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Published in:
Journal of Comparative Effectiveness Research

DOI:
10.2217/cer-2021-0222

Publication date:
2022

Research Article

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Economics of implementing an early deterioration detection solution for general care patients at a US hospital

Journal of **Comparative Effectiveness Research**

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Aim: This study estimates the costs and outcomes pre- versus post-implementation of an early deterioration detection solution (EDDS), which assists in identifying patients at risk of clinical decline. **Materials & methods:** A retrospective database analysis was conducted to assess average costs per discharge, length of stay (LOS), complications, in-hospital mortality and 30-day all-cause re-admissions pre- versus post-implementation of an EDDS. **Results:** Average costs per discharge were significantly reduced by 18% (US$16,201 vs $13,304; p = 0.007). Average LOS was also significantly reduced (6 vs 5 days; p = 0.033), driven by a reduction in general care LOS of 1 day (p = 0.042). Complications, in-hospital mortality and 30-day all-cause re-admissions were similar. **Conclusion:** Costs and LOS were lower after implementation of an EDDS for general care patients.

Lay abstract: Early deterioration detection solutions (EDDS) assist in identifying patients at risk of clinical decline to enable a timely response. This study estimates the costs and outcomes before and after implementation of an EDDS at a US hospital for general care patients. Results show average costs per discharge and average length of stay were significantly reduced after implementation. Complications, in-hospital mortality and 30-day all-cause re-admissions were similar in the two time periods.

First draft submitted: 21 September 2021; Accepted for publication: 26 November 2021; Published online: 15 December 2021

Keywords: change management • clinical decision support • health economics • monitoring • outcomes research • real-world evidence

Patients hospitalized in lower acuity areas, also known as general care, are at risk for missed signs of deterioration potentially leading to adverse events, a longer hospitalization and increased costs [1]. Signs of deterioration, such as changes in vital signs, have been shown to be present 6–8 h before a critical event [2,3]. It has been estimated that up to 50% of adverse events occurring among hospitalized patients could have been prevented if caught earlier [4]. This can be more of a challenge in general care where patients are monitored less frequently than in critical care [5].

Early deterioration detection solutions (EDDS) guide caregivers in detecting patient deterioration by collecting vital signs, calculating early warning scores (EWS), notifying caregivers of patient status and escalating events to the appropriate individuals such as rapid response teams. This allows for faster patient response hours before adverse events occur. These solutions have been shown to improve patient outcomes, but evidence is inconsistent [6–8]. Even if hospitals install and implement these systems, including proper training, issues can remain if there is lack of coordination and clinical adoption [8]. Successful implementation consists of not only the installation of the right hardware but also education and successful change management [9]. Limited evidence exists regarding the cost impact to hospitals implementing these solutions, with more focus on the return-on-investment [10], acquisition costs [11] and the total investment for a national healthcare system [12].

Future Medicine

This study examines the costs and outcomes for inpatient stays on general care floors pre- versus post-implementation of an EDDS, consisting of monitoring devices, analytics, clinical transformation services, training and education (Philips IntelliVue MP5SC monitors, GuardianSoftware and professional services) at Saratoga Hospital in New York State. The solution was implemented with full staff training and successful change management, which led to clinical adoption and efficient coordination of multidisciplinary caregiving teams. Our aim was to estimate the costs and outcomes of implementing an EDDS in general care.

Materials & methods

Study design & population

A retrospective, observational study was conducted using Medicare inpatient claims for the Saratoga Hospital in Saratoga Springs, NY. The Saratoga Hospital is a regional provider, serving a growing population of 240,000 people with 171 beds and over 3000 Medicare and 10,000 total discharges [13]. The claims specific to the Saratoga Hospital were identified by Medicare Provider number (#330222) for inpatient stays that occurred between February 2013 through January 2015 for the pre-implementation period and between June 2017 through November 2018 for the post-implementation period. The initial implementation of the solution occurred in February 2015 starting with one general care unit and additional units was sequentially implemented over the next couple of years. The postimplementation period was chosen to begin in June 2017 to account for the time to learn the technology and for full clinical adoption.

Patients were included if they had continuous Medicare enrollment for the index admission and for 30-day post-discharge, as well as at least a 1 day stay in general care. Patients were excluded if they were transferred from another facility or discharged to another facility as an inpatient since the observed stay would not account for the full costs of their hospitalization. Patients were also excluded if they had an interim or partial bill claim or had missing data to conduct the analysis.

Solution description

An integrated EDDS (IntelliVue MP5SC spot check patient monitors, IntelliVue GuardianSoftware [IGS] automated EWS system and professional services, Philips, MA, USA) was implemented for general care patients at the Saratoga Hospital. The integrated EDDS automates the capture and recording of vital signs through the MP5SC spot check patient monitors and sends these to the IGS, a system with a standardized user interface. The IGS provides staff the ability to view patient status trends more accurately than with manual data acquisition and entry. Prior to this implementation, caregivers would manually log vital signs into the electronic medical record. Using the Saratoga Hospital's modified EWS algorithm, the new system streamlined the manual process by automating the EWS and transferring the vital signs into the electronic medical record. EWS notifications were sent electronically to the appropriate personnel.

The conversion process began before monitor and IGS installation to obtain nursing staff buy-in and have change management discussions. Nurses had a hands-on look at the monitors before installation, so they could think through how to work with the new technology. Philips professional clinical services were employed to provide Go-Live assistance for first use of the clinical system and to facilitate full clinical adoption and change management. After all technologies were installed, post-Go-Live services were used to recheck configuration and determine if the new workflow was optimal. In collaboration with the Saratoga Hospital, Philips staff continuously checked the configuration to adapt the IGS system specifically to the Saratoga Hospital. There were actions to continuously follow-up with nursing staff, fix issues and change the process if needed.

Data

We used the Medicare limited dataset inpatient standard analytic files 5% sample, which represents claims for a 5% random sample of Medicare beneficiaries [14]. Medicare is the US national health payer for people over 65 years old as well as for patients of all ages with end-stage renal disease and select disabilities. The inpatient file provides fee-for-service claims for inpatient stays. This file was used along with the Medicare denominator and master beneficiary summary files to obtain coverage details. The Medicare final rule impact files were used to obtain cost-to-charge ratios for the Saratoga Hospital to derive costs from charges, as reported on the patient claim [15]. All costs and payments were converted to constant 2020 dollars using the medical consumer price index as reported by the US Bureau of Labor Statistics [16].

Outcome measures

The primary outcome was average total costs per patient for the inpatient stay, calculated for the pre- versus post-implementation periods. We also calculated the median costs per patient and the average costs by department for 13 aggregated revenue centers as defined by Medicare data. Secondary outcomes included average total length of stay (LOS), complications, in-hospital mortality and 30-day all-cause re-admission.

Complications were predefined as acute myocardial infarction, acute pulmonary edema, acute renal failure, acute respiratory failure, cardiac arrests, pneumonia, pulmonary embolism, sepsis and stroke. These events were identified by ICD-9-CM or ICD-10-CM diagnoses codes and could be listed as primary or tertiary. Appendix Table 1 provides the specific ICD-9-CM and ICD-10-CM codes used. Events listed as present on admission were excluded since we were only interested in counting complications that occurred during the hospital stay. All-cause re-admission included any re-admission, either planned or unplanned, to any hospital within 30-days and not only to the Saratoga Hospital.

Additional outcomes included percentage of patients with procedure codes indicating medication use, defined as use of vasopressors, antibiotics, bronchodilators, steroids, respiratory medication, thrombolytic agents or anticoagulants; percentage of patients with mechanical ventilation use and excluding cases with obstructive sleep apnea; and percentage of patients with cardiopulmonary resuscitation. We also calculated average and median total Medicare payments. For LOS, we separated total LOS into its components of general care and intensive care unit (ICU) LOS since the technology was implemented in general care.

Statistical methods

All outcome measures, patient demographics and hospitalization characteristics were compared for pre- versus post-implementation. Patient demographics and hospitalization characteristics were compared using two sample t-tests for continuous variables and using Chi-squared tests for categorical variables unless the assumptions were not satisfied, and then the Fisher's exact test was used. All binary and continuous outcomes were compared using generalized linear models adjusting for patient age, sex, race, admission status, and the Elixhauser comorbidity index [17]. Median outcomes were compared using quantile regressions.

Outcomes were adjusted to account for confounding factors. We adjusted for age (as a continuous variable) given that age is a risk factor for the outcomes of interest, and for sex, which has been shown to impact LOS, costs and in-hospital mortality [18–20]. Race was included since racial disparities have been shown for LOS and mortality [19,21]. We controlled for admission status since previous research on this technology made this adjustment in multivariate regressions given the potential for it to impact hospital resource use and outcomes [11]. The Elixhauser comorbidity index was used to control for patient severity. The index consists of 30 individual co-morbid conditions based on secondary diagnoses codes listed on the claim. The Healthcare Cost and Utilization Project updates were used to adapt the original index based on ICD-9-CM codes to ICD-10-CM codes [22].

All adjusted analyses for binary outcome variables were analyzed using generalized linear regression models with a binomial family and a logit link, which is equivalent to a logistic regression. Adjusted analyses for continuous variables were analyzed using generalized linear regression models with a gamma family and a log link. The benefit of generalized linear models is that outcomes do not have to be normally distributed, as is usually the case with healthcare costs that tend to be skewed. Standard errors were derived using the bootstrap method with 1000 replications. p-values less than 0.05 were considered statistically significant. All data analyses were conducted using STATA v.12.1 (StataCorp LP, TX, USA) statistical software.

Results

A total of n = 796 inpatient claims were identified for the Saratoga Hospital in the years of interest, and of these, n = 258 and n = 323 were observed in the pre-implementation and post-implementation periods, respectively. Imposing the inclusion and exclusion criteria decreased the pre-implementation total by 64 cases and by 93 for the post-implementation period. Our final sample for analysis compared n = 194 cases in the pre-implementation period to n = 230 in the post-implementation period. Figure 1 shows the sample population flow chart.

Comparisons of patient characteristics (Table 1) show that the patient populations are similar except for the Elixhauser comorbidity index, indicating a more severe patient population in the post-implementation period. Patients in both time periods were similar in age with the majority being over 65 years old (84% pre-implementation period vs 80% post-implementation period). Over half of all patients were female and the majority were white. Patients in the post-implementation period had significantly more co-morbid conditions (3.6 vs 4.0; $p = 0.048$).

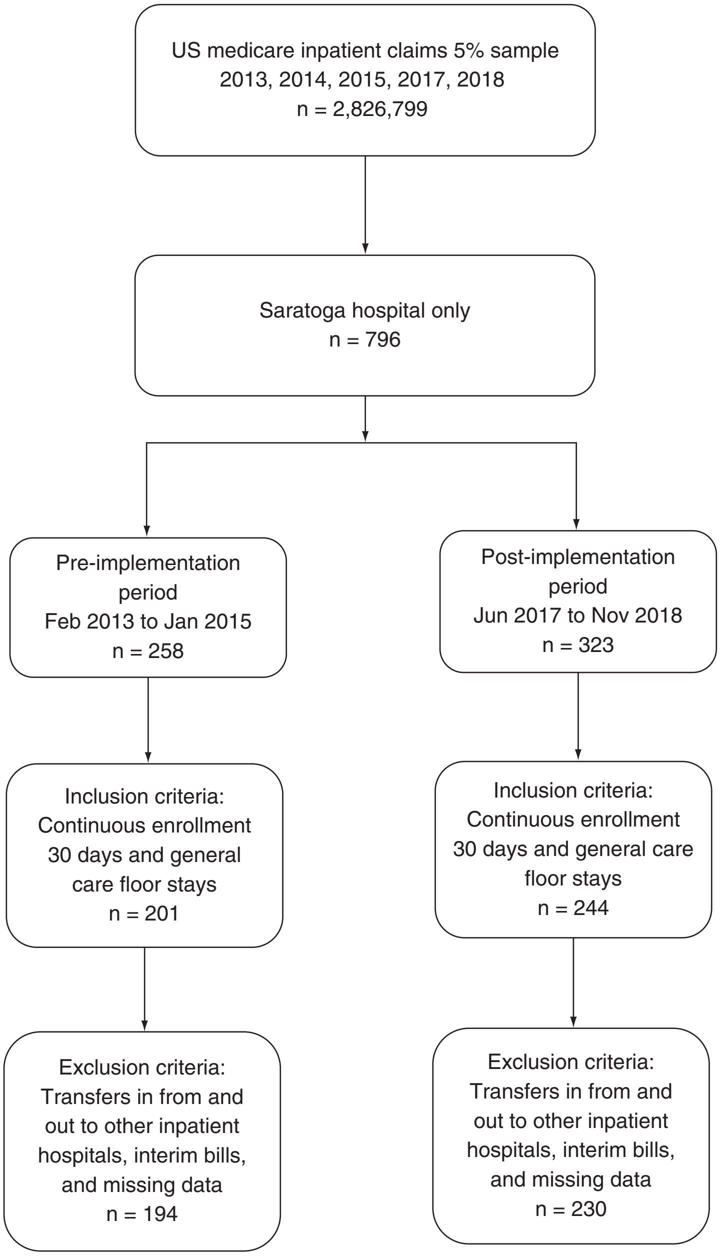

Figure 1. Sample population flow chart.

The most frequent conditions across all cases were hypertension (70%), fluid and electrolyte disorders (35%), chronic pulmonary disease (32%) and renal failure (29%).

Comparing the hospital admission characteristics shows that the percentage of emergency admissions as well as ICU admissions were similar in both time periods (Table 1). Approximately 80% of all cases were emergency versus elective, and less than 10% of patients had an ICU admission during their stay. More cases in the post-implementation period were discharged to home or self-care compared with other destinations (56.7 vs 70.4%; $p = 0.003$).

Outcomes

Average total costs per discharge in the post-implementation period were significantly reduced by 18% compared with the pre-period ($16,201 vs $13,304; $p = 0.007$) (Table 2). Median costs were also significantly lower by 25% ($13,648 vs $10,232; $p < 0.001$). A histogram of average total costs in each period shows a higher percentage of cases toward the lower end of the distribution in the post-implementation period (Figure 2).

Table 1. Patient and hospitalization characteristics pre- and post-implementation.

Parameters	Pre-implementation	Post-implementation	p-value
N	194	230	
Age, mean (SD) years	73.4 (12.9)	71.7 (14.1)	0.184
Age, % (N) years			0.325
– <64	16.0% (31)	19.6% (45)	
– 65–74	35.1% (68)	34.8% (80)	
– 75–84	28.4% (55)	31.3% (72)	
– 85+	20.6% (40)	14.3% (33)	
Sex, % (N)			0.708
– Female	58.8% (114)	57.0% (131)	
– Male	41.2% (80)	43.0% (99)	
Race/ethnicity, % (N)			0.139
– White	95.4% (185)	92.7% (215)	
– Black	4.6% (9)	4.3% (10)	
– Other	0.0% (0)	2.1% (5)	
Co-morbid conditions			0.048
– Elixhauser comorbidities count, mean (SD)	3.6 (1.9)	4.0 (2.3)	
Admission type, % (N)			0.397
– Emergent	79.4% (154)	82.6% (190)	
– Elective	20.6% (40)	17.4% (40)	
Discharge destination, % (N)	N = 193	N = 229	0.003
– Home/self care	56.7% (110)	70.4% (162)	
– Skilled nursing or rehabilitation facility	39.7% (77)	28.3% (65)	
– Other	2.6% (5)	0.4% (1)	
ICU stay, % (N)	9.3% (18)	8.3% (19)	0.733

p-values: Two sample t-tests are used for continuous variables and Chi-squared tests for categorical variables, except for the race variable, which used the Fisher's exact test.
ICU: Intensive care unit; N: Sample size; SD: Standard deviation.

Table 2. Patient outcomes pre- and post-implementation, risk adjusted.

Parameters	Pre-implementation	Post-implementation	Difference (95% CI)	p-value
N	194	230		
Complications, %	8.6%	2.9%	-5.7% (-1.2 to 1.0%)	0.094
In-hospital mortality, %	1.8%	0.9%	-0.9% (-2.5 to 0.6%)	0.230
30-day all-cause re-admission, %	15.4%	19.5%	4.0% (-4.7 to 12.7%)	0.367
LOS (days)				
– Total, mean (SD)	6.0 (3.7)	5.0 (3.1)	-1.0 (-1.9 to -0.1)	0.033
– Total, median (SD)	4.0 (3.6)	3.0 (3.5)	-1.0 (-1.7 to -0.3)	0.007
– ICU, mean (SD)	0.4 (1.2)	0.4 (1.2)	0.0 (-0.7 to 0.7)	0.983
– General care, mean (SD)	5.6 (2.9)	4.6 (2.4)	-1.0 (-2.0 to -0.04)	0.042
Total hospital costs				
– Mean (SD)	$16,201 ($7006)	$13,304 ($5753)	-$2897 (-$4986 to -$808)	0.007
– Median (SD)	$13,648 ($7,805)	$10,232 ($7714)	-$3416 (-$5003 to -$1828)	<0.001
Medicare payment				
– Mean (SD)	$8,932 ($3166)	$8793 ($3116)	-$139 (-$1198 to $920)	0.797
– Median (SD)	$7820 ($4174)	$7193 ($4125)	-$627 (-$1476 to $221)	0.147

Mean rates were calculated from generalized linear models and medians were calculated using quantile regressions. All were adjusted for patient age, sex, race, the Elixhauser comorbidity index and whether the patient admission was an emergency or elective.
ICU: Intensive care unit; LOS: Length of stay; N: Sample size; SD: Standard deviation.

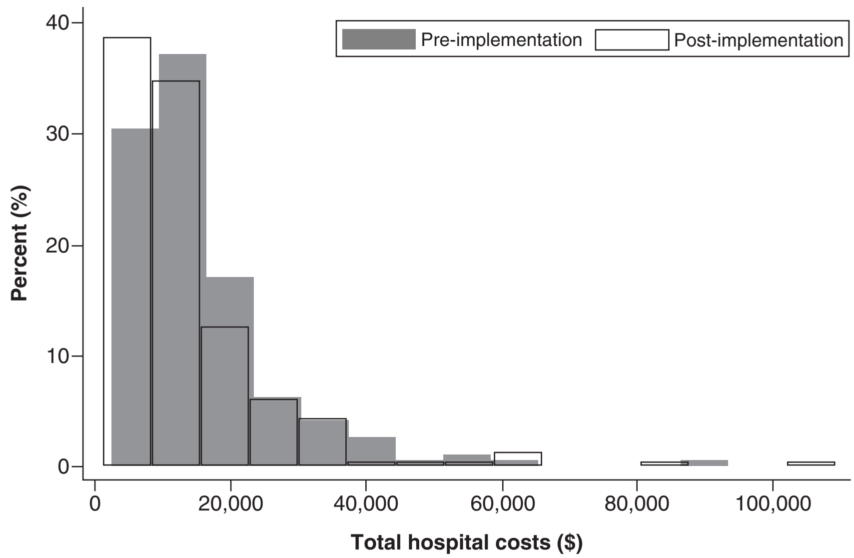

Figure 2. Histogram of total hospital costs for pre- and post-implementation periods.

Table 3. Complications and procedures pre- and post-implementation, risk adjusted.

Parameters	Pre-implementation	Post-implementation	Difference (95% CI)	p-value
n	194	230		
Complications (%)				
– Acute myocardial infarction	0.0	0.0	0.0 (-0.0 to 0.0)	.
– Acute pulmonary edema	0.0	0.0	0.0 (-0.0 to 0.0)	.
– Acute renal failure	6.7	0.2	-6.5 (-16.8 to 3.9)	0.220
– Acute respiratory failure	2.8	1.9	-0.9 (-8.5 to 6.7)	0.825
– Cardiac arrests	0.2	0.2	0.0 (-0.0 to 0.0)	1.00
– Pneumonia	5.7	0.5	-5.2 (-11.9 to 1.4)	0.121
– Pulmonary embolism	0.0	1.3	1.3 (-1.8 to 4.4)	0.402
– Sepsis	0.2	0.2	0.0 (-0.0 to 0.0)	1.00
– Stroke	0.2	0.2	0.0 (-0.0 to 0.0)	1.00
Procedures (%)				
– Medication use	18.8	4.5	-14.3 (-22.2 to -6.3)	<0.001
– Mechanical ventilator use	2.6	1.0	-1.6 (-8.5 to 5.3)	0.642
– Cardiopulmonary resuscitation	0.2	0.2	0.0 (-0.0 to 0.0)	1.00

Rates were calculated from generalized linear models and adjusted for patient age, sex, race, the Elixhauser comorbidity index and whether the patient admission was an emergency or elective.

Average LOS was significantly reduced by 1 day (6.0 vs 5.0; p = 0.033), as well as the median LOS (4.7 vs 3.7; p = 0.007). Separating out total LOS into general care and ICU stays, we found similar ICU LOS (0.4 vs 0.4; p = 0.983), but significantly lower LOS in general care by 1 day (5.6 vs 4.6; p = 0.042), indicating that the total LOS difference is driven by the reduction in general care. Complications, in-hospital mortality, 30-day all-cause re-admissions and Medicare payments were similar between the two time periods. All results are presented as risk adjusted to account for patient baseline characteristics and severity. Unadjusted estimates are provided in Appendix Table 2.

Examining the predefined complications separately, all rates were found to be similar in the two time periods. Rates tended to be low except for acute renal failure and pneumonia in the pre-implementation period (6.7% and 5.7%, respectively; Table 3). The 30-day all-cause re-admission rate was not statistically significant, although an increase of 4% was observed. For medication use, there was a 76% reduction from 18.8% to 4.5% (p < 0.001), mostly driven by a reduction in respiratory medication accounting for 78% and 91% of the medication use pre-

Table 4. Costs per patient by department pre- and post-implementation, risk adjusted.

Parameters	Pre-implementation	Post-implementation	Difference (95% CI)	p-value
n	194	230		
Department, mean (SD)				
– General Care	$4848 ($2437)	$3871 ($1956)	-$977 (-$1683 to -$270)	0.007
– ICU	$565 ($1143)	$510 ($1143)	-$56 (-$467 to $356)	0.791
– Pharmacy and IV therapy	$1982 ($1418)	$1412 ($1010)	-$570 (-$928 to -$212)	0.002
– Medical/surgical supplies	$1644 ($2337)	$1061 ($1508)	-$583 (-$1828 to $662)	0.359
– Laboratory	$2234 ($1381)	$1663 ($1028)	-$571 (-$846 to -$295)	<0.001
– Imaging services	$1379 (1075)	$1044 ($813)	-$335 (-$727 to $57)	0.094
– OR services and anesthesia	$201 ($283)	$419 ($283)	$218 (-$27 to $463)	0.081
– Blood storage and processing	$116 ($98)	$51 ($98)	-$65 (-$122 to -$9)	0.023
– Respiratory and pulmonary services	$526 ($1160)	$832 ($1836)	$306 (-$1195 to $1807)	0.690
– Physical, occupational and speech therapy	$187 ($105)	$119 ($105)	-$68 (-$112 to -$25)	0.002
– Cardiology, EKG and EEG services	$447 ($419)	$512 ($419)	$65 (-$167 to $297)	0.583
– ASC, clinic and ER services	$1902 ($1639)	$1530 ($1319)	-$371 (-$790 to $47)	0.082
– Other costs	$960 ($2176)	$517 ($1172)	-$443 (-$2114 to $1228)	0.603

Mean rates were calculated from generalized linear models and adjusted for patient age, sex, race, the Elixhauser comorbidity index and whether the patient admission was an emergency or elective.
ASC: Ambulatory surgery center; EEG: Electroencephalogram; EKG: Electrocardiogram; ER: Emergency room; ICU: Intensive care unit; IV: Intravenous; N: Sample size; OR: Operating room; SD: Standard deviation.

and post-implementation, respectively. Mechanical ventilator usage and cardiopulmonary resuscitation were similar before and after implementation. However, the rate of mechanical ventilator usage was lower but not statistically significant (2.6% vs 1.0%; p = 0.694).

We also examined average costs incurred in each department (Table 4). Cost differences in general care, pharmacy and intravenous (IV) therapy, laboratory, blood storage and processing, and physical, occupational and speech therapy departments were significantly lower in the post-implementation period. All other departments had similar cost differences across the two time periods. The largest difference was seen in general care with a $977 reduction per case ($4848 vs $3871; p = 0.007), accounting for approximately 28% of the total cost difference. The pharmacy and IV therapy departments had a significant reduction of $570 per case ($1982 vs $1412; p = 0.002), which coincides with the reduction observed in medication usage.

Discussion

The results of this study show that in the post-implementation period of the EDDS, average total costs and LOS were observed to be significantly lower. These differences were driven by LOS and cost reductions in general care, where the system was implemented. We also observed medication use decrease in the post-implementation period, mainly driven by the lower use of respiratory medication. In addition, pharmacy and IV costs were significantly lower in the post-implementation period coinciding with the lower percentage of cases that used medication.

The lower costs observed can partially be attributed to the lower LOS, specifically in general care. The EDDS is intended to capture a patient who is at risk of deterioration to treat the patient promptly and prevent them from deteriorating further. Although we did not observe statistically significant reductions in complications, the incidence rates were lower indicating that less resources were potentially required to treat patients in the post-implementation period incurring less costs. For LOS, the hospital implemented additional initiatives to lower LOS during this time, and therefore the reduction in LOS cannot be fully attributed to the changes in the EDDS.

The lower medication use can partly be explained by a change in protocols at the Saratoga Hospital that detailed a switch from using nebulizers to using inhalers during the study period. Nebulizers require larger doses compared with inhalers [23], which could partly explain the lower costs spent in the pharmacy and IV therapy department post-implementation period. The lower costs in blood storage and processing can be partly explained by a new transfusion protocol that was implemented in 2018. These changes were not a result of the EDDS but likely due to the change in treatment protocol implemented at the hospital. The 30-day re-admission rate increase of 4%, although not statistically significant, could be due to hospitalization characteristics, such as specific procedures performed during hospitalization, that put the patient at higher risk for re-admission. A larger sample size would be needed to draw conclusions.

Previous research on these types of solutions has consistently examined the impacts on LOS and in-hospital mortality. For LOS, results range from having no impact [24–26] to reducing LOS by almost 3 days [27]. In studies conducted for US hospitals, the evidence has shown significant reductions ranging from 0.4 days to 1 day [11,28,29], which is in line with the 1-day reduction we observe in our study. For in-hospital mortality, most studies report no differences in the pre- and post-implementation periods [11,26–28]. One large study, conducted for a similar intervention and with a pre- versus post-implementation study design, reported low in-hospital mortality rates (1.5% pre vs 1.6% post), even with very large patient numbers (N = 7940 pre vs N = 7012 post), and no significant differences between time periods [11].

Significant reductions in serious events have been shown for a hospital in the UK (9.7–7.3%), with significant reductions in cardiac arrests and severe sepsis [30], but no significant reductions in other complications. In Germany, a study showed reductions in cardiac arrests [24]. For US and for international sites, Bellomo *et al.* [11] showed no significant differences in complications comparing the intervention and control periods. Our work did not show differences in these events likely due to the small-sample sizes available in the Medicare 5% inpatient claims database. Overall, our results are consistent with the evidence on these technologies. Variations in the current evidence could be due to differences in the technology implemented, the clinical adoption at the hospital and the size of the studies.

Limited evidence exists estimating the costs or cost–effectiveness associated with implementing an EDDS. One study [10] estimates the costs pre- versus post-implementation of a continuous monitoring system at a single center in California. Although not the same as the EDDS in this study, the system does include monitoring of vital signs and notifying staff of patient deterioration. The authors develop a return-on-investment model and show that reduced LOS contributes the largest cost savings, similar as our findings. A Health Technology Assessment in Ireland conducted a cost analysis of implementing an electronic early warning system in the general ward and found a potential LOS benefit, with investment requirements ranging from €1.0–€1.3 million over 5 years for one site [12].

Another study [11] reports the acquisition costs of the MP5SC monitors and IGS system at $6597 per monitor (adjusted from $5275 in 2012 to 2020 dollars) with a 5% yearly maintenance cost for 5 years, for a total of $1649 per monitor per year. Using this value as the investment cost, then even if just a small fraction of the total cost-savings per discharge ($2897 reduction) can be attributed to the EDDS, the additional $1649 investment would be offset even if just a few cases were treated per year. Considering that our sample accounts for approximately 5% of total annual Medicare discharges at the Saratoga Hospital, if we extrapolated to the total number of Medicare discharges in 2018 of 2820 (based on the 5% sample of 141 in 2018), then the estimated total dollars saved would be $8.2 million annually for Medicare beneficiaries at one hospital alone.

Limitations of the study include the retrospective study design and sample size. The observational analysis leveraged the Medicare claims database, which is collected for the purposes of Medicare payment and not for research. Thus, several claims identified for the Saratoga Hospital in the pre- and post-implementation periods had to be excluded (N = 157) to ensure outcomes were being measured similarly across all patients and due to missing data. The retrospective design also limits how the study outcomes are defined since we must rely on data that is already collected, such as on ICD-9-CM and ICD-10-CM codes for complications.

The sample size for the analysis was based on a convenience sample of the number available in the Medicare database, which was only a 5% sample. This limits the statistical power to be able to detect differences in outcomes, especially for low frequency events. A larger study would need to be conducted to understand whether there were significant changes in the clinical outcomes observed in this study, such as in complications or 30-day all-cause re-admission.

As is the case with all observational research, it is not possible to control for all confounding factors that could impact our outcomes of interest. We acknowledge that there were other factors at play throughout this period that could have also impacted outcomes. It is possible that the EDDS impact was only part of the overall impact we capture. Given this was a single-center study, results are representative of the Saratoga Hospital only. Larger multicenter studies would need to be conducted to understand whether results translate to broader populations.

Conclusion

An early deterioration detection solution (EDDS) can be an effective tool in identifying early patient deterioration that can contribute to lowering costs and LOS. The results showed the EDDS implemented at a US hospital led to cost savings and a lower LOS, especially in general care where the system was implemented. This information provides evidence of the benefits to hospitals and patients of implementing these systems in general care.

Future perspective

The focus on improving patient outcomes and reducing costs will continue to drive the need for patient monitoring and innovative solutions in lower acuity areas of the hospital. This research is one of the first to show evidence of the potential cost benefits of implementing an early deterioration detection solution in general care. Future research will continue to focus on these types of solutions, the economic value they bring to hospitals and whether they are cost-effective.

Summary points

- An early deterioration detection solution (EDDS) implemented in general care units is intended to capture patients at risk of clinical deterioration to treat patients promptly.
- In the post-implementation period of an EDDS at a US hospital, average and median total costs and average length of stay (LOS) were observed to be significantly lower driven by LOS and cost reductions in general care, where the system was implemented.
- Medication usage was observed to be significantly lower mainly driven by the lower use of respiratory medication.
- Cost differences in general care, pharmacy and IV therapy, laboratory, blood storage and processing, and physical, occupational and speech therapy departments were significantly lower in the post-implementation period. All other departments had similar cost differences across the two time periods.
- Complications, in-hospital mortality, 30-day all-cause re-admissions and Medicare payments were similar between the two time periods.

Author contributions

All the authors contributed to the design, interpretation, writing and approval of the report. BA Mohr acquired and analyzed the data. All the authors agree to be accountable for all aspects of the work.

Disclaimer

This article reflects the opinions of the authors and does not represent endorsement by the affiliated institutions.

Financial & competing interests disclosure

BA Mohr, S Dickson, L Bucsi, M Vente and G Medic are employees of Philips. Material support was provided by Philips. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

No writing assistance was utilized in the production of this manuscript.

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