Impact of Smart Pump Integration with Electronic Medical Records on Safety Events and Programming Compliance at a Large Healthcare System

Hina Afaq, PharmD,[1] Lejia Hu, MS,[2] Sebastian Colunga, MSN,[1] Jacqueline Meyer, PhD, CNE, RN,[1] Rebekah Silberhorn, PharmD, BCPS, BCOP, DPLA[1]

[1]University of Texas Medical Branch, Galveston, TX, US, [2]Boston Strategic Partners, Inc., Boston, MA, US

BACKGROUND

- Intravenous (IV) medication errors are common, potentially catastrophic, and often preventable causes of patient harm.[1,2]
- To reduce medication errors, the Institute for Safe Medication Practices (ISMP) and the American Society of Health-System Pharmacists (ASHP) recommend smart pumps with advanced safety features, such as a dose-error reduction system (DERS)[3,4] and electronic medical record (EMR) integration to allow for auto-programming.[3]
- A real-world understanding of smart pump-EMR integration on patient safety and user compliance with DERS and auto-programming protocols is lacking, and challenges with safety and compliance persist.[2,5]

OBJECTIVE

- This quality improvement (QI) initiative aimed to evaluate the impact of smart pump-EMR integration on critical patient safety events and user compliance with both auto-programming and DERS programming protocols at a large, academic health system.

METHODS

Study Design

- Retrospective analysis of de-identified infusion data from Spectrum IQ smart pumps (Baxter International, Deerfield, IL, US) across six University of Texas Medical Branch (UTMB) hospitals (1/21/2021 to 8/21/2024). Safety and compliance data were analyzed in relation to EMR integration in Q4 of 2022.
- Infusions were **included** if they were administered through the Critical Care or Acute Care drug library profiles as a positive dose (>0).
- Infusions were **excluded** if they had multiple care areas listed, or a duration >24 hours from the first system event to first pump run event.[b] Infusions without an administered drug name or where the use of Basic Mode was unclear were also excluded.

Outcomes

- Number of safety events: hard limit alerts, soft limit alerts, single step rate change (SSRC or titration soft limit) alerts, pullback and override rates, "Good Catches" (sum of hard limit attempts followed by reprogramming, soft limit pullbacks, and SSRC pullbacks)
- DERS and auto-programming compliance rates

Analysis

- Outcomes were assessed by integration status, care area, infusion programming type, top 20 medications (based on alert frequency), and high alert medications (HAMs)/medications requiring Risk Evaluation and Mitigation Strategies (REMS).
- Chi-squared tests, 2-sample independent t-tests, or Wilcoxon rank-sum tests were used to compare outcomes, as appropriate.

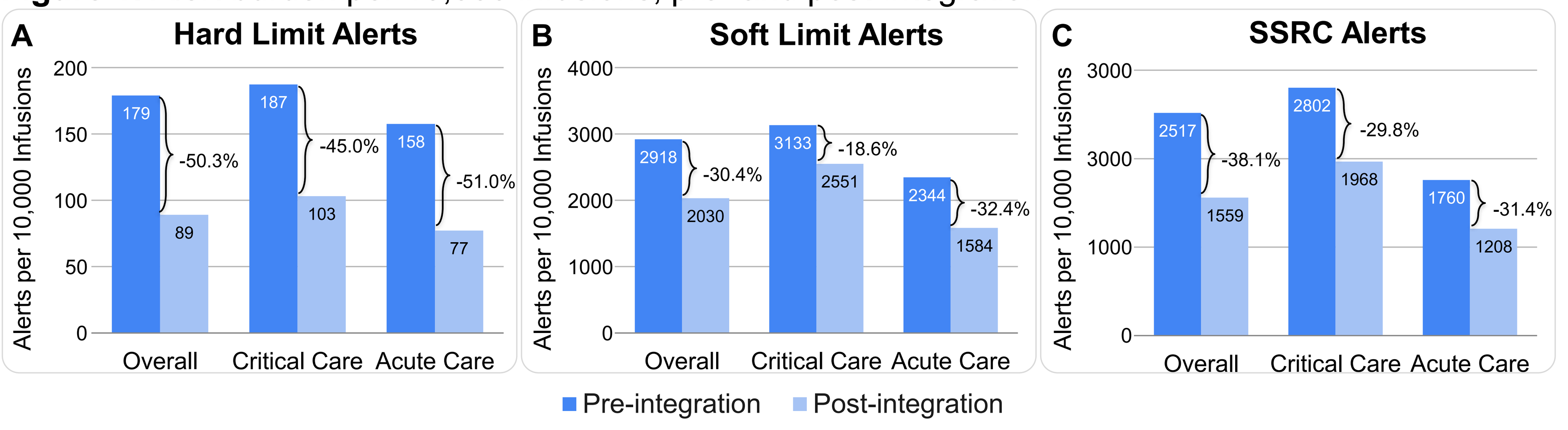
RESULTS

- A total of 1,773,780 infusions were identified during the time period, and 1,333,056 met the eligibility criteria for inclusion.
- There were 343,347 infusions before smart pump-EMR integration and 989,709 infusions after integration.

Safety

- Compared to pre-integration, overall post-integration (per 10,000 infusions) hard limit alerts decreased by 50.3%, soft limit alerts decreased by 30.4%, and SSRC alerts decreased by 38.1% (all p<0.001; **Figure 1**).

Figure 1. Alert burden per 10,000 infusions, pre- and post-integration



- Good catches decreased from 8% to 6% of total alerts after integration (data not shown), suggesting drug library optimization with auto-programming resulted in fewer required interventions.
- Among medications qualified for auto-programming, auto-programming substantially reduced hard limit (45 vs. 67), soft limit (985 vs. 3,118), and SSRC (1,100 vs. 1,753) alerts per 10,000 infusions compared to manual programming (all p<0.001; **Table 1**).

Table 1. Safety events by programming type: alert counts per 10,000 infusions

	Unique Infusions	Hard Limit Alerts per 10,000 infusions	Soft Limit Alerts per 10,000 infusions	SSRC Alerts per 10,000 infusions
Pre-Integration				
All Infusions	343,347	179	2,918	2,517
Manual Programming	343,347 (100%)	179	2,918	2,517
With DERS	323,042 (94.1%)	179	3,101	2,503
With Basic Mode[a]	20,305 (5.9%)	180	5	2,744
Post-Integration				
All Infusions	989,709	89	2,030	1,559
Auto-Programming	525,190 (53.1%)	45	985	1,100
Manual Programming	464,519 (46.9%)	139	3,212	2,077
With DERS	427,477 (92.0%)	133	3,490	2,022
With Basic Mode[a]	37,042 (8.0%)	205	6	2,722
Infusions with Qualified Medications				
Auto-Programming	525,190	45	985	1,100
Manual Programming	324,050	67	3,118	1,753

Abbreviations: DERS, dose-error reduction system; SSRC, single-step rate change.

- Alerts occurred less frequently when infusions were administered via auto-programming vs. manual programming (p<0.001; **Figure 2**).
- All alert types decreased immediately after integration and continued to decrease over time (**Figure 3**).

Figure 2. Alerts counts per 10,000 infusions distributed by programming types pre- and post-integration

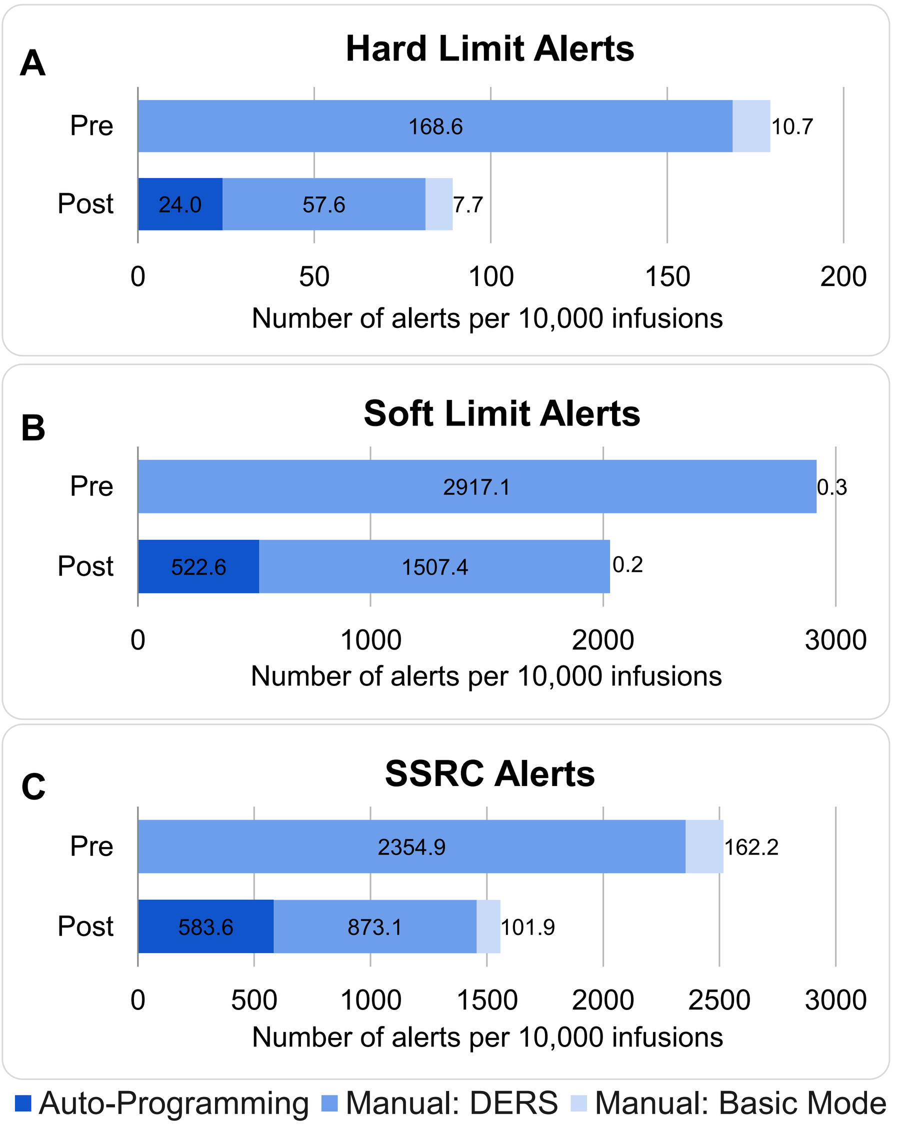
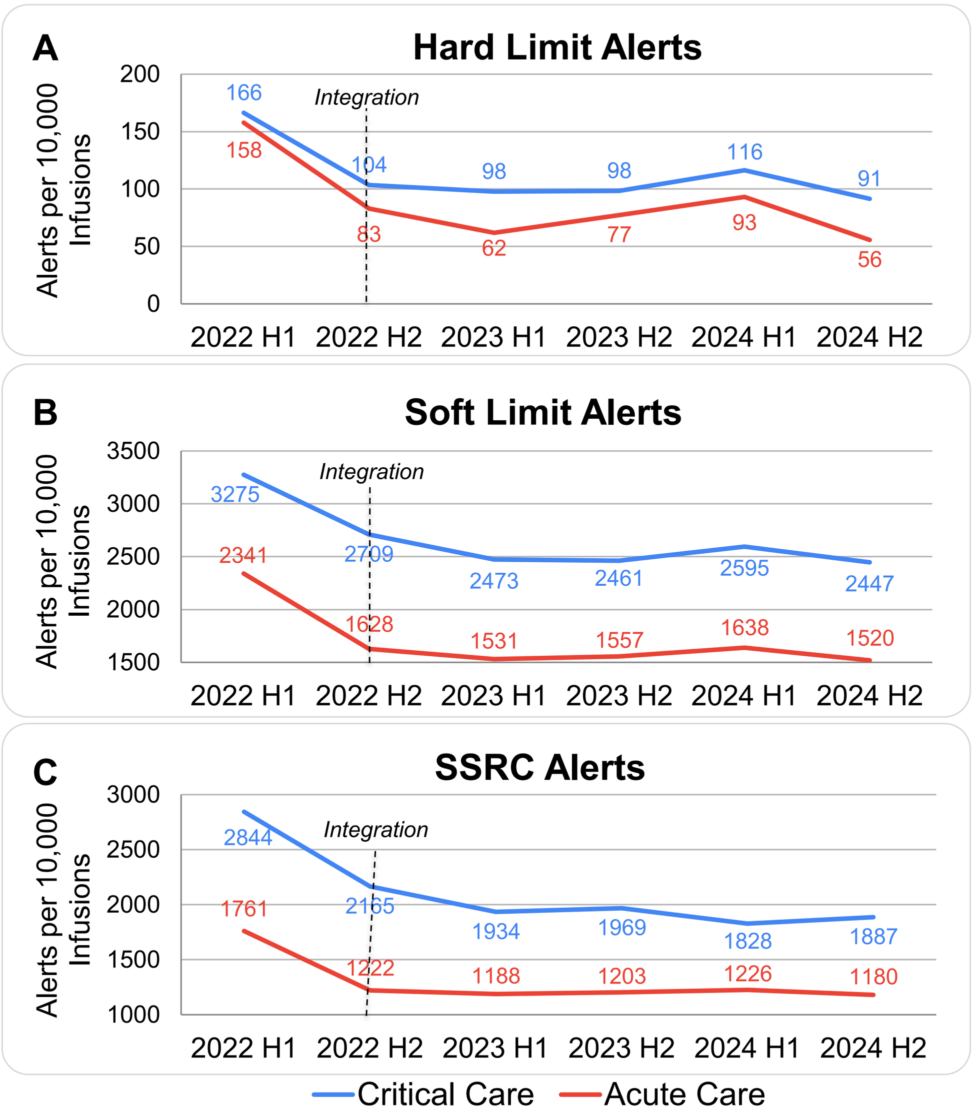


Figure 3. Alert burden per 10,000 infusions over time



Compliance

- Following integration, 53.37% of all infusions were compliant with auto-programming, with an even higher rate of compliance (68.26%) observed for HAMs/REMS medications (**Table 2**).
- DERS compliance was high overall both pre- and post-integration, with significant improvement post-integration (96.12% vs. 94.09%; p<0.001; **Table 2**).

Table 2. Compliance rates (DERS and auto-programming)

	Pre-integration		Post-integration		Post-integration	
	DERS Compliance	P-value	DERS Compliance	P-value	Auto-Programming Compliance	P-value
All Infusions	94.09%	N/A	96.12%	N/A	53.37%	N/A
Critical Care	93.32%	<0.001	96.42%	<0.001	54.98%	<0.001
Acute Care	96.14%		95.87%		52.02%	
HAMs/REMS	99.96%	N/A	99.98%	N/A	68.26%	N/A
Top 20 Meds	99.99%		99.99%		53.41%	
Day Shift	93.60%	<0.001	94.89%	<0.001	51.25%	<0.001
Night Shift	94.70%		97.70%		55.97%	
Weekday Shift	94.03%	0.029	95.92%	<0.001	53.34%	0.372
Weekend Shift	94.23%		96.64%		53.46%	

Abbreviations: DERS, dose error reduction system; HAMs, high-alert medications; REMS, Risk Evaluation Mitigation Strategy.

CONCLUSIONS

- Smart pump-EMR integration and auto-programming demonstrated a significant reduction in patient safety alerts, aligning with recommendations from ISMP and ASHP.[3,4]
- Although these findings suggest benefits, opportunities remain for consistent use across all care areas and shift types.
- QI and root-cause analyses may help to further improve auto-programming compliance and inform optimization of drug libraries and medications qualified for auto-programming, all of which aim to enhance patient safety.
- Continued evaluation of the broader impact of integration, including patient outcomes, clinical productivity, and operational efficiency is warranted.

LIMITATIONS

- This analysis was limited to infusion data and pump-generated actions. Future analyses should incorporate linked patient and outcomes data.
- Access to the care area drug libraries was not restricted. As a result, care areas not explicitly categorized as Critical Care or Acute Care may have used either drug library.
- Currently, there is no standardized benchmark for auto-programming compliance which may limit comparability across studies.
- Direct comparisons to auto-programming were limited to qualified medications, which may limit the generalizability of findings.

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PRESENTING AUTHOR: Hina Afaq (hiafaq@utmb.edu) and Rebekah Silberhorn (rlsilber@utmb.edu), Pharmacy Informatics Analysts, Department of Pharmacy, University of Texas Medical Branch. **REFERENCES: 1.** UC Davis PET. *PSNet [internet]*. 2024. **2.** Skog J, et al. *J Patient Saf.* 2022;18(3):e666-e671. **3.** ISMP. 2020. **4.** ASHP. 2021. **5.** Schnock KO, et al. *BMJ Qual Saf.* Feb 2017;26(2):131-140. **FOOTNOTES:** [a]Basic Mode: manual programming option that bypasses the built-in drug library and its safety software (DERS). [b]Infusions with a hard limit event followed by Basic Mode within 15 minutes were excluded. **ACKNOWLEDGEMENTS:** Writing and editorial support was provided by Boston Strategic Partners, Inc.
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