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Research Paper

Age-related healthcare services utilization for the management of sickle cell disease among treated Texas Medicaid patients

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Abstract

Objectives To determine if there are age-related differences in sickle cell disease (SCD)-related healthcare utilization and to describe temporal healthcare utilization following an emergency department (ED) visit or hospitalization in treated SCD patient population.

Methods Texas Medicaid prescription and medical claims from 1 September 2011 to 31 August 2016 were used. Patients aged 2–63 years with at least one inpatient or outpatient SCD medical claim and receiving one or more SCD-related medications (hydroxyurea, opioid or non-opioid analgesics) were included. The primary outcomes were utilization of SCD-related ED, inpatient and outpatient visits, all-cause prescription medications and type of SCD-related service at index and subsequent healthcare services. Age group was the primary independent variable.

Key findings Overall (N = 2339), healthcare service utilization was relatively higher among age groups 2–12, 18–25 and 26–40. Proportions of patients having ≥1 ED and ≥1 inpatient visits, respectively, were significantly higher among age groups 2–12 (33.2%; 23.0%), 18–25 (29.3%; 25.1%) and 26–40 (32.3%; 22.4%) as compared with age group 13–17 (21.3%; 12.9%). The number of outpatient visits was highest among children aged 2–12 (4.5 ± 7.6, $P < 0.0001$), while mean number of all-cause medications was the highest for older adults aged 41–63 (22.4 ± 16.3; $P < 0.0001$). After an index ED visit (N = 598), outpatient visits were the most prevalent healthcare services. After an index hospitalization (N = 203), a subsequent hospitalization was the most prevalent healthcare service.

Conclusions Texas Medicaid SCD patients receiving treatment have a high use of healthcare services, especially among children and young adults who are transitioning from childhood to adulthood. Age-specific interventions should be developed to promote optimal care transitions among young adults.

Keywords: sickle cell disease; healthcare services utilization; hydroxyurea

Introduction

Sickle cell disease (SCD) is an inherited chronic disorder occurring due to a defect in the sickle cell haemoglobin (Hb) gene that leads to sickle-like red blood cells (RBCs).[1] Approximately, 100 000 people suffer from SCD in the USA. Most of these people are of African descent, with 1 in every 365 African Americans suffering from SCD.[2, 3] This disease can be detected at the time of birth and affected individuals suffer from mild to severe complications throughout their

lives. Common SCD complications include vaso-occlusive pain crises (VOC), acute chest syndrome (ACS), bacterial infections, ulceration in the extremities, venous incompetence and anaemia.[1, 2, 4] Hence, SCD is associated with significant morbidity that adversely affects patients' quality of life. Moreover, SCD complications lead to early mortality and shorter lifespan among patients with SCD as compared with the general population.[5] A 2009 study by Kauf *et al.* estimated the total lifetime healthcare cost to be $1 million per person with SCD, with annual costs ranging from $10 000 for children to $30 000 for adults.[6] More recently in 2018, Huo *et al.* estimated that the annual incremental cost burden of SCD was $2.98 billion in the USA. On average, 57% of these costs (per patient) were attributed to inpatient costs ($15 040), 38% were attributed to outpatient costs ($10 079) and 5% were patients' out-of-pocket expenses ($1293).[7]

Apart from its clinical implications and premature deaths, SCD leads to significant healthcare-related services utilization and financial burden due to frequent hospitalizations, emergency department (ED) visits, outpatient visits and medication use.[8–14] A study by Shankar *et al.* that evaluated patterns of medical care utilization among children and adults with SCD in the state of Tennessee reported hospitalization rates of about 1000 per 1000 population per year in children less than 5 years, 600 per 1000 in children aged 5–9 years, 1000 per 1000 in adolescents/young adults aged 10–19 years and 1800 per 1000 in adults aged 20–59 years.[12] An Illinois study reported that the median number of hospitalizations per patient in 2005 was three among adult patients with SCD.[11] Another study that analysed data on SCD-related ED and inpatient visits among patients from nationally representative Healthcare Cost and Utilization Project (HCUP) data found an average of 2.59 [95% confidence interval (CI), 2.53 to 2.65] total encounters per patient per year, 1.52 (95% CI, 1.48 to 1.55) inpatient encounters and 1.08 (95% CI, 1.04 to 1.11) ED visits.[9] Furthermore, 10% of children with SCD had at least one outpatient visit per year with a haematologist for comprehensive specialty care.[14]

In particular, findings from several previous studies revealed a pattern of higher SCD-related morbidity and healthcare resource utilization, especially ED and inpatient utilization, among young adults when compared with children and older adults.[9, 10, 12, 15, 16] The HCUP study results showed that SCD-related ED and inpatient encounters increased by age group with a peak at 18–30 years of age, followed by a decline in the older age groups.[9] A similar trend was observed in a study by Hemker *et al.*, which found increased ED visits and lower outpatient visits among patients aged 18–19 years old transitioning from paediatric to adult providers and young adults aged 20–30 years old when compared with children <18 years old and older adults ≥46 years.[10] Another study by Paulukonis *et al.* found a 3-fold increase in mean annual ED visits in patients with SCD who were 20–29.9 years old when compared with patients 10–19.9 years old.[16] Hence, the literature provides evidence of gaps in care for patients with SCD during the transition from adolescence to young adulthood.[15, 17, 18]

To assist healthcare providers, patients and their caretakers in managing SCD and its various complications, the National Heart, Lung, and Blood Institute (NHLBI) SCD guidelines provide recommendations regarding routine health maintenance, treatment of acute and chronic SCD complications and medication utilization (mainly hydroxyurea and opioid and non-opioid analgesics) for SCD management. As incidence rates and the nature of SCD complications may vary by age of the patients (e.g. higher incidence rate of leg ulcers among adults as compared with children,[19] higher risk of chronic conditions among older adults),[2] the NHLBI guidelines provide age-specific recommendations for SCD management. For instance, NHLBI guidelines provide age-specific recommendations for utilization of hydroxyurea therapy, which is known to reduce frequency and severity of SCD complications, among patients with SCD.[2] Previous studies have shown differences in healthcare resource utilization among young adults as compared with children and older adults.[9, 10, 12, 15, 16] Moreover, although previous studies have evaluated healthcare utilization among patients with SCD in other states,[9, 12, 16, 20] Texas Medicaid represents a large, diverse SCD patient population. Thus, it is important to understand healthcare utilization patterns in SCD management among Texas Medicaid patients of different age groups to identify gaps in care and where interventions may be targeted. The primary objective of this study was to determine if there are age-related differences in SCD-related healthcare utilization, in terms of ED visits, inpatient hospital admissions, outpatient visits and all-cause prescription medication utilization among Texas Medicaid patients with SCD receiving treatment. Additionally, there is a lack of understanding on how patients with SCD are managing SCD-related complications, particularly those triggering medical attention (e.g. VOC, ACS, leg ulcers or stroke), in the real world. Research is needed to understand temporal healthcare utilization patterns in patients with SCD receiving treatment, that is, whether patients reactively seek drug therapies or medical care following a trigger event (e.g. ED visit or inpatient hospital admission due to SCD-related complications). Identifying temporal real-world healthcare utilization patterns can help identify high utilizers of SCD-related healthcare services. Thus, the secondary objective was to examine temporal healthcare utilization among patients with SCD receiving treatment after an index ED or inpatient visit by describing subsequent healthcare utilization (ED visit, inpatient visit, outpatient visit or SCD-related drug utilization) patterns.

Methods

Study design and patient population

This study was a retrospective secondary database analysis of Texas Medicaid prescription and medical claims from 1 September 2011 to 31 August 2016. This study included Texas Medicaid recipients aged 2 to 63 years at the index date with at least one inpatient or outpatient diagnosis for SCD [International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 280.60-282.69, 282.41, 282.42 or ICD-10 D57.xx]. While SCD is detected at birth in the USA using a blood test, this screening alone may not be adequate to identify patients with SCD receiving treatment. Many patients with SCD have a milder form of the disease which does not require medical care and can be managed at home. Therefore, the inclusion criteria of one inpatient or one outpatient SCD medical claim were utilized to identify patients with SCD receiving treatment. Although this criterion may exclude patients with milder form of SCD, it provides protection against inclusion of patients that may be misdiagnosed or miscoded as patients with SCD [e.g. patients with sickle cell trait (SCT)] in the claims database. Moreover, this criterion is consistent with previous literature and has been used in several other retrospective claims database studies.[21–25]

For the primary objective, the index date was identified using the prescription claims and was defined as the date of dispensing of the first SCD-related drug (hydroxyurea, opioid analgesic and non-opioid analgesic) within the identification period from 1 March 2012 to 31 August 2015. The prescription claim was utilized as the index to include patients who were being actively treated for SCD. Also, we wanted to utilize the same cohort of patients from a previously

published study by the authors.[20] A duration of 6 months before the index date was defined as the pre-index period when patients were not dispensed any SCD-related drug (hydroxyurea, opioid analgesic and non-opioid analgesic). Patients were followed for 12 months after the index date to observe their SCD-related healthcare resource utilization. Patients were also required to be continuously enrolled in Texas Medicaid during the 18-month study period (see Figure S1).

To examine temporal healthcare resource utilization (the secondary objective), patients with SCD-related ED or inpatient visits within the 12-month post-index follow-up period were identified. For these patients, the index service date was defined as the date of their first ED or inpatient visit with an SCD diagnosis during the study follow-up period. These patients were followed for varied lengths of time until the end of the 12-month follow-up period to identify subsequent SCD-related healthcare services. Since the study utilized de-identified data from Texas Medicaid, the University of Texas at Austin Institutional Review Board determined the study to be exempt.

Study measures

The dependent variables included SCD-related healthcare service utilization which was defined as the proportion of patients having one or more SCD-related ED visits, proportion of patients having one or more SCD-related hospitalizations, mean number of SCD-related outpatient visits and mean number of all-cause unique prescription medications. Furthermore, temporal SCD-related healthcare service utilization was evaluated as the proportion of patients having an SCD-related ED visit or hospitalization as their index service during the follow-up period. Within the patient groups that had an ED visit or hospitalization as their index service, the proportions of patients having ED visits, hospitalizations, outpatient visits or prescription drugs as their subsequent healthcare services were determined. Age groups (i.e. 2–12, 13–17, 18–24, 25–40 and 41–63) served as the primary independent variable because guidelines for SCD management differ based on patient age (children, adolescents and adults).[2]

Statistical analysis

Descriptive statistics (mean, standard deviation and frequency) were used to describe demographic and healthcare utilization characteristics of the study population. Chi-square tests were conducted to determine if there were differences in the proportion of patients with one or more SCD-related ED visit and one or more SCD-related hospital admission by age groups. A Kruskal–Wallis test was used to determine if the number of SCD-related outpatient visits differed among patients by age group. Analysis of variance (ANOVA) was used to determine if the mean number of all-cause prescription medications differed among patients by age group. In addition, *post hoc* pairwise comparisons and Duncan's *post hoc* analyses were conducted using a family-wise error rate of 0.05. Finally, descriptive statistics were used to describe temporal use of healthcare services among patients with SCD after an ED visit or hospitalization. Statistical tests were two-sided with an *a priori* significance level of $P < 0.05$ and were performed using SAS version 9.4 (SAS Institute, Cary, NC).

Results

The initial population was comprised of 11 995 Texas Medicaid recipients with a diagnosis of SCD or SCT (ICD-9 282.5 or ICD-10 D57.3) between 1 September 2011 and 31 August 2016. Among these, 3450 patients did not have any SCD-related prescription drug claims during this period, resulting in a sample size of 8545 subjects. Of these 8545 patients, only 4466 (52.3%) patients received their first SCD-related drug within the identification period between 1 March 2012 and 31 August 2015. After applying the remaining inclusion criteria, the final study sample for the primary objective was 2339 patients. For the secondary objective, 801 patients out of 2339 patients were identified who had an SCD-related ED or inpatient visit during the 12-month post-index follow-up period (Figure 1).

Table 1 describes demographic and healthcare service utilization characteristics. The mean age was 19.1 ± 14.6 years, with the highest proportion in the 2–12 age group (41.3%), and approximately two-thirds (62.5%) of the sample were female. Regarding healthcare services utilization in the 12-month post-index period, 703 (30.1%) patients had one or more SCD-related ED visits with a mean of 1.2 ± 4.5 (median = 0) visits. Moreover, 503 (21.5%) patients had one or more SCD-related inpatient visits with mean number of 1.8 ± 6.9 (median = 0) visits. The mean number of SCD-related outpatient visits was 4.0 ± 8.4 (median = 1), and the mean number of all-cause unique prescription medications dispensed was 14.3 ± 12.0 (median = 11).

Table 2 presents the comparisons regarding healthcare service utilization and age groups. For each overall test, a significance level of $P < 0.05$ was used, but for *post hoc* comparisons, $P < 0.005$ was used to account for the 10 pair-wise comparisons. A chi-square test showed that the proportion of patients with one or more SCD-related ED visits was significantly ($P < 0.001$) higher for age groups 2–12 (33.2%) and 26–40 (32.3%) compared with age group 13–17 (21.3%). A chi-square test showed that the proportion of patients with one or more SCD-related hospital admissions was significantly ($P < 0.05$) lower for age group 13–17 (12.9%) compared with age groups 2–12 (23.0%), 18–25 (25.1%) and 26–40 (22.4%).

A Kruskal–Wallis test showed that the number of SCD-related outpatient visits was significantly ($P < 0.0001$) higher among age group 2–12 (4.5 ± 7.6) compared with all other age groups such as 13–17 (2.9 ± 5.4), 18–25 (3.6 ± 8.4), 26–40 (4.3 ± 10.6) and 41–63 (3.9 ± 8.9). ANOVA revealed that the mean number of all-cause unique prescription medications differed significantly ($P < 0.0001$). Duncan's *post hoc* analysis showed that the mean number of all-cause unique prescription medications for age group 41–63 years (22.4 ± 16.3) was significantly higher than that of all other age groups such as 2–12 (13.7 ± 9.9), 13–17 (11.8 ± 9.8), 18–25 (11.9 ± 10.8) and 26–40 (14.8 ± 13.2).

Regarding the secondary temporal analysis of SCD-related healthcare service utilization, 801 (34.2% of total sample) patients had an ED visit or hospitalization. Among the 801 patients, 598 (74.7%) had an ED visit as the index healthcare service (Figure 2) and 203 (25.3%) had a hospitalization as the index healthcare service (Figure 3). Among the 598 patients with ED visits as an index service, 513 (85.8%) had an outpatient visit and 85 (14.2%) had a subsequent hospitalization after their index ED visit. After receiving these services, 256 (42.8%) patients had a subsequent outpatient visit, while 187 (31.3%), 110 (18.4%) and 39 (6.5%) patients had SCD-related prescription drug, ED visit and hospitalization, respectively. The overall pattern showed that after an index ED visit, patients had several subsequent outpatient visits. Among the 203 patients with a hospitalization as index service, 87 (42.8%), 72 (35.5%), 26 (12.8%) and 16 (7.9%) patients had a hospitalization, outpatient visit, SCD-related prescription drug and an ED visit, respectively, as the next subsequent healthcare service. After receiving these services, 108 (53.2%), 56 (27.6%), 28 (13.8%) and 7 (3.4%) patients had subsequent hospitalizations, outpatient

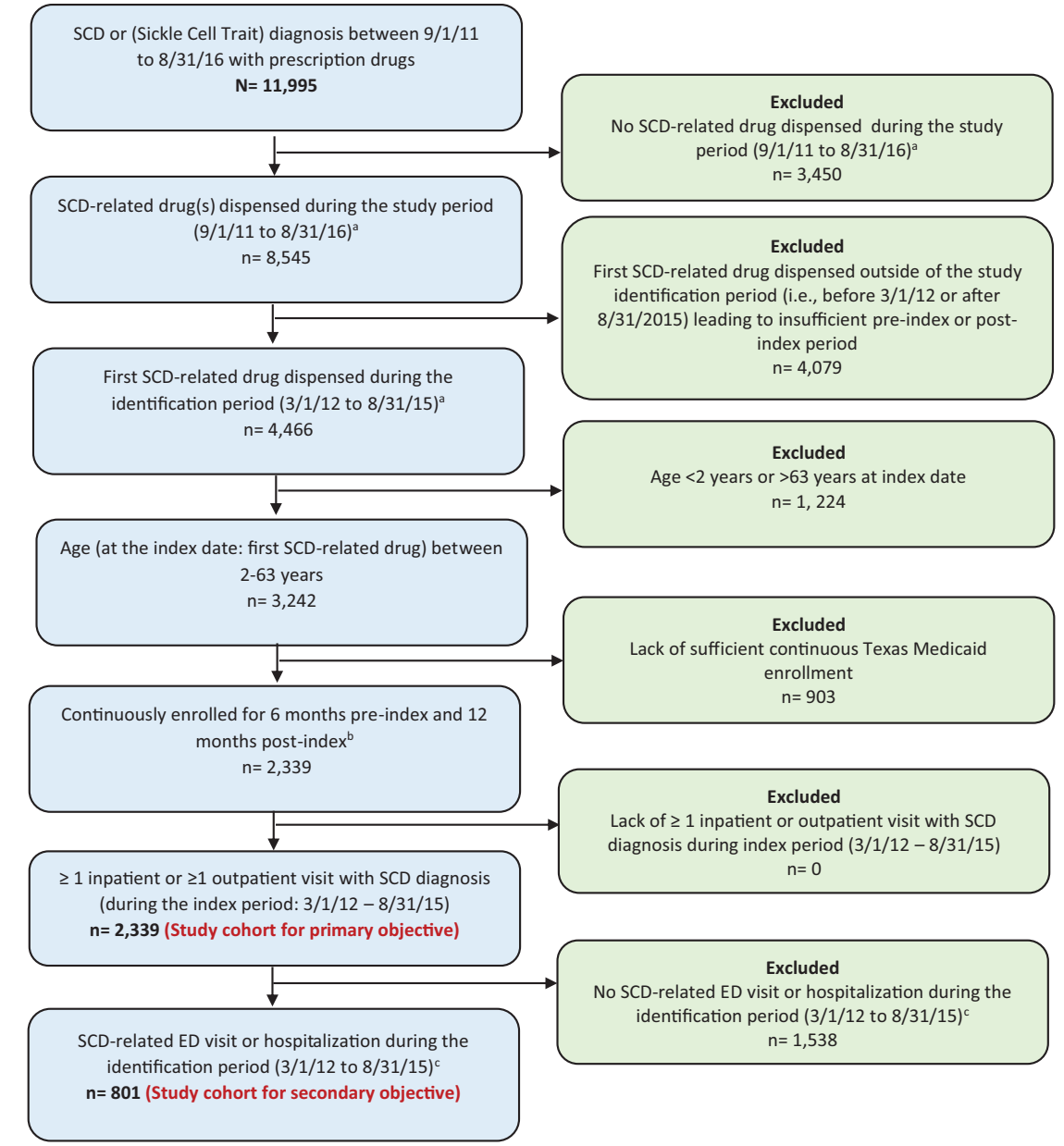

Figure 1 Patient attrition among Texas Medicaid recipients. [a]SCD-related drugs include hydroxyurea, opioid and non-opioid analgesics. [b]Index date for the primary objective = date of dispensing of the first SCD-related drug within the identification period (1 March 2012 to 31 August 2015). [c]Index date for the secondary objective = date of the first SCD-related ED visit or hospitalization within the identification period (1 March 2012 to 31 August 2015); follow-up period varies per patient and ends 31 August 2016. ED, emergency department; SCD, sickle cell disease.

visits, SCD-related prescription drug and ED visits, respectively. The overall pattern showed that after an index hospitalization, patients had several subsequent hospitalizations.

Discussion

This study examined healthcare utilization patterns among Texas Medicaid enrollees, which constitute a large, diverse SCD patient population. Regarding healthcare service utilization by age group, trends of higher utilization of SCD-related ED visits and hospitalizations among young and middle-aged adults were expected. In the current study, children 2–12 years (33.2%), young adults 18–25 years (29.3%) and middle-aged adults 26–40 years (32.3%) had higher proportions of patients with SCD-related ED visits, while adolescents aged 13–17 years (21.3%) and older adults aged 41–63 years (24.2%) had lower proportions. Similarly, children (23.0%), young adults (25.1%) and middle-aged adults (22.4%) had higher proportions of patients with SCD-related hospitalizations, while adolescents (12.9%) and older adults (18.0%) had lower proportions. Studies suggest that most SCD-related ED visits and hospitalizations have VOC pain crisis as the primary diagnosis.[8, 9, 13] Several studies have also found a higher incidence of VOC pain events[26] and higher utilization of ED visits[10, 16] and hospitalizations[9, 12] in patients with SCD of ages 18–30 years as compared with children and older adults, possibly due to reasons such as gaps in access to healthcare services and lack of knowledge about their disease and

Table 1 Demographic and healthcare service utilization characteristics (*N* = 2339)

Patient characteristics	All patients with SCD (*N* = 2339)
Demographic characteristics	
Age at index date	
Mean ± SD	19.1 ± 14.6
Age groups, *N* (%)	
2–12 years	965 (41.3)
13–17 years	272 (11.6)
18–25 years	375 (16.0)
26–40 years	483 (20.7)
41–63 years	244 (10.4)
Total	2339 (100.0)
Gender, *N* (%)	
Female	1461 (62.5)
Male	878 (37.5)
Total	2339 (100.0)
Healthcare service utilization – 1-year follow-up	
ED visits	
≥1 *N* (%)	703 (30.1)
Mean ± SD	1.2 ± 4.5
Median	0.0
Hospitalizations	
≥1 *N* (%)	503 (21.5)
Mean ± SD	1.8 ± 6.9
Median	0.0
Outpatient visits	
Mean ± SD	4.0 ± 8.4
Median	1.0
All-cause prescription medications	
Mean ± SD	14.3 ± 12.0
Median	11.0

ED, emergency department; SCD, sickle cell disease.

need for preventive interventions resulting in sudden and severe complications.[9, 10, 12, 16] Furthermore, retrospective database studies conducted within different states in the USA reveal suboptimal utilization of hydroxyurea among children and adult populations with SCD.[27–32] Therefore, it is possible that patients of age groups 18–25 and 26–40 had frequent pain crises requiring medical care through ED visits and hospitalizations.

Interestingly, this study showed a higher than expected proportion of children of age group 2–12 with one or more ED visits and hospitalizations, which stands in contrast to the findings of Brousseau *et al*.,[9] Hemker *et al*.[10] and Paulukonis *et al*.[16] This higher utilization of ED visits among children of this study could be explained by the following reasons. First, the inclusion criterion regarding age was different in this study as compared with the other studies. While studies by Hemker *et al*. and Paulukonis *et al*. had no minimum age inclusion criteria (i.e. included newborns and infants), Brousseau *et al*. included patients aged 1 year and older. This study only included children aged 2 years and older at the index date. Previous literature suggests that newborns and infants have fetal haemoglobin (HbF), which prevents the sickling of RBC and, therefore, prevents SCD complications. As the infant grows, HbF is replaced by sickle haemoglobin which causes sickling of RBC.[32–34] The inclusion of children aged 2 years and above may explain higher utilization of ED visits among children of this study. Second, a previously published study that utilized the same cohort of patients as the current study reported underutilization of and low adherence to hydroxyurea among Texas Medicaid children with SCD.[20] Low adherence to hydroxyurea therapy in the children of the current study may have resulted in frequent acute SCD complications leading to higher utilization of ED visits.

With respect to utilization of SCD-related outpatient visits, children (4.5 ± 7.6) had significantly higher mean outpatient visits as compared with all other age groups. This finding can be explained

Table 2 Healthcare service utilization by age group (*N* = 2339)

Healthcare resource utilization 1-year follow-up		Age group					Test results
		2–12	13–17	18–25	26–40	41–63	
SCD-related ED visits							
Proportion of patients with ≥1 ED visits (*N* = 703)	*N* (col%)	320 (33.2)[a]	58 (21.3)[b,c]	110 (29.3)[a,c]	156 (32.3)[a]	59 (24.2)[a,c]	Chi-square[1] $\chi^2 = 19.5$ $P < 0.001$
SCD-related hospital admissions							
Proportion of patients with ≥1 hospital admission (*N* = 503)	*N* (col%)	222 (23.0)[d]	35 (12.9)[e]	94 (25.1)[d]	108 (22.4)[d]	44 (18.0)[d,e]	Chi-square[1] $\chi^2 = 18.1$ $P < 0.05$
SCD-related outpatient visits							
Mean number of SCD-related outpatient visits Mean (SD)		4.5 (7.6)[f]	2.9 (5.4)[g]	3.6 (8.4)[g]	4.3 (10.6)[g]	3.9 (8.9)[g]	Kruskal–Wallis[2] $\chi^2 = 58.2$ $P < 0.0001$
All-cause prescription drugs							
Mean number of all-cause unique prescription medications Mean (SD)		13.7 (9.9)[h]	11.8 (9.8)[i]	11.9 (10.8)[i]	14.8 (13.2)[h]	22.4 (16.3)[j]	ANOVA[3] $F = 37.4$ $P < 0.0001$
Total		965	272	375	483	244	2339 (100.0%)

ANOVA, analysis of variance; ED, emergency department; SCD, sickle cell disease.

[1]Pairwise comparisons using α-level = 0.005 (10 comparisons).

[2]Although a Kruskal–Wallis test was used, mean (sd) values are shown in the table for ease of interpretation. Pairwise multiple comparisons were conducted using Dwass, Steel, Critchlow–Fligner (DSCF) method using α = 0.005.

[3]Duncan's *post hoc* test was used.

Like letters are not significantly different. [a–c]Pairwise comparisons: SCD-related ED visits; [d,e]Pairwise comparisons: SCD-related hospital admissions; [f,g]Pairwise comparisons: SCD-related outpatient visits; [h–j]Pairwise comparisons: All-cause prescription drugs.

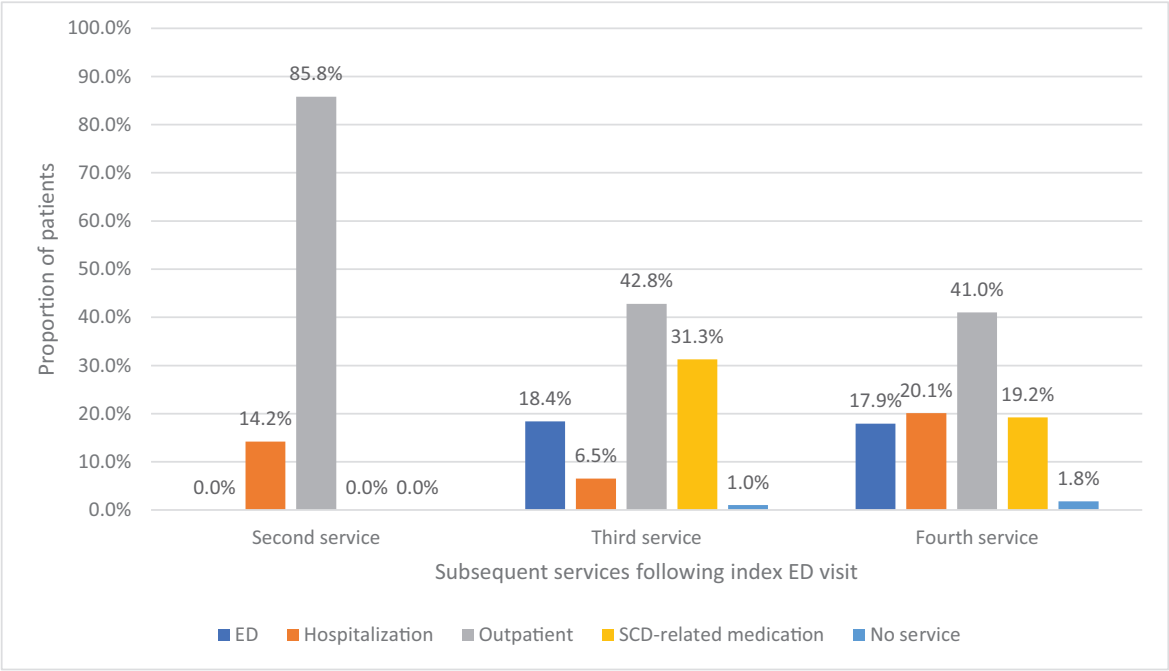

Figure 2 Temporal use of healthcare services after an index ED visit ($N = 598$). ED, emergency department; SCD, sickle cell disease.

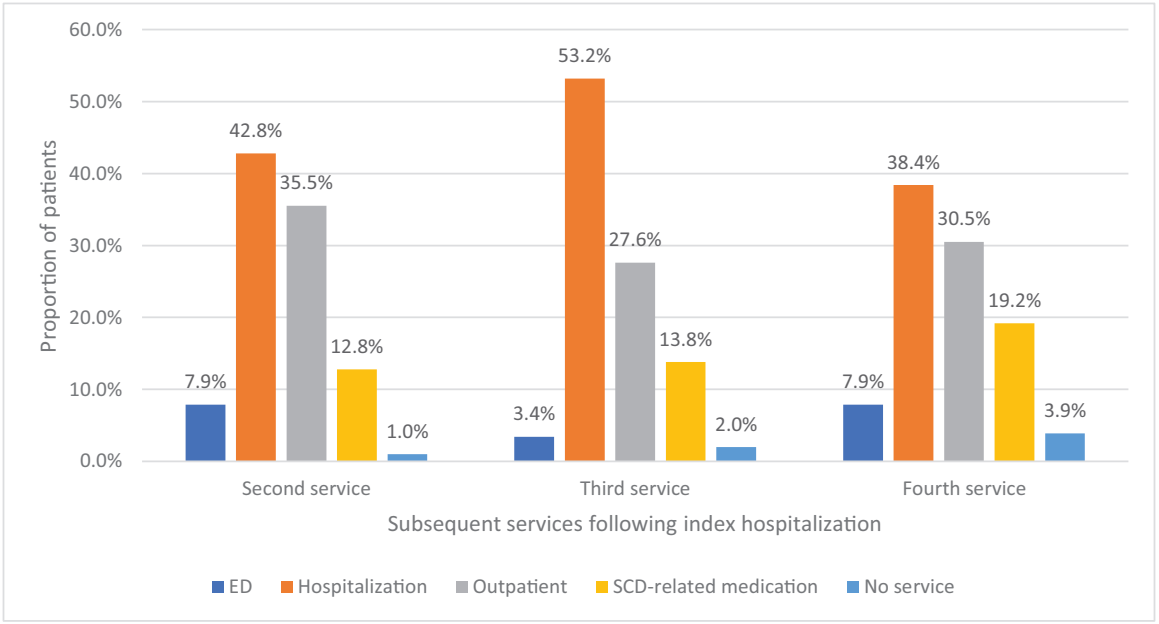

Figure 3 Temporal use of healthcare services after an index hospitalization ($N = 203$). ED, emergency department; SCD, sickle cell disease.

through the concept of emergency department reliance (EDR) discussed in the Kroner *et al.*,[17] Blinder *et al.*[18] and Hemker *et al.*[10] studies. EDR distinguishes the patients with high utilization of ED visits due to more severe disease from the patients who rely on ED visits due to lack of access to outpatient services. In this current study, high utilization of outpatient visits in addition to significant reliance on ED visits among children aged 2–12 could be due to more severe SCD. In contrast, fewer outpatient visits alongside high dependence on ED visits in young adults aged 18–25 could be because these patients are transitioning from paediatricians to adult medicine providers. A similar trend was observed in the Hemker *et al.* study which concluded that patients transitioning from childhood to adulthood have fewer outpatient visits and greater reliance on ED visits.[10]

For all-cause prescription medication utilization, findings were as expected. Older adults had a significantly higher number of unique prescription medications as compared with all other age groups. This high utilization of prescription medications among older adults may be due to an increase in prevalence of chronic conditions, which are often further exacerbated due to SCD.[2] Hence, older adults may use multiple medications to manage their chronic conditions.

Lastly, the descriptive analysis of temporal patterns of use of SCD-related healthcare services suggests a high utilization of ED visits (75%) as the index service type as compared with hospitalizations (25%). This trend may indicate that a large proportion of patients might experience an acute VOC event that requires urgent care, which is similar to the findings of Woods *et al.*[13] The results also indicate that most of the patients (~85%) had a subsequent outpatient visit which could have been a referral to a primary care physician (PCP) or a haematologist, after being discharged from the ED. Moreover, the outpatient visit to a PCP or haematologist may have been required since a blood test is needed before initiating hydroxyurea therapy. The 15% of patients who were admitted to the hospital after the ED visit may have had a severe crisis needing further observation and treatment. For the third and fourth services in the index ED visit group, about 18% of patients had another ED visit, which may indicate that these were more severe patients who suffer frequent VOC events requiring urgent medical care. This result is similar to findings of other studies,[8, 9, 26] which reported that about 16% to 30% of patients with SCD have 3 to 10 VOC events annually and frequently require medical care.

Interestingly, the 25% of patients who had a hospitalization as an index service type also had hospitalizations as subsequent services (second service: 42.8%, third service: 53.2% and fourth service: 38.4%). Again, this pattern could indicate high utilizers with more severe SCD, suffering from advanced and chronic SCD-related complications (e.g. ACS, leg ulcers, seizures and multiorgan failure) requiring rehospitalization.[5, 8, 9] In this group, the next most prevalent service was outpatient visits (~30 to 40%). However, SCD-related prescription drug use as subsequent service after a hospitalization was observed in a smaller proportion of patients (~13 to 20%).

Limitations

While this study is important in establishing the healthcare utilization patterns among patients with SCD receiving treatment, there are some limitations. First, the scope of the study is limited by the information collected in the Texas Medicaid database. The database may not capture any prescription medication or healthcare service that is not paid for through Texas Medicaid such as over-the-counter pain relievers not covered by the Texas Medicaid formulary that may have been purchased out of pocket. Moreover, the database does not include information on patients' SCD genotype, which has an impact on the disease severity, and further, on healthcare services utilization. Second, the first SCD diagnosis within the observation period may not represent the first-ever SCD diagnosis for the patient since this disease is typically identified at birth using a blood test. Third, for study inclusion criteria, patients were required to have at least one inpatient or one outpatient medical claim with a SCD diagnosis. Since the population of interest was treated patients with SCD, screening at birth alone may not be adequate to identify treated SCD patients. Therefore, the inclusion criteria of one inpatient or one outpatient SCD medical claim prevents inclusion of misdiagnosed or miscoded patients, though some patients with milder form of SCD may be excluded. Similar inclusion criterion has been used in previously published retrospective cohort studies.[21–25] Furthermore, patients were required to have a prescription claim for an SCD-related medication. This may have biased the sample to include more severe patients (i.e., treated) and exclude patients with milder form of SCD (i.e. asymptomatic patients, patients with mild symptoms manageable at home with over-the-counter medications or lifestyle changes). On the other hand, opioid and non-opioid analgesics could have been used for reasons other than SCD complications, such as headache, lower back pain, arthritis or myalgia or an injury. This could have led to an overestimate regarding SCD-related analgesic use.

A *post hoc* analysis showed that untreated SCD patients ($n = 3450$) excluded from the study were significantly younger than those in our study cohort (11.0 ± 14.5 vs. 19.1 ± 14.6 years, $P < 0.0001$). This could be explained by high proportion (45%) of infants in the excluded cohort who have high levels of HbF, which prevents sickling of RBC, thus preventing SCD complications and reducing the need for medical care.[2] Also, there was a significantly higher proportion of females in the treated versus untreated SCD groups. This difference in the proportion of females may be attributed to how the study index date was defined, which was the date of dispensing of the first SCD-related prescription medication during the follow-up period. While SCD affects males and females equally, females are more likely to receive opioid and non-opioid analgesics than males. This gender distribution is similar to that of the studies by Han *et al.*[35] and Smith *et al.*[36] (63% females and 37% males) that evaluated the opioid utilization patterns in SCD patients and found females were more likely to use analgesics than males. In summary, the results may only be generalizable to a more severe population of SCD patients who require treatment, which was the population of interest for this study. While generalizability may be limited, the economic burden of treated SCD patients is substantial, and the study findings may lead to more informed decision-making for healthcare providers.

Conclusion

In summary, Texas Medicaid patients with SCD receiving treatment have high use of healthcare services such as ED visits, hospitalizations and outpatient visits, especially among children and young adults who are transitioning from childhood to adulthood. Gaps may arise during this transition of care; therefore, further research is needed to identify characteristics of high utilizers and design strategies specific to this age group to promote more appropriate care transitions. Future studies may also evaluate the impact of new SCD therapies on the trends of healthcare service utilization among treated Texas Medicaid patients with SCD.

Supplementary Material

Supplementary data are available at *Journal of Pharmaceutical Health Services Research* online.

Figure S1. Study design. *SCD-related prescription medications include hydroxyurea, opioid and non-opioid analgesics.

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Author Contributions

The primary researchers, NS and JCB, were responsible for conception, design, data collection, and analysis of the work. All authors provided input on research design and with the interpretation of the data. All authors read and approved the final manuscript.

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Conflict of Interest

No conflict of interest and financial disclosures were reported by the authors of this paper.

Data Availability

The data is proprietary and is not publicly available.

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