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Socioeconomic status impacts outcomes following pediatric anterior cruciate ligament reconstruction

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Abstract

Previous research has shown that delays in pediatric anterior cruciate ligament (ACL) reconstruction are associated with increased prevalence of concomitant knee injuries and worse outcomes following surgery. However, few studies have described factors that may contribute to these delays and adverse outcomes. This study seeks to determine the effect of socioeconomic status on clinical outcomes following ACL reconstruction.

A retrospective review of patients who underwent primary ACL reconstruction at a tertiary pediatric hospital between 2009 and 2015 was conducted. Variables included chronologic, demographic, and socioeconomic data, and postoperative complications. Socioeconomic status was measured using health insurance type and median household income levels derived from 2009 to 2015 US Census Bureau.

A total of 127 patients (69 male, 58 female) were included. The mean age at time of surgery was 15.0 years. Overall, 68 patients had commercial insurance and 59 patients had government-assisted insurance. The mean household median income for patients with commercial insurance was $87,767 compared to $51,366 for patients with government-assisted insurance. Patients with government-assisted insurance plans demonstrated greater delays in time from injury to initial orthopaedic evaluation ($P = .0003$), injury to magnetic resonance imaging (MRI) examination ($P = .021$), injury to surgery ($P < .0001$), initial orthopaedic evaluation to surgery ($P = .0036$), and injury to return to play clearance, $P = .044$. Median household income was significantly related to time from injury to MRI examination ($P = .0018$), injury to surgery ($P = .0017$), and initial orthopaedic evaluation to surgery ($P = .039$). Intraoperatively, 81% of patients with government-assisted insurance had concomitant meniscal injuries compared 65% of patients with commercial insurance, $P = .036$. Postoperatively, 22% of patients with government-assisted insurance were found to have decreased knee range of motion ("stiffness") compared to 9% of patients with commercial insurance, $P = .034$.

Pediatric patients who have government-assisted plans may experience delays in receiving definitive injury management and be at risk for postoperative complications. Our findings suggest a significant discrepancy in time to treatment as well as rates of concomitant knee injuries and postoperative complications between government and commercial insurance types.

Level of Evidence: III

Abbreviations: ACL = anterior cruciate ligament, ACLR = anterior cruciate ligament reconstruction, ANOVA = analysis of variance, CPT = current procedural terminology, HMO = health maintenance organization, MRI = magnetic resonance imaging, PPO = preferred provider organization.

Keywords: Delayed treatment, healthcare access, insurance status, orthopaedic surgery

1. Introduction

Healthcare reform in the United States has focused attention on optimizing healthcare delivery with respect to quality, outcomes, efficiency, and cost containment. As a result, many barriers to healthcare access have been identified by researchers. Children and people from lower socioeconomic classes are among the populations with the greatest difficulty acquiring healthcare.[1–5] This can make scheduling timely procedures for acute injuries unreasonably difficult. Newman et al showed that the orthopaedic field is not immune to these delays.[5] Orthopaedic surgeons have been operating on anterior cruciate ligament (ACL) injuries for over a century. With the introduction of advanced arthroscopic techniques, indications for reconstruction procedures have grown substantially. This is reflected by the 134,000 anterior cruciate ligament reconstructions (ACLR) performed in 2007, which represents a 55% increase from 1994 to 2006.[6,7] This same trend holds true for pediatric patients as well.[8] These increases in demand make equitable access to healthcare resources all the more important.

An impetus for healthcare policy reform stems from surgical outcomes data. ACL reconstruction is associated with a number of common complications, including reduction in range of motion (stiffness), graft failure, and need for reoperation.[9,10] Appropriately-timed surgical intervention is an important modifiable risk factor for reduction of these complications. Meniscal injuries often occur in conjunction with ACL tears, and delays from date of injury to physician intervention have been shown to increase the rate of meniscal pathology.[11–14] Consequently, increased morbidity and medical costs are directly correlated with delays in treatment. In patients with open physes at the time of ACL injury, ACLR surgery has been shown to reduce instability compared to patients treated nonoperatively with a lower rate of the development of concomitant intraarticular pathology and a low rate of iatrogenic physeal injury.[15,16]

The purpose of this investigation is to assess the clinical impact of socioeconomic status on ACLR outcomes. Previous work has demonstrated that significant delays from the time of injury to intervention with ACLR are strongly associated with lower socioeconomic status, however, surgical outcomes have not been carefully scrutinized. We hypothesize that children from lower-income households or on government-assisted health insurance are more likely to experience delayed injury management and clinically significant complications.

2. Methods

This study was approved by the Institutional Review Board at Children's Hospital Los Angeles. A query of current procedural terminology (CPT) procedural codes (29888) was used to identify all patients who underwent primary ACL reconstruction between 2009 and 2015. A retrospective chart review was conducted to collect demographic, socioeconomic, and clinical variables from patients younger than 21 years at the time of surgery. Exclusion criteria included the following: subjects with multiligamentous or multiple knee injuries, a history of prior ipsilateral ACL reconstruction at an outside institution, missing medical records data, or those patients who presented at our institution for evaluation more than 365 days after initial injury.

Demographic variables included age at time of surgery and sex. Socioeconomic variables included household income and health insurance type. Household income was estimated based on the city block group median household income levels associated with each subject's home address during the year of surgery. This information was derived from 2009 to 2015 US Census Bureau data. Similar investigations in the current literature have utilized census data obtained at the zip code level; however, this study is the first, to our knowledge, to use census data obtained at the city block level, which may provide a more accurate representation of median household income for subjects in this study. Health insurance type was classified as commercial and government-assisted. Commercial insurance types included health maintenance organization (HMO) and preferred provider organization

(PPO) plans. Government-assisted insurance types included Medi-Cal and Medicaid plans.

Clinical variables of interest included time in days from injury to initial orthopaedic evaluation at our institution, injury to magnetic resonance imaging (MRI) examination, injury to ACLR surgery, initial orthopaedic evaluation to ACLR surgery, injury to return to play clearance by an orthopaedic surgeon, and ACLR surgery to return to play clearance by an orthopaedic surgeon. The presence of associated meniscal and chondral injuries identified intraoperatively was recorded. ACLR with autografts (hamstring, patellar tendon, quadriceps tendon, and iliotibial band) or allografts were included in the analysis. Clinical postoperative outcomes of interest included graft failure, return to operating room, decreased postoperative range of motion at the knee as indicated by the treating surgeon, and infection.

2.1. Statistical analysis

Demographics and clinical characteristics of our study population were summarized using descriptive statistics. An analysis of variance (ANOVA) was conducted to determine the effect of insurance type on chronologic variables including time from injury to initial orthopaedic evaluation, injury to MRI examination, injury to surgery, initial orthopaedic evaluation to surgery, injury to return to play clearance, and surgery to return to play clearance. A Spearman's correlation was conducted to assess the relationship between median household income and the aforementioned chronologic variables. Analysis with a Chi-square test of independence was conducted to determine the effect of insurance type on the prevalence of concomitant knee injuries and postoperative clinical complications. Analysis with a Chi-square test of independence was also used to determine the effect of ACLR graft choice (hamstring, patellar tendon, quadriceps tendon, and iliotibial band) on postoperative clinical complications. Results were considered significant if they were below the 0.05 alpha level. All statistical analyses were performed using STATA (version 14.2, StataCorp LP, College Station, TX).

3. Results

A total of 127 subjects (69 male, 58 female) were included in data analysis for this study. The mean age at time of surgery was 15.0 ± 2.3 years (range = 9–21 years). There were 68 patients total in the commercial insurance group (PPO, HMO) and 59 patients in the government insurance group (Medi-Cal, Medicaid). The average length of follow-up after surgery was 302 days (10.1 months). Based on home address, the mean median household income for the cohort (n = 123) was $70,307 ± $37,375. Household income was unable to be determined for 4 subjects in our cohort. The commercial insurance group was found to have a larger household income (M = $87,767) compared to the government insurance group (M = $51,366), P < .0001 (Table 1). In our cohort, 59% (75/127) of patients received hamstring autografts, 23% (29/127) received patellar tendon autografts,

Table 1

Comparison of insurance types by block group level household median income (2009–2015 US Census Bureau).

Insurance type	Mean household median income	Standard deviation	P
Commercial (n = 64)	$87,767	$38,325	<.0001
Government (n = 59)	$51,366	$25,330	

13% received iliotibial band autografts, 4% received quadriceps tendon autografts, and 1% (2/127) received allografts. Type of ACLR graft was not significantly associated with postoperative knee stiffness, graft failure, return to operating room, and infection (all $P > .05$). Twenty-four percent (30/127) did not receive return to play clearance by an orthopaedic surgeon and were presumed to be lost to follow-up.

3.1. Socioeconomic factors related to timeliness of injury management

3.1.1. Time from injury to initial orthopaedic evaluation. The mean number of days from injury to initial orthopaedic evaluation at our institution for our cohort was 71.0 ± 75.2 days. Patients with government-assisted insurance plans ($M = 96.5$ days) experienced significantly longer times from injury to initial orthopaedic evaluation compared to those with commercial insurance plans ($M = 48.9$ days), $P = .0003$ (Table 2). A Spearman's correlation was run to assess the relationship between household income and time from injury to initial orthopaedic evaluation at our institution, which was not statistically significant, $P = .066$.

3.1.2. Time from injury to MRI examination. The mean number of days from injury to MRI examination for our cohort was 68.8 ± 83.9 days. Patients with government-assisted insurance plans ($M = 85.9$ days) experienced significantly longer times from injury to MRI examination compared to those with commercial insurance plans ($M = 44.2$ days), $P = .021$ (Table 2). A Spearman's correlation was run to assess the relationship between household income and time from injury to MRI examination. A negative correlation was observed, which was statistically significant, $r_s = -0.33$, $P = .0018$.

3.1.3. Time from injury to surgery. The mean number of days from injury to ACLR surgery for our cohort was 129.5 ± 111.2 days. Patients with government-assisted insurance plans ($M = 174.6$ days) experienced significantly longer times from injury to surgery compared to those with commercial insurance plans ($M = 90.4$ days), $P < .0001$ (Table 2). A Spearman's correlation was run to assess the relationship between household income and time from injury to surgery. A negative correlation was observed, which was statistically significant, $r_s = -0.28$, $P = .0017$.

3.1.4. Time from initial orthopaedic evaluation to surgery. The mean number of days from initial orthopaedic evaluation to ACL reconstructive surgery for our cohort was 58.8 ± 70.4 days. Patients with government-assisted insurance plans ($M = 78.1$ days) experienced significantly longer times from initial orthopaedic evaluation to surgery compared to those with commercial insurance plans ($M = 41.9$ days), $P = .0036$ (Table 2). A Spearman's correlation was run to assess the relationship between

household income and time from injury to MRI examination. A negative correlation was observed, which was statistically significant, $r_s = -0.19$, $P = .039$.

3.1.5. Time from injury to return to play clearance. The mean number of days from injury to return to play clearance by an orthopaedic surgeon for our cohort was 363.6 ± 144.0 days. Patients with government-assisted insurance plans ($M = 394.7$ days) experienced significantly longer times injury to return to play clearance compared to those with commercial insurance plans ($M = 336.2$ days), $P = .044$ (Table 2). A Spearman's correlation was run to assess the relationship between household income and time from injury to return to play clearance, which was not statistically significant, $P = .35$.

3.1.6. Time from surgery to return to play clearance. The mean number of days from ACL reconstructive surgery to return to play clearance by an orthopaedic surgeon for our cohort was 247.8 ± 108.4 days. No significant difference was found in the mean number of days between government-assisted patients ($M = 238.8$ days) and patients with commercial insurance plans ($M = 255.7$ days), $P = .445$ (Table 2). A Spearman's correlation was run to assess the relationship between household income and time from surgery to return to play clearance, which was not statistically significant, $P = .49$.

3.2. Socioeconomic factors related to concomitant knee injuries

3.2.1. Associated meniscus injuries. At time of surgery, 81% (48/59) of patients with government-assisted insurance plans presented with concomitant meniscus tears compared to 65% (44/68) of patients with commercial insurance plans. The incidence of concomitant meniscus tears at time of ACLR was significantly associated with insurance type ($\chi^2 = 4.39$, $P = .036$).

3.2.2. Associated chondral injuries. At time of surgery, 14% (8/59) of patients with government-assisted insurance plans presented with concomitant chondral injuries compared to 10% (7/68) of patients with commercial insurance plans. The presence of associated chondral injuries at time of ACLR was not significantly associated with insurance type ($\chi^2 = 0.32$, $P = .57$)

3.3. Socioeconomic factors related to postoperative complications

3.3.1. Decreased knee range of motion ("knee stiffness"). Postoperatively, 22% (13/58) of patients with government-assisted insurance plans had incidence(s) of decreased range of motion after evaluation by an orthopaedic surgeon compared to 9% (6/68) of patients with commercial insurance plans. The incidence of decreased range of motion postoperatively was significantly associated with insurance type ($\chi^2 = 4.51$, $P = .034$).

Table 2

Comparison of insurance types by chronologic variables.

	Commercial	Government	P
Injury to first appointment (days)	48.9 ± 57.1	96.5 ± 85.4	.0003
Injury to MRI (days)	44.2 ± 83.3	85.9 ± 80.8	.021
Injury to surgery (days)	90.4 ± 83.7	174.6 ± 122.2	<.0001
First appointment to surgery (days)	41.9 ± 65.2	78.1 ± 71.8	.0036
Injury to return to play (days)	336.2 ± 130.4	394.7 ± 153.6	.044
Surgery to return to play (days)	255.7 ± 116.8	238.9 ± 98.5	.445

3.3.2. Graft failure.
Postoperatively, 8% (4/53) of patients with government-assisted insurance plans experienced graft failure compared to 6% (4/68) of patients with commercial insurance plans. The average time from initial surgery to graft failure was found to be 254.9 days (8.5 months). The incidence of graft failure was not significantly associated with insurance type ($\chi^2 = 0.13$, $P = .72$).

3.3.3. Return to operating room.
Postoperatively, 9% (5/53) of patients with government-assisted insurance plans returned to the operating room for a complication (which included infection, arthrofibrosis, graft failure, meniscal pathology, etc) compared to 10% (7/68) of patients with commercial insurance plans. The incidence of returning to the operating room for a postoperative complication was not significantly associated with insurance type ($\chi^2 = 0.02$, $P = .88$).

3.3.4. Infection.
Postoperatively, 4% (2/54) of patients with government-insurance plans experienced a wound infection compared to 0% (0/68) of patients with commercial insurance plans. The two patients who experienced a superficial wound infection were treated with antibiotics and return to the operating room was not required. The incidence of infection was not significantly associated with insurance type ($\chi^2 = 2.56$, $P = .11$).

4. Discussion

The results of this study demonstrate that pediatric patients who have government-assisted health insurance plans and live in less affluent neighborhoods may experience delayed orthopaedic care and progression to ACL reconstruction, increased incidence of concomitant meniscus tears, and greater risk for postoperative complications such as decreased knee range of motion.

In the current literature, insurance type has been implicated by several studies as a strong predictor of access to orthopaedic-related health care and ACL surgery timing.[4,5,17–19] In a study of patients presenting at a tertiary pediatric hospital, Newman et al found that time from injury to ACL reconstruction for subjects covered by a noncommercial insurance plan nearly doubled that of subjects covered by a commercial insurance plan (3.0 months vs 1.5 months).[5] Comparatively, our study found that mean time from injury to ACL reconstruction for both commercially insured and government-assisted patients was longer overall (3.0 months vs 5.8 months, respectively) than previously reported, suggesting that navigating the complexities of the healthcare system may be even more challenging for patients living in a major metropolitan city such as Los Angeles, CA.

In a study of patients concentrated in South Florida, Baraga et al highlighted system-related delays in obtaining care and the resultant discrepancy between insurance types in time to receiving a definitive diagnosis. Privately insured patients living in this region were found to be diagnosed with an ACL tear at a median 14 days post-injury compared to 56 and 121 days post-injury for government-assisted and uninsured patients, respectively.[17] Pierce et al analyzed insurance-related discrepancies in accessing care by surveying orthopaedic surgery practices' willingness to schedule an appointment for a fictitious, 14-year old male patient with an acute ACL tear. Ninety percent (90%) of practices offered a privately insured patient an appointment within 2 weeks, while only 14% of practices offered a Medicaid patient an appointment within the same timeframe. The odds of scheduling a timely appointment was calculated to be 57 times higher for a privately insured patient compared to a Medicaid patient.[18]

In addition to ACL tears, insurance status has also been linked to delays in the treatment of other orthopaedic-related injuries, including slipped capital femoral epiphysis (SCFE)[19] and extremity fractures.[20] Skaggs et al randomly surveyed 50 orthopaedic practices in the state of California to compare the availability of timely orthopaedic care to a child with a fractured extra-physeal upper extremity fracture insured by either Medi-Cal or by private insurance. It was found that 100% (50/50) of the surveyed practices offered the child with private insurance an appointment within 7 days, while only 2% (1/50) of the same practices offered a child insured by Medi-Cal an appointment with the same timeframe.[4]

Additionally, we found a significant association between insurance status and presence of meniscal injuries at time of ACL reconstruction. Overall, 81% of patients with government-assisted insurance plans presented with a concomitant meniscus injury compared to 65% of patients with commercial insurance plans. This finding aligns with previous studies that have found similar associations between health insurance type and prevalence of additional knee injuries.[5,21]

Few prior studies, however, have investigated the relationship between insurance status and clinical outcomes and complications. In the present study, 22% of patients with government-assisted insurance plans were documented to have decreased range of motion during the postoperative period compared to only 9% of commercially insured patients, $P = .034$. It is not likely that insurance status is directly related to the prevalence of postoperative knee stiffness. But rather, insurance status may be acting as a barrier to accessing appropriately timed postoperative rehabilitation, such as outpatient physical therapy.

Postoperative rehabilitation is considered the standard of care in the orthopaedic community.[22] The current literature on rehabilitation after ACL reconstruction emphasizes accelerated protocols, involving range-of-motion, strengthening, and functional exercises, that have been deemed necessary for a successful surgical outcome.[23] At our institution, patients are referred to outpatient physical therapy early in the postoperative period following primary ACL reconstruction, and efforts are made to begin postoperative physical therapy within one week after surgery. However, similar to accessing their initial orthopaedic care, patients with government-assisted insurance plans may have difficulties finding eligible providers or scheduling timely physical therapy appointments, resulting in greater risk for postoperative complications. As a result, the injury recovery timeline for patients with government-assisted insurance plans in our study was two months longer than that of patients with commercial insurance plans. Additionally, a common delay in beginning physical therapy is not only scheduling an appointment at a facility accepting of the patient's insurance, but also awaiting insurance authorization, which is required prior to scheduling an appointment. For this study, data was not available regarding the number of days that were needed to obtain insurance authorization, but it is likely that the government-assisted insurance group experienced significant delays with this process.

Several factors, including financial deterrents and a lack of resources, appointment times, and providers willing to see patients insured by government-assisted plans, may play a role in delaying definitive injury management and surgical treatment.[5,17,18,24] A national study by Skaggs et al randomly surveyed 230 pediatric orthopaedic practices and found that 38% limited the number of Medicaid patients they were willing to see, while 18% refused to see a child with Medicaid insurance

under any circumstance. It was determined that providers' willingness to see a Medicaid patient was significantly correlated to the state-based physician reimbursements rates for the orthopaedic procedures surveyed.[24]

Additionally, we focused primarily on the pediatric population, which faces additional barriers to obtaining care. Pediatric patients are highly dependent on parents and other family members for scheduling and attending appointments, as well as covering the high financial costs of medical care and rehabilitation. Moreover, it is important to consider the substantial burden placed on family members of the many diagnostic, operative, and postoperative appointments required during the treatment of an ACL tear. Families of lower socioeconomic status may not have the appropriate resources to address these demands as effectively as families of higher socioeconomic status.[5]

The present study had several important limitations that must be addressed. Since data for this study was collected retrospectively, inaccuracies in documentation within the electronic medical record by medical personnel at time of service must be considered. Recall bias is also plausible, as some patients presented at our institution nearly a year after injury. Due to the retrospective nature of this study, we were unable to obtain to direct measures of socioeconomic status. We elected to utilize indirect measures, such as patients' insurance status and estimates of their household incomes derived from the US Census Bureau using home addresses, which were readily available in the electronic medical record. Future investigations on this topic should attempt to better characterize socioeconomic status using patient reports of education levels, household income, wealth, and occupation. Additionally, future studies should attempt to more specifically identify the causes of delay in the various phases of patient care, which could include identifying a provider, awaiting insurance authorization, scheduling an appointment, and any other financial or logistical barriers to care.

Factors such as patient skeletal maturity, parental education level, and parental English language fluency may have also contributed to the delays in receiving definitive injury management that were observed in this study. Additionally, not all patients within our sample were treated by the same orthopaedic surgeon, which may have created inconsistencies in each patient's injury management timeline. In order to reduce such variability, future research may benefit from studying all of these variables in a controlled, prospective fashion.

Our study included patients from a single institution in an urban setting. Hospital-specific factors at our institution, such as an insufficient number of specialized providers or a lack of available appointments, may have influenced this study's results and may not be present at other hospitals. Additionally, our institution is a tertiary care center, suggesting that some patients may have had prior evaluation; however, did not receive definitive injury management until presenting at our institution. Our study population also consisted of pediatric patients living in a single geographic location, which may not be fully representative of the general population. Future investigations should seek to compare patients from multiple centers and geographic locations in order to analyze differences on a national level.

The present study was unique in that it attempted to determine the impact of socioeconomic status on postoperative clinical outcomes. Reports of graft failure, return to operating room, and infection were available in the electronic medical record; however, numeric measures of decreased knee range of motion ("stiffness") were not available. We instead relied on subjective physician reports of decreased knee range of motion observed during clinical assessments. In order to better understand the impact of socioeconomic status on postoperative clinical outcomes and complications, future studies should record numeric knee range of motion measurements throughout the postoperative period, as well as analyze the results of validated clinical and functional outcomes measures

Government-assisted insurance plans were significantly associated with delays in receiving orthopaedic care and greater risk for associated meniscus injuries and postoperative decreased knee range of motion. These disparities are likely due to a multitude of factors, namely a lack of hospital resources, appointment times, and/or providers will to see patients with government-assisted insurance plans.

Author contributions

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