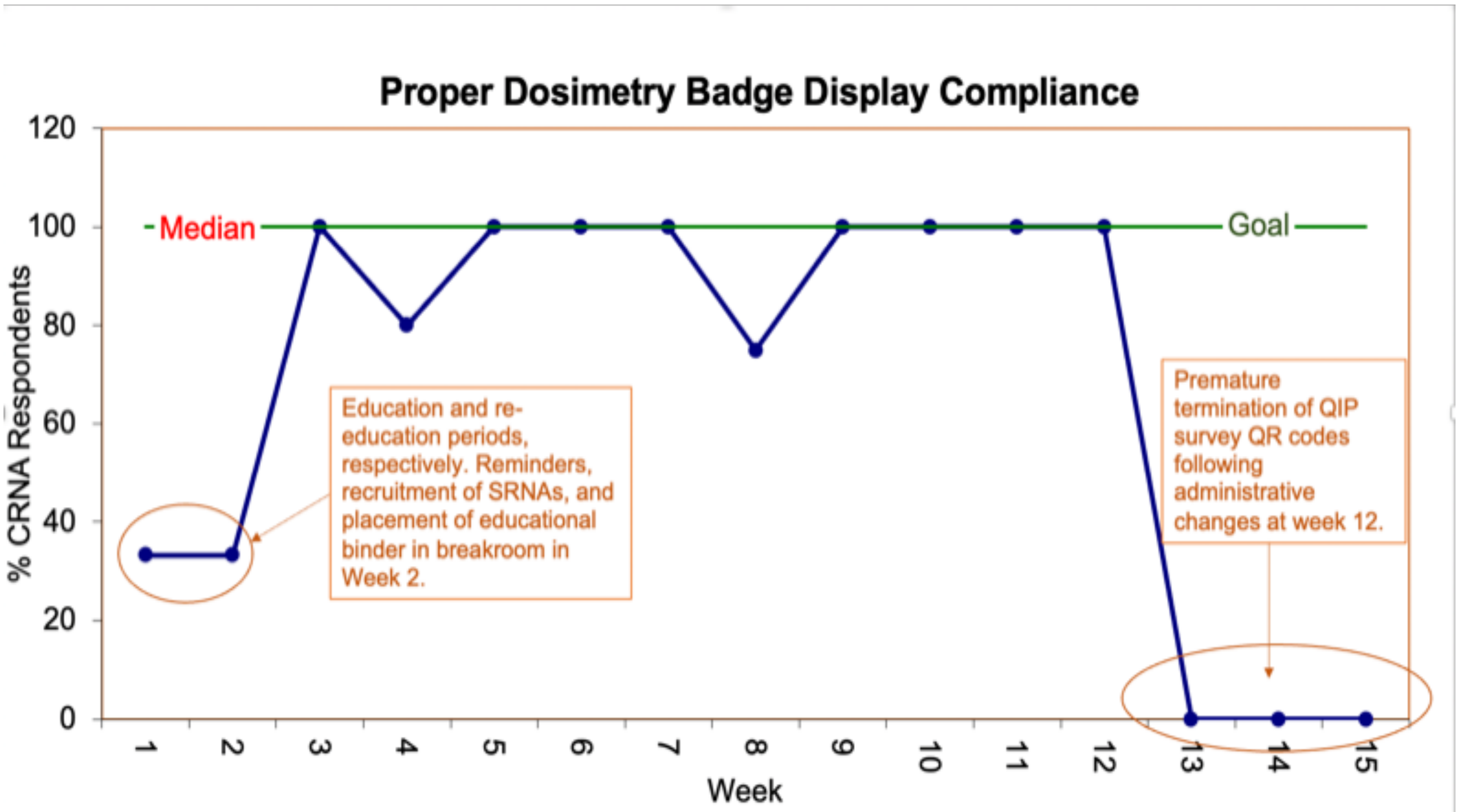
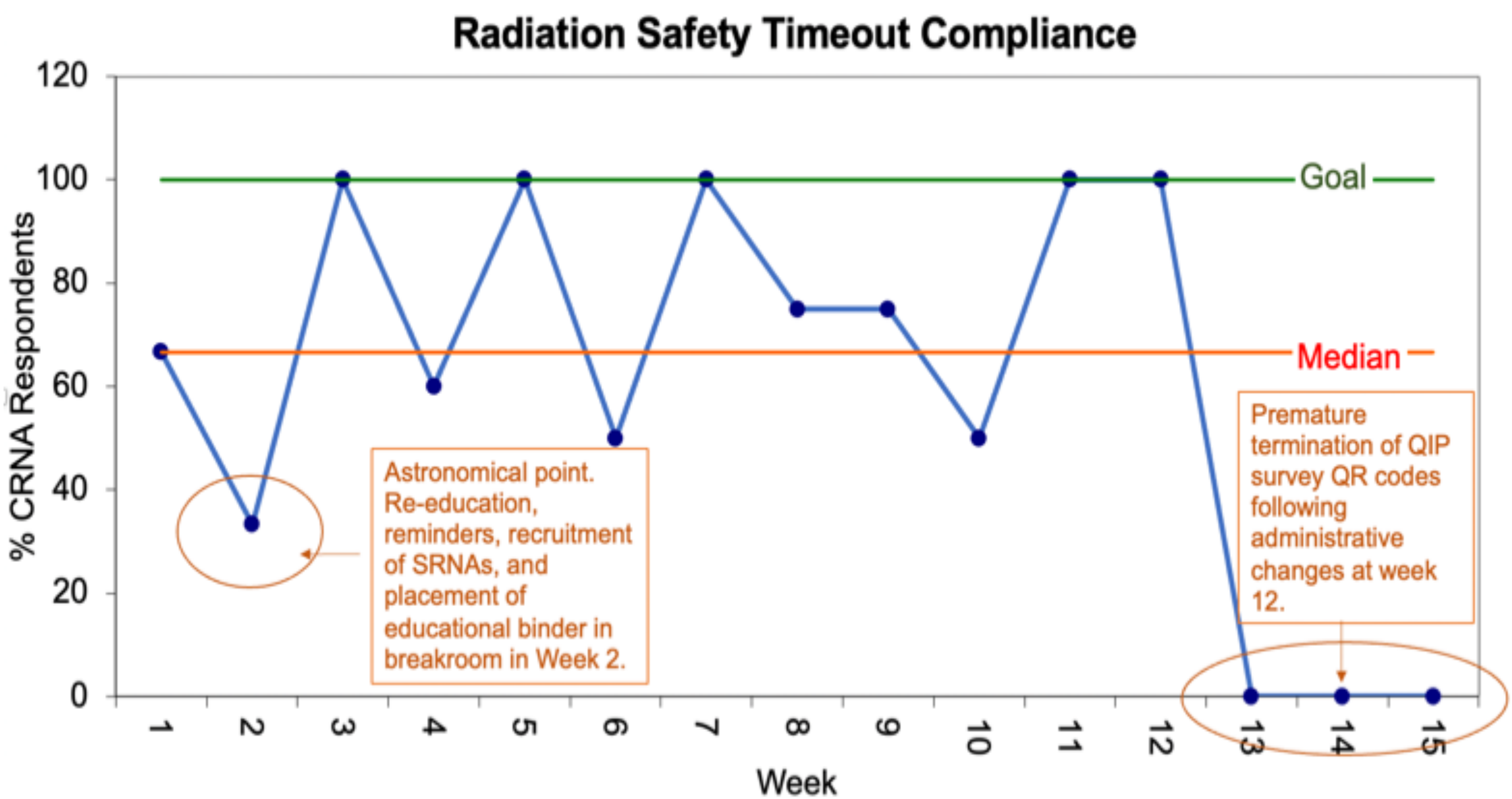


Figure 8

Radiation Safety Timeout Compliance Rate



Appendix A

Radiation Safety Timeout Checklist for Endoscopy Nurses

UNIVERSITY of MARYLAND

Radiation Safety Timeout Procedure for Fluoroscopy Cases

(Perform following the procedure timeout)

Are all radiation shields and protective equipment in place?	☐
Are all staff members properly wearing personal dosimeter badges (at the collar, midline, and external to any lead shields)?	☐

Appendix B

Education PowerPoint

https://docs.google.com/presentation/d/1Uu7NVFMs9FoVEWgzbligwFJZ5rKWwBGwN5Kfq9YUvew/edit?usp=sharing

Click on the link above to view the PowerPoint used for radiation safety and timeout procedure education and training

Appendix C

Education Tracking Sheet

Education Tracking Sheet

Please complete the survey below.

Thank you!

1)	Name	______________________
2)	Role	◯ Endoscopy Tech ◯ RN ◯ CRNA
3)	Date	______________________
4)	Education Completed	◯ Yes ◯ No
5)	Do you exchange your personal radiation dosimeter badge every month, per the radiation safety protocol?	◯ Yes ◯ No

Appendix D

CRNA Workstation QR Code for the Dosimetry Badge Compliance Survey

UNIVERSITY *of* MARYLAND

Daily Radiation Dosimetry Badge Compliance Survey

(To be completed by endoscopy CRNAs following any shift where fluoroscopy was utilized)

Please scan the QR code below:

Appendix E

Daily Radiation Dosimetry and Timeout Compliance Form

Page 1

Daily Radiation Dosimetry Compliance Form

Please complete the survey below. If survey questions pertain to didactic style information, please answer to the best of your knowledge.

Thank you!

1) Date ______________________

2) Room Number
- ◯ Endo 5
- ◯ Endo 6
- ◯ OR 37

3) Radiation protective equipment, including a lead apron, thyroid shield, and lead glasses are worn for every fluoroscopy procedure?
- ◯ Yes
- ◯ No

4) Do you wear your personal radiation dosimeter badge outside, on the front collar, and near the midline of the lead apron for every fluoroscopy procedure?
- ◯ Yes
- ◯ No

5) The radiation safety timeout is being performed before each procedure involving fluoroscopy or other high radiation emission sources?
- ◯ Yes
- ◯ No

6) Please provide any feedback, comments, or questions below: ______________________

Appendix F

Returned REDCap Surveys

PLEASE NOTE : DO NOT collect live data if project is in development mode .

Data Exports, Reports, and Stats

Number of results returned: 38
Total number of records queried: 38

All data (all records and fields)

Record ID record_id	**Survey Identifier** redcap_survey_identifier	**Survey Timestamp** daily_radiation_dosimetry_compliance_form_timestamp	**Date** date	**Room Number** room_number	**Radiation protective equipment, including a lead apron, thyroid shi ... r every fluoroscopy procedure?** radiation_ppe_v2	**Do you wear your personal radiation dosimeter badge outside, on the ... r every fluoroscopy procedure?** dosimeter_location_v2	**The radiation safety timeout is being performed before each procedu ... gh radiation emission sources?** rad_timeout_compliance_v2	**Please provide any feedback, comments, or questions below:** comments	**Complete?** daily_radiation_dosimetry_compliance_form_complete
1		[not completed]	09-08-2023	Endo 6 (2)	Yes (1)	No (0)	Yes (1)		Incomplete (0)
2		09-15-2023 11:49	09-15-2023	Endo 5 (1)	No (0)	No (0)	No (0)	I do not have a badge and haven't in months. Department is aware. My glasses are with my shield which is other side if hospital. It would be nice if department supplied eye shields! Thank you...	Complete (2)
3		[not completed]	09-13-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
4		09-20-2023 17:26	09-13-2023	Endo 6 (2)	No (0)	No (0)	No (0)	no glasses	Complete (2)
5		09-20-2023 17:26	09-01-2023	Endo 5 (1)	No (0)	No (0)	No (0)	no glasses	Complete (2)
6		09-22-2023 23:29	09-05-2023	Endo 5 (1)	No (0)	Yes (1)	Yes (1)	No glasses	Complete (2)
7		[not completed]	09-20-2023	Endo 5 (1)	No (0)	Yes (1)	Yes (1)		Incomplete (0)
8		09-23-2023 00:11	09-19-2023	Endo 6 (2)	No (0)	Yes (1)	Yes (1)	No glasses	Complete (2)
9		09-23-2023 00:12	09-21-2023	Endo 5 (1)	No (0)	Yes (1)	Yes (1)	No glasses	Complete (2)
10		09-26-2023 08:46	09-26-2023	Endo 6 (2)	No (0)	No (0)	No (0)	Glasses not provided and I do not have a badge.	Complete (2)
11		09-26-2023 13:20	09-26-2023	Endo 6 (2)	No (0)	Yes (1)	Yes (1)	no glasses	Complete (2)
12		09-27-2023 16:59	09-27-2023	OR 37 (3)	Yes (1)	Yes (1)	Yes (1)	N/A	Complete (2)
13		[not completed]	09-29-2023	Endo 5 (1)	Yes (1)	Yes (1)	No (0)		Incomplete (0)
14		10-02-2023 11:34	09-29-2023	Endo 6 (2)	No (0)	Yes (1)	Yes (1)	Was not a planned fluoroscopy case, so did not have lead glasses in the room and forgot to grab before procedure began.	Complete (2)
15		[not completed]	10-03-2023	OR 37 (3)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
16		10-03-2023	10-03-	OR 37 (3)	Yes (1)	Yes (1)	Yes (1)	None	Complete (2)

Record ID record_ id	**Survey Identifier** redcap_ survey_ identifier	**Survey Timestamp** daily_ radiation_ dosimetry_ compliance_ form_ timestamp	**Date** date	**Room Number** room_ number	**Radiation protective equipment, including a lead apron, thyroid shi ... r every fluoroscopy procedure?** radiation_ ppe_v2	**Do you wear your personal radiation dosimeter badge outside, on the ... r every fluoroscopy procedure?** dosimeter_ location_v2	**The radiation safety timeout is being performed before each procedu ... gh radiation emission sources?** rad_ timeout_ compliance_ v2	**Please provide any feedback, comments, or questions below:** comments	**Complete?** daily_ radiation_ dosimetry_ compliance_ form_ complete
		14:16	2023						
17		10-12-2023 07:18	10-10-2023	Endo 5 (1)	Yes (1)	Yes (1)	No (0)	The nurse forgot to do time out, and I didn't realize until case had already started.	Complete (2)
18		10-13-2023 06:58	10-13-2023	Endo 5 (1)	Yes (1)	Yes (1)	Yes (1)	no	Complete (2)
19		[not completed]	10-16-2023	Endo 5 (1)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
20		[not completed]	10-17-2023	Endo 5 (1)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
21		10-19-2023 15:17	10-19-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)	None	Complete (2)
22		[not completed]	10-23-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
23		10-23-2023 10:31	10-20-2023	Endo 5 (1)	Yes (1)	Yes (1)	No (0)	n/a	Complete (2)
24		10-24-2023 08:51	10-24-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)	None	Complete (2)
25		10-25-2023 13:46	10-25-2023	Endo 5 (1)	Yes (1)	No (0)	Yes (1)	na	Complete (2)
26		10-27-2023 15:44	10-27-2023	OR 37 (3)	No (0)	Yes (1)	No (0)	Due to wearing glasses, none of the lead glasses fit appropriately overtop of my personal glasses. Unfortunately have not heard the RN include the lead safety in time out	Complete (2)
27		11-01-2023 09:47	10-31-2023	Endo 6 (2)	Yes (1)	Yes (1)	No (0)	There is usually not an official timeout	Complete (2)
28		[not completed]	11-01-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
29		11-02-2023 14:24	11-02-2023	OR 37 (3)	Yes (1)	Yes (1)	Yes (1)	Reminded RN to do radiation timeout.	Complete (2)
30		11-02-2023 15:13	11-02-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)	None	Complete (2)
31		[not completed]	11-08-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
32		11-10-2023 13:39	11-10-2023	Endo 5 (1)	Yes (1)	Yes (1)	No (0)	none	Complete (2)
33		[not completed]	11-14-2023	Endo 5 (1)	Yes (1)	Yes (1)	Yes (1)		Incomplete (0)
34		11-15-2023 06:46	11-14-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)	N/a	Complete (2)
35		11-20-2023 15:10	11-20-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)	None	Complete (2)
36		11-21-2023 06:57	11-17-2023	Endo 6 (2)	Yes (1)	Yes (1)	Yes (1)	None	Complete (2)
37		11-21-2023 13:25	11-21-2023	OR 37 (3)	Yes (1)	Yes (1)	Yes (1)	No	Complete (2)

Record ID record_ id	**Survey Identifier** redcap_ survey_ identifier	**Survey Timestamp** daily_ radiation_ dosimetry_ compliance_ form_ timestamp	**Date** date	**Room Number** room_ number	**Radiation protective equipment, including a lead apron, thyroid shi ... r every fluoroscopy procedure?** radiation_ ppe_v2	**Do you wear your personal radiation dosimeter badge outside, on the ... r every fluoroscopy procedure?** dosimeter_ location_v2	**The radiation safety timeout is being performed before each procedu ... gh radiation emission sources?** rad_ timeout_ compliance_ v2	**Please provide any feedback, comments, or questions below:** comments	**Complete?** daily_ radiation_ dosimetry_ compliance_ form_ complete
38		02-20-2024 10:33	02-20-2024	OR 37 (3)	Yes (1)	No (0)	Yes (1)	Typically wear radiation safety badge but have not received my new one yet.	Complete (2)