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Implementation of Barcode Medication Administration to Reduce Vaccine Errors

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Vaccine administration errors have been a persistent problem within a large ambulatory medical group, particularly within family practice locations, which have the most variety of vaccines given. The organization identified 574 vaccine errors between September 2021 and December 2023 out of 188,895 vaccine doses administered, equaling an error rate of 30.4 per 10,000 doses ordered. Patient safety organizations have issued recommendations to reduce vaccine errors, including implementing barcode medication administration (BCMA). This project implemented BCMA in two family practice locations (project sites A and B) and was part of a larger organizational effort to improve vaccine administration safety. Plan-Do-Study-Act (PDSA) cycles guided BCMA workflow development. Vaccine error rates and clinic throughput times were monitored before and after implementation, and clinic-administered medication (CAM) scan rates and compliance with workflows were measured after BCMA go-live to measure project results.

Problem Statement and Gap Analysis

In the project organization, there have been high rates of vaccine administration errors. The organization found 574 documented vaccine errors in 27 months using targeted audits and vaccine error incident reports. The error rate was calculated to 30.4 per 10,000 doses ordered. By contrast, a 2020 meta-analysis found that the pooled prevalence of vaccine errors within 17 studies was 1.15 per 10,000 doses dispensed (Morse-Brady & Hart, 2020). Twelve studies in Morse-Brady and Hart's (2020) meta-analysis relied solely on voluntary incident reports rather than audits, so 1.15 errors per 10,000 doses was likely a severe undercount. The five studies that used active monitoring via audits had a pooled prevalence of 15.3 errors per 10,000 doses, roughly one-half of this organization's pre-implementation error rate. The project team chose

15.3 vaccine errors per 10,000 doses as its phase one goal for vaccine error reduction.

Through discussions with staff nurses, the vaccine coordinator, and the patient safety and quality nurse, several root causes of vaccine errors within the organization were identified. Deidentified vaccine error case reports were used as exemplars, and conversations were focused on what factors may have led to the errors. Some of the identified error causes included heavy reliance on verbal orders, with nurses having felt uncomfortable questioning orders or requesting verbal read-back in a physician-driven culture. Significant knowledge gaps existed, and rapid changes and new vaccine approvals contributed to confusion. Many nurses were not bringing their computers to prepare and administer their meds, meaning that medication and identification checks were not consistently being done. Additionally, the EHR allowed staff access to functionality that was out of scope for NY state. These and many other factors presented issues across training, workflow, technology, and organizational culture that contributed to vaccine errors.

The estimated revenue loss from vaccine errors over 27 months was $118,400. At least $38,200 of loss was due to errors that BCMA would have likely prevented. In addition to monetary loss, vaccine errors in the project organization have led to patients' loss of trust and nurses' and providers' loss of confidence (Vaccine Safety Committee, Personal Communications, April-December 2023). The Institute for Safe Medication Practices (ISMP,2022) and the Centers for Disease Control (CDC, 2021) have issued guidance to reduce vaccine errors, which includes implementing BCMA in outpatient settings. Data on the organization's vaccine error rate, average national vaccine error rates, estimated revenue loss, and best practice guidelines were presented to the organization's outpatient vaccine safety and nurse governance committees. Both committees supported the implementation of BCMA as part of a multi-pronged effort to reduce

vaccine errors.

Background and Significance of the Problem

Vaccine administration safety has been a focus area within the organization and at a national level. Vaccine errors within the organization have persisted despite several initiatives over the past decade. In addition to the BCMA project, storage units have been standardized with labeling that meets ISMP guidelines. EHR upgrades have been made through collaborative efforts between the organization and its parent company.

Background

Vaccine errors have historically been an issue within the organization; some offices, including project site B, have temporarily lost vaccine ordering access from New York State due to their high volume of errors. Over the last decade, the organization has taken steps to reduce vaccine errors, including forming a vaccine safety committee and a vaccine coordinator role. In the last two years, the amount of education delivered to nurses regarding vaccine schedule changes has increased, and education is reinforced when trends in vaccine error types are discovered. In 2023, an audit revealed 329 doses of COVID-19 vaccines were given after their beyond-use date. Education clarifying the difference between beyond-use dates and expiration dates was delivered. However, education alone has not significantly improved the safety of nurse workflows for administering vaccines. Despite policy mandating vaccine and patient verification against the EHR, many nurses were not using their computers when administering meds. Wrong vaccine, expired vaccine, and wrong patient errors occurred as a result. There have also been errors stemming from failure to review the patient's immunization record, choosing the wrong vaccine from the storage unit, and confusion over which vaccine should be ordered. The vaccine administration process used before BCMA go-live and opportunities for safer practice are

documented in Appendix A.

Significance of the Problem

Vaccines are widely regarded as one of the most valuable disease prevention methods available. The CDC estimates that worldwide childhood vaccines prevent 4 million deaths yearly (CDC, 2023). COVID-19 vaccines saved almost 20 million lives worldwide in their first year of use alone (Watson et al., 2022). However, vaccine hesitancy threatens vaccine programs' success; the World Health Organization (2019) named vaccine hesitancy a top threat to global health. Vaccine administration errors threaten to further undermine confidence in vaccine programs. Improving vaccine administration safety is crucial to maintaining public trust.

The growing complexity of the vaccine schedule plays a role in vaccine errors within the organization and on a broader scale. A fully vaccinated child born in the US in 2024 will have received 48 immunizations by age six (CDC, 2024). Each vaccination opportunity is also a chance for errors, including missing doses. Morse-Brady and Hart (2020) noted that few reported additional dose vaccine errors caused patient harm and that missed dose errors may pose a greater risk to the patient and population health due to lack of protection. During the project implementation, team members noted several missed opportunities to vaccinate adult patients at project site B. While the primary aim of this project was to prevent vaccine errors, its broader purpose was to improve public health through safe vaccination practices.

Overarching Aim of the Project

This project aimed to improve the safety of vaccine administration within the ambulatory division of a large healthcare organization. The project implemented BCMA in two family practice locations, chosen due to proximity and vaccine error rates, to develop workflows before expanding them to all practice locations. This project was part of a larger organizational effort to

reduce vaccine errors, which included several interventions, including changes to the EHR interface, improved labeling of vaccine storage units, and staff education regarding safe administration of vaccines.

Summary of the Evidence

BCMA is widely used in inpatient acute care units to reduce medication errors. While BCMA's adoption has been slower in non-inpatient areas, patient safety groups like the ISMP (2022) advocate its expansion beyond the inpatient settings where it has become expected practice. In 2019, the ISMP suggested using BCMA in outpatient care areas "when possible," by 2022, they upgraded their guidance to "strongly recommend" expanding BCMA to outpatient areas (ISMP, 2019; ISMP, 2022). The PICOT question "How does BCMA, compared with manual data entry, affect vaccine errors in outpatient care environments over a 12-week implementation time period?" helped guide the literature review. Literature indicates that BCMA decreases med errors, streamlines vaccine administration, enhances staff satisfaction, and improves vaccine data accuracy (Evanson et al., 2020; Holder et al., 2021; Reed et al., 2020; Reza et al., 2024). These findings suggest that BCMA has significant potential to improve safety and efficiency in outpatient settings, aligning with the ISMP's recommendations.

Manual data entry can be time-consuming when administering vaccines, due to lot numbers, national drug codes, and expiration dates as federally required data fields. BCMA has been shown to reduce medication administration time by 33% (Moore et al., 2020). Vaccine scanning with BCMA takes seven seconds compared to an average of 29.5 seconds for manual data entry (Evanson et al., 2020). BCMA improves data reliability, with over 99% accuracy in scanned vaccines versus 47%-95% with manual entry (Reed et al., 2020; Reza et al., 2024). High satisfaction rates were reported among those using BCMA for vaccines; perceived benefits

included improved safety and data accuracy, time savings, and reduced eye strain (Evanson et al., 2020; Holder et al., 2021; Owens et al., 2020). BCMA not only supports documentation compliance, it reduces the potential for human error. Thus, BCMA can enhance overall workflow and staff's experience of care delivery.

Despite the benefits of BCMA, barriers to scanning persist. Holder et al. (2021) state that selecting the correct scanner initially is critical to project success, and involving staff in procedure development facilitates compliance. Reed et al. (2020) found that monitoring scan rates helped maintain compliance. This project monitored scan rates and involved nurses in workflow design. Engaging staff and tracking compliance were key strategies to address potential challenges and support consistent BCMA use.

Project Design

This project used the Institute for Healthcare Improvement (IHI) 's "Model for Improvement" and the OhioHealth Change Management Model. According to the IHI (n.d.), quality improvement (QI) is an iterative process wherein a team of people assess the current state and outcomes, identify the root causes of poor outcomes, and form a plan to address the underlying issues, focusing on improving systems rather than individual behaviors. The IHI's model uses PDSA cycles to make small tests of change, allowing the project team to gather and analyze data on the effectiveness of changes (IHI, n.d.). OhioHealth's model (2021) was used to engage stakeholders in the transition.

Project outcomes were used to guide PDSA cycles. The primary process outcome that guided PDSA cycles was *greater than or equal to 90% of all vaccines and CAMs in the project sites will be administered via BCMA by week three after site go-live*. This was tracked via reports obtained directly from the organization's EHR, EPIC.

The project leader and nursing informaticists developed a suggested workflow for scanning vaccines and CAMs; PDSA cycles allowed the nurses using BCMA to influence changes to the workflow plan. Data gathered during the implementation period influenced PDSA cycles, which included re-education, equipment troubleshooting, and workflow redesigns. The OhioHealth Change Management Model (OhioHealth, 2021) was incorporated to help identify and engage stakeholders and prepare them for the process change. Utilizing tools and best practices from the OhioHealth Model yielded high engagement from the nurses most impacted by the change in med administration workflows.

The first PDSA cycle occurred before site A's go-live during hands-on education sessions when nurses demonstrated the use of the barcode scanners and gave feedback on the proposed workflows. One of the first issues noted was that although the med room computer had badge reader access, it was not functioning properly. The issue required a technician to fix the computer on-site before BCMA go-live.

Subsequent PDSA cycles occurred after each site's go-live date. One PDSA cycle was initiated by nurses at site A, who experimented with scanning different components of two-part vaccines. Guidance from other organizations suggested that nurses needed to scan the outer carton rather than a vial when administering two-part vaccines (i.e., vaccines where two vials both contain active ingredients). Nurses discovered that scanning the powder component would populate all required information into EPIC. This information successfully carried over into scan reports. Thus, scanning the powder vial became the accepted workflow.

While scan rates remained above the benchmark of 90% at site A, a trend of COVID-19 vaccines not being scanned more than other vaccine types prompted further investigation. It was determined that documentation data were auto-populating for the COVID-19 vaccine before it

was scanned, causing nurses to believe they did not need to scan the vaccine or had already scanned the vial. The cause for the issue was that EPIC auto-populates the administration details when only one lot number remains in a clinic's vaccine lot manager (the vaccine inventory manager in EPIC). Nurses at both pilot sites were educated about this system flaw, and the issue was brought to system-level EPIC administrators.

Due to site B's small number of orders, just one to two missed scans significantly impacted scan rate percentages. During the week of July 22, there was a steep drop in scan rates from 92% to 51.9%; this drop was traced to one nurse's non-compliance. Upon further inquiry, the nurse stated she was not scanning meds because she did not want to undock her laptop to scan or verify her meds or patient. The manager and clinical lead at the site completed re-education and reinforcement of medication administration policies. Lessons learned from the two project sites informed plans to spread BCMA to the rest of the organization's outpatient division.

Project Implementation

BCMA was implemented in two large family practices. It was introduced to the larger office (site A) on May 28, 2024; site B went live on June 17. Data were collected through August 31. Site A is a large family practice that gives an average of 480 vaccines per month. It had a lower vaccine error rate than the organizational average (20.5/10,000 doses ordered), most of which were provider errors. Site B gives an average of 200 vaccines per month; it had the highest vaccine error rate in the organization (215.4/10,000 doses ordered). Most errors at site B were due to nurses' failure to complete three med checks. These two offices are one mile apart and were chosen due to their proximity and characteristics, with site A serving as a high-functioning pilot and site B presenting a chance for significant error reduction.

The primary participants in this QI project were the nurses at the two family practices; all nurses at both sites used BCMA once their site adopted it. All nurses met inclusion criteria; other staff were affected by the project but were not included participants because they did not use BCMA. Site A had eight nurses plus an RN nurse manager, and site B had six nurses plus an RN clinical lead. The change also affected the providers, managers, and other site staff. The project implementation team members were the project leader, the organization's vaccine coordinator, two nurse informaticists, the practice administrator who oversees both offices and the managers and lead nurses at each location.

Prior to go-live, the team met with the nurses at both sites to gather input on what would work within each office. The team worked with IT to ensure all needed equipment was ordered and with informatics to ensure nurses had the education required on using and troubleshooting issues that might arise with the scanners. Hands-on training for nurses occurred the week before launch, once all necessary equipment had been installed. Lessons learned from site A informed adjustments to the site B go-live plan. A project team member was available on-site during go-live weeks.

Weekly virtual check-ins and periodic in-person visits helped the team gather nurse feedback, which guided workflow adjustments. After a standardized workflow was established through repeated PDSA cycles, a checklist was created for nurses to use as a reference and auditing tool. Nurses at both project sites participated in peer audits using the team-developed BCMA workflow audit tool (Appendix B). Two staff nurses at site A conducted peer med audits from July 18 to August 15. The clinical lead RN at site B conducted six med audits during the week of July 22. The intended audit collection practice was carried out at site A as written in the project proposal. Due to unforeseen barriers related to the departure of the clinical lead RN at

site B, the audits were not completed at site B for the intended length of time. Nurse feedback was key to refining workflows; audits were used as a final assessment to ensure that workflows were being used as intended.

Budget

Site A is one of six office locations with hardwired computers in each patient room. Best practice for BCMA is to scan the medication in the patient's presence (Holder et al., 2021). The ideal configuration to facilitate scanning in front of the patient would have been to outfit each of site A's rooms with barcode scanners, but the budget to achieve this (more than $6,000) was not approved. Instead, a computer with a scanner and badge reader was installed in the med room, where nurses began the scanning process. The nurse would save the administration in progress before leaving the med room, then open the patient's chart in the patient's exam room to complete the patient verification and med administration. Site B used work-issued laptops with wired scanners. The project repurposed existing equipment as much as possible to remain within budget limits. The only purchases were a $160 badge reader for site A and two $60 rolling laptop carts for site B, totaling $280.

Outcomes and Data Analysis

Data collection for the BCMA project involved multiple team members, including the patient safety nurse, vaccine coordinator, nurse informaticists, institutional report writer, and project leader. All patient identifiers, except age, were removed from the final reports, and the project leader analyzed the data.

The effectiveness of the BCMA project was measured by vaccine error rates and vaccine and CAM scan rates. The overarching goal for this project was: after implementation of BCMA within two family practice locations, the vaccine error rate would be less than or equal to 15.3

errors per 10,000 vaccine doses ordered over the 12-week implementation period. Before and after implementation of the BCMA project, the organization collected and analyzed the number of vaccine errors voluntarily reported to the organization's incident reporting system. According to the ISMP (2023), incident reporting is not a good measure of overall errors; it "serves as a barometer of safety culture." To better represent the volume of vaccine errors, the team also gathered all vaccine error audits from the organization's vaccine coordinator. Vaccine error audits are typically done after a trend in error types is discovered within the organization; therefore, they do not capture all vaccine errors. In addition, data on the number of vaccines and CAMs ordered were obtained via the Tableau dashboard, which obtains data directly from EPIC.

After initiation of BCMA, vaccine scan rates were tracked weekly. This organization has a 90% scan rate benchmark for all medications; the project aimed for a 90% or higher scan rate for all vaccines and CAMs by the third-week post-implementation. Vaccine scan rates were tracked by reports directly downloaded by the team leader from EPIC, whereas scan rates of other CAMs were obtained from the organization's institutional reports writer. There were delays in obtaining CAM scan rates, which prevented immediate PDSA cycles based on CAM scan rates from occurring. Reports of the number of times the barcode scanner detected and prevented an error were obtained via nurse self-report. A simple handwritten tool was developed and hung in the med room on a clipboard (see Appendix C). The organization has a poor rate of near-miss events being voluntarily reported to the incident reporting system, and this easier-to-use handwritten format has offered some insight into near-miss events that may not otherwise be reported.

Compliance with nurses' use of the approved workflow was tracked via team-developed auditing as an indirect measure of workflow usability. The goal for this measure was 90%

compliance with the new workflow by the last week of the implementation period, as measured by the auditing tool. In the absence of literature identifying a benchmark for workflow audit compliance, this benchmark was agreed upon by the BCMA workgroup consensus vote.

Lastly, average throughput (time from clinic check-in to check-out) was tracked for four weeks before and after each site's go-live date as a balancing measure to determine whether implementing the new work process negatively impacted clinic productivity. Throughput times were obtained directly from EPIC.

Data Analysis

The data analysis for this QI project relied primarily on run charts that were shared with participants at the project sites. Data at each site was compared to pre-implementation data where applicable. To analyze vaccine errors per 10,000 doses, the total number of vaccine errors (from incident reports and audits) for the organization and each project site was plotted on annotated run charts with the total number of orders. To analyze scan rates and promote continual improvement, scan rates were posted in the project sites and plotted as the percentage of CAMs scanned on an annotated run chart. To analyze throughput, average daily throughput times for each clinic were plotted on a run chart for four weeks before and four weeks after go-live. Finally, compliance with the new workflows was measured via team-developed audits. Compliance was tracked as a percentage of steps being followed correctly divided by the total number of steps possible to be followed correctly.

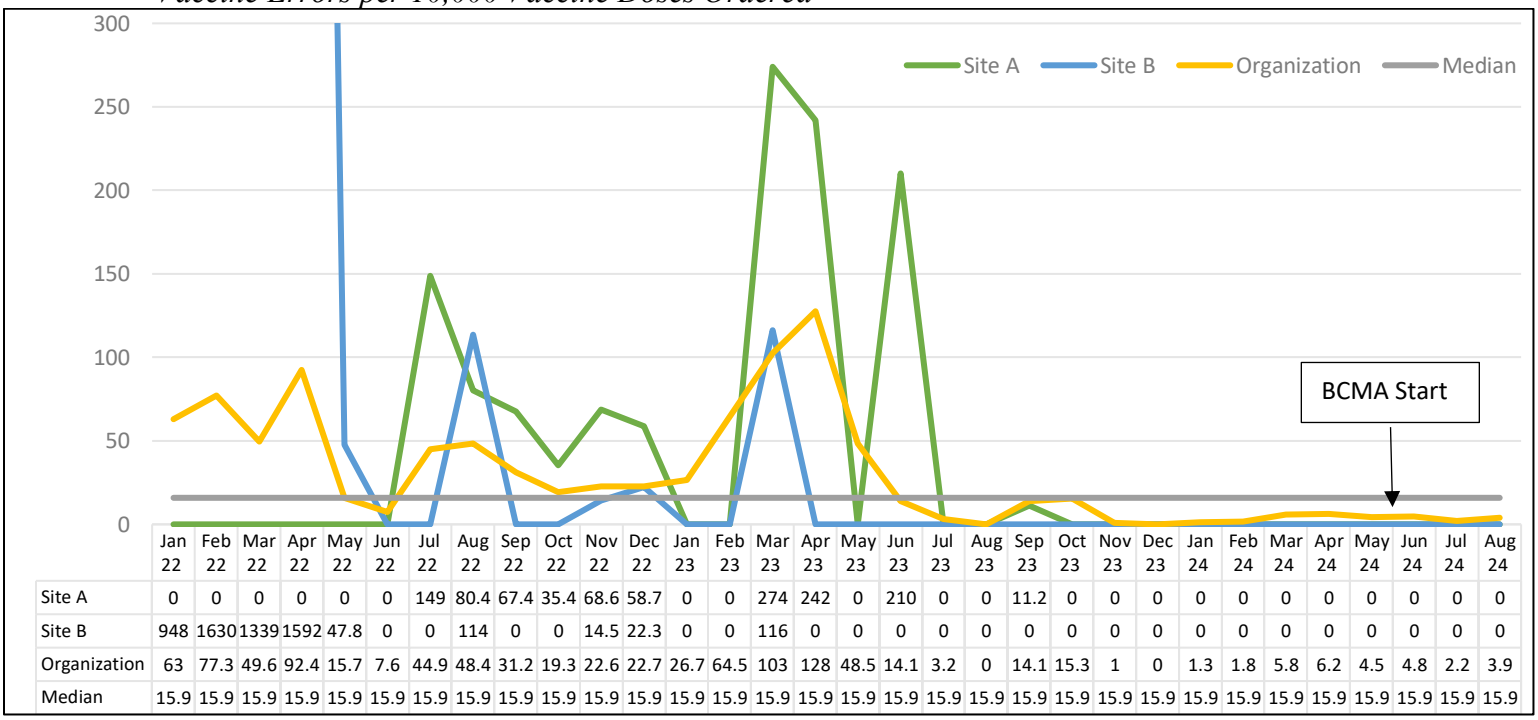
Results/Findings

The overarching goal for this project was to maintain a vaccine error rate at or below 15.3 errors per 10,000 doses ordered in the two family practice sites after the implementation of BCMA. This goal was achieved with vaccine error rates of zero during the implementation

period. Utilizing the handwritten near-miss reporting tool, four potential vaccine errors prevented by barcode scanning (two in each site) were identified. The project leader prevented two wrong-route CAM errors during direct observation of medication administration while teaching a nurse how to use BCMA. This observation prompted organization-wide re-education on correct needle size selection. Caution should be taken in implying that BCMA had a positive effect on reducing vaccine errors in the two project sites because both sites and the organization as a whole had already seen a downward trend in vaccine errors (see Figure 1) and because the organization's vaccine error rates rely mainly on self-reported incidents.

Figure 1

Vaccine Errors per 10,000 Vaccine Doses Ordered



	Jan 22	Feb 22	Mar 22	Apr 22	May 22	Jun 22	Jul 22	Aug 22	Sep 22	Oct 22	Nov 22	Dec 22	Jan 23	Feb 23	Mar 23	Apr 23	May 23	Jun 23	Jul 23	Aug 23	Sep 23	Oct 23	Nov 23	Dec 23	Jan 24	Feb 24	Mar 24	Apr 24	May 24	Jun 24	Jul 24	Aug 24
Site A	0	0	0	0	0	0	149	80.4	67.4	35.4	68.6	58.7	0	0	274	242	0	210	0	0	11.2	0	0	0	0	0	0	0	0	0	0	0
Site B	948	1630	1339	1592	47.8	0	0	114	0	0	14.5	22.3	0	0	116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Organization	63	77.3	49.6	92.4	15.7	7.6	44.9	48.4	31.2	19.3	22.6	22.7	26.7	64.5	103	128	48.5	14.1	3.2	0	14.1	15.3	1	0	1.3	1.8	5.8	6.2	4.5	4.8	2.2	3.9
Median	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9	15.9

Process Measure Results

The primary process measure monitored throughout the project was vaccine scan rates. CAM scan rates were analyzed once available, but there was a lag in CAM scan rate reporting. Site A maintained vaccine scan rates above the organizational benchmark of 90% by the end of

week one and overall scan rates above 90% by week 2. Site B achieved vaccine scan rates above 90% except for one week, but overall scan rates were less consistent (See Tables 1 and 2). Due to fewer overall med orders, site B's scan rates were more affected by each individual missed scan. During the week of July 22, one nurse at site B stopped scanning their vaccines and medications altogether, which prompted a PDSA cycle. Re-education and policy enforcement led to improvements the following week.

Table 1

Site A Scan Rates

Week Of	Vaccines	Vaccine scan rate	CAMs	Total scan rate
27-May	83/91	91.0%	3/6	88.7%
3-Jun	98/101	98.0%	10/15	93.1%
10-Jun	94/94	100.0%	2/6	96.0%
17-Jun	90/92	97.8%	8/10	96.1%
24-Jun	102/105	97.1%	8/9	96.5%
1-Jul	73/76	96.0%	7/10	93.0%
8-Jul	56/57	98.2%	10/13	94.3%
15-Jul	77/78	98.7%	7/9	96.6%
22-Jul	97/97	100.0%	4/4	100.0%
29-Jul	76/76	100.0%	8/12	95.5%
5-Aug	78/78	100.0%	11/16	94.7%
12-Aug	71/72	98.6%	8/8	97.8%
19-Aug	58/58	100.0%	4/4	100.0%
26-Aug	87/89	97.8%	5/8	97.9%

Table 2

Site B Scan Rates

Week Of	Vaccines	Vaccine scan rate	CAMs	Total scan rate
17-Jun	10/11	90.9%	7/10	81.0%
24-Jun	3/3	100.0%	5/5	100.0%
1-Jul	1/1	100.0%	4/5	83.3%
8-Jul	9/10	90.0%	5/9	73.7%
15-Jul	16/16	100.0%	7/9	92.0%
22-Jul	5/12	41.7%*	9/15	51.9%*
29-Jul	13/13	100.0%	7/9	86.4%
5-Aug	16/17	94.1%	10/11	92.9%
12-Aug	9/9	100.0%	8/9	94.4%
19-Aug	16/16	100.0%	15/19	88.6%
26-Aug	22/23	95.7%	7/14	78.4%

Peer audits were used as an indirect measure of workflow usability. Compliance was measured by dividing the number of steps completed correctly by the number of steps possible for that CAM or vaccine administration situation. The goal for audit compliance was for at least 90% of audit steps to be followed correctly by week 12, which was met (see Table 3). The step most often missed was nurses cleaning their hands before preparing their meds.

Table 3

Medication Audit Compliance

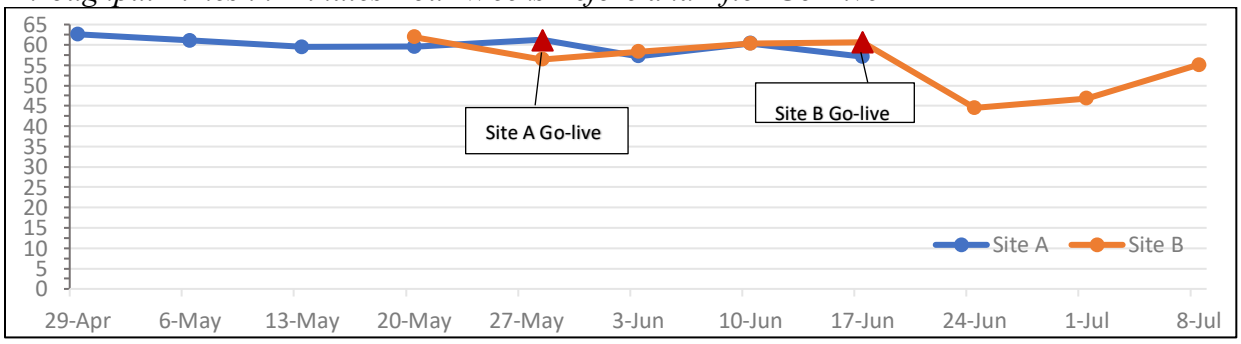
	Week of	**7/18**	**7/22**	**7/29**	**8/5**	**8/13**
Site A		25/27 **92.6%**	62/65 **95.4%**	49/51 **96.1%**	56/56 **100%**	40/41 **97.6%**
Site B			76/82 **92.7%**			

Balancing Measure Results

To assess the impact of BCMA on clinic productivity, throughput times were monitored before and after implementation. Data showed no significant change in throughput beyond the go-live week at either site (see Figure 2). BCMA implementation likely did not negatively impact clinic flow, but other factors may have influenced throughput times, including lighter schedules due to provider vacations.

Figure 2

Throughput Times in Minutes Four Weeks Before and After Go-Live



Findings

In addition to the measurable outcomes discussed, the project implementation process has led to the creation of tools the organization has used to expand BCMA throughout its outpatient

division. Nurses are using the audit tool as a checklist reference to learn the new BCMA workflows, and staff have expressed that the handwritten tool for reporting near-miss events is less cumbersome than the institution's electronic incident reporting system, MIDAS.

Nurses at the pilot sites have expressed satisfaction with BCMA; nurses at site A expressed that BCMA is safer and faster than previous methods of medication administration. Nurses at site B stated that they like not having to search for information on vaccine vials and cartons. These findings mirror available literature, which lists improved safety, time savings, and reduced eye strain as perceived benefits (Evanson et al., 2020).

It is difficult to determine whether BCMA has provided any financial benefit at the two pilot sites, but the errors prevented would have cost the organization approximately $1,000. BCMA could improve vaccine inventory management, which would, in turn, lead to cost savings. The organization has identified BCMA's effect on inventory accuracy as a topic for future analysis.

Limitations

A key limitation of the project was the reliance on voluntary self-reports for vaccine error tracking, which likely led to an inaccurate error count. Since error audits were not conducted during the project period, the zero-error rate at the project sites and low organizational error rate should be interpreted cautiously. Seasonal factors, such as fewer vaccines administered in the summer, may have also influenced the results. Future projects should consider error auditing in the project sites before and after project implementation to improve the accuracy of error data.

Another limitation was the feedback collection method. Since project team members in leadership roles gathered feedback, nurses may have felt pressured to provide positive feedback

or withheld negative comments about the BCMA project. Future projects could elicit feedback via anonymous surveys to mitigate courtesy bias.

Discussion

The organization has been satisfied with the overall results of the BCMA project. Within one month of the project launch, the scan rate reports, nurse feedback, and vaccine errors prevented by BCMA alone prompted the organization to move forward with their plans to spread BCMA to other sites. The workflows, tools, and reports used for the project have been used in the organization's rollout of BCMA to its other outpatient sites. All of its other sites that administer medications have gone live with BCMA. Responsibility for ongoing monitoring will be transferred to the organization's quality improvement and safety nurse.

Vaccine and CAM scan rates and total vaccine errors per 10,000 doses will continue to be monitored for all practice sites. Reed et al. (2020) found that monitoring scan rates helped maintain compliance with scanning workflows. Vaccine scan rate reports are accessed via EPIC download, and CAM reports are emailed once monthly, but an interactive dashboard is being created. Downloading vaccine scan rate reports for each office individually has already become time-consuming, with over 60 offices using BCMA, so creating a dashboard will be key to the sustainability of monitoring scan rates. The near-miss reporting tool has been introduced to all outpatient sites, and several near-miss events throughout the organization have been reported using the tool. In addition, BCMA's effect on vaccine inventory management will be monitored.

Although procedure changes are underway, there have yet to be any changes in official policy. Updates to the institutional medication administration and patient safety event reporting policy will be required. Changes in procedure without corresponding policy changes could threaten the standardization of workflows that the spread plan sets to achieve.

Summary

Scan rates have been reported to each project site throughout the project. Nurse feedback was instrumental in developing the workflows that have been spread to other sites. The sites' zero percent vaccine error rates and audit compliance results have been reported at site-level and organization-wide meetings.

BCMA is a safeguard that meets two of the Institute of Medicine's six aims for improvement (Committee on Quality Health Care in America, Institute of Medicine, 2001). It improves patient safety by reducing the risk of medication errors and improves efficiency by reducing the waste of medications as well as wasted practitioner time. Additionally, it meets the Institute for Healthcare Improvement's aim of improving the experience of providing care (IHI, n.d.). BCMA is a valuable tool in advancing patient safety by meeting key healthcare improvement aims.

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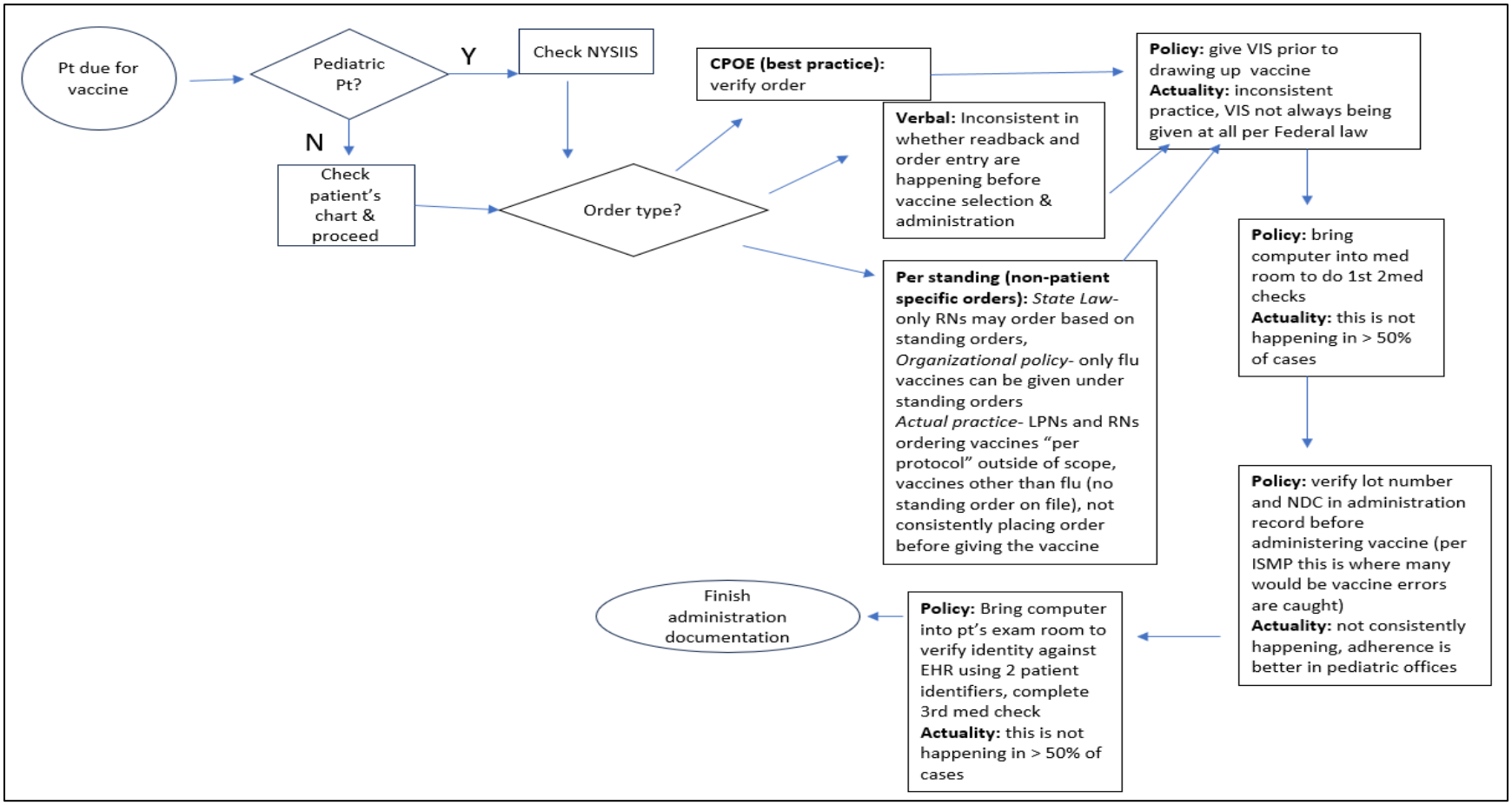
Appendix A

Vaccine Administration Workflow Process Diagram



Appendix B

Barcode Medication Administration Audit Tool

Standard of Care	Standard Met	Standard Not Met	N/A	Comments
Prepares medication in med room.				
Confirms medication/ immunization ordered in EHR.				
Immunizations only: Ensure the patient/ guardian has an up-to-date Vaccine Information Sheet (VIS).				
Immunizations only in patients under 18 years old: Confirms the patient's insurance to determine whether the child is VFC eligible.				
Cleans/ sanitizes hands before preparing medications.				
Removes the medication from the correct stock in the medication storage unit.				
From the Immunizations or Medication Administration tab: Scan the QR code of the medication. *If no QR code is available, scan the linear barcode.*				
Confirms that lot number, NDC and expiration date have populated in the correct fields after scanning.				
Prepares the correct dose for administration.				
Saves administration as incomplete if needed.				
Completes administration of medication in the patient's exam room.				
Cleans/ sanitizes hands *in front of the patient* before patient contact.				
Confirms patient's identity *out loud* using at least 2 patient identifiers, and compares the information against the immunization record/ medication record in EPIC.				
Confirms with the patient/ guardian which medication(s) the patient is about to receive. Answers any patient/ guardian questions.				
Completes pertinent screening questions in EPIC before administering medication/ immunization.				
Administers medication using medical asepsis, via the correct route.				
Completes any remaining pertinent documentation in EPIC and clicks accept.				

Appendix C

Near Miss Event Reporting Form

Near Miss Events: Email completed forms to (Quality Improvement Nurse)		
Date	MRN	Brief Description of Event