Impact of Smart Pump Integration with Electronic Medical Records on Clinicians' Bedside Productivity within a Large Healthcare System

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BACKGROUND

- Nursing staff shortages and burnout intensified during the coronavirus-19 pandemic and remain top priorities for health systems, as is managing workloads (e.g., by reducing inpatient alert burden) to reduce cognitive overload on nurses.[1,2]
- There is an estimated shortage of 200,000-450,000 nurses in the US, with Acute Care most affected.[1,2]
- To address this challenge, health systems are redesigning care delivery workflows and identifying operational improvements to enhance nursing productivity, reduce cognitive burden, and mitigate burnout from high-volume, repeat manual tasks.

OBJECTIVE

- This quality improvement (QI) initiative evaluated the impact of smart pump technology, specifically dose-error reduction systems (DERS), electronic medical record (EMR) interoperability and auto-programming, on productivity and operational performance metrics 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). Productivity data were analyzed in relation to EMR integration in Q4 of 2022.
- Infusions were **included** if they were administered using 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

- **Steps taken to program an infusion** (defined as entries in the database leading up to a pump run code), median [25th, 75th percentiles] **time to initiate an infusion** (calculated from the initial pump programming step timestamp to the first pump run event), and **mean time to resolve** soft limit and single-step rate change (SSRC or titration soft limit) **alert pullbacks** (measured as the elapsed time between the alert and the final pump run action) were observed.

Analysis

- Outcomes were analyzed descriptively and compared across various factors including integration status, care area, and infusion programming type (manual vs. auto-programming; DERS vs. Basic Mode).
- Comparisons between manual and auto-programming occurred post-integration and only among infusions with medications qualified for the auto-programming function.
- Categorical and continuous variables were compared by Chi-squared tests and 2-sample t-tests/Wilcoxon rank-sum tests, respectively.
- SSRC alert pullback times were Winsorized at the 95th percentile to reduce influence of extreme outliers.

RESULTS

- Of 1,773,780 total infusions in the dataset, 1,400,329 infusions met criteria
- A total of 343,347 infusions were administered pre-integration and 989,709 post-integration.

Steps

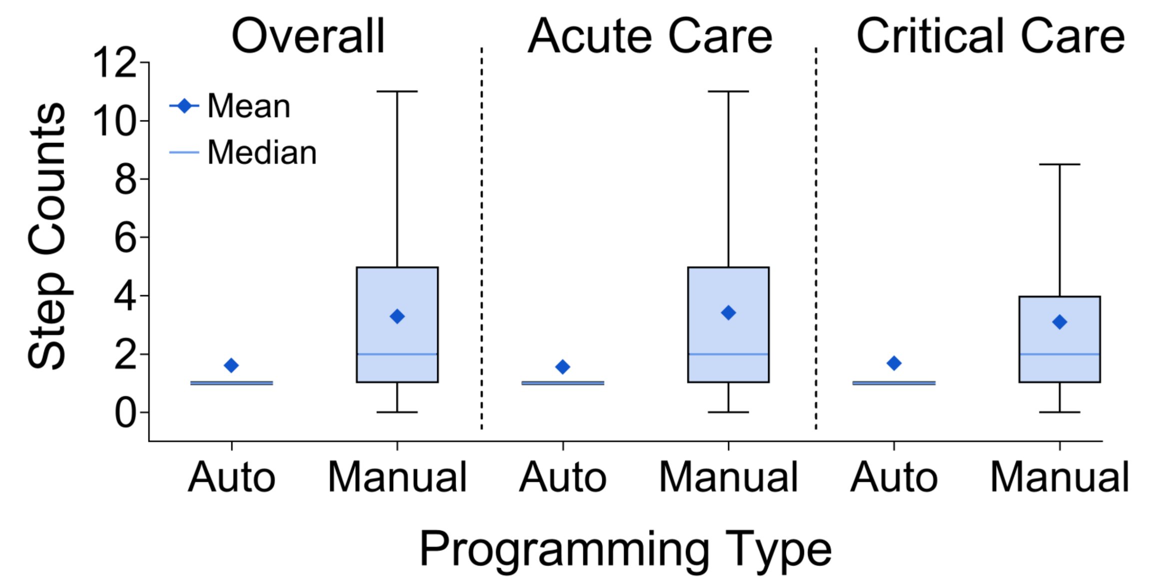
- Overall, auto-programming resulted in significantly fewer steps than manual programming in the acute care and critical care areas ($p<0.001$; **Table 1**; **Figure 1**).
- Within manual programming (overall), there were significantly more steps for Basic Mode compared to DERS ($p<0.001$; **Table 1**).
- Significantly different number of steps were observed across care areas ($p<0.001$; **Table 1**).

Table 1. Number of steps and time (seconds) to initiate infusions by programming type and care area

	Number of Steps			Time (sec)		
	Mean (SD)			Median [25th, 75th]		
	Overall	Acute Care	Critical Care	Overall	Acute Care	Critical Care
Auto-Programming	1.6 (2.1)	1.6 (1.9)	1.7 (2.2)	4 [3, 13]	5 [3, 16]	4 [2, 10]
Manual	3.3 (3.6)	3.4 (3.7)	3.1 (3.6)	10 [4, 84]	14 [4, 401]	7 [3, 29]
DERS	3.2 (3.7)	3.3 (3.7)	3.1 (3.6)	9 [4, 78]	13 [4, 297]	7 [3, 29]
Basic Mode	4.0 (3.4)	4.3 (3.4)	3.7 (3.3)	17 [7, 271]	39 [9, 1612]	11 [6, 30]

Abbreviations: DERS: dose error reduction system; SD, standard deviation. **Note:** Steps were defined as the number of entries in the infusion database leading up to a pump run code and do not include all direct keystrokes. Steps related to the interaction with the EMR system were not included in this analysis.

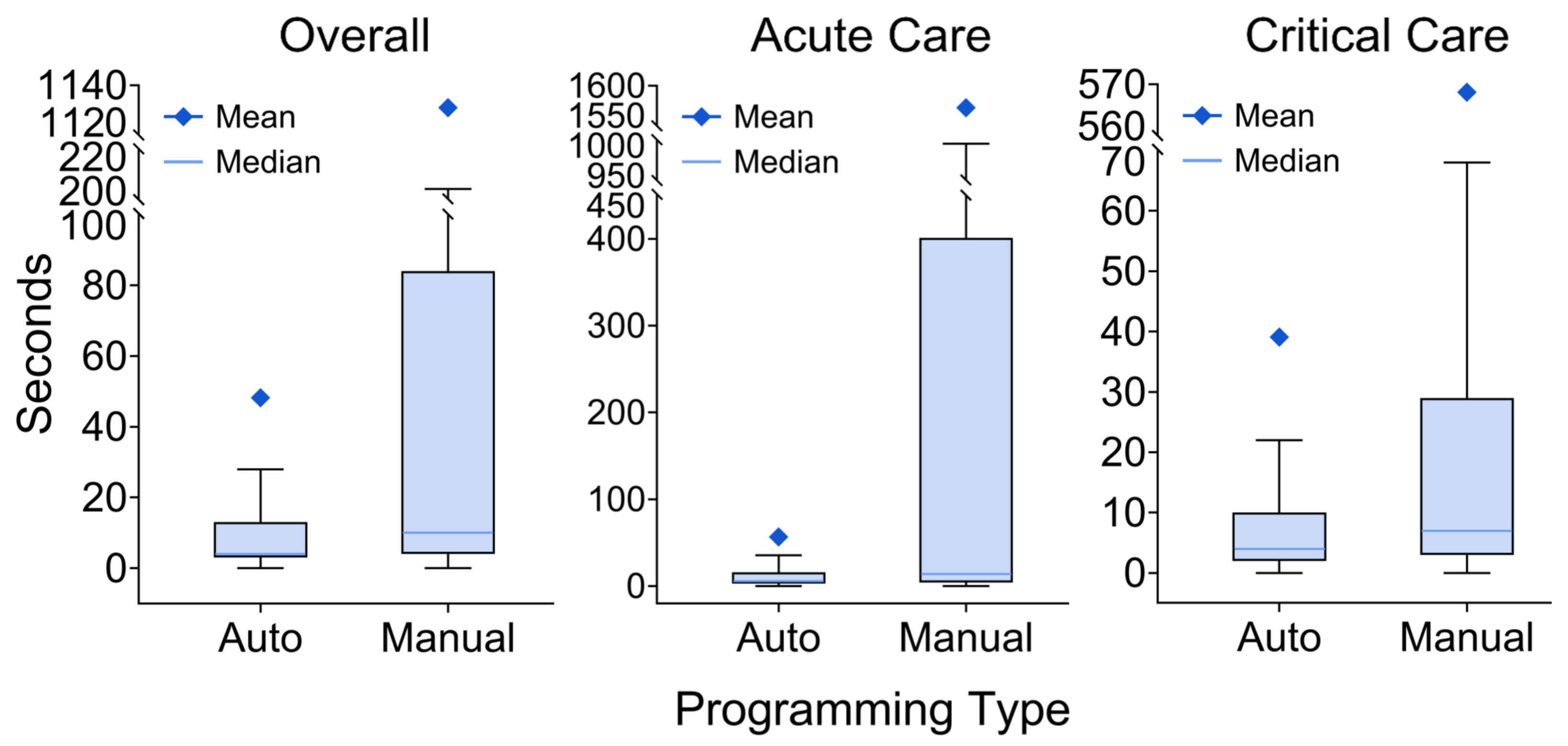
Figure 1. Number of steps to initiate infusions by programming type and care area[c]



Time

- Overall, auto-programming resulted in shorter median times to infusion than manual programming (4 vs. 10 sec; $p<0.001$; **Table 1, Figure 2**), and within manual programming, DERS provided significantly shorter times to infusion than Basic Mode (9 vs. 17 sec; $p<0.001$; **Table 1**).

Figure 2. Time to initiate infusions by programming type and care area[c]



- The overall average time taken to address soft limit pullbacks per 10,000 infusions pre- vs. post-integration decreased by 46.28% (9.29 vs. 4.99 sec; **Table 2**).
- Compared to pre-integration, the overall average time to address SSRC alert pullbacks per 10,000 infusions post-integration decreased by 55.04% (221.70 vs. 99.70 sec; **Table 2**).

Table 2. Mean time (seconds) to resolve alert pullbacks (per 10,000 infusions)

	Soft Limit Alerts		SSRC Alerts	
	Mean time to resolve (sec)		Mean time to resolve (sec)	
	Pre	Post	Pre	Post
All Infusions	9.29	4.99	221.70	99.70
Critical Care	10.05	6.94	253.46	136.81
Acute Care	7.26	3.32	137.17	67.89

Abbreviations: SSRC: single-step rate change, sec: seconds.

- Comparing productivity impact across care areas, we observed that critical care programming observed shorter times to infusion than acute care (median [25th, 75th percentiles] , seconds; manual: 7 [3, 29] vs. 14 [4, 401], $p<0.001$; auto-programming: 4 [2, 10] vs. 5 [3, 16], $p<0.001$; **Table 1**). Critical care alerts (both soft limit and SSRC, per 10,000 infusions) took a longer average time to resolve than acute care (**Table 2**).

CONCLUSIONS

- DERS, smart pump-EMR integration, and auto-programming were associated with notable reductions in programming steps to infusion, time to infusion initiation, and time to resolve alerts.
- By streamlining manual workflows, these technologies may reduce medication errors, decrease time spent on error correction within total infusions, and ease clinicians' physical/cognitive burdens to enhance productivity, reduce burnout, and in total, give time back to nurses.
- These benefits depend on seamless bidirectional integration and sustained efforts in implementation, including drug library optimization and upkeep.
- Further evaluation of comprehensive pump and EMR action data should be explored to capture a more comprehensive view of mitigated patient harm.

LIMITATIONS

- Programming steps were captured via infusion data. Thus, actions taken off the pump, such as scanning the patient or medication, could not be accounted for within the scope of this project.
  - Future analyses of comprehensive combined pump and EMR action data may be warranted.
- Care area drug libraries did not have restricted access and some care areas not explicitly categorized as Critical Care or Acute Care may have used either drug library.
- While most analyses performed explored all medications administered, direct comparisons to auto-programming were limited to qualified medications, which may limit the generalizability of these findings.

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REFERENCES: 1. Berlin G, et al. McKinsey and Company. 2023. **2.** Rosseter R. American Association of Colleges of Nursing. 2024.
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.[c] The box presents the mean and median [25th, 75th percentiles], and the whiskers show the box +/-1.5x IQR.
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