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## Timely Analgesia, Reduced Hospitalization Rate, and Improved Economic Efficiency Following Implementation of a New Emergency Department Sickle Cell Pain Management Algorithm

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### Abstract

**Context:** Adults with sickle cell disease (SCD) presenting to emergency departments (EDs) with severe pain often experience treatment delays and long, costly hospitalizations.

**Objectives:** A fast-track ED SCD pain management algorithm was developed and then evaluated for its clinical and economic impact.

**Methods:** We conducted a retrospective chart review to compare outcomes of ED visits for SCD-related pain two years before and after algorithm implementation. Patient demographics, ED utilization, and treatment outcome measures including time from registration to first opioid treatment, ED length of stay, hospitalization rate, hospitalization length of stay, and both hospital and ED revenue production were compared.

**Results:** There was a total of 699 consecutive ED visits for SCD-related pain (131 pre- and 568 post-algorithm). Median time to first opioid dose decreased from 53 to 32 minutes ( $p < 0.001$ ). Disposition was determined more efficiently (210 vs. 168 minutes,  $p < 0.001$ ) leading to reduction in ED length of stay (345 vs. 271 minutes,  $p < 0.001$ ). Although ED utilization increased, this was due to a few high utilizers whose patterns of use skewed the mean. Hospitalization rate per ED visit significantly decreased (54% vs. 38%,  $p = 0.001$ ). Average length of stay per hospitalization decreased from 12 to 8 days ( $p < 0.03$ ) which was economically beneficial to the hospital in that revenue production per inpatient day increased by 28%.

**Conclusions:** Our findings suggest algorithmic ED SCD pain management significantly improves quality and economic outcomes.

**Keywords:** Sickle cell disease; Pain management; Vaso-occlusive crisis; Emergency management

### Introduction

The hallmark of SCD is severe unpredictable bodily pain termed a vaso-occlusive pain episode (VOE). The etiology of VOE is not well-understood, but is, in part, due to complex adhesion of sickled red blood cells to leukocytes and endothelial cells leading to vaso-occlusion, distal ischemia, and resultant pain [1-5]. There remains no specific anti-VOE targeted therapy, thus treatment relies on prompt delivery of opioid-based analgesia to treat the pain sufficiently until the underlying VOE dissipates.

Nationally, SCD-related ED visit charges coupled with costs associated with high inpatient hospitalization rates (~40%) were an estimated \$2.4 billion in 2006 [6]. The majority of these costs are related to the management of VOE pain. One-third of SCD deaths occur during a painful VOE [7] and patients with frequent VOEs suffer the earliest mortality [8]. Standard of care for VOE requires rapid evaluation and treatment to insure analgesic efficacy and reduced need for hospitalization. Guidelines indicate that parenteral opioid therapy should be administered within 30 minutes of ED presentation [9]. However, studies document a three-fold median increase in the time SCD patients wait in agonizing pain [10,11]. Race, provider bias and

doctor-patient mis-trust are key determinants of this disparate care [12-14]. Thus, algorithmic approaches to the VOE management in the ED may ameliorate the current subjective and often sub-standard approach to care and perhaps improve outcomes.

In 2008, the University of Connecticut Health Center (UConn) opened the region's only comprehensive adult SCD clinical center. This effort included the establishment of a formal transition program with the regional pediatric SCD program [15] as well as community

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outreach to capture adults with SCD without established care elsewhere. The center's first quality improvement initiative was to insure that SCD patients presenting to its hospital's ED with painful VOs received care according to national standards. Therefore, a fast-track ED SCD pain treatment algorithm was developed in 2009 and implemented in 2010.

We hypothesize that the implementation of this algorithm has led to improved patient wait times for analgesia, a reduction in rate of hospitalization, and more efficient hospital revenue production. The goal of this study is to illustrate the clinical and economic impact of this algorithm. Our primary outcome measure is time to first opioid treatment for SCD-related pain. Our secondary outcomes include ED utilization, ED length of stay, hospitalization rate and length of stay, and both hospital and ED revenue production.

## Methods

### Study design and setting

We conducted a retrospective pre-/post-intervention comparison of adults presenting to a single ED with SCD-related pain. A chart review of all ED visits for SCD-related pain from January 2008 to December 2011 was undertaken in accordance with UConn institutional review board policies. As the intervention was implemented in January of 2010, the comparison periods were January 2008-December 2009 vs. January 2010-December 2011.

The setting was a single suburban hospital ED located about 10 miles west of Hartford, Connecticut's capital city. Physician and nursing staffing stayed relatively constant in the ED, SCD center and hospital during the study period. Patients admitted for SCD-related pain were assigned a bed on the oncology or medical inpatient floors and attended by the same six rotating hematologists.

### Selection of participants

Patients were included in the study if they presented with SCD-related pain to the ED during the evaluation period. After review of all such patients, it was discovered that they all were established patients of the hospital's SCD center. Thus, to create comparison groups of ED utilizers vs. non-utilizers, a database of all patients receiving care at the SCD center was developed.

### Algorithm development

The fast-track ED SCD pain treatment algorithm was developed in a multi-disciplinary fashion by a committee including hematology and ED physicians and nurses through a series of bimonthly meetings and after review of evidence-based literature. The committee undertook a review of current practice by conducting a chart audit of patients presenting to the ED for SCD-related [16]. The committee identified delays in care including prolonged wait times for first and subsequent opioid doses (median 82 and 60 minutes, respectively). No patients received patient-controlled analgesia (PCA) in the ED or upon hospitalization due to a hospital-wide policy prohibiting PCA with continuous basal rates in any patient regardless of diagnosis.

The audit identified that the major delay in care was the assessment and ordering of the first dose of opioid therapy by the physician. Patients were fully assessed in a median of 20 minutes by the ED nurse. It was therefore determined that nurses should be empowered to administer the first dose of parenteral opioid based on defined eligibility criteria and a verbal physician order.

The algorithm was subsequently written according to national

guidelines [9]. Patients who presented to the ED for SCD-related acute pain management were to be fast-tracked upon registration and then assessed by the nurse for algorithm eligibility. Patients were defined as meeting eligibility criteria if they were 18 years or older with a self-reported history of SCD and presented with pain. Patients were excluded if (1) they had any abnormal vital signs upon arrival: temperature >101 F, heart rate >130, respiratory rate <10 or >24, SPO<sub>2</sub> <93% on room air, or (2) the chief complaint was chest or abdominal pain atypical of a usual pain episode, shortness of breath, severe headache, or other altered neurological status.

Patients meeting algorithm eligibility were further interviewed by the nurse to determine opioid preference: morphine sulfate or hydromorphone. The nurse determined the drug dose depending on whether the patient reported taking opioid therapy within the preceding 24 hours. Patients who had taken opioids were given either 2 mg of hydromorphone or 10 mg of morphine sulfate parenterally. Patients who had not taken opioids were considered opioid-naïve and given a lower dose of medication, either 1 mg of hydromorphone or 5 mg of morphine sulfate. The goal was to administer a first dose of parenteral opioid therapy within thirty minutes of registration.

Pain reassessment within 20 minutes of each opioid dose was a key algorithm component. Re-dosing of opioid was to be administered within 30 minutes of the prior dose if the pain level was unacceptable to the patient and only if the physician had assessed the patient in the intervening time. This cycle of reassessment/re-dosing was to occur for a maximum of three total opioid doses, at which time a decision regarding discharge or hospital admission was determined by the physician.

Admitted patients were to be placed on patient-controlled anesthesia (PCA) in the ED with a continuous basal rate to insure continued analgesia while awaiting admitting physician evaluation and transport to a hospital bed.

### Algorithm implementation

The committee presented the draft algorithm to hospital administration which deemed it necessary to obtain (1) permission from the State Board of Nursing, and (2) approval from the Pharmacy and Therapeutics committee regarding utilization of PCA with a continuous basal rate. The State Board of Nursing subsequently determined that the nursing activities in the algorithm were within nursing practice standards. Additionally, permission was granted for PCA use.

A case-based educational presentation on the new algorithm was disseminated via the hospital-wide web-based education site as a mandatory course for all medical and nursing providers. Before the go-live date, a mock run of the algorithm was conducted. Issues identified were resolved and the algorithm was modified to reflect these minor logistical changes.

### Methods of measurement

Clinical and demographic data for each patient were extracted from the electronic medical chart using a standardized data collection instrument with clear definitions on what constituted reliable vs. missing data. The dataset consisted of two years of data before and after the intervention. Demographic data included age, gender, race, and insurance. Clinical data included hemoglobin genotype, hydroxyurea use, chronic transfusion therapy, and ED utilization. ED utilization was defined as the number of visits by a patient to the ED under study

as data on utilization at other EDs was not available. Patients were defined as high ED utilizers if they had 10 or more visits to the ED in a two year period. Other data included ED treatment time points, length of stay in the ED, disposition, and hospital length of stay. Economic data for these clinical encounters were obtained from the hospital's claims database.

### Outcome measures

The primary outcome measure of this study was the amount of time patients waited from registration to receiving a first dose of opioid analgesia. Secondary outcome measures included ED utilization for SCD-related pain, ED length of stay, hospitalization rate and length of stay, and both hospital and ED revenue.

### Primary data analysis

Comparisons were made two years pre- and post-algorithm

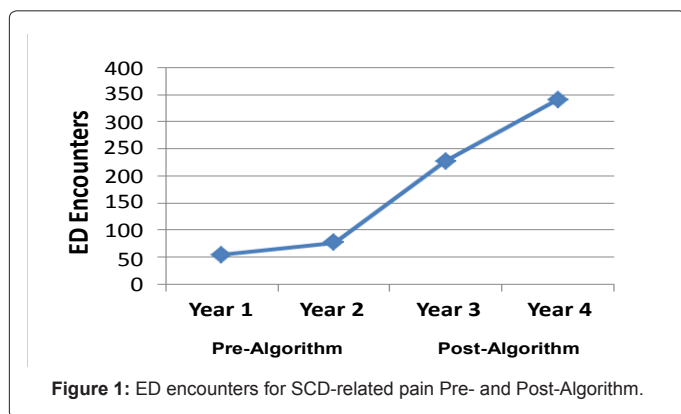


Figure 1: ED encounters for SCD-related pain Pre- and Post-Algorithm.

implementation. All data analyses were performed using SAS 9.3 (SAS Institute, Cary, NC). Event rates were compared between patient groups using a chi-squared test of proportions. Due to non-normality of the distributions, numeric variables were analyzed using the two group Wilcoxon rank-sum test. McNemar's test of symmetry was used to assess the extent to which patients changed their ED utilization habits pre- and post-algorithm. The economic impact of the algorithm was estimated using two-tailed t-tests assuming unequal variances. A two-sided alpha level of significance was used to assess statistical significance.

## Results

### Enrollment

There were 699 consecutive eligible ED visits for SCD-related pain over the study period. Nineteen percent occurred in the two-year period prior to algorithm implementation and 81% occurred in the subsequent two-year period (Figure 1). While clinical charts were available for all visits, claims data were only available for 678 of the 699 ED encounters. All 699 visits were made by patients who were receiving comprehensive SCD care at the hospital's outpatient sickle cell center.

### Characteristics of patient population

The substantial increase in ED utilization was evaluated in the context of a growing outpatient SCD patient base. Demographic and clinical characteristics of all SCD patients receiving treatment at the comprehensive SCD center were compared two years before and after the SCD pain ED algorithm was implemented (Table 1). Prior to algorithm implementation, there were 81 patients receiving care at the SCD center with equal distribution of genders (54% female, 46% male)

	Pre-Algorithm			Post-Algorithm		
	All Patients (n=81)	ED Utilizers (n=35)	ED visits (n=131)	All Patients (n=119)	ED Utilizers (n=57)	ED visits (n=568)
Gender, n (%)						
Male	37 (46)	17 (49)	55 (42)	53 (45)	25 (44)	296 (52)
Female	44 (54)	18 (51)	76 (58)	66 (55)	32 (56)	272 (48)
Race, n (%)						
Black	71 (88)	29 (83)	120 (92)	107 (90)	53 (93)	538 (95)
White	2 (2)	0 (0)	0 (0)	3 (2)	0 (0)	0 (0)
Latino	8 (10)	6 (17)	11 (8)	9 (8)	4 (7)	30 (5)
Age, mean (SD)	33 (9)	30 (7)	-	32 (9)	30 (9)	-
Insurance, n (%)						
Private	31 (38)	13 (37)	32 (24)	41 (34)	16 (28)	224 (39)
Medicaid	26 (32)	13 (37)	73 (56)	44 (37)	24 (42)	175 (31)
Medicare	15 (19)	6 (17)	21 (16)	23 (19)	13 (23)	163 (29)
DOC*	9 (11)	3 (9)	5 (4)	11 (9)	4 (7)	6 (1)
Genotype, n (%)						
SS	52 (64)	27 (77)	94 (72)	76 (64)	40 (70)	429 (76)
SB <sup>0</sup>	1 (1)	0 (0)	0 (0)	3 (2)	1 (2)	1 (<1)
SB <sup>+</sup>	8 (10)	4 (11)	10 (7)	15 (13)	7 (12)	68 (12)
SC	20 (25)	4 (11)	27 (21)	25 (21)	9 (16)	70 (12)
Hydroxyurea, n (%)						
Yes	14 (17)	8 (23)	32 (24)	22 (18)	13 (23)	250 (44)
No	67 (83)	27 (77)	99 (76)	97 (82)	44 (77)	318 (56)
Transfusions, n (%)						
Yes	17 (21)	9 (26)	39 (30)	25 (21)	16 (28)	84 (15)
No	64 (79)	26 (74)	92 (70)	94 (79)	41 (72)	484 (85)

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Table 1: Patient Demographic and Clinical Characteristics.

and a mean age of 33 years. Although the majority of patients were black, 10% of the patients were Latino and 2% were white. Nearly 40% of patients were privately insured. Two-thirds of patients had the SS genotype. A majority of patients were not taking hydroxyurea or on chronic transfusion therapy.

The first two years following the implementation of the algorithm there was a contemporaneous 47% growth in the comprehensive center’s SCD patient population to a total of 119 patients. This larger population was similar in terms of demographics and clinical characteristics as seen in Table 1 (“All Patients” Pre-Algorithm vs. “All Patients” Post-Algorithm). The ED algorithm did not influence the growth of the patient population as all the patients presenting to the ED for SCD pain had already established care with the SCD center prior to the first visit to the ED.

### Demographic and clinical characteristics of ED utilizers do not change post algorithm

The subgroup of SCD patients who utilized the ED for SCD pain management before and after algorithm implementation is reported in Table 1 (“ED Utilizers” Pre-Algorithm vs. “ED Utilizers” Post-Algorithm). Prior to algorithm implementation, 35 unique patients with SCD utilized the ED for a total of 131 episodes of SCD-related pain. After the algorithm was in place, 57 unique SCD patients utilized the ED for pain over a two year period. These 57 patients were responsible for 568 ED visits during the same timeframe. No clinical or demographic factors were notably different among ED utilizers pre- and post-algorithm.

### High utilizers influence increase in ED visits for SCD pain

The post-algorithm increase in the number of ED visits exceeded the growth of the SCD clinic population. While the SCD patient base grew from 81 to 119 patients (46% increase) after algorithm implementation, the number of ED visits increased from 131 to 568, a >300% increase in ED utilization for SCD pain (Figure 1).

In order to understand the factors accounting for the increase in ED utilization after algorithm implementation, we analyzed two groups of patients. We defined group 1 as the outpatient SCD patient base during the two years pre-algorithm implementation and group 2 as the outpatient SCD patient base two years post-algorithm implementation. The proportion of patients in group 1 who utilized the ED at least once was similar to group 2 (43% vs. 48%). The median number of visits for groups 1 and 2 were 0 and 1, respectively, indicating that over half of the patients only came to the ED once or not at all during each two year timeframe.

To identify patients with high utilization, patients were categorized as high ED utilizers (10 or more ED visits) and typical ED utilizers (0-9 visits) over each two year period (Table 2). 97% of patients in group 1 exhibited typical ED utilization compared to 87% of patients in group 2. Three patients in group 1 were high ED utilizers and accounted for 35% of the ED visits. This is in contrast to the fifteen patients in group 2 who were high ED utilizers and responsible for 79% of the ED visits. The 38 patients in group 2 who were new to the SCD program were as likely to be high ED utilizers (16%) compared to established patients (11%) ( $p = 0.47$ ). However, the 81 established patients from group 1 were more likely to become high ED utilizers after the algorithm was implemented (3 established patients were high utilizers pre-algorithm compared to 9 patients post-algorithm,  $p < 0.05$ ).

Closer analysis of the 81 original patients from group 1 for ED

	Pre-Algorithm		Post-Algorithm	
	All Patients (n=81)	ED Utilizers (n=131)	All Patients (n=119)	ED Utilizers (n=568)
<b>Typical Usage, n (%)</b>				
0 Visits	46 (57)	0 (0)	62 (52)	0 (0)
1 Visits	16 (20)	16 (12)	14 (12)	14 (2)
2-5 Visits	12 (15)	42 (32)	23 (19)	69 (12)
6-9 Visits	4 (5)	28 (21)	5 (4)	36 (6)
<b>High Usage, n (%)</b>				
10 Visits	0 (0)	0 (0)	1 (1)	10 (2)
11-15 Visits	2 (2)	27 (21)	7 (6)	87 (16)
16-20 Visits	1 (1)	18 (14)	1 (1)	18 (3)
20+ Visits	0 (0)	0 (0)	6 (5)	334 (59)

**Table 2:** Number of Patients and Visits by Group and Usage Category.

utilization (yes vs. no) across timeframes indicates that 15 patients followed a utilization pattern of (yes:no) across the time frames (group1:group2) which was essentially equal to the number (14) who had the reverse pattern (no:yes) (McNemar’s test,  $p=0.85$ ). This suggests that existing patients were no more or less likely to utilize the ED after algorithm implementation. The same analysis for high utilizers (10+ED visits), however, indicates that there was only one patient who had a (yes:no) pattern compared to 7 who had a (no:yes) pattern. Taken together, these findings suggest that the overall increase in ED utilization is primarily due to a statistically significant increase in the number of patients who became high utilizers in group 2. (McNemar’s test,  $p=0.03$ ).

### Algorithm is associated with reduction in time to first opioid and disposition

In order to assess the clinical impact of the algorithm, we compared pre- and post-algorithm care delivery time points. As indicated in Table 3, the median time decreased to 32 minutes which was very close to our 30 minute goal. In fact, the percent of individuals who received a first dose of opioid analgesia within 30 minutes of registration doubled from 22% to 44%.

The median time of ED physician determination of patient disposition was also significantly reduced by 42 minutes. This improvement was more pronounced in patients who required admission. However, overall median length of stay in the ED from registration to departure was reduced by more than one hour among all patients regardless of final disposition (345 vs. 271 minutes).

### Algorithm implementation is associated with decreases in admission rate and hospital length of stay

The rate of hospital admission following ED presentation for VOE pain and hospital length of stay was compared pre- and post-algorithm implementation. As demonstrated in Table 3, hospitalization rates from the ED decreased from 54% to 38% after algorithm implementation ( $p=0.001$ ). Similarly, the average length of stay for those who were admitted to the hospital decreased significantly by 4 days ( $p=0.03$ ).

### Hospital revenue increases after algorithm implementation

In 2008-2009, before the algorithm went into effect, the mean

hospital payment per patient presentation in the ED was \$9,910. In 2010-2011, after the algorithm was implemented, the mean hospital payment per patient presentation was \$6,118; a decrease of \$3,791 per presentation. While there were more total hospitalizations per year post-algorithm, on average, lengths of stay shortened by 4 days. These changes were economically beneficial to the hospital, in that revenue production per SCD inpatient day increased from \$1,407 to \$1,809; a 28% increase (Figure 2). Changes in reimbursements did not cause the majority of this increase, as the average hospital payment per SCD-related inpatient stay resulting from an ED visit decreased from \$17,422 (standard deviation \$19,600) to \$14,811 (standard deviation \$17,900); an 18% decrease. Thus, the hospital increased revenue production per inpatient day by reducing length of stay, rather than by receiving more lucrative reimbursement arrangements.

## Discussion

The acute, unpredictable nature of painful VOE genesis coupled with limited adult SCD provider accessibility [17] has contributed to EDs being the *de facto* provider of care for this most common clinical manifestation of the disease. Yet, there remain significant complexities regarding patient-provider mis-trust and stigma associated with the high doses of opioid analgesia often needed to treat the subjective nature of SCD pain in the ED [12,18]. Our intervention provides an un-biased alternative approach to the management of acute SCD-related pain.

One of the most striking findings of our study was the increased ED

	Pre-Algorithm (n=131) Median (IQR)	Post-Algorithm (n=568) Median (IQR)	P-value
Time from registration to first opioid, all*	53 (31.5, 83)	32 (23, 45)	< 0.001
Time from registration to disposition, all†	210 (134, 296)	168 (121, 216)	< 0.001
Time to disposition, admitted	223 (144, 318)	163 (114, 214)	< 0.001
Time to disposition, discharged	190 (117, 267)	171 (125, 217)	0.22
Time from registration to departure, all‡	345 (218, 493)	271 (194, 374)	< 0.001
Time to departure, admitted	467 (355, 576)	368 (298, 471)	< 0.001
Time to departure, discharged	237 (162, 304)	214 (170, 284)	0.47
Admission rate	54% (71/131)	38% (217/568)	< 0.001
Admission length of stay (days)‡	12	8	0.03

All time data are in minutes. IQR refers to Inter-quartile range. \*Missing 11 pre-algorithm and 30 post-algorithm observations. † Missing 3 pre-algorithm (1 discharged patient and 2 admitted patients) and 11 post-algorithm observations (all 11 were admitted patients). ‡ Reported as a mean and missing 9 post-algorithm observations.

Table 3: Pre-Algorithm and Post-Algorithm ED Visit Comparison.

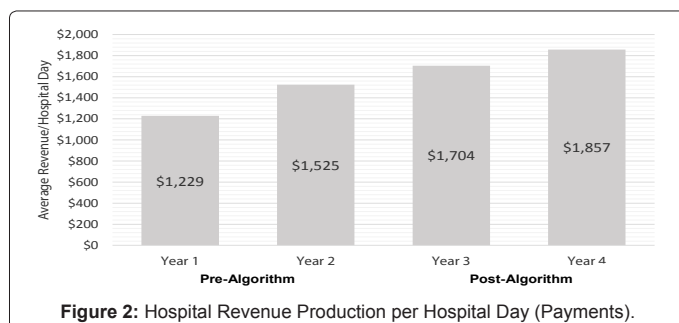


Figure 2: Hospital Revenue Production per Hospital Day (Payments).

utilization for painful VOE treatment after algorithm implementation. We have demonstrated that this increase was not explained by changes in volume of the patient base nor related to differences in demographics or clinical phenotypes. Rather, the algorithm itself appears to have influenced patient behavior as the increase in visits was primarily attributable to those who became high utilizers. However, it is conceivable that these patients were always high utilizers but previously sought acute care from numerous EDs. Perhaps the patient-centered, timely care afforded by this algorithm encouraged patients to seek ED care at the same hospital thus influencing the patterns, rather than overall quantity, of use.

Other groups have also developed clinical pathways designed to improve the management of SCD pain in the ED [19-21]. However, to our knowledge we are the first to demonstrate that a single algorithm produces a reduction in wait times for both opioid analgesia and disposition as well as in hospitalization rates. Moreover, we are the first to demonstrate how the implementation of an ED SCD pain treatment algorithm can impact healthcare costs and hospital revenue, primarily by reducing admissions and shortening hospitalizations. We believe our success may stem from the fact that our algorithm allowed nurses to quickly place patients into rooms to administer IV analgesia whereas others only allowed oral or subcutaneous administration in the waiting area. Although our protocol is not the first to utilize PCA in the ED, our algorithm utilized PCA only for admitted patients whereas another similar study used PCA as part of the initial treatment schema and required successful PCA wean in order to discharge the patient home. Perhaps an inability to successfully wean influenced their higher rate of admission. The fact that our hospital length of stay decreased also differentiates our protocol from others. We postulate that timely analgesia, disposition and institution of PCA in the ED collectively contributed to a reduced length of hospitalization as patients were optimally managed before ever reaching a hospital bed. The vast majority of a hospital's costs are incurred during the first days of an inpatient stay, as they are the most clinically and administratively intensive. Thus, reducing admissions likely has a far stronger impact on hospital resource consumption than reducing length of stay [22,23].

Our data show that the rate of hospitalization decreased significantly after the algorithm was in place suggesting a potential savings on the part of insurers. However, one major limitation of our study is that our algorithm was not implemented as part of a closed system. Therefore, we were not able account for potential utilization of other EDs by our patients during the period under study and cannot with confidence evaluate overall insurer savings. However, if we make the assumption that the hospital's ED visits were substitutes for ED visits that would have occurred at other facilities, and that the payments that the other facilities would have received would have been comparable to the average payment per ED presentation that was received before the program went into effect, it would suggest that the savings from reduced hospitalization rate was \$2,073,751 over the two year course of the program. Accordingly, our next step is to implement this algorithm across the EDs in the state of Connecticut and use claims data and hospital records to prospectively measure its impact on total ED utilization, hospitalization rates, costs, as well as patterns of ED use across the state's healthcare system.

It is notable that the hospital in this study was reimbursed through traditional prospective payment contracts, in which inpatient services were billed to insurers using diagnosis-related groups (DRGs). As payments received by the hospital were primarily determined by the condition of the patients treated, rather than by length of stay, the

reduction in the length of admissions the hospital experienced after the algorithm enabled the hospital to increase its revenue production per hospital day. If the hospital were to be capacity constrained, this change would increase its profitability.

There are a number of limitations that impact the generalizability of this study. This is a single hospital study whose ED practices and presence of an adult comprehensive SCD center may have influenced outcomes. Furthermore, it is possible that there were other changes that the SCD patients experienced during the four years of observation which may have impacted their ED utilization patterns. Due to limited data availability, we cannot tell whether the increased ED utilization that was associated with the program substituted for care in other EDs or in other settings. The decrease in length of stay found after the algorithm could also be attributed to having less sick patients admitted after implementation, or that the simultaneous development of the outpatient SCD program enabled the hospital to address patients' needs more rapidly, resulting in speedier recoveries. Factors such as these were not measured and are a limitation of the current study.

Although SCD is a relatively rare disease, it accounts for more than 200,000 ED visits per year in the U.S. with an estimated annual acute care hospitalization cost exceeding \$2 billion [6]. The development of a novel, unbiased, algorithmic approach to treatment of VOE pain in SCD patients is therefore critical. Our fast-track ED VOE pain management algorithm offers a method for timely, patient-centered management which translates into measurable improvements in health care quality and hospital economic productivity.

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