



Impact of Patient-Controlled Analgesia (PCA) Smart Pump-Electronic Health Record (EHR) Interoperability with Auto-Documentation on Chart Completion in a Community Hospital Setting

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ABSTRACT

Introduction: Complete and accurate documentation of opioids administered by patient-controlled analgesia (PCA) pumps is critical for ensuring a high-quality medication record and an accurate conversion of the intravenous (IV) regimen to oral therapy. Incomplete charting of PCA usage through a manual process may be associated with fragmented documentation of delivered therapy affecting the completeness of the medical record and the IV to oral dose conversion. This study is the first to evaluate the association between auto-documentation of opioid administration provided by PCA smart pump—electronic health record (EHR) interoperability and the completion of PCA opioid administration charting tasks.

Methods: This retrospective cohort study was conducted at Lancaster General Hospital, Lancaster, Pennsylvania. Patients were assigned to pre-auto-documentation ($n = 55$) or post-auto-documentation groups ($n = 58$) based on

whether they received PCA therapy prior to or after PCA-EHR interoperability was implemented. Charting of PCA therapy included documentation of the number of patient attempts, number of doses given, and total volume infused for both pre- and post-auto-documentation groups. In addition, total dose delivered was documented for the post-auto-documentation group. The overall chart-field completion rate was evaluated as the primary outcome. Individual chart completion percentages were assessed by stratified groups as secondary outcomes.

Results: PCA smart pump—EHR interoperability with auto-documentation was associated with an increase in overall chart-field completion rate from 69.9 to 97.0% ($p < 0.001$). Auto-documentation was also associated with an increase in fully completed charts from 38 to 91% (139.3% increase, $p < 0.001$) and reductions of incomplete records in each stratified group ($p < 0.001$).

Conclusions: PCA smart pump—EHR interoperability with auto-documentation is associated with significant improvements in the completion of opioid administration chart-fields. Improved documentation of PCA administered opioids may have implications for the safety of opioid administration. Additional studies will be needed to assess the potential clinical impact of these results.

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INTRODUCTION

Interoperability between smart pumps and electronic health record (EHR) systems is transforming how intravenous (IV) infusions are documented and administered. Interoperability, also known as integration, refers to the bi-directional communication between the two systems, allowing for automatic programming of the infusion pump with the physician-ordered, pharmacy-reviewed infusion parameters sent directly from the EHR, while enabling automatic documentation in the EHR of time-stamped infusion data from the pump [1, 2].

Large-volume smart pump—EHR interoperability is established in clinical practice while patient-controlled analgesia (PCA) pump—EHR interoperability is a relatively new technology. Interoperability improves medication safety through several mechanisms, including association of the infusion pump with the patient order, reducing manual keystroke errors, and delivering infusions within the dose-error reduction software (DERS) limits [2–10]. The added safety with interoperability and the availability of several infusion platforms has led nearly 200 hospitals (approximately 4% of all hospitals in the United States) to implement this technology with their large-volume smart pumps [11]. The expansion of interoperability to improve outcomes with patient-controlled analgesia (PCA) pump use is of great interest, as documentation-related errors are prevalent with PCAs [12–14] and adverse events due to medication errors with opioids may lead to severe harm [15–19]. In contrast to large-volume pumps, PCA pump integration is available with only one device and used in less than 1% of hospitals [20].

Benefits of interoperability with auto-documentation extend beyond infusion safety and include improvements in the accuracy,

completeness, and timeliness of infusion data documentation [1–3]. There are a growing number of publications describing experience with large-volume infusion pump interoperability [3–10], but evidence describing the PCA interoperability and auto-documentation of infusion parameters has not been published. The purpose of this study is to evaluate the association between auto-documentation provided by PCA smart pump—EHR interoperability and PCA opioid administration charting task completion at a community hospital.

METHODS

Study Design

A retrospective cohort study was conducted to determine the effect of PCA smart pump—EHR interoperability with auto-documentation on infusion therapy chart completion. The data were from patients admitted to Lancaster General Hospital, a 663-bed community health system (Pennsylvania, PA, USA) during the August–October 2016 and April–June 2017 study periods. This research was approved by the Lancaster General Hospital Institutional Review Board. Patient consent was not required for this retrospective, chart review study.

Inclusion/Exclusion Criteria

Convenience sampling of PCA dispensing data was used to identify patients who had received PCA therapy during the study periods. Patients were categorized into two groups: PCA therapy pre-auto-documentation and PCA therapy post-auto-documentation. Patients who received PCA therapy prior to interoperability were included in the pre-auto-documentation group, while those who received therapy after interoperability were included in the post-auto-documentation group. All patients identified as receiving PCA therapy were included in the analysis. There were no specific patient exclusion criteria, as this study focused on the number of administered and charted medication doses rather than specific patient

characteristics. Demographic and disease state information were not available or included in this analysis. Enrollment was completed when at least 55 patient records were present in each comparison group.

Variables: Documentation Process

Pre-Auto-Documentation Group

In the pre-auto-documentation group, the clinicians manually documented infusion data at various stages of clinical care, such as shift change or PCA vial change. The data were collected by accessing administration history data from the pump user interface. Data charted included the number of patient bolus attempts, number of doses given, and total volume delivered in milliliters.

Post-Auto-Documentation Group

Auto-documentation of infusion data was enabled through interoperability of the ICU Medical LifeCare PCA[®] infusion pumps, ICU Medical MedNet[®] safety software, and the Epic EHR[®]. Infusion data was transmitted from the infusion pump, to the safety software server, and then transmitted into the EHR through the Epic PCA Verify tool. Once data was present in the EHR, it required clinician review, data verification, and active acceptance of the data for chart entry. The transmitted data included the number of patient bolus attempts, administered doses, total volume delivered in milliliters, and total dose delivered (mg or mcg).

For both groups, the chart-field counts during the study periods were identified from chart review by a pharmacist.

Study Outcomes

The primary outcome of the study was the overall percentage of chart-fields completed defined as the number of chart-fields completed divided by the total number of chart entries that were possible. A comparison between pre- and post-auto-documentation groups was completed for total chart-field completion percentage.

Secondary outcomes were the percentage of charts conforming to five stratified chart-field completion percentage rates: < 25%, 25–49%, 50–74%, 75–99%, and 100%. A comparison between pre- and post-auto-documentation groups was completed for each stratified percentage.

Statistical Analysis

The data were collected and analyzed in Microsoft Excel. The sampling and statistical data analyses were performed after validation of raw counts associated with the respective analyses. The number of patients and charting opportunities were expressed as counts. Comparisons using descriptive statistics were made between the study groups. Chi-square tests were used to determine the associations between the variables. Data were managed in Microsoft Excel, and all analyses were performed in R (v 3.4.1).

RESULTS

Study Population

The study included a total of 113 patient records. The pre-auto-documentation group contained 55 patient records, and the post-auto-documentation group contained 58 patient records (Fig. 1). Demographic details of the patients were not available and hence not included. Data were sampled from closed

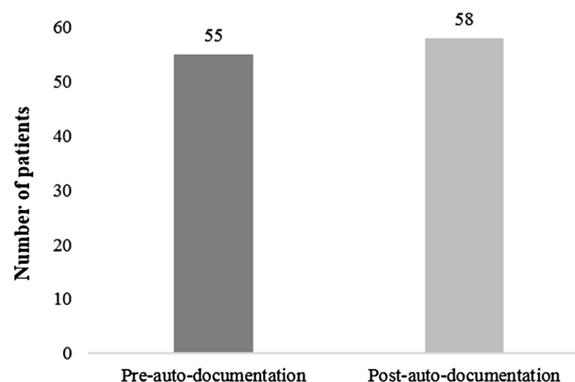


Fig. 1 Number of patients in study groups

hospital admission records without a longitudinal component.

Percentage of Chart-Fields Completed

No significant difference ($p = 0.58$, Fig. 2) was observed in the total number of charting opportunities in the pre-auto-documentation group ($n = 519$) versus the post-auto-documentation group ($n = 496$). The total number of charting opportunities per patient is presented in Fig. 3 for informational purposes and was not statistically analyzed. The implementation of auto-documentation was associated with an increase in chart-field completion percentage

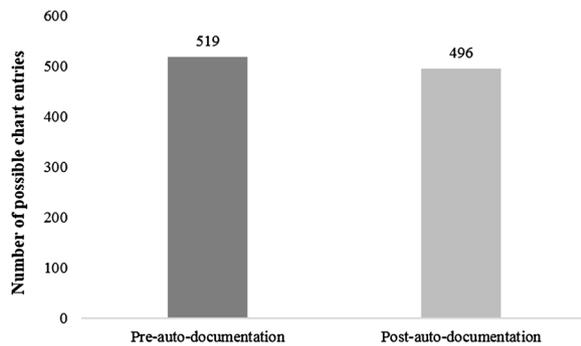


Fig. 2 Total number of charting opportunities

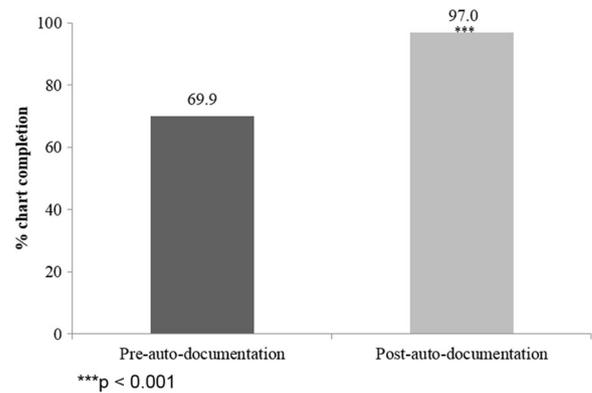


Fig. 4 Percentage of chart-fields completed

from 69.9 to 97.0% (Fig. 4, 39% increase, $p < 0.001$).

Stratified Chart-Field Completion Percentages

Post-auto-documentation, charts 100% complete increased from 38.2% to 91.4% (Fig. 5, 139.3% increase, $p < 0.001$). Auto-documentation implementation was also associated with a decrease of incomplete charts in each stratified group including reducing charts less than 25% complete to 0 (Fig. 5, 100%, $p < 0.001$).

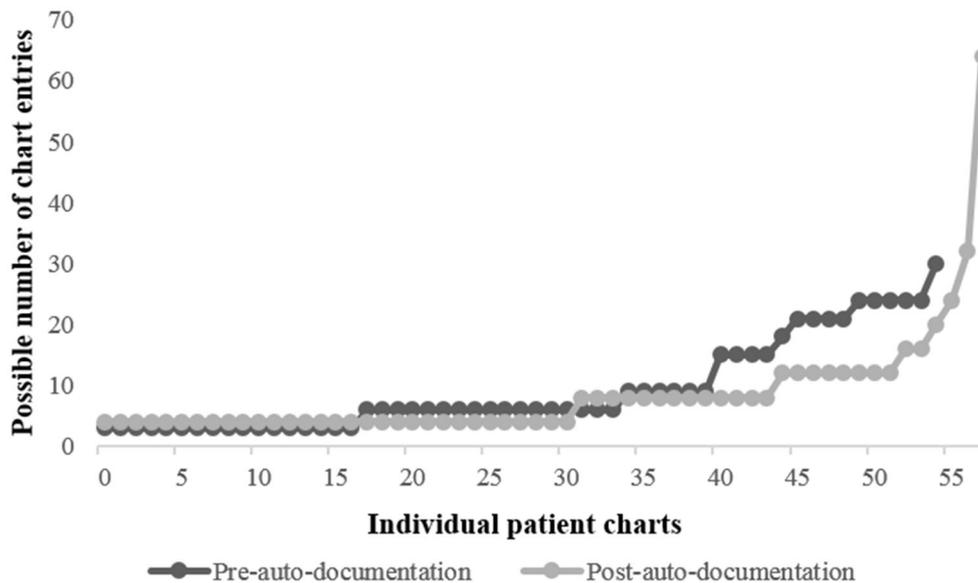


Fig. 3 Number of charting opportunities by individual patient

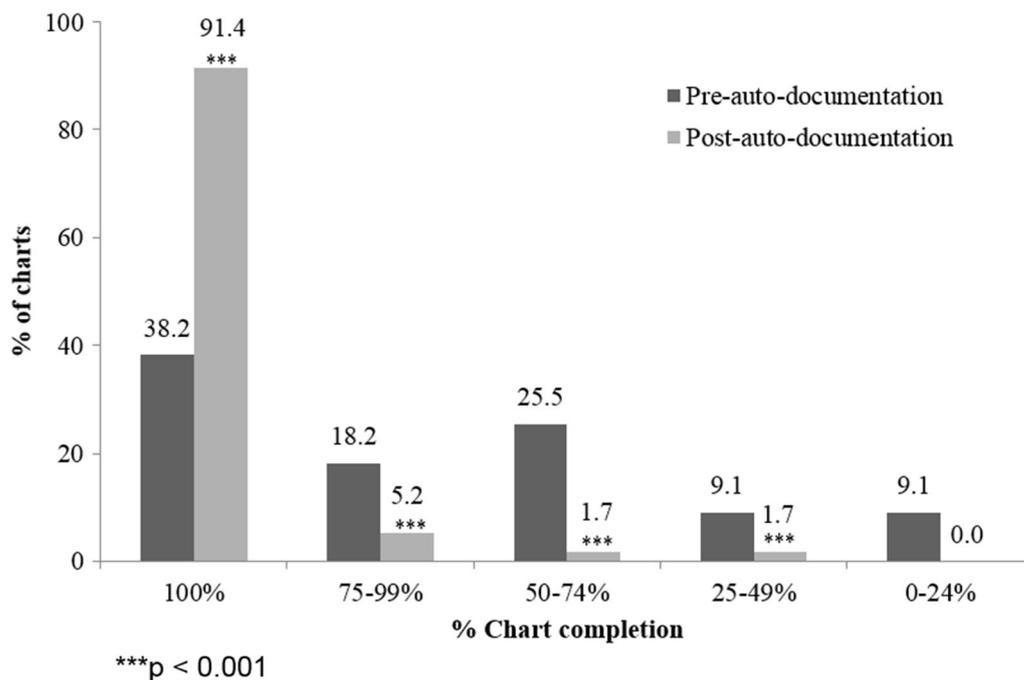


Fig. 5 Chart completion percentages in stratified groups

DISCUSSION

In this retrospective cohort study, higher chart completion rates were observed when PCA infusion therapy was administered with auto-documentation of infusion data enabled by PCA smart pump—EHR interoperability. The increase in chart entry percentage was present in the overall counts and in each stratified group. It is also notable that individual patient records demonstrate a broad range of total charting opportunities with PCA therapy, which may be reflective of the broad spectrum of patient conditions and treatment durations managed with this therapy.

The increase of charting task completion in the post-auto-documentation group suggests that interoperability led to a significant shift in documentation practice. The manual process used in the pre-auto-documentation group was associated with variable chart completion, with 38% of charts fully complete and 18% of charts less than 50% complete, including 9% of charts less than 25% complete. The lack of charting consistency may have been a result of a number of factors including record-keeping processes,

cognitive load, distraction, or prioritization of other patient-care activities. The process of manually collecting infusion data from the pump in the pre-auto-documentation group was replaced with a reduced number of steps to pull a complete record of infusion data from the safety software server into the EHR for clinician verification. The auto-documentation workflow may fit into clinical practice more effectively, leading to increased compliance as well as removing manual steps that may be associated with error.

In this study, interoperability with auto-documentation did not lead to 100% of charts being fully completed. The incomplete charting with this technology may exist as auto-documentation itself requires clinician review, data verification, and an active step to accept the data for chart entry. These retained manual processes are necessary to ensure clinician confirmation of accurate infusion data and require ongoing training, maintenance, and accountability for effective use over time.

Additional interventions have not been identified at the study location that may have contributed to the outcomes. There are no

evident changes to institutional policy, clinician emphasis on chart completion, or managerial priority that explain these results. It appears most likely that implementation of PCA smart pump—EHR interoperability with auto-documentation is associated with the observed changes. It is notable that the implementation of interoperability was itself associated with staff training, which may have had a positive impact, and that this training is expected to be repeated with similar efficacy and have a similar impact at all locations where this technology is implemented.

Interpretation, Generalizability

Opioid administration in the hospital setting is complex and critical for effective patient care. The findings of this study in a community hospital, using commercially available technology, support the generalizability of these results to other healthcare settings and may contribute to safer, more effective pain management. It is important to note that successful implementation of interoperability can be complex and expensive, present technological and cultural challenges, and require long-term investments in hospital infrastructure for EHR systems, smart pumps, safety software, and wireless capability [1, 2, 21, 22].

Interoperable infusion pumps have been shown to increase safety by reducing errors associated with manual programming [2–10]. We believe that the same safety benefits are applicable to PCA smart pumps by reducing manual steps in programming infusions and documenting data. Medication error reduction with PCA smart pumps could potentially reduce morbidity associated with opioids, which have significant side effects and are considered high-alert medications [23]. Auto-documentation with interoperability may also increase safety through improved accuracy of conversion from IV to oral opioid administration. At the time of this route conversion, the patient's current opioid requirements should be precisely understood to establish an oral regimen for pain experienced currently and that which is expected based on the course of illness. Inaccurate

data could lead to inexact conversions, which have been described as leading to under-dose with poorly treated pain, which has its own associated morbidities [24–26]. Conversely, inaccurate IV to oral opioid conversion may lead to over-dose and opioid toxicity [27, 28].

Although not included in this study, it may be informative to evaluate the impact of auto-documentation on clinician workflow efficiency [2, 3, 21, 29]. The number of steps to deliver and document infusions is different in a manual versus an interoperable environment, with potential impact on cognitive load and time availability for other aspects of patient care.

Financial benefits of interoperability have recently been described for large-volume pumps and may be applicable to PCA smart pumps as well [2, 3, 21, 22, 30]. Potential drivers of financial gains with the technology include a reduction in adverse events, increased clinician efficiency, and improved billing practices and charge capture [2, 3, 21, 22, 30]. The evaluation of these additional potential benefits requires future study.

An additional category of potential benefit of PCA smart pump interoperability comes through data analysis. Interoperability enables the collection and analysis of infusion therapy parameters, which may enable improved understanding of opioid consumption for a broad population. An understanding of opioid consumption may facilitate management of medication during times of shortage, may help evaluate patterns of use for quality improvement activity, and may assist in disease management by identifying patients who are not following the clinical course to those previously treated for similar conditions.

This study is the first to describe the effect of PCA smart pump—EHR interoperability with auto-documentation on the completion of infusion therapy charting tasks. These results from a community hospital suggest that auto-documentation was associated with significant charting improvements during the administration of opioid, high-alert medications. The results of this study, along with others presented in the literature, suggest that PCA smart pump—EHR interoperability may result in increased patient safety, improved caregiver

efficiency, and financial benefits while providing a robust data set for quality improvement efforts and health system management of opioid-requiring hospital conditions.

Limitations

The data from the two study groups were not matched by demographic or treatment characteristics, since these details were not included in the data set. In addition, causal inferences cannot be made considering the cross-sectional nature of the data. It is also important to note that a limited time period was considered for the study and extension of this time period may yield different study results. Additionally, the study periods of August–October 2016 and April–June 2017 may have had associated seasonal workload variations that may have impacted documentation.

CONCLUSIONS

The benefits of large-volume smart pump—EHR interoperability are widely recognized but the experience with PCA smart pump—EHR interoperability is limited. The current study addresses this gap by demonstrating a significant improvement in the completion of infusion therapy charting tasks with auto-documentation provided by PCA smart pump—EHR interoperability. Additional long-term studies will be needed to confirm these results.

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Authorship Contributions. Tina Suess and John Beard contributed to study design, data analysis, interpretation of results, and manuscript drafting. Barbara Trohimovich acquired and analyzed study data and provided input on manuscript content.

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Compliance with Ethics Guidelines. This research was approved by the Lancaster General Hospital Institutional Review Board. Patient consent was not required for this retrospective, chart review study.

Data Availability. The datasets generated during and/or analyzed during the current study are not publicly available due to the medical center institutional policy but are available from the corresponding author on reasonable request.

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