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National Analysis of Secular Trends and Racial Disparities in Age at Kasai Hepatoportoenterostomy for Infants with Biliary Atresia, 2005-2025

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Introduction

Biliary atresia (BA) is the leading indication for pediatric liver transplant.[1] Age at Kasai hepatoportoenterostomy (HPE) is a critical determinant of time to transplant.[2] A recent multicenter study demonstrated that each one-day delay in age at HPE decreases the odds of transplant-free survival by 2%.[3] Prior analyses have suggested that non-White infants in the United States (US) undergo HPE later than White infants,[4–6] but more recent data are unexplored. We examined secular trends in age at HPE over the past two decades and assessed whether the racial gap in age at HPE has changed over time.

Methods

All infants with BA who underwent HPE between 1/1/2005-12/31/2025 were identified within the Pediatric Health Information System, an administrative database of tertiary care children's hospitals in the US (**eMethods, eFigure1, eTable1**, Supplemental Digital Content 1, http://links.lww.com/SLA/F832). For descriptive purposes, we grouped study years into 3-year intervals. We examined associations between calendar year and age at HPE at the 10th, 25th, 50th (median), 75th, and 90th percentiles using quantile regression models with cluster robust bootstrapped confidence intervals at the hospital level. Quantile regression can estimate exposure effects across an outcome distribution, including the extremes.[7] Models were adjusted for race/ethnicity (non-Hispanic White vs. non-White) and included a year-race interaction term. As a sensitivity analysis, we fit linear regression models with robust standard errors. Data were analyzed in Python (v3.13.15).

This study was deemed exempt from review by the UCSF Institutional Review Board given that only deidentified data were used. We adhered to the STROBE reporting guidelines.

Results

Among 2,507 infants with BA who underwent HPE at 48 children's hospitals from 2005–2025, 55% (n=1,372) were non-White. Median age at HPE declined from 62 days (IQR 48-75) in 2005 to 56 days in 2025 (IQR 41-73). **Figure 1** illustrates secular trends in age at HPE, stratified by race, at the 10^{th}, 50^{th}, and 90^{th} percentiles of the age distribution.

In the unadjusted model, median age at HPE declined by 0.57 days per year (95% CI −0.85, −0.27), corresponding to an 11.4-day reduction over the 21-year study period. Similar trends were observed at other quantiles across the age at HPE distribution. After race/ethnicity and a year-race interaction term were added to the models, we observed a consistent baseline disparity in age at HPE between non-White and White infants, increasing from a 6-day difference for infants undergoing very early HPE (10^{th} percentile; 95% CI 0.50, 11.00) to a 16-day difference for those undergoing very late HPE (90^{th} percentile; 95% CI 8.33, 26.69). The year-race interaction terms were negative, indicating narrowing in the racial gap over time, but reached statistical significance only at the 10^{th} and 25^{th} percentiles (**Table 1**).

In sensitivity analyses, mean age at HPE was 9 days higher among non-White infants (95% CI 4.47, 12.87), adjusted for calendar year, and the year-race interaction was significant (β= -0.38, 95% CI -0.67, -0.09) (**eTable 2**, Supplemental Digital Content 1, http://links.lww.com/SLA/F832).

Discussion

Our analysis illustrates meaningful progress in timely surgical care for infants with BA. We observed an 11-day decrease in median age at HPE over the past 21 years, which is clinically significant given that every one-day delay in age at HPE has been associated with 2% lower odds of bilirubin normalization at three months as well as 2% lower odds of transplant-free survival in recent multicenter studies.[3,8] However, we also identified baseline racial disparities, as non-White infants underwent HPE significantly later than White infants in 2005; the largest disparities were seen among infants undergoing delayed surgeries. This baseline racial gap narrowed across the study period, but statistical significance was limited to early HPE, with no significant improvement at or above the median.

BA is typically diagnosed after 2-4 weeks of life, and expeditious surgical intervention depends on prompt diagnosis and rapid coordination of care between outpatient pediatricians, gastroenterologists, and pediatric surgeons.[8,9] Universal screening programs using stool color cards and fractionated serum bilirubin levels have been implemented abroad, but not in the US.[10] Hospital- and regional-level efforts to improve early BA diagnosis and referral[9,10] may have contributed to the overall decline in age at HPE observed in our analysis. However, pronounced disparities and the persistent racial gap seen for infants undergoing delayed surgery suggest these broad efforts may not fully address barriers to timely care for all infants; thus, additional targeted interventions to support structurally minoritized patients will also be needed.

Study strengths include our use of quantile regression to illustrate a nuanced pattern of trends and disparities over time. Limitations include potential misclassification bias and inaccuracies in race reporting. Additionally, we excluded infants who underwent upfront liver transplant. Future studies should investigate potential racial differences in incidence of liver transplant without prior HPE due to late diagnoses.

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Figure 1. Secular trends in age at Kasai Hepatoportoenterostomy, stratified by White vs Non-White, at the 10th, 50th, and 90th percentiles of the age distribution.

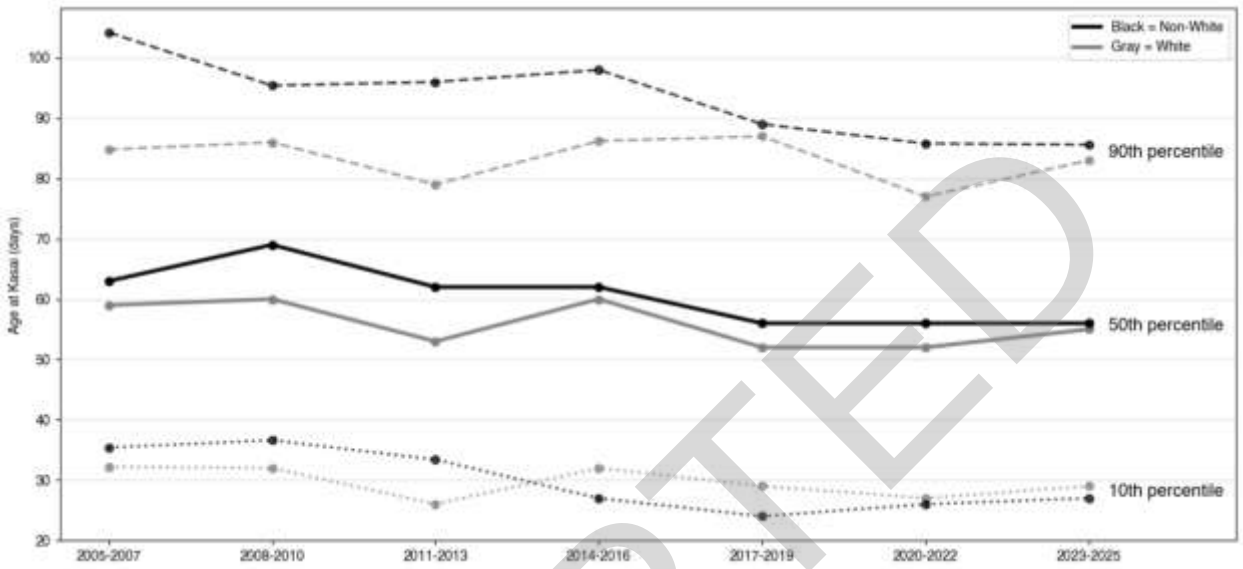

Table 1. Change in age at Kasai by calendar year and race, 2005-2025.

	Change in Age at Kasai, β (95% CI), days				
	10th percentile	25th percentile	50th percentile (median)	75th percentile	90th percentile
Unadjusted model					
Calendar year since 2005	-0.50 (-0.81, -0.20)*	-0.50 (-0.83, -0.2)*	-0.57 (-0.85, -0.27)*	-0.38 (-0.64, -0.25)*	-0.63 (-1.0, 0.00)*
Adjusted model					
Calendar year since 2005 for White infants	-0.17 (-0.58, 0.11)	-0.29 (-0.58, 0.00)	-0.30 (-0.63, 0.00)	-0.33 (-0.56, -0.08)*	-0.14 (-0.50, 0.36)
Non-White vs. White infants in 2005	6.44 (0.50, 11.00)*	7.67 (2.33, 11.45)*	9.13 (4.00, 13.71)*	8.17 (2.23, 12.64)*	16.32 (8.33, 26.69)*
Calendar year x non-White interaction[a]	-0.65 (-0.96, -0.11)*	-0.41 (-0.76, -0.03)*	-0.37 (-0.76, 0.00)	-0.29 (-0.60, 0.17)	-0.77 (-1.50, 0.00)

Unadjusted and adjusted results of quantile regression models at the 10th, 25th, 50th (median), 75th, and 90th percentiles of the age distribution are shown. Abbreviations: β – beta; CI – confidence interval.

[a] Interaction term represents the difference in change in age at Kasai per calendar year between non-White and White infants.

* $p<0.05$.