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Slipped capital femoral epiphysis in an Indigenous Australian population

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Aims

The aim of this study was to examine the epidemiology and outcomes of slipped capital femoral epiphysis (SCFE) in Australian Indigenous populations, and risk factors of contralateral slip.

Methods

This multicentre, retrospective study included 85 Australian Indigenous patients with SCFE from two Northern Territory hospitals between February 2010 and February 2024. Data such as age, posterior slope angle, and slip characteristics were collected. Risk factors for contralateral slip were identified via penalized logistic regression, and the number needed to treat (NNT) was calculated for prophylactic fixation.

Results

The median age at diagnosis was 12. 1 years (IQR 11.2 to 13.0), with a high incidence of valgus slips (10.6%). In total, 73 patients (85.9%) did not have prophylactic contralateral hip pinning, of which 13 patients (17.80%) developed a contralateral slip, with younger age and elevated posterior slope angle as significant risk factors. Patients aged under 12 years with a posterior slope angle greater than 9° had a NNT of two for prophylactic fixation, suggesting targeted benefit. Prophylactic fixation showed no subsequent slip or fixation-related complications in our patient population.

Conclusion

SCFE in Australian Indigenous patients presents unique challenges, with a higher proportion of valgus slips than reported in other populations. Prophylactic fixation may be beneficial in younger, high-risk patients. These findings highlight the importance of individualized care and a multidisciplinary approach, particularly in remote communities where healthcare access is limited. Tailored interventions for at-risk individuals may improve outcomes and address healthcare disparities in this vulnerable cohort.

Take home message

- There is a higher proportion of valgus slipped capital femoral epiphysis in Australian Indigenous patients than that reported in other populations.
- We advocate for individualized care and consideration of prophylactic fixation in younger, high-risk patients.

Introduction

Slipped capital femoral epiphysis (SCFE) is the most common hip disorder seen in pre-adolescent and adolescent children, typically occurring during the period of rapid growth between the ages of eght and 15 years. Risk factors for SCFE include male sex and those with a high weight percentile.[1,2] SCFE is classified by the direction and severity of slippage,[3] as well as the stability of the epiphysis.[4] Untreated SCFE may result in femoroacetabular impingement and subsequent early degenerative osteoarthritis.[5,6] The management of SCFE may include in situ fixation,

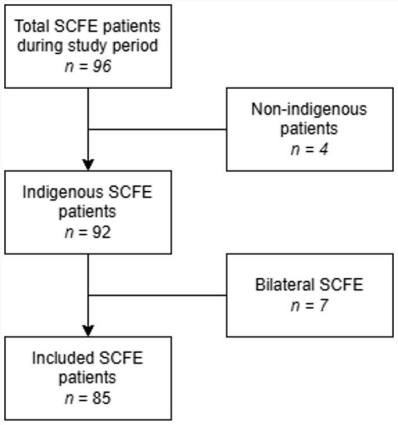

Fig. 1
Flow diagram of the patient inclusion process for the study.

or even capital re-alignment procedures in more severe slips.[7] Patients with unilateral SCFE require vigilant monitoring for the potential development of a contralateral slip. Prophylactic contralateral fixation may be considered for high-risk individuals, particularly those with endocrinopathies, obesity, male sex, or a posterior sloping angle of 14° or greater.[8,9]

The role of prophylactic contralateral pinning in SCFE remains controversial. Some studies advocate for prophylactic fixation in high-risk patients,[8-10] as it may prevent the morbidity associated with a contralateral slip and reduce the need for future surgeries, especially important in populations with limited access to healthcare. On the other hand, routine prophylactic pinning is not without risks, with potential complications include chondrolysis, infection, and hardware-related issues, which may outweigh the benefits for lower-risk patients.[11,12] This ongoing debate underscores the importance of individualized patient care, considering factors like age, posterior slope angle, and the presence of endocrinopathies when deciding on prophylactic interventions. This issue is particularly significant in Australian Indigenous populations where a majority reside in remote areas, where timely follow-up care is challenging, and complications can have a profound impact on patient outcomes.

The Northern Territory of Australia has a population of 246,500 spread across 1.42 million squared kilometres, with approximately 30.8% of the population identifying as Australian Indigenous. A majority of Australian Indigenous people in the Northern Territory reside within remote or very remote areas, where they face significant barriers to healthcare access, which may lead to delayed presentation of SCFE.[13] Nguyen et al[14] have previously shown that Australian Indigenous children are three times more likely to develop SCFE than non-Australian Indigenous children. This heightened risk highlights the critical need for vigilant diagnosis, as well as prompt and appropriate treatment to effectively manage SCFE in this population. Despite the prevalence of SCFE among Australian Indigenous children, research specifically addressing its impact and management within this vulnerable population remains limited. This retrospective study seeks to address this research gap by analyzing the epidemiology of Australian Indigenous patients presenting with SCFE, risk factors for contralateral slip, and the role of prophylactic fixation in this population.

Table I. Demographics and clinical characteristics of Australian Indigenous slipped capital femoral epiphysis patients in our study.

Variable	Data
Median age at diagnosis, yrs (IQR)	12.1 (11.2 to 13.0)
Sex, n (%)	
Female	43/85 (50.6)
Male	42/85 (49.4)
Median weight percentile (IQR)	86.0 (55.0 to 98.0)
Presence of endocrinopathies, n (%)	5/85 (5.9)
Risser Score at index presentation, n (%)	
0	64/85 (75.3)
1	12/85 (14.1)
2	8/85 (9.4)
3	1/85 (1.2)
Median posterior slope angle, ° (IQR)	9.0 (7.0 to 13.5)
Slip type, n (%)	
Valgus	9/85 (10.6)
Varus	76/85 (89.4)
Temporal classification, n (%)	
Acute (≤ 3 weeks)	19/85 (22.4)
Chronic (> 3 weeks)	66/85 (77.7)
Loder's classification, n (%)	
Stable lip	81/85 (95.3)
Unstable slip	4/85 (4.7)
Southwick's slip severity, n (%)	
Mild	54/85 (63.5)
Moderate	21/85 (24.7)
Severe	10/85 (11.8)

SCFE, slipped capital femoral epiphysis.

Methods

This is a multicentre retrospective study that was conducted at Alice Springs Hospital (ASH) and Royal Darwin Hospital (RDH), the two primary referral centres within the Northern Territory of Australia. Human Research Ethics Committee approval was sought and obtained prior to commencement of this study (NT HREC Reference Number: 2024 to 4867). Reporting of this study was performed based on the recommendations by Strengthening the Reporting of Observational Studies in Epidemiology (STROBE).[15]

Both institutions prospectively maintained a database of all hospital admissions, categorized using the International Classification of Diseases of the World Health Organization (ICD) coding system.[16] Consecutive patients presenting to RDH and ASH between 1 January 2010 and 1 January 2024 with an admission diagnosis of SCFE (ICD-10: M93.0 or ICD-9: 732.2)

Table II. Demographics and clinical characteristics of valgus slips in our study.

Variable	Data
Median age at diagnosis, yrs (IQR)	11.3 (10.8 to 11.8)
Sex, n (%)	
Female	7/9 (77.8)
Male	2/9 (22.2)
Median weight percentile (IQR)	87 (55 to 99)
Presence of endocrinopathies, n (%)	2/9 (22.2)
Risser Score at index presentation, n (%)	
0	7/9 (77.8)
1	2/9 (22.2)
2	0/9 (0.00)
3	0/9 (0.00)
Median posterior slope angle, ° (IQR)	7.5 (6.5 to 11.5)
Temporal classification, n (%)	
Acute (≤ 3 weeks)	1/9 (11.1)
Chronic (> 3 weeks)	8/9 (88.9)
Loder's classification, n (%)	
Stable slip	9/9 (100)
Unstable slip	0/9 (0)
Southwick's slip severity, n (%)	
Mild	9/9 (100.00)
Moderate	0/9 (0.00)
Severe	0/9 (0.00)

were identified and extracted from this database. The medical records were then retrieved to confirm the diagnosis. Those with an inaccurate diagnosis, bilateral simultaneous SCFE on initial presentation, or did not identify as Australian Indigenous were excluded from our study.

Patient demographics

In total, 85 Australian Indigenous patients with SCFE were identified from our database, of which 13 patients had a contralateral slip. A flow diagram demonstrating the process for inclusion in our study is shown in Figure 1. Of note, seven patients presented with bilateral simultaneous SCFE during this period which was excluded from our analysis. The median follow-up was nine months (IQR 7 to 12).

Our demographic data are found in Table I. The median age at diagnosis was 12.1 years (IQR 11.2 to 13.0). There were approximately equal number of male and female patients, with 42/85 (49.4%) males. The median weight percentile was 86 (IQR 1 to 99), indicating a substantial number of overweight patients. Endocrinopathies were present in five patients (5.9%) – three had diabetes, one had hypothyroidism, and one had skeletal dysplasia. Most patients had a Risser score of zero (75.3%) at the time of index presentation. Median posterior slope angle was 9.0° (IQR 7.0° to 13.5°).

At the time of the index presentation, 66 slips (77.7%) were chronic slips (symptom present for three weeks or more).[6] Of 85 patients, 54 (63.5%) had a mild slip, 21 (24.7%) had a moderate slip, and the ten (11.8%) had a severe slip, based on the Southwick classification.[17] Four patients (4.7%) presented with an unstable slip, defined as the inability of the child to walk, even with the aid of crutches.[4]

Data extraction and outcomes of interest

We extracted epidemiological and treatment data from our population of interest including age at diagnosis, sex, weight percentile, history of endocrinopathies, Loder's classification[4] of slip stability at the time of diagnosis (stable or unstable), Risser score,[18] posterior slope angle, direction of the slip (valgus or varus), and Southwick's slip severity, as well as the treatment received, and the complications encountered from these treatments. Our primary objective was to describe the epidemiological and treatment outcomes for Australian Indigenous patients with SCFE. The secondary objectives were to establish risk factors for contralateral slip and to evaluate the role of prophylactic fixation in this population by assessing the number needed to treat (NNT). Of note, prophylactic fixation in both institutions were performed based upon surgeon and patient preference, with no established guidelines.

Statistical analysis

Continuous variables were displayed as median (IQR), whereas binary variables were displayed as count (percentage). Independent risk factors for contralateral slip were identified from patients who did not receive prophylactic fixation using a penalized logistic regression model as described by Firth[19] and displayed using odds ratio (OR). The NNT was then assessed by comparing populations who had received prophylactic fixation and those who have not. Lastly, sensitivity analysis was performed to measure any variance in patient demographics or outcomes between sites, which may be attributed to variation in local practice. All analyses were performed using Stata v. 18.0 (StataCorp, USA). The threshold for statistical significance was set at $p < 0.05$.

Results

Epidemiological and treatment outcomes

All but one patient was managed with in situ pinning using either one or two cannulated screws. The remaining patient received a serendipitous closed reduction and percutaneous pinning with two cannulated screws. Major complications were observed in nine (10.6%) of these surgeries, with three patients required revision to a shorter screw length following postoperative CT scan. Two patients had avascular necrosis: one with a stable slip, and the other with an unstable slip; both cases involved severe slips. Of these two patients who had avascular necrosis, one was managed expectantly following removal of hardware, while the other received an arthrodesis. Two patients required return to theatre for debridement of a surgical site infection and the remaining two patients received a subsequent surgery for symptomatic anterior impingement. Prophylactic fixation was performed for 12 patients, with no complications or subsequent slips seen. Nine (10.6%) valgus slips were observed in during our study period. Demographic data on valgus slips are found in Table II.

Table III. Risk factor analysis for contralateral slip.

Variable	OR	SE	95% CI	p-value*
Age at diagnosis, yrs	0.24	0.15	0.07 to 0.83	0.023
Male sex	8.61	11.60	0.61 to 120.66	0.110
Weight percentile	0.99	0.02	0.96 to 1.03	0.687
Presence of endocrinopathies	2.19	3.42	0.10 to 46.38	0.613
Risser Score at index presentation				
0	Baseline			
1	0.10	1.20	0.00 to 4.25	0.232
2	0.02	0.04	0.00 to 1.00	0.050
3	25.24	71.84	0.10 to 6687.80	0.257
Posterior slope angle, °	1.68	0.42	1.02 to 2.75	0.038
Varus slip type	0.77	1.33	0.03 to 23.36	0.878
Chronic slip (> 3 weeks)	5.44	8.67	0.24 to 123.62	0.288
Unstable slip	0.89	1.80	0.02 to 47.34	0.953
Southwick's slip severity				
Mild	Baseline			
Moderate	0.24	0.64	0.00 to 43.90	0.591
Severe	2.86	5.76	0.06 to 148.11	0.602

*Regression analysis.
OR, odds ratio; SE, standard error.

A total of 13 patients (17.8%) suffered from subsequent contralateral slip. The median time to contralateral slip was 191 days (IQR 155 to 411), and the median age at time of contralateral slip was 12.0 years (IQR 10.9 to 12.6). Of these patients, eight (61.5%) were acute slips. Only one slip was a valgus slip, whereas the remaining were varus slips. Most slips (76.9%) were stable. Based on the Southwick's classification, ten (76.9%) were mild slips, one was a moderate slip, and the remaining two were severe slips. All contralateral slips were also managed with in situ fixation with nil complications noted.

Risk factors for contralateral slip and indications for prophylactic fixation

Our regression analysis found that younger age (OR = 0.24, p = 0.023) and increasing posterior slope angle (OR = 1.68, p = 0.038) were independently associated with higher odds of a contralateral slip. The remaining of our analyzed covariates were not significant. Our regression analysis is shown in Table III.

None of the 12 patients who had prophylactic fixation had a subsequent slip or complications associated with prophylactic fixation. Of the remaining 73 patients who were not prophylactically fixated, 13 had a contralateral slip. Therefore, our overall NNT was six. Using the median age and posterior slope angle as cutoffs, the NNT for those who were aged less than 12 years was only seven, and those who only had a posterior slope angle of greater than 9° was six. However, in patients who were both aged below 12 years and had a posterior slope angle of greater than 9°, the NNT was two.

Sensitivity analysis

We found that in terms of patient demographics and treatment outcomes, patients from ASH (Central Australia) tended to have more severe slips based on Southwick's classification (p = 0.023), as well as a higher Risser score at the index presentation (p < 0.001). The remaining variables did not vary significantly across sites. Risk factors for contralateral slip did not vary even when adjusted for site.

Discussion

Australian Indigenous patients present unique social and geographical challenges in the provision of safe and effective care. Our study showed that SCFE in Australian Indigenous patients tends to occur in high BMI individuals during their adolescent years, which is not dissimilar to that described in literature. Nevertheless, there are several key differences. First, the distribution of cases was equal among sexes. Second, there appeared to be a significantly higher proportion of valgus slips. Despite non-Indigenous patients accounting for approximately 70% of our geographical catchment area, there were only four cases of SCFE within this population. Thus, the incidence of SCFE among Australian Indigenous children is likely to be significantly greater. We were unable to obtain population-at-risk data to further quantify this disparity. In terms of management, we found that our complication rate was lower than that reported in literature. Although our results do not support routine prophylactic fixation, we feel that

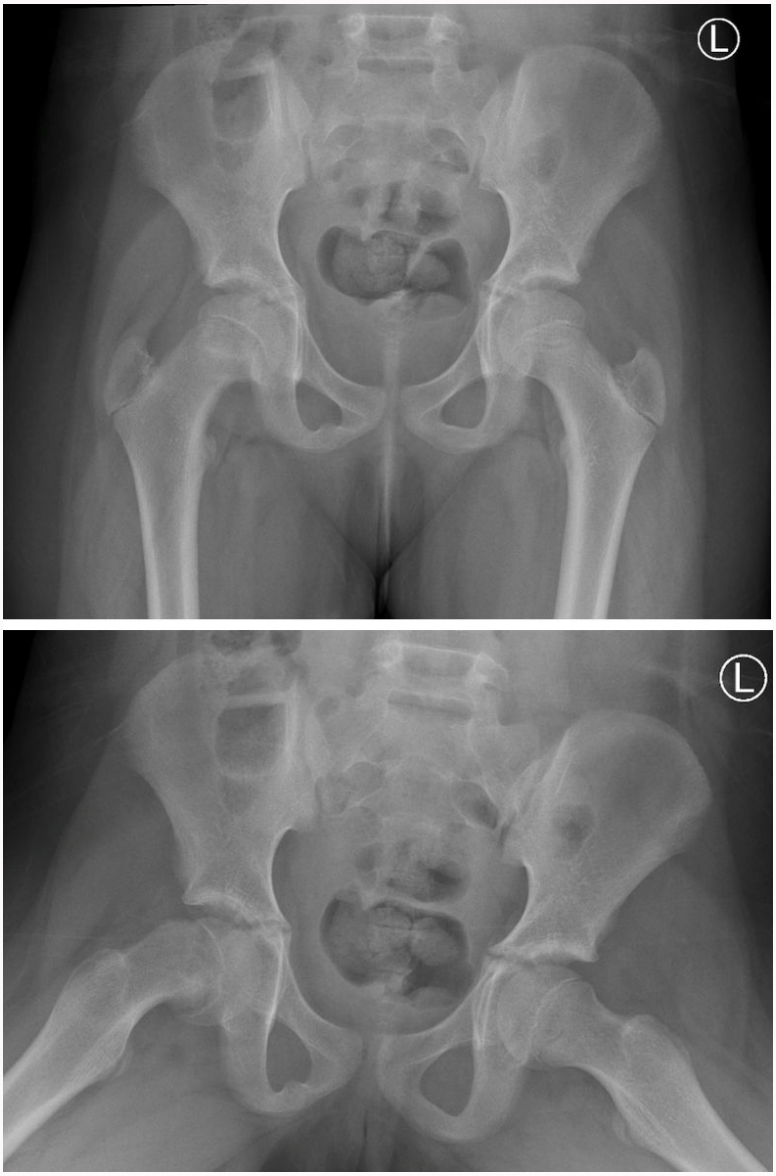

Fig. 2
Anteroposterior (AP) and lateral roentgenograms demonstrating typical findings in a right-sided varus (normal) slipped capital femoral epiphysis. In the AP view, Klein's line does not intersect with the lateral overhand of the epiphysis and there is blanching of the proximal femoral metaphysis (Steel's sign). The lateral view shows a disrupted S sign.

this may have a role in younger patients with an elevated posterior slope angle. Our sensitivity analysis found that patients presenting to ASH tend to have more severe slips. Nevertheless, the lack of site-specific effect on the risk factor analysis demonstrates the generalizability of our findings across different healthcare settings.

Almost all patients were managed with in situ fixation, with one in ten patients experiencing a major complication. Although this complication rate is higher than most routine orthopaedic surgical procedures,[20] this is significantly lower than previously reported.[21] These differences may be attributed to a short follow-up period, as a significant proportion of patients were lost to follow-up following their first few postoperative outpatient appointments. Australian Indigenous patients have long been a victim of systemic racism, resulting in ingrained mistrust towards the healthcare system.[22] Further work needs to be performed to rebuild this trust and undo the generational trauma inflicted by past experiences on this vulnerable population, in order to address the healthcare disparities faced by the Australian Indigenous populations.[23] Additionally, several authors have also recommended safe surgical dislocation with modified Dunn's osteotomy for management of severe slips.[24–26] This management strategy was not offered in both our institutions in the first instance, due to concerns of avascular necrosis.[27] Our use of cannulated screws for fixation may also be criticized, as there is an emerging body of evidence supporting the use of 'growing' screws, which allows for femoral head remodelling.[28,29]

Of the 73 patients who were not managed with prophylactic fixation, 13 (17.8%) suffered from a subsequent contralateral slip. This finding is similar to that previously reported in literature.[30,31] Our risk factor analysis found that younger age at presentation and a higher posterior

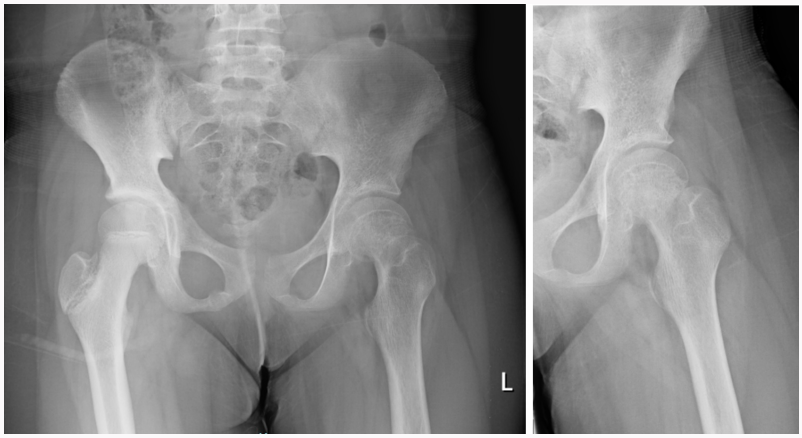

Fig. 3
Anteroposterior (AP) and lateral roentgenograms demonstrating typical findings in a left-sided valgus slipped capital femoral epiphysis. Note that due to the posterolateral displacement of the epiphysis relative to the etaphysis, Klein's line is always intact. The proximal femur has a more rounded appearance.

slope angle were independent risk factors for developing a contralateral slip, aligning with existing literature.[30,31] In select patients who both initially present prior to aged 12 years and have a posterior slope angle of greater than 9°, we advocate for routine prophylactic fixation, as the NNT was two. Interestingly, 15% of children who experienced a contralateral slip had an initial severe slip (2/13). Although this was not identified as a risk factor for contralateral slip in our regression analysis, it is worth noting that 3/12 patients (25%) who received a prophylactic fixation had a severe slip initially. As such, we would also recommend prophylactic fixation in this subgroup.

Patients who underwent prophylactic fixation had no subsequent slips or fixation-related complications; however, this must be interpreted with caution given the limited number of patients within our study. Although almost all initial cases were chronic, most contralateral slips presented acutely. This may be due to improved awareness among patient and parents, highlighting the importance of effective communication within the healthcare setting.[32,33] At both institutions, we employ a multidisciplinary approach for patient follow-up, involving Aboriginal liaison officers, paediatric nurses, and social workers to ensure comprehensive care and support. Early recognition and timely intervention are essential for minimizing complications and optimizing long-term outcomes.

Valgus SCFE is a rare condition marked by the posterolateral displacement of the epiphysis relative to the metaphysis with only 96 known cases in literature.[34,35] Although the reported prevalence of valgus slips ranges between 1.9% to 4.7% of all SCFE cases,[34,36,37] 10.6% of our patients had valgus slips. This is a significantly higher rate compared to existing literature and represents a unique finding which has not been previously described. Valgus slips were seen in younger, female patients (77.8%) with a lower BMI compared to the rest of the cohort, with a median age of 11.3 years (IQR 10.8 to 11.8) and a mean weight percentile in the 68th percentile (versus a mean of 74th percentile in varus slips). We postulate that this may be due to dietary routines, genetic differences in the bone metabolic profile, and/or differences in the proximal femoral geometry within the Australian Indigenous cohort. In adult hip fracture populations, several studies have found differences in bone microarchitecture and proximal femoral geometry which may account for racial differences in hip fracture rates.[38] There are no published studies evaluating the effect of bone quality and structure on the likelihood of developing hip disorders, representing a future avenue of research. The radiological differences between a varus (typical) slip and valgus slip are illustrated in Figures 2 and 3.

Our study has several limitations which must be acknowledged. First, the retrospective design of the study relies upon the accuracy of available medical records. Second, although this represents one of the largest series of Australian Indigenous SCFE patients, the sample size is still small and therefore underpowered to provide robust recommendations on the safety and efficacy for both in situ fixation and prophylactic pinning. Furthermore, we had a significant number of patients who were lost to long-term follow-up. It is possible that a proportion of these patients may have developed an untreated contralateral SCFE, or complications of in situ fixation which may include femoroacetabular impingement and avascular necrosis, some of which may also have been treated elsewhere. An excellent study by Schlenzka et al[39] has reported a 40% conversion rate of in situ fixation to total hip arthroplasty at long-term follow-up. Despite these limitations, our study provides valuable insights into the unique challenges and opportunities for improving SCFE care in the Australian Indigenous population.

In summary, this study provides a longitudinal analysis of Australian Indigenous patients with SCFE. One in ten patients managed with in situ fixation experienced a major complication. When prophylactic fixation was not performed, 17.9% experienced a contralateral slip. Interestingly, a significantly higher proportion of patients experienced valgus slips when compared to literature. Although the overall number NNT was high, we found that prophylactic pinning may be warranted among the Australian Indigenous population in a subgroup of patients who have an index presentation at less than 12 years of age and a posterior slope angle

of greater than 9°. Our findings highlight the importance of tailored, patient-specific approaches to SCFE care, which is essential for improving outcomes and reducing disparities in this vulnerable patient cohort.

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