Does marginalization status and distance from the hospital impact the timing of pediatric pyeloplasty in a universal access-to-care system?

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ABSTRACT

INTRODUCTION: Prior research in the U.S. suggests that marginalized populations tend to undergo pyeloplasty earlier, likely reflecting concerns about the challenges of reliable followup care in this population. This study assessed the effect of sociodemographic marginalization and geographic distance on the timing of pyeloplasty in a universal, single-payer healthcare system.

METHODS: We performed a single-center, retrospective study on children undergoing pyeloplasty from 2008–2019. We assessed the impact of marginalization indices (with the Ontario Marginalization Index [ON-Marg]) and geographic distance on timing of pyeloplasty, preoperative ultrasound findings, and renogram features. Unadjusted analysis and Cox proportional regression were performed to determine the effect of marginalization and geography on timing of pyeloplasty.

RESULTS: Among 503 patients who underwent pyeloplasty, the median age at surgery was 16 months. Median preoperative anteroposterior diameter (APD) was 22 mm, and split renal function on renogram was 43%. There was no significant effect of marginalization indices on age at surgery. Patients living >50 km from the hospital had a later age at surgery than those living <10 km (p=0.04); however, there was no significant difference in preoperative APD or split function by marginalization index or geographic distance. Adjusted analyses revealed no significant associations between ON-Marg variables or geographic distance with age at surgery.

CONCLUSIONS: In a universal healthcare system, marginalization status and geographic distance were not associated with the timing of pyeloplasty. These results contrast with literature from other settings and suggest that access to care can mitigate disparities in pediatric urology care.

INTRODUCTION

Hydronephrosis is among the most common abnormalities detected in children seen by pediatric urologists. While many cases are transient, up to 20% are caused by a ureteropelvic junction obstruction (UPJO), and this patient population can benefit from a timely pyeloplasty to prevent renal deterioration.[1] Even though the decision to offer surgical correction is impacted by provider and parental factors, variations in practice should not be independent of demographic factors.[2,3] Otherwise, patients that experience delays are placed at increased risk of adverse outcomes driven by limitations in access to care and administrative issues related to the healthcare system, rather than clinical factors.

Prior evidence has demonstrated the impact of sociodemographic factors on clinical decision-making.[4,5] Early evidence of variation by race in timing of surgery and UPJO correction has been shown, where non-white patients were reported to undergo pyeloplasty at an average of three years earlier than white patients in the U.S.[5] This finding was corroborated in multiple American institutional and national datasets, along with additional factors, such as hospital volume/location, insurance status, and disease severity.[4,6,7]

Earlier surgery in marginalized patients was thought to be attributed to provider concerns over patients' ability to attend followups and the potential for more severe disease pathology in non-white individuals.

KEY MESSAGES

- In 503 patients, marginalization status and distance had no significant association with pyeloplasty timing in a universal healthcare system.
- Patients >50 km away had slightly later surgeries, but preoperative findings were similar.
- Universal care may reduce disparities in pediatric urology access compared to cohorts in other countries.

The risks and benefits of early pyeloplasty should not unfairly impact families based on their race or background. Surgical complications and the need for re-intervention should depend on clinical factors, rather than be biased by non-clinical ones.[3,6]

It remains unclear if and how social determinants of health impact surgical decision-making in this population, particularly in other healthcare systems or settings. We hypothesize that a universal, single-payer healthcare system may mitigate these disparities compared to fragmented, multipayer healthcare systems. Thus, we aimed to determine whether socioeconomic and geographic factors may affect UPJO treatment in Canada, a universal healthcare system. We aimed to provide the first Canadian report on these concerns in pediatric hydronephrosis.

METHODS

Data sources

Following research ethics board approval, we included patients who underwent pyeloplasty at the Hospital for Sick Children (Toronto, ON), the largest quaternary referral center in Canada. Patients were included between January 2008 and April 2019. This cutoff was selected to avoid confounding from the COVID-19 pandemic, which impacted surgical timing from 2019 onwards. Patients were excluded only if their home address was outside of Ontario or if the medical records failed to provide sufficient data.

Variables, outcomes, and exposures

The following variables were collected: demographic details (including age, sex, forward sortation areas, three-digit postal codes), age at presentation, ultrasound findings (anteroposterior diameter [APD]) at diagnosis and during followup, date of surgery, surgical complications, and postoperative emergency department visits or readmission (at any hospital within Ontario).

The primary outcome was age at surgery. Secondary outcomes included APD on ultrasound and split renal function on diuretic renogram prior to surgery. Significant split renal function is considered >10% decrease (i.e., <40% function in affected kidney), and prolonged drainage is considered >20 minutes, which are relative surgical indications.

Marginalization was measured by the Ontario Marginalization Index (ON-Marg; *https://www.publichealthontario.ca/en/data-and-analysis/health-equity/ontario-marginalization-index*),[8] calculated based on each patient's neighbourhood of residence. Since multiple iterations of ON-Marg have been developed to reflect changes in the Ontario census, the most recent version of ON-Marg available at the time of surgery for each patient was used.[8]

ON-Marg was developed using factor analysis from multiple indicators from the Canadian population census and encompasses four domains:

- Household and dwellings: A measure of types and density of residential accommodation.
- Material resources: Measures access and attainment to basic material needs.
- Age and labor force: Measures percent of seniors and population not participating in the labor force.
- Racialized and newcomer populations: Measures percent of recent immigrants and self-identified visible minorities.

Each ON-Marg dimension was presented as a quintile, where quintile 1 represents the lowest level of marginalization (i.e., less marginalized), while quintile 5 represents the highest level of marginalization (i.e., more marginalized).

Geographic distance from the hospital was calculated by determining the distance between two postal code coordinates (hospital of interest and home postal code), which were translated to latitude and longitude via the 'geosphere' package within R statistical software (R Foundation for Statistical Computing, Vienna, Austria; *https://www.R-project.org/*). Geographic distance was then categorized into four categories: <10 km (urban), 10–20 km (suburban), 20–50 km (rural), and >50 km (distant), which were defined arbitrarily.

Statistical analyses

Categorical variables were summarized with counts and proportions, and continuous variables were summa-

rized with median and interquartile range (IQR). We assessed age of pyeloplasty between marginalization quintiles and geographic distance categories with the Kruskal-Wallis test. We confirmed non-normal distribution in preoperative APD and age at surgery with the Shapiro-Wilk test. In cases with significant differences, we performed a post-hoc Dunn-Sidak test to determine pairwise differences between groups. In addition, we performed subgroup analysis in patients who had pyeloplasty within the first year of life, as this represents children who are more likely to be detected antenatally, in contrast to older patients, who are diagnosed based on the development of symptoms.

We developed a Cox proportional hazards model for age at surgery. The primary covariate was sex, while exposures were preoperative APD, ON-Marg quintiles, and geographic category. Hazard ratios (HR) were calculated with 95% confidence intervals (CI). We assessed each ON-Marg factor and geographic category within a comprehensive and separate model. As there was no difference between these, the model encompassing all factors was presented. Statistical tests were two-sided, and $p<0.05$ was considered statistically significant. All data were analyzed using MATLAB® 2021a (MathWorks Inc., Natick, MA, U.S.).

RESULTS

Study population and baseline characteristics

A total of 515 patients underwent pyeloplasty within the study interval, and 12 patients were excluded (two address outside Ontario, 10 missing data), resulting in a total sample of 503 patients (354 males; 70%). Baseline characteristics are summarized in Table 1.

The median age at surgery was 16 months (IQR 5, 92) and a median of 46 surgeries (IQR 39, 54), were conducted per year. Of the 503 cases, 301 (60%) were performed via an open approach. The median number of ultrasounds prior to indication for surgery was 2 (IQR 2, 6), the preoperative APD was 22 mm (IQR 16, 30), and the baseline affected kidney split function was 42% (IQR 36, 54). The most common indication for surgery was worsening hydronephrosis in 279 patients (56%), followed by diuretic renogram findings in 179 patients (36%), and symptomatic presentation in 45 patients (9%).

Effect of marginalization indices and geographic distance

The age at surgery across each ON-Marg quintile is provided in Figures 1A–D. In unadjusted analyses, there was no significant difference in age at surgery when stratified by racialized and newcomer populations, material resources, or households and dwellings. For age and labor force, there was a significant difference, suggesting a later age at surgery in quintile 4 vs. quintile 1 ($p=0.02$), while no other pairs were significantly different. There was no significant difference in preoperative APD and baseline split renal function on diuretic renogram across quintiles for racialized and newcomer populations, age and labor force, material resources, or households and dwellings, as shown in Figures 1E–L.

Patients who lived >50 km from the hospital underwent surgery at a later age than patients who lived <10 km ($p=0.04$) or between 20 and 50 km ($p=0.01$) from the hospital, as shown in Figure 2A; however, there was

Table 1. Baseline characteristics of study population

Variable (measure)	Proportion (%) or median (IQR)
N	503
Sex (%)	Male: 54 (70%)
Female: 149 (30%)	
Followup (mo)	24 (12, 46)
Geographic distance (km)	31 (17, 51)
Number of US (per patient)	2 (2, 6)
Number with renogram (%)	475 (94%)
Age at surgery (months)	16 (5, 92)
Surgical approach	Open: 301 (60%) Laparoscopic: 166 (33%) Laparoscopy-assisted: 23 (5%) Robotic: 13 (3%)
Length of stay (days)	1 (1, 2)
30-day emergency department visit (%)	Total: 83 (17%) UTI: 26 (31%) Stent colic: 24 (29%) Pain: 15 (18%) Incision problem: 5 (6%) Fever: 11 (13%) Other: 2 (2%)
30-day re-admission (%)	29 (6%)
Year of surgery	2008–2011: 144 (28.6%) 2011–2016: 221 (43.9%) 2016–2019: 138 (27.4%)
Preoperative APD on US (mm)	22 (16, 30)
Preoperative split kidney function, affected kidney (%)	43 (36, 54)

APD: anteroposterior diameter; IQR: interquartile range; US: ultrasound; UTI: urinary tract infection.

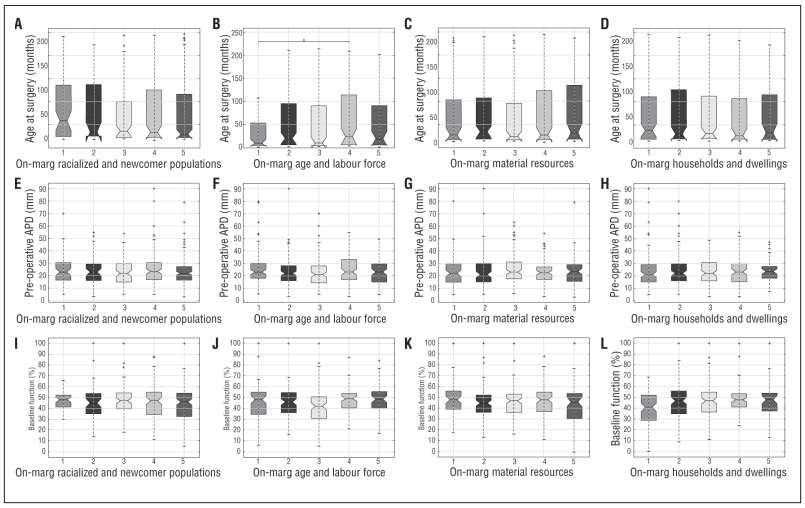

Figure 1. (A–D) Age at surgery by ON-Marg dimensions. (E–H) Preoperative anteroposterior diameter (APD) by ON-Marg dimensions. (I–L) Baseline split renal function on diuretic renogram by ON-Marg dimensions. Statistical comparison with Kruskal-Wallis with post-hoc Dunn-Sidak test (*p<0.05).

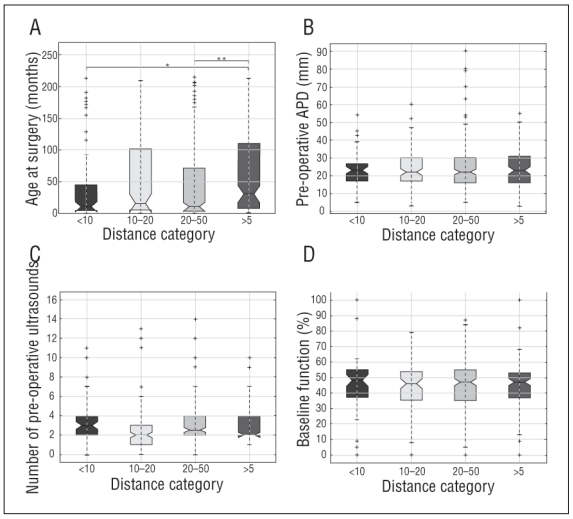

Figure 2. (A) Age at surgery. (B) Preoperative anteroposterior diameter (APD). (C) Number of ultrasounds prior to surgical decision. (D) Baseline split renal function by distance from institution. Statistical comparison with Kruskal-Wallis with post-hoc Dunn-Sidak test (*p<0.05, **p<0.01).

no difference between distance categories and preoperative APD (Figure 2B), number of ultrasounds performed per patient prior to surgical indication (Figure 2C), or baseline split renal function (Figure 2D).

Among 236 patients (47%) who underwent surgery within one year of life, there was no significant difference in age at surgery across categories for distance from hospital or in quintiles for racialized and newcomer populations, age and labor force, material resources, or households and dwellings.

The rates of 30-day emergency department visits were not significantly associated with racialized and newcomer populations (p=0.27), age and labor force (p=0.85), material resources (p=0.41), households and dwellings (p=0.38), or distance to hospital (p=0.30).

Adjusted association with marginalization and geography

On Cox proportional hazards regression, none of the ON-Marg dimensions or geographic categories were significantly associated with age at pyeloplasty (Figure 3). Similarly, when assessing each ON-Marg or geographic category independently while adjusting for patient sex and preoperative APD, there was no significant association with age at time of surgery.

DISCUSSION

Reliable measures are critical to understand and mitigate inequalities in access to care. The present study employs two robust indicators of potential disparities, applying them to a common pediatric urologic condition that has been previously recognized as susceptible to sociodemographic factors.[4,5] The ON-Marg, a deprivation index, has been extensively employed to analyze how area-based marginalization impacts health inequalities at a granular community level.[8,9] The aggregate score, as well as its four dimensions, have been associated with health and social gradients when stratified by quintiles. Similarly, the distance a family travels to receive care for their child is a common metric used in health services research. Despite limitations, distance to care can be used as a tool for identifying high-risk populations and exploring regional differences in health outcomes.[10,11]

Our findings indicate that marginalization is not associated with the timing of pediatric pyeloplasty, while there may be a weak association between geographic distance from hospital and scheduling surgery; however, distance from hospital loses statistical significance on multivariable adjustment. The findings regarding certain pairwise differences with greater distance from hospital resulting in later age at surgery for patients distant from hospital was not consistently detected across groups.

Moreover, when assessing timing of surgery, there was no significant trend towards urban or suburban patients receiving surgery at a younger age. Therefore, there is an absence of a strong association between geographic accessibility and age at surgery within this population. Overall, these findings indicate that the selected variables do not impact surgical management of UPJO, which contrasts with prior studies from the U.S. that had revealed discrepancies in surgery timing based on sociodemographic factors.

Single-payer, universal healthcare systems have the potential to facilitate and democratize pediatric surgical care.[12] In contrast, other important factors — namely insurance status and hospital type — have been shown to affect timing of surgery in analyses of pediatric cohorts and administrative databases from multiple-payer systems.[4,6,7] These variables do not play a major role in Canada's pediatric surgical care, which is more centralized than adult urologic care.

In the Canadian system, all individuals have the right to care, regardless of their socioeconomic status. Nevertheless, this utopic principle may be affected by barriers that go beyond coverage for the cost of care. Of these, the ability to navigate the system and to reach centers that provide care is concerning. The current research aimed to address that by exploring two important variables that reflect critical geographic and demographic factors. Reassuringly, we found no impact, which highlights one of the benefits of the Canadian healthcare system.

Limitations

This study should be interpreted considering several limitations.

First, we assessed timing of surgery and indications, which are inherently subjective outcomes and vary between institution. For example, our institution relies heavily on ultrasound metrics to determine indication, and if ultrasound parameters and morphology suggest UPJO with worsening dilation, we will forego renogram for upfront pyeloplasty; however, the summarized measures of ultrasound and renogram parameters are generally accepted as fair indications for pyeloplasty. In addition, we included a subgroup analysis of children who underwent surgery <1 year, who predominantly consist of asymptomatic prenatal hydronephrosis referrals, a population that is often challenging, as some providers rely on multiple ultrasounds or renogram results before offering surgery.

Second, ON-Marg-determined marginalization quintiles reflect community characteristics, thus making the case for a strong correlation with individual socioeconomic status complicated. This could introduce error in assessing the association with timing of surgery; however, there is literature validating ON-Marg indices as reliable and valid measures for social disadvantage.[13,14]

Third, the population treated at our institution is quite diverse, as shown by information from the Canadian census;[15] however, race data was not collected reliably enough to be reported upon.

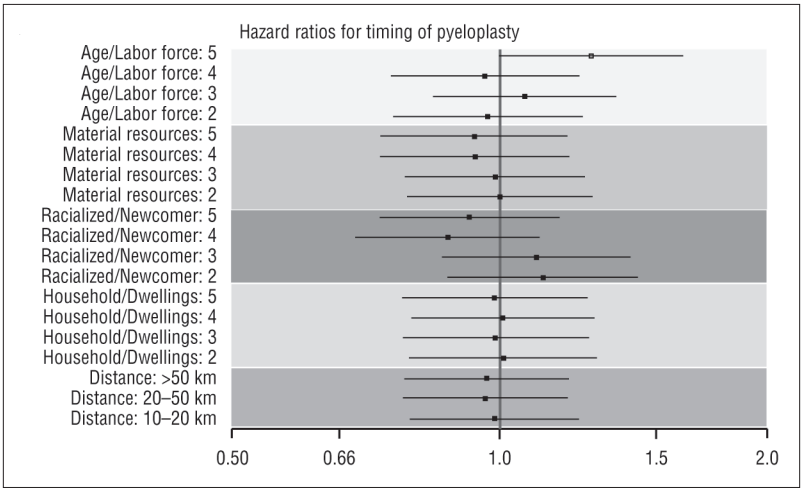

Figure 3. Hazards ratio for age at pyeloplasty from Cox regression model, for each ordinal factor. In the case of geographic distance, the reference odds ratio of 1.00 is distance <10 km. In cases of ON-Marg indices, the reference odds ratio of 1.00 is a quintile of 1 (least marginalized).

Lastly, the analysis conducted in this work reflects the practice at a single quaternary care center in Canada and may not reflect the practice patterns of other pediatric institutions within Canada.

Despite these limitations, we propose that there is value in the presented information. Social disparities, immigration status, and income inequality impact marginalization and distance to major centers located at the heart of metropolitan areas. Our data supports the notion that by removing insurance status as a variable, the absence of significant differences indicates that access to timely pediatric surgical care can be improved by adopting a system that ensures equal coverage for all children.[16]

CONCLUSIONS

Marginalization indices and geographic distance were not significantly associated with timing of pyeloplasty in our institution. These results contrast previous literature from the U.S., where sociodemographic variables impact the decision for early surgery.

COMPETING INTERESTS: The authors do not report any competing personal or financial interests related to this work.

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