POKE-R
Using Analytics to Reduce Patient Harm

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Abstract: Major events and surgeries are not the only sources of trauma during a hospital encounter. Many small, less invasive events such as shots, line placements, blood draws, and imaging studies happen throughout a patient's hospital stay. Many of these less traumatic events have the potential to negatively impact patient outcomes by increasing the risk of hospital-acquired infections through skin invasions and exposure to organisms, reducing the patient experience by causing pain and frustration, increasing cost and causing other complications. The goal of this project is to reduce such events when they are not clinically required. This is an analytics project so this goal is facilitated by making accurate and meaningful information available to the appropriate personnel. This includes timely information to clinicians so they can alter treatment, and retrospective trend analysis to enable and track performance improvement and identify opportunities for additional process improvement.

1 BACKGROUND

This project is based on the Prevent Pain and Organisms from sKin and catheter Entry (POKE) project initiated at Dixie Regional Medical Center. Dixie Regional implemented the POKE initiative within their Neonatal Intensive Care Unit (NICU) (Ridout, 2014). The results at Intermountain Health System show that the POKE project has resulted in reduced POKEs for NICU patients and significant financial savings estimated at $3.5 million over 5 years for a single hospital. Reduction in length of stay was also identified. Figure 1 and Figure 2 quantify cost reduction associated with the original Dixie Regional Medical Center project.

We are calling our project POKE-R because we are including Radiology events. Radiology images can cause serious complications later in life for pediatric patients due to the much higher sensitivity children have to radiation, and also reduce patient/parent experience (Medscape, 2014) (Slovis, 2002) (Brenner, 2002). We are leveraging this prior research and enhancing it. We are considering anything a POKE which invades the skin or opens a line or drain into the patient. This includes medication administrations, blood draws, placement of lines, drains and airways (LDAs), surgeries, and other invasive procedures.

The goal of our project is to reduce POKE-R events by providing detailed information to the clinicians. Often lab draws or procedures are not medically necessary and may cause more harm than good (Salisbury et al, 2011). Also, many times lab tests can be combined to use a single specimen collection. A patient sees many providers throughout a hospital stay and there may be redundant orders or orders which are no longer medically warranted.

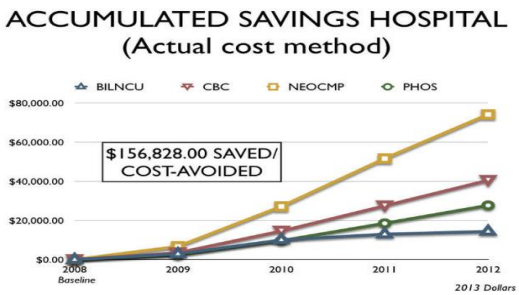


Figure 1: Hospital savings experienced by Dixie Regional Medical Center POKE initiative.

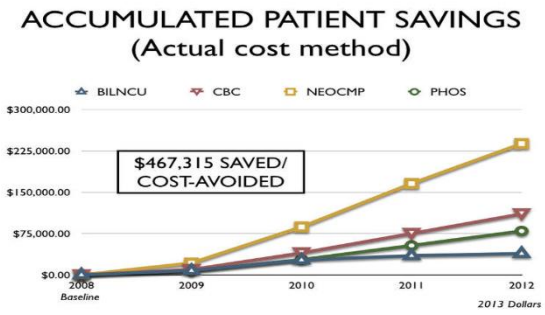


Figure 2: Patient savings experienced by Dixie Regional Medical Center POKE initiative.

By reducing POKEs we hope to achieve each of the following potential improvements:

- Reducing hospital-acquired infections

Every time a patient's skin is punctured, line is opened, or catheter is placed, there is an increased risk of a hospital-acquired infection. For example, there is significant evidence that risk of Central Line Associated Blood Stream Infections (CLABSI) is increased by repeated blood lab draws (Foster and Sabella, 2011) (Grissinger, 2011) (Sengupta et al, 2010).

- Improving the patient experience and the satisfaction of the patient and his/her family

The pain caused by invasive procedures, shots, and placement of lines, drains and airways has a clear effect on the patient experience and satisfactions.

- Reducing anemia, blood loss and blood transfusions

Each time blood is removed from a patient to perform a lab test, there is an increased risk of side effect or even the need for a blood transfusion. This is particularly prevalent with neo-natal patients and young pediatric patients and also with acute myocardial infarction (AMI) patients (Bateman et al, 2008) (Salisbury et al, 2011) (McVoy and Shandler, 2013)

- Reducing complications from radiology

Radiology imaging have been connected to complications for pediatric patients including cancer. Children have a greater sensitivity (10 times more than a middle aged adult) to radiation dose and computed radiography. Furthermore, the necessary movement required for a radiological exam can increase risks of further injury or disrupt lines, drains and airways (Foster and Sabella, 2011) (Brenner, 2002). Finally, the physical methodology of many imaging procedures, such as MRIs, can cause psychological trauma and reduce the quality of the patient experience.

- Reducing length of stay

Reducing POKEs has been shown to reduce the median length of stay for neonatal patients. Furthermore, POKEs increase the risk of infection, and hospital-acquired infections dramatically increase average length of stay for patients (Alharfi et al., 2014) (Foster and Sabella, 2011).

- Reducing cost

All procedures performed incur costs so the simple act of reducing the number of procedures directly reduces costs. Costs are also indirectly reduced through reduction in hospital-acquired infections and reduced length of stay.

The principle behind our approach is value-based medicine. The concept is to focus practice on patient and financial value of the medical interventions. The goal is to incorporate the highest level of evidence based interventions while ensuring adequate patient care and minimizing healthcare costs (Bae, 2015).

2 TECHNICAL IMPLEMENTATION

At Loma Linda, we have an enterprise data warehouse sourced from the clinical data in the Epic Electronic Medical Record (EMR) System. We implemented the POKE-R process by using the information in this data warehouse to build a new POKE-R fact table using standard industry dimensional modelling data warehouse practices.

The foundation for the data warehouse is provided by the EMR vendor, but we have extended it to include more detailed information useful for this project including

a) Lines, drains and airways

Needed to determine when a LDA was placed and when it was removed.

b) Procedure performance details

Needed to know if a procedure or image was actually performed, by who and when

c) Medication Administration Route

Needed to know how a medication was administered

Additionally, we had to add two extensions specifically for this project. We added an extension and modified EMR workflow specifically for LDAs to know how many attempts the LDA placement took. Furthermore, physician-performed LDAs such as central lines were documented in a different manner so we created a special extract to get the placement times and attempts. Finally, it was not enough to know when a specimen was taken. We needed to know which procedure orders shared blood draws and which required separate blood draws. If 5 lab draws

show the same collection time, it is important to know whether they were separately drawn, or all of the tests used the same blood collection.

With these extensions, all of the data needed to mine the POKE-R information was available in the data warehouse. However, before we could search for the POKE-R events, we had to configure which events were defined as POKEs. We did not want to hard-code this information and we did not want the information determined or maintained by IT personnel as it is clinical in nature. Therefore, we established an interface to configure POKE-R.

We needed to define every event which was a POKE-R event and whether it was painful. This needs to be configured using attributes of the data elements. The following attributes were identified by the clinician as identifying POKEs:

1. Medication Administration: Route and Administration Event
2. Lab Test: Specimen Type and Specimen Source
3. Procedure Order: Type and Code

Additionally, the presence of a line or drain prior to the event can impact whether the event is a POKE and whether it is painful. For example, blood tests and medication administrations are considered non-painful if they use an existing line. A urine sample is not a POKE at all unless there is a catheter used to obtain the specimen.

Finally, if the patient is under anesthesia at the time of the event, it is considered non-painful.

We created a simple secure interface for the Patient Safety and Reliability leadership to provide and administer this clinical information. This interface contains the data points listed above prepopulated from the actual clinical data warehouse. The user can then choose which values for each data point indicate a POKE and can combine data points.

We developed software code using Microsoft SQL Server Integration Services (SSIS) to read the POKE-R configuration file and then extract POKE-R events from the data warehouse into a new table within the data warehouse called PokeFact. This fact table contains the following information:

1. Encounter ID: The encounter the POKE happened during
2. POKE type: LDA Placement, LDA Placement Extra Attempts, Medication Administration, Image, Specimen Collection, Point of Care Test (POCT), Invasive Procedure, Surgery
3. Whether the POKE has already happened or is scheduled to happen in the future
4. When the POKE was ordered
5. The provider who ordered the POKE
6. When the POKE was scheduled to occur
7. When the POKE occurred
8. Whether the POKE is painful
9. Who performed the POKE

One thing that was very important was to determine the scheduled POKE-R events. Our goal was to show the clinician the upcoming POKE-R schedule so that treatment could be altered to reduce the POKEs. To do this we brought in every scheduled medication administration, procedure, surgery, image or lab test.

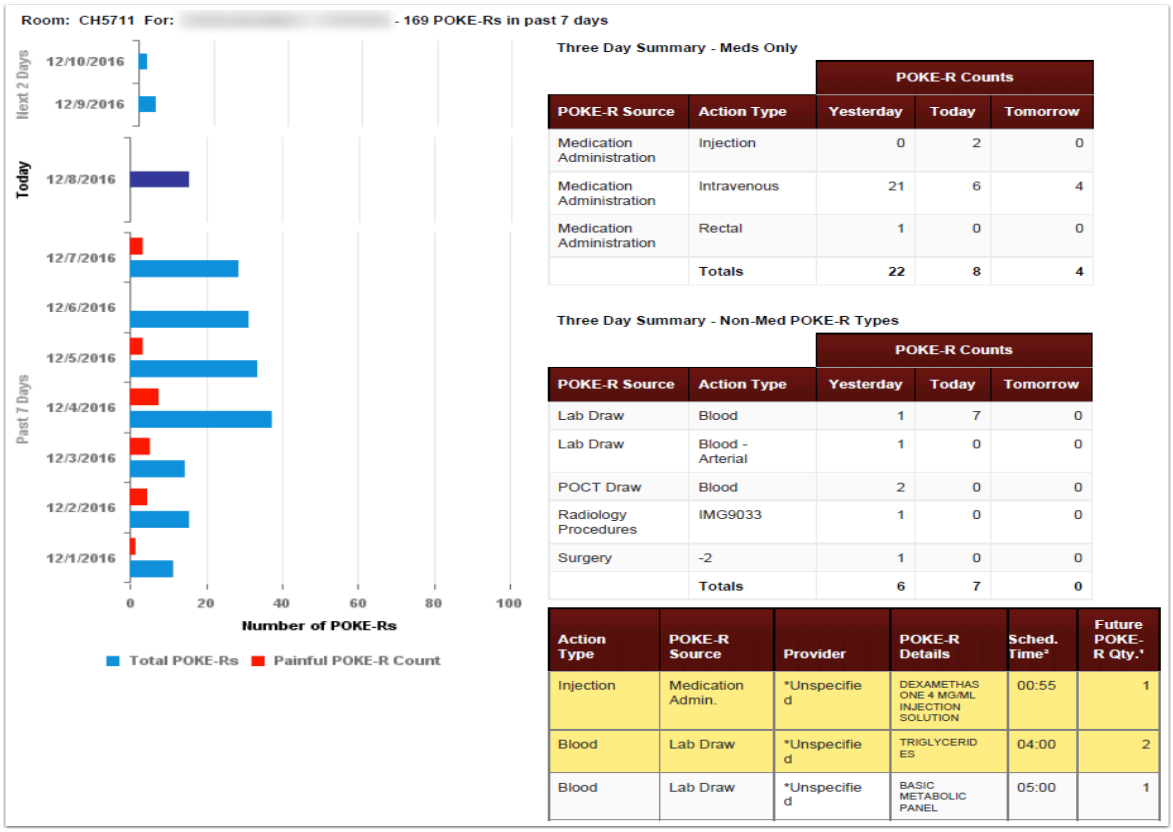
3 INFORMATION PRESENTATION

At this point, we had aggregated all of the information necessary to analyze POKE-R. The next step was to make this information useful to a clinician.

We developed three reports. The first report was a detailed report of patients currently in the hospital. This report lists for each patient the total number of pokes and painful pokes, the number of pokes and painful pokes in the last 7 days and the number of scheduled pokes for the next 3 days in graphical format. This poke counts are then shown grouped by the type of poke. Finally, every POKE performed in the last 7 days and every POKE scheduled for the next 3 days was individually listed with details. This reported was filtered by department so that an individual department could see each patient in the department. Scheduled POKEs are not always ever performed or cancelled. They can be left in pending status. So we dropped any scheduled POKE in the past which was never performed. The second report was the abridged version of the first report, showing only the number of POKEs over the past 7 days and what POKEs were scheduled for today. This made it more simpler for clinicians to digest the POKE-R information and make actionable decisions. Figure 3 shows an example of this report.

The third report was a trend of POKEs per Patient per Day over time so we could see if performance improvement was being achieved. This report was able to be filtered by location, unit, or attending provider. Figure 4 shows an example of this retrospective report.

Together, these reports enable process improvement and improved treatment. The provider and treatment team are supported by the detailed report, while the analysts in Patient Safety and Reliability have the aggregate and retrospective information to identify improvement opportunities.



Three Day Summary - Meds Only

POKE-R Source	Action Type	POKE-R Counts		
		Yesterday	Today	Tomorrow
Medication Administration	Injection	0	2	0
Medication Administration	Intravenous	21	6	4
Medication Administration	Rectal	1	0	0
	Totals	**22**	**8**	**4**

Three Day Summary - Non-Med POKE-R Types

POKE-R Source	Action Type	POKE-R Counts		
		Yesterday	Today	Tomorrow
Lab Draw	Blood	1	7	0
Lab Draw	Blood - Arterial	1	0	0
POCT Draw	Blood	2	0	0
Radiology Procedures	IMG9033	1	0	0
Surgery	-2	1	0	0
	Totals	**6**	**7**	**0**

Action Type	POKE-R Source	Provider	POKE-R Details	Sched. Time²	Future POKE-R Qty.¹
Injection	Medication Admin.	*Unspecified	DEXAMETHASONE 4 MG/ML INJECTION SOLUTION	00:55	1
Blood	Lab Draw	*Unspecified	TRIGLYCERIDES	04:00	2
Blood	Lab Draw	*Unspecified	BASIC METABOLIC PANEL	05:00	1

Figure 3: Example of abridged Patient POKE-R report.

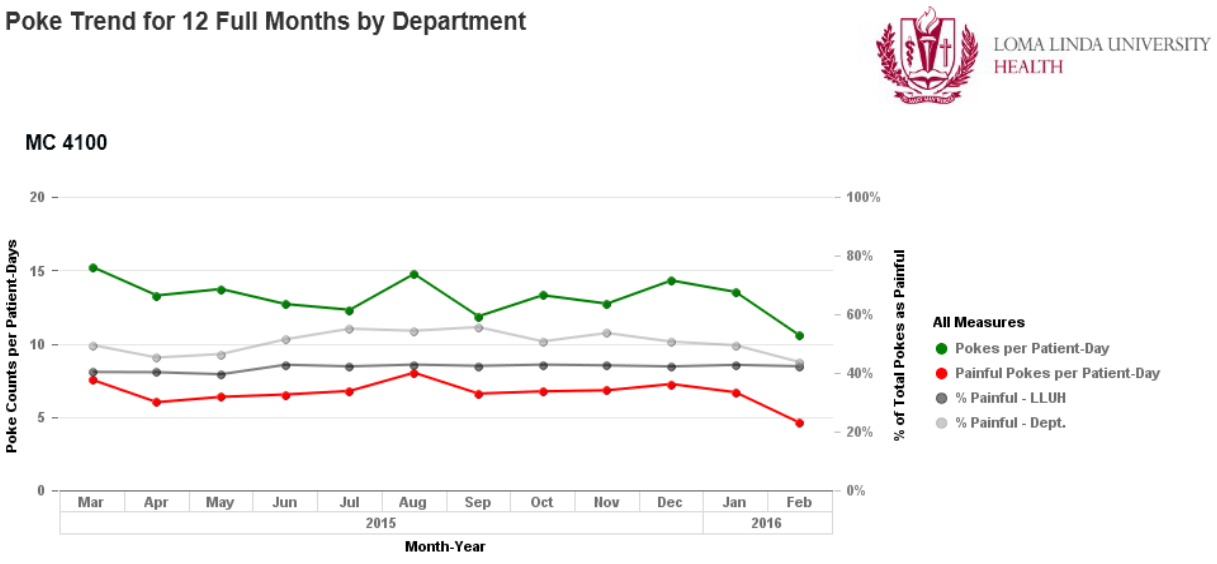


Figure 4: Example of POKE-R trend report.

4 PROCESS IMPLEMENTATION

To pilot the program, we chose a single department, the Pediatric Intensive Care Unit (PICU). We chose this department specifically because of the increased risk of complications in critical care pediatric patients including anemia and infection (Bateman et al, 2008) (Ridout, 2014) (Sengupta et al, 2010). The abridged report was scheduled to be automatically printed in the PICU at 5 am every morning so clinicians could (r to most POKEs being performed for the day. A resident fellow and a clinical nurse specialist were assigned specifically to manage the implementation of the program and received the daily detailed report. This allowed them to examine the most critical patients and suggest opportunities for POKE-R reduction.

At Loma Linda, the PICU uses structured interdisciplinary bedside rounds (SIBR). Under the SIBR methodology, all members of a patient's care team visit and communicate with the patient as a unit. Figure 5 shows the SIBR methodology. Because the SIBR methodology includes careful review of lab work, it provides a perfect opportunity to address potential POKEs. We have adjusted the SIBR methodology to include POKE-R.

The methodology includes:

1. Discuss and justify each care intervention.
2. Choose interventions that are:
   - Supported by evidence (consider pre-test probability)
   - Lead to change in treatment plan
   - Lowest cost
3. Considers cost in terms of financial burden and patient experience
   - Deliver best possible care, at the lowest cost to the healthcare system and the patient.
   - Reduction in patient harm, exposure, and pain are all considered.
4. Minimize ordering labs, instead perform a risk vs. benefit analysis for each test

Please see Figure 6 for an illustration of the SIBR POKE-R approach.

Additionally, three sets of patients were targeted as providing significant opportunity and actively managed using the daily report. These were patients with traumatic brain injury (TBI), patients with asthma and patients with external ventricular drain (EVD) placements. These patients are especially susceptible to infections and complications (Alharfi et al, 2008). Furthermore, asthma patients often experience an excessive number of lab tests in order to monitor the effects of medication on patient potassium levels (Schuh et al, 1989). Traumatic brain injury patients often experience sodium instability which requires monitoring (Atchinson et al, 1993). Therefore, these patients are likely to have a substantial number of POKE-R events and are particularly vulnerable to harm from these events.

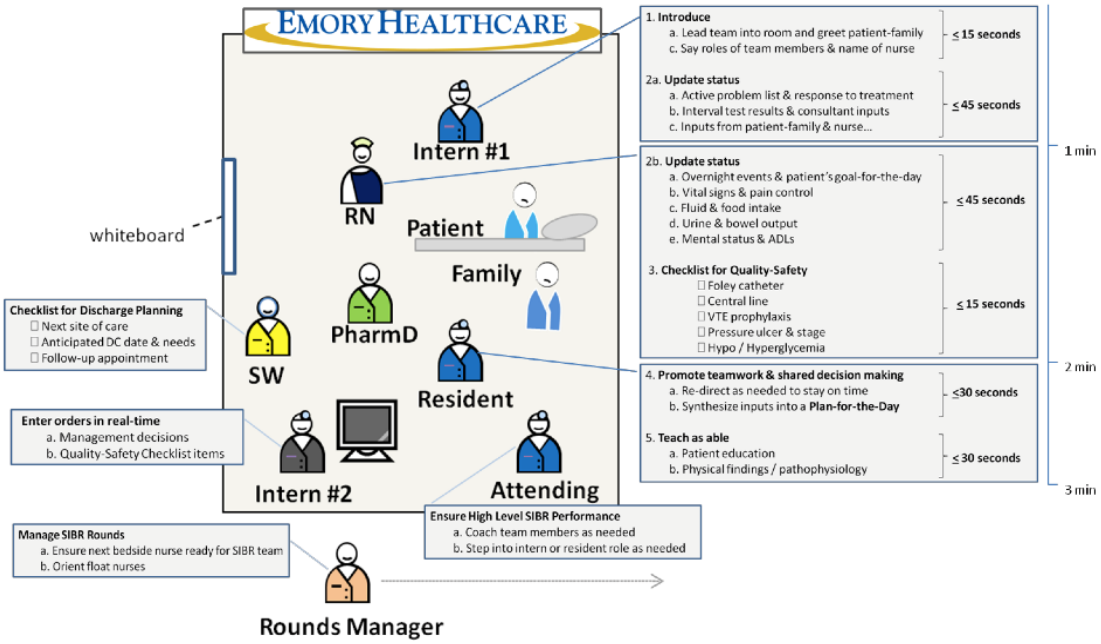


Figure 5: Structured interdisciplinary bedside rounds roles and process.

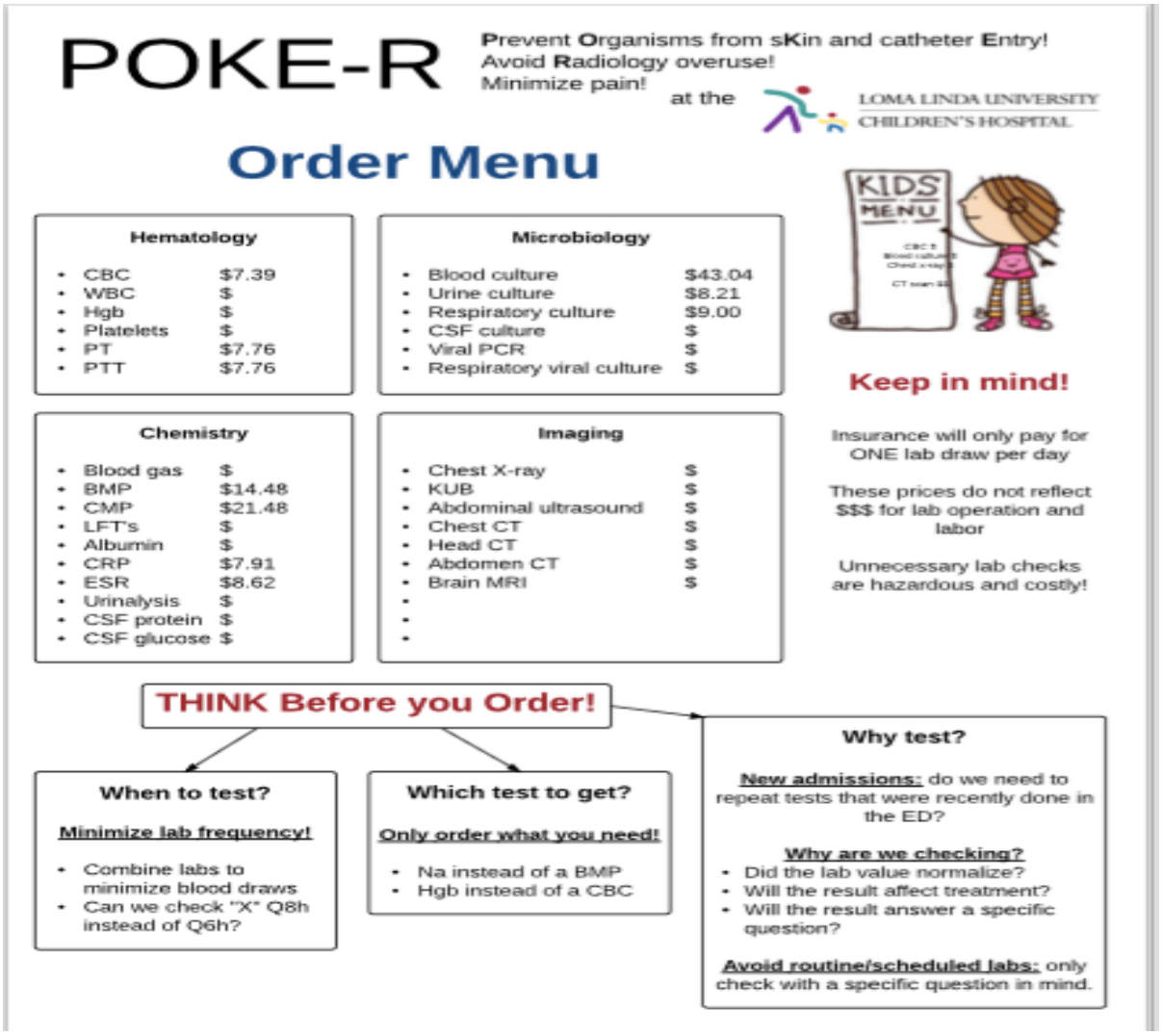


Figure 6: Order menu customized for POKE-R awareness.

5 RESULTS

Our project is in production in the PICU at Loma Linda University Children's Hospital. To analyze the success of the project, we compared patients prior to the introduction of both POKE-R and SIBR to patients after these programs were instituted. In all, we analysed 3,338 pediatric ICU patients.

We have seen a reduction in POKE-R events by 8.7%. Specifically, this was a decrease of 1.8 POKE-R events per patient per week. We compared this patient cohort with a historical control set using standard t-test methodology. This result was statistically significant with $p < 0.012$. Statistical significance for our purpose is defined as $p<0.05$.

Furthermore, we saw significant reductions based on event type. Medication administrations were reduced by 1.2 administrations per patient per week. Specimen collections were reduced by 0.3 pokes. Radiology procedures and point of care tests were also reduced. We saw an increase in line pokes, but this was expected because inserting a line actually reduces the pokes for medication administrations and lab draws and therefore is not discouraged by the program. Finally, we saw a reduction in surgeries but we do not think this change was influenced by our POKE-R program.

To determine the statistical significance of the data we utilized t-tests and chi-square goodness of fit tests and one-way analysis of variance (ANOVA). All of our results met the criteria for statistical

significance except for painful poke counts and point-of-care testing. Table 1 shows the means, deltas and statistical significance from our analysis. The two rows marked in red are not considered statistically significant due to p>0.05. Figure 7 shows the the one-way analysis of variance (ANOVA) graph for all pokes, where stage 1 is prior to implementing our program and stage 2 is after program implantation. The graph has green diamonds on it which describe the 95% confidence intervals of the mean within the upper and lower peaks of the diamond. The line across the middle is the mean, and the width of the diamond is proportional to the sample size. Figure 8 shows the control chart for all pokes.

We also analyzed specifically the asthma patients and found a decrease in metabolic panels by 30% with p<0.0001. For patients with hypo/hypernatremia, the metabolic panel reduction was 16%. These results demonstrate drops in Basic Metabolic Panels performed during the post-implementation period. Figure 9 shows the ANOVA graph for asthma and cerebral salt wasting patients.

Table 1: Statistics for poke analysis

Statistical Variable	Mean Pokes /patient week	Δ Control Set	p (Prob > |t|)
All pokes	14.372	-1.76	0.003
Painful	2.638	+0.10	0.472
MAR	10.57	-1.19	0.007
Specimen	2.220	-0.306	.003
POCT	0.811	-0.190	.157
BMP (Asthma and CSW)	1.741	-0.357	.000

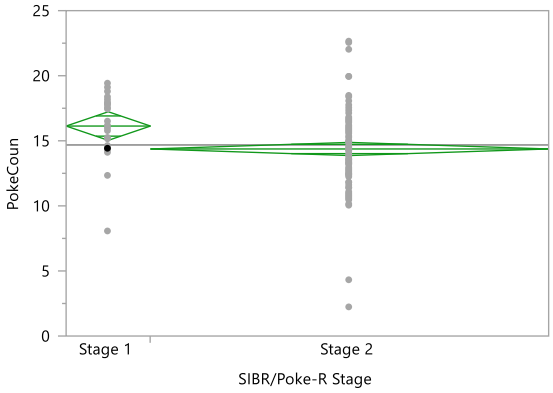


Figure 7: ANOVA graph for all pokes

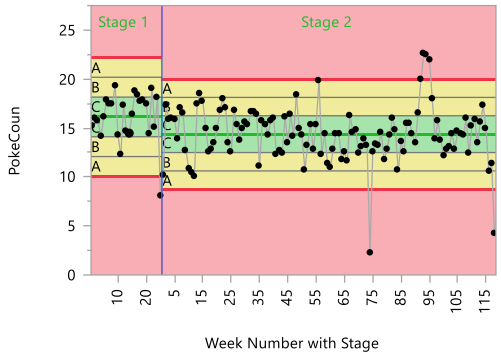


Figure 8: Control chart for all pokes

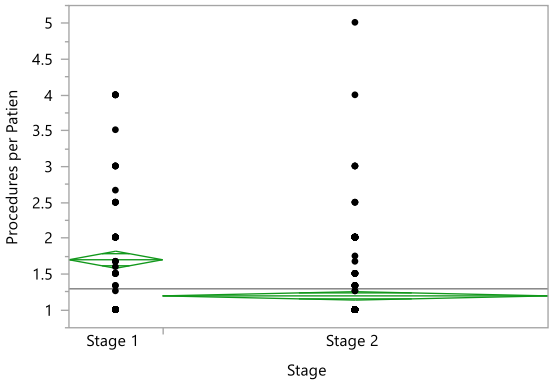


Figure 9: ANOVA graph for BMP for asthma and cerebral salt wasting patients.

6 FUTURE WORK

We would like to do more data analysis and research to quantify the benefits of the program including:

- Reduction in hospital-acquired infections such as Central Line-associated Bloodstream Infection (CLABSI)
- Reduction in cost
- Improved patient satisfaction

Additionally, patient satisfaction and cost information are not currently in our data warehouse. So, additional future work is to bring in these data points. This will not only allow us to more accurately monitor performance improvement, it will also enable greater cost transparency to the provider, patient and guarantor. We plan to integrate patient (and parent) experience survey data to quantify improved customer satisfaction and the cost benefits of our results to the hospital, the guarantor and the payor.

Currently, the POKE-R evaluation process is facilitated through printed and emailed reports even though the data is in the Enterprise Data Warehouse.

This is to eliminate the provider from having to access multiple systems. We plan to have the POKE-R details for a patient be directly linked to the patient's electronic health record. This way they can simply view the needed POKE-R information when they are already reviewing the patient's chart.

Currently, we have the number of laboratory tests but not the volume of specimen taken for the tests. Another enhancement we want to make is to interface with our laboratory system to get the precise volume of blood collected. This will give us more accuracy in measuring POKEs and associated risk for anemia.

We are also planning to roll out our POKE-R analytics and process to more departments throughout the hospital in the coming year.

7 CONCLUSION

We have implemented a comprehensive and configurable analytics solution to give providers the information they need to address excessive POKE-R events in patients. While our project has only gone into production in one hospital unit, we are already seeing considerable evidence of improvement. This project has the opportunity to reduce cost, improve patient outcomes and increase customer satisfaction.

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