OPTN

Briefing to the OPTN Board of Directors on

Refit Kidney Donor Profile Index without Race and Hepatitis C Virus

OPTN Minority Affairs Committee

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Refit Kidney Donor Profile Index without Race and Hepatitis C Virus

Affected Policies: *8.4.B: Deceased Donor Classifications*
Sponsoring Committee: *Minority Affairs*
Public Comment Period: *January 23, 2024- March 19, 2024*
Board of Directors Meeting: *June 17-18, 2024*

Executive Summary

The Kidney Donor Profile Index (KDPI) is a measure that combines deceased donor factors including clinical parameters and demographics to summarize the quality of deceased donor kidneys into a single number.[1] Lower KDPI scores are associated with longer estimated organ function, while higher KDPI scores are associated with shorter estimated organ function and an increased chance of organ non-use.[2] Currently, kidneys from African American/Black and Hepatitis C virus (HCV) positive deceased donors have an increased KDPI of up to 20% for each factor.[3] Race is a poor proxy for human genetic variation and due to innovations in treatment, post-transplant outcomes for HCV positive deceased donor kidney transplants are similar to that of HCV negative donor kidneys.[4,5] These factors inflate the KDPIs of deceased donor kidneys from African American/Black and HCV positive donors. The OPTN Minority Affairs Committee (the Committee) proposes refitting the KDRI (Kidney Donor Risk Index) and subsequently the KDPI calculation without race or HCV donor factors to better reflect the likelihood of graft failure for kidneys from African American/Black and HCV positive deceased donors.[6] The Committee reviewed all feedback and determined no post- public comment changes were needed.[7]

Purpose

The Committee proposes refitting the KDRI calculation without race or HCV and re-mapping to KDPI to better reflect the likelihood of graft failure for kidneys from African American/Black and HCV positive deceased donors.[8]

[1] Organ Procurement and Transplantation Network. April 19, 2023. A Guide to Calculating and Interpreting the Kidney Donor Profile Index (KDPI). Retrieved November 10, 2023, from https://optn.transplant.hrsa.gov/media/j34dm4mv/kdpi_guide.pdf.
[2] Kadatz M, Gill J, Gill J. Lan J, McMichael L, Chang D, Gill J (2023). The Benefits of Preemptive Transplantation Using High-Kidney Donor Profile Index Kidneys. Clinical Journal of the American Society of Nephrology. 18(5):p 634-643 doi: 10.2215/CJN.0000000000000134.
[3] Rao P, Schaubel D, Guidinger MK, Andreoni KA, Wolde RA, Merion RM, Port FK, Sung RS. (2009) A Comprehensive Risk Quantification Score for Deceased Donor Kidneys: The Kidney Donor Risk Index. Transplantation, 88(2), 231–6.doi: 10.1097/TP.0b013e3181ac620b.
[4] Ibid.
[5] Miller J, Lyden GR, McKinney WT, Snyder JJ, Israni AK. (2023). Impacts of removing race from the calculation of the kidney donor profile index. American Journal of Transplantation, 23(5):636-641. https://doi.org/10.1016/j.ajt.2022.12.016.
[6] See OPTN Minority Affairs Committee meeting summary. September 18, 2023. https://optn.transplant.hrsa.gov/media/wogcgpiq/20230918_mac_summary.pdf.
[7] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/

[8] See OPTN Minority Affairs Committee meeting summary. September 18, 2023. https://optn.transplant.hrsa.gov/media/wogcgpiq/20230918_mac_summary.pdf.

Background

The KDPI is a measure that combines deceased donor factors including clinical parameters and demographics to summarize the quality of deceased donor kidneys into a single number.[9]

In 2009, Rao et al. proposed KDRI as an improvement to Expanded Criteria Donor (ECD).[10] Before the use of KDRI, kidneys were considered ECD if:

1. the donor age was more than or equal to 60 years **or**
2. the donor age was 50 to 59 years, with at least **two** of the following criteria:
    a. serum creatinine more than 1.5 mg/dL
    b. death due to cerebrovascular accident
    c. history of hypertension

In the development of KDRI, Rao et al. sought a more granular tool to assess the risk associated with deceased donor organs with varying characteristics, including those known to influence graft failure.[11] All donor factors potentially associated with graft failure rates were included in the initial model. These factors included:

- age
- race
- sex
- height
- weight
- cause of death
- donation after cardiac death
- serum creatinine
- diabetes
- hypertension
- cigarette use
- hepatitis C virus (HCV) positivity
- pulsatile perfusion
- cold ischemia time
- organ sharing (local, regional, and national)
- human leukocyte antigen (HLA) mismatch score
- year of transplant
- en bloc transplant
- double transplant
- ABO compatibility.

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[9] Organ Procurement and Transplantation Network. April 19, 2023. A Guide to Calculating and Interpreting the Kidney Donor Profile Index (KDPI). Retrieved November 10, 2023, from https://optn.transplant.hrsa.gov/media/j34dm4mv/kdpi_guide.pdf.
[10] Rao P, Schaubel D, Guidinger MK, Andreoni KA, Wolde RA, Merion RM, Port FK, Sung RS. (2009) A Comprehensive Risk Quantification Score for Deceased Donor Kidneys: The Kidney Donor Risk Index. Transplantation, 88(2):231–6.doi: 10.1097/TP.0b013e3181ac620b.
[11] Ibid.

After analysis, the model was refined to exclude donor factors with non-significant effects on graft failure.[12] The remaining factors included:

- age
- weight
- height
- race
- serum creatine
- history of Hypertension
- history of Diabetes
- cause of death
- HCV status
- HLA mismatch/transplant parameter
- cold time
- en bloc transplant
- double kidney transplant.

Each factor's hazard ratio for graft failure was assigned by comparison with a reference donor.[13] A hazard ratio describes the chance of the event occurring for one group versus another. A hazard ratio of 1 means that the chance of graft failure is the same, but a hazard ratio greater than 1 means that the risk of the event, graft failure, is higher. The model was compared to the rate of graft failure for a "reference donor", that was representative of a healthy 40-year-old deceased donor. Based on this comparison, a hazard ratio of 1.20 was assigned to African American/Black deceased donor kidneys and a hazard ratio of 1.27 was assigned to HCV positive deceased donor kidneys. The authors of the study concluded that characteristics that influence graft outcomes into one metric conferred major advantages over its binary predecessor, ECD.

KDPI in OPTN Policy

The OPTN started using KDPI in 2014 as part of the implementation of the Kidney Allocation System (KAS).[14] Currently, the OPTN KDPI calculator includes ten donor factors: [15, 16]

- age
- height
- weight
- race
- history of hypertension
- history of diabetes

[12] Rao P, Schaubel D, Guidinger MK, Andreoni KA, Wolde RA, Merion RM, Port FK, Sung RS. (2009) A Comprehensive Risk Quantification Score for Deceased Donor Kidneys: The Kidney Donor Risk Index. Transplantation, 88(2): 231–6.doi: 10.1097/TP.0b013e3181ac620b.

[13] Characteristics of the reference donor included: 40-year-old, non-African American race, serum creatinine 1.0 mg/dL, non-hypertensive, non-diabetic, cause of death other than cerebrovascular accident, height 170 cm, weight more than or equal to 80 kg, brain dead donor (not donation after cardiac death), and HCV negative.

[14] Organ Procurement and Transplantation Network. September 17, 2014. The New Kidney Allocation System (KAS) Frequently Asked Questions. Retrieved November 10, 2023, from https://optn.transplant.hrsa.gov/professionals/by-topic/guidance/the-new-kidney-allocation-system-kas-frequently-asked-questions/#bookmark5.

[15] The KDPI displayed on the OPTN calculator, is the scaled, donor-only version of the KDRI. As explained in Rao, et al, several factors pertaining to the recipient and/or transplant procedure (cold ischemic time, degree of HLA mismatching, single vs. double vs. en-bloc kidneys) can also be used to calculate a "full" KDRI.

[16] Organ Procurement and Transplantation Network. KDPI calculator. Retrieved November 11, 2023, from https://optn.transplant.hrsa.gov/data/allocation-calculators/kdpi-calculator/.

- cause of death
- serum creatinine
- HCV Status from serological or nucleic acid test (NAT)
- donation after circulatory death (DCD) status

The KDPI is derived by first calculating the KDRI for a deceased donor, as KDPI is a mapping of the KDRI into a cumulative percentage scale. The KDRI is an estimate of the relative risk of post-transplant kidney graft failure for a given donor compared to the median/reference kidney donor. KDRI is translated into a KDPI percentage from 0 – 100% for the purposes of OPTN allocation.[17] Lower KDPI scores are associated with longer estimated function, while higher KDPI scores are associated with shorter estimated function. For example, a donor with a KDPI of 9% has a higher expected risk of graft failure than 9% of all kidney donors recovered last year. A donor with a KDPI of 82% has a higher expected risk of graft failure than 82% of all kidney donors recovered last year.

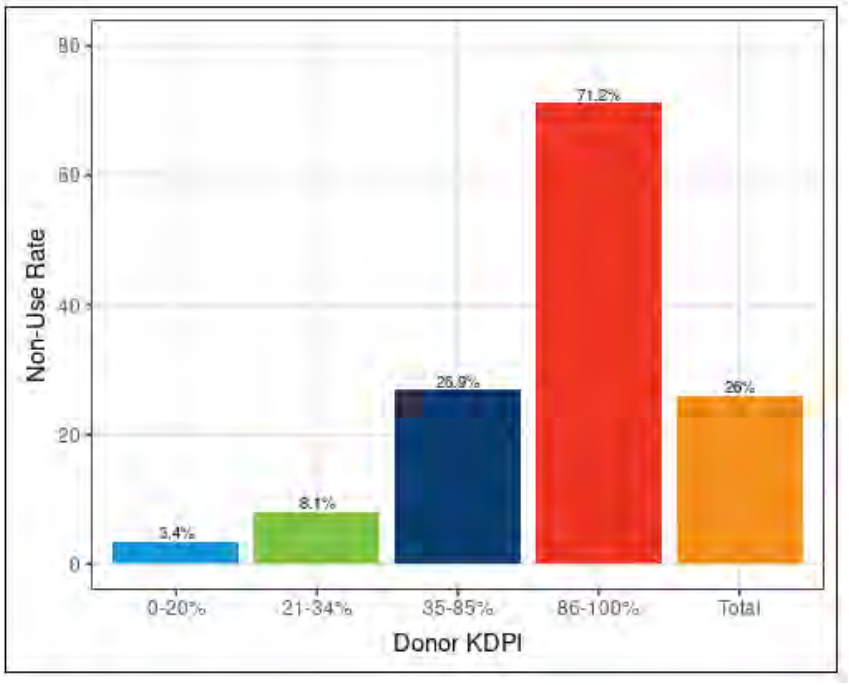
There are four KDPI categories, known as allocation sequences:

- Sequence A: 0-20%
- Sequence B: 21-34%
- Sequence C: 35-85%
- Sequence D: 86-100%

These KDPI sequences are used to allocate deceased donor kidneys to candidates based on candidate clinical information outlined in *OPTN Policy: 8.4 Kidney Allocation Classifications and Rankings.*
Kidneys in Sequence D (86-100% KDPI) can be more challenging to place and have a greater chance of non-use.[18] **Figure 1** shows the non-use of deceased donor kidneys from 03/15/2021 – 03/15/2023 by KDPI sequence. 26% represents the percent of all recovered kidneys that were recovered for transplant, but not ultimately transplanted. 71.2% represents the number of 86-100% kidneys that were recovered for transplant but were ultimately not transplanted. This means 26% can be described as the overall non-use rate for kidneys and 71.2% is the non-use rate for kidneys with 86-100% KDPI.

[17] Organ Procurement and Transplantation Network. April 19, 2023. A Guide to Calculating and Interpreting the Kidney Donor Profile Index (KDPI). Retrieved November 10, 2023, from https://optn.transplant.hrsa.gov/media/j34dm4mv/kdpi_guide.pdf.
[18] Kadatz M, Gill J, Gill J. Lan J, McMichael L, Chang D, Gill J (2023). The Benefits of Preemptive Transplantation Using High-Kidney Donor Profile Index Kidneys. Clinical Journal of the American Society of Nephrology. 18(5):p 634-643 doi: 10.2215/CJN.0000000000000134.

Figure 1. Non-use of deceased donor kidneys from 03/15/2021 – 03/15/2023 by KDPI



Transplant professionals use the KDPI to help make informed decisions about donor organ suitability for their candidates.[19] The KDPI serves as a tool for evaluating organ quality when deceased donor kidney offers are made but is not intended to serve as the only metric for determining donor suitability.[20] *OPTN Policy 5.3.C: Informed Consent for Kidneys Based on KDPI Greater than 85%* requires transplant programs to obtain written, informed consent from each kidney candidate willing to receive offers for kidneys in allocation Sequence D.

Race

Recently the medical field and kidney patient advocacy groups have called for the removal of race in algorithms and calculators, asserting that race is a poor proxy for human genetic variation because it is a social construct that lacks biological meaning.[21, 22] Racial identity fluctuates from person to person, making it neither discrete nor measurable when used as a variable in medicine.[23] In 2022, Samira Farouk noted that including race factors in medical calculations reinforces beliefs regarding the inferiority of minoritized groups and contributes to inequities and healthcare disparities.[24]

[19] Organ Procurement and Transplantation Network. September 17, 2014. The New Kidney Allocation System (KAS) Frequently Asked Questions. Retrieved November 10, 2023, from https://optn.transplant.hrsa.gov/professionals/by-topic/guidance/the-new-kidney-allocation-system-kas-frequently-asked-questions/#bookmark5.

[20] Ibid.

[21] Vyas DA, Einstein LG, Jones DS. Hidden in Plain Sight — Reconsidering the Use of Race Correction in Clinical Algorithms. The New England Journal of Medicine. 2020. 383(9): 874-882.

[22] Delgado, C., Baweja, M., Crews, D. C., Eneanya, N. D., Gadegbeku, C. A., Inker, L. A., et al.Powe, N. R. (2022, February). A unifying approach for GFR estimation: Recommendations of the NKF-ASN task force on reassessing the inclusion of race in diagnosing kidney disease. Am J Kidney Dis, 79(2), 268–288.e1. 10.1053/j.ajkd.2021.08.003.

[23] AMA J Ethics. 2022;24(3):E226-232. doi: 10.1001/amajethics.2022.226.

[24] Farouk S. (2022). Reenvisioning the Kidney Donor Risk Index without Race. Kidney News Online. 14(1) p:9-10. Retrieved November 11, 2023, from https://www.kidneynews.org/view/journals/kidney-news/14/1/kidney-news.14.issue-1.xml.

When KDRI was developed in 2009, race was often used as a proxy for genetic difference.[25] The contemporary medical understanding acknowledges that using race in KDRI, and subsequently KDPI, inflates the KDPI of African American/Black donor kidneys, making them appear of lower quality.[26]

Currently, the race coefficient in the KDRI increases the hazard ratio for graft failure by 1.2 and the KDPI by up to 20%, making African American/Black donor grafts appear less suitable for transplant.[27] Kidneys that appear less suitable for transplant are more challenging to place and have a higher risk of nonuse.[28] There are eight race selections available when prompted by the KDPI calculator.[29] When all other donor characteristics remain the same, African American/Black is the only race that increases the KDPI of a deceased donor kidney.[30] In **Figure 2** two kidneys with the same KDPI calculator inputs differ only by race, with one kidney from a deceased African American/Black donor and the other as White. As a result of this

coefficient, the kidney from the deceased African American/Black donor has KDPI that is 13% greater, placing it in allocation Sequence D.

[25] Rao P, Schaubel D, Guidinger MK, Andreoni KA, Wolde RA, Merion RM, Port FK, Sung RS. (2009) A Comprehensive Risk Quantification Score for Deceased Donor Kidneys: The Kidney Donor Risk Index. Transplantation, 88(2): 231–6.doi: 10.1097/TP.0b013e3181ac620b.

[26] Doshi M, Schaubel D, Xu Y, Rao P, Sung R. (2022). Clinical Utility in Adopting Race-free Kidney Donor Risk Index. Transplantation Direct. 8(7):p e1343 doi: 10.1097/TXD.0000000000001343.

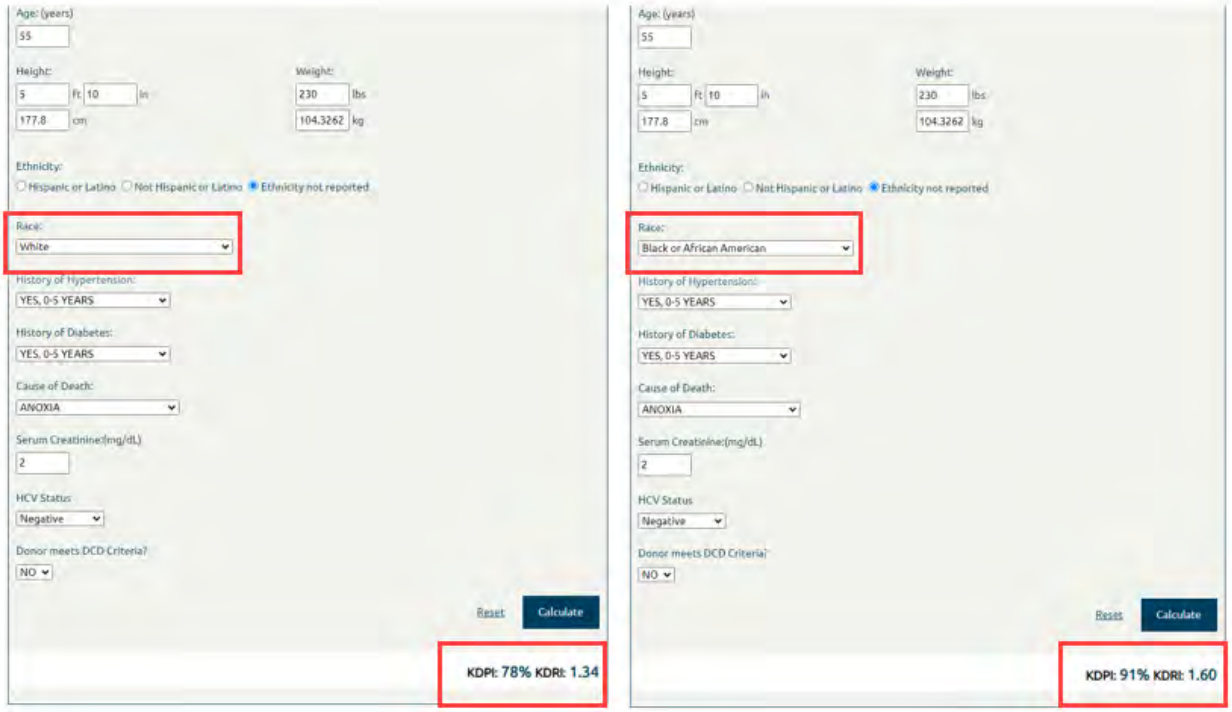
[27] Ibid.

[28] Kadatz M, Gill J, Gill J. Lan J, McMichael L, Chang D, Gill J (2023). The Benefits of Preemptive Transplantation Using High-Kidney Donor Profile Index Kidneys. Clinical Journal of the American Society of Nephrology. 18(5):p 634-643 doi: 10.2215/CJN.0000000000000134.

[29] American Indian or Alaskan Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White, Multi Racial, Race Not Reported.

[30] Organ Procurement and Transplantation Network. KDPI calculator. Retrieved November 11, 2023, from https://optn.transplant.hrsa.gov/data/allocation-calculators/kdpi-calculator/.

Figure 2. Difference in KDPI by Race



When compared to the original KDRI, recalculation with the race-free KDRI results in the shift of African American/Black donor kidneys into a lower KDPI allocation sequence.[31] Excluding race from the KDPI shifts how risk is attributed to these clinical risk factors but has no impact on the calculation's predictive ability.[32] The Scientific Registry of Transplant Recipients (SRTR) also conducted a study in which the KDRI model was refitted without the race coefficient.[33] The study resulted in a decrease of Black donors in KDPI Sequence D, from 31.09% of all Black donors to 17.75%, which is closer to the 15.68% in Sequence D among non-Black donors. The authors note that KDPI is a zero-sum measure, so the number of Black donors moving out of the top KDPI sequence would be offset by an almost equal number of non-Black donors moving into it. Their conclusion states that medical algorithms contribute to systematic bias by overemphasizing differences between groups and recommends the removal of race from the KDPI model to improve equity.

Evidence also suggests that it is not race, but the presence of the APOL1 gene 1 and gene 2 that confers a worse kidney allograft outcome.[34] Individuals who identify as Black, African American, Afro- Caribbean and Latinx are more likely to have APOL1 gene mutations, but they are only present in 13% of African Americans in the United States. Not everyone who has two copies of APOL1 genetic mutations will get kidney disease; there is a 1 in 5 chance that an individual with two copies of APOL1 will go on to develop kidney disease.[35] The National Institutes of Health (NIH) developed the APOL1 Long-term Kidney

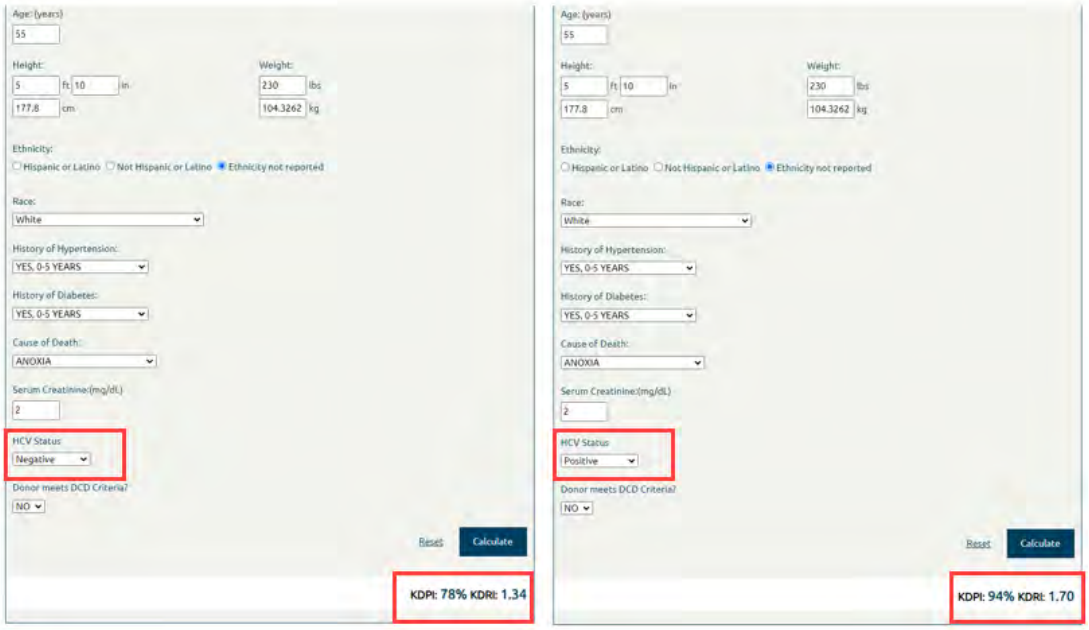
[31] Doshi M, Schaubel D, Xu Y, Rao P, Sung R. (2022). Clinical Utility in Adopting Race-free Kidney Donor Risk Index. Transplantation Direct. 8(7):p e1343 do: 10.1097/TXD.0000000000001343.
[32] Chong K, Litvinovich I, Chen, S, Zhu, Y, Argyropoulos C, Ng Y. (2021). Reconsidering Donor Race in Predicting Allograft and Patient Survival Among Kidney Transplant Recipients. Kidney360 2(11):p 1831-1835| doi: 10.34067/KID.0002932021.
[33] Miller J, Lyden GR, McKinney WT, Snyder JJ, Israni AK. (2023). Impacts of removing race from the calculation of the kidney donor profile index. American Journal of Transplantation, 23(5):636-641. https://doi.org/10.1016/j.ajt.2022.12.016.
[34] NephCure. (2023). Understanding APOL1 Kidney Disease Among Black Americans. Retrieved on November 12, 2023, from https://nephcure.org/understanding-apol1-kidney-disease-among-black-americans/.
[35] NephCure. (2023). Understanding APOL1 Kidney Disease Among Black Americans. Retrieved on November 12, 2023, from https://nephcure.org/understanding-apol1-kidney-disease-among-black-americans/.

Transplantation Outcomes (APOLLO) Consortium and began enrolling participants in 2019.[36] This study will prospectively observe the effects of renal-risk variants (RRVs) in the apolipoprotein L1 gene (APOL1) on kidney outcomes from donors with recent African ancestry and the recipients of their kidneys, after deceased- and living-donor renal transplantation.[37] The results from the APOLLO study have the potential to provide evidence for the replacement of race with APOL1 in the KDRI calculation.[38] The APOLLO study's estimated completion date is Fall 2025.[39]

HCV

Like the race coefficient, HCV positive donor kidneys are automatically designated a higher KDPI which can increase the likelihood the graft will not be used. Currently, the HCV coefficient in the KDRI calculation has a hazard ratio of 1.27 and increases the KDPI by up to 20%.[40] In **Figure 3** below two kidneys with the same KDPI calculator inputs differ only by HCV status, with one kidney from a deceased HCV negative donor and the other a deceased HCV positive donor. As a result of this coefficient, the kidney from the HCV positive donor has KDPI that is 16% greater, placing it in allocation Sequence D.

Figure 3. Difference in KDPI by HCV Status



[36] NIH US Clinical Library of Medine. June 5, 2023. APOL1 Long-term Kidney Transplantation Outcomes Network (APOLLO). Retrieved on November 12, from https://classic.clinicaltrials.gov/ct2/show/NCT03615235.
[37] Ibid.
[38] Freedman BI, Moxey-Mims MM, Alexander AA, Astor BC, Birdwell KA, Bowden DW, Bowen G, Bromberg J, Craven TE, Dadhania DM, Divers J, Doshi MD, Eidbo E, Fornoni A, Gautreaux MD, Gbadegesin RA, Gee PO, Guerra G, Hsu CY, Iltis AS, Jefferson N, Julian BA, Klassen DK, Koty PP, Langefeld CD, Lentine KL, Ma L, Mannon RB, Menon MC, Mohan S, Moore JB, Murphy B, Newell KA, Odim J, Ortigosa-Goggins M, Palmer ND, Park M, Parsa A, Pastan SO, Poggio ED, Rajapakse N, Reeves-Daniel AM, Rosas SE, Russell LP, Sawinski D, Smith SC, Spainhour M, Stratta RJ, Weir MR, Reboussin DM, Kimmel PL, Brennan DC. (2019) APOL1 Long-term Kidney Transplantation Outcomes Network (APOLLO): Design and Rationale. Kidney Int Rep. 13;5(3):278-288. doi: 10.1016/j.ekir.2019.11.022.
[39] NIH US Clinical Library of Medine. June 5, 2023. APOL1 Long-term Kidney Transplantation Outcomes Network (APOLLO). Retrieved on November 12, from https://classic.clinicaltrials.gov/ct2/show/NCT03615235.
[40] Sibulesky L, Kling CE, Limaye AP, Johnson CK. Is Kidney Donor Profile Index (KDPI) Valid for Hepatitis C Aviremic Kidneys? Ann Transplant. (2017)6;22:663-664. doi: 10.12659/aot.905428.

Including HCV positive donor kidneys as a risk factor aligns with earlier literature that suggests these grafts have inferior survival outcomes.[41] Studies completed before 2014 associated HCV positive donor kidneys and HCV infection with hepatic complications including cirrhosis and hepatocellular carcinoma (HCC) along with extrahepatic complications, including glomerulonephritis.[42, 43] Before 2014, treatments for HCV were poorly tolerated and had limited efficacy.[44]

In 2014, interferon-free direct-acting antivirals (DAAs) were approved by the FDA as treatment for HCV.[45] These drugs revolutionized HCV management as they can be taken orally, usually have few side effects, and cure more than 95% of people in 8-12 weeks.[46] When compared to HCV positive donor kidneys pre-development of DAAs, HCV positive donor kidneys from post-development of DAAs have similar 1 year patient and graft survival to HCV negative donor kidneys.[47] Since 2015, HCV positive donor kidneys transplanted into HCV negative recipients show excellent function at 12 months post-transplant.[48] In its current state, the KDRI calculation overestimates risk and underestimates quality of HCV positive deceased donor kidneys.[49, 50]

Proposal for Board Consideration

The Committee proposes removing the aforementioned race and HCV coefficients by refitting the KDRI model and re-mapping it to KDPI.[51] The removal of race and HCV aims to improve the KDRI calculation by more accurately reflecting the quality and post-transplant survival of kidneys from deceased donors who

[41] Abbott KC, Bucci JR, Matsumoto CS, Swanson JS, Agodoa LYC, Holtzmuller KC, Cruess DF, Peters TG. (2003) Hepatitis C and Renal Transplantation in the Era of Modern Immunosuppression. Journal of the American Society of Nephrology 14(11):p 2908-2918, doi: 10.1097/01.ASN.0000090743.43034.72 x.

[42] Kevin PH, Esther-Lee M, Ran T. (2005) Chronic Hepatitis C Virus Infection in Older Adults, Clinical Infectious Diseases, Volume 41(11):p 1606-12 Pages 1606–1612, https://doi.org/10.1086/497597.

[43] Johnson RJ, Gretch DR, Yamabe H, Hart, J, Bacchi CE, Hartwell P, Couser WG, Corey , Wener MH, Alper CE, Willson R (1993). Membranoproliferative Glomerulonephritis Associated with Hepatitis C Virus Infection. N Engl J Med 1993; 328:465-470 doi: 10.1056/NEJM199302183280703.

[44] D.A. Axelrod, M.A. Schnitzler, T. Alhamad, F. Gordon, R.D. Bloom, G.P. Hess, H. Xiao, M. Nazzal, D.L. Segev, V.R. Dharnidharka, A.S. Naik, N.N. Lam, R. Ouseph, B.L. Kasiske, C.M. Durand, K.L. Lentine. (2018). The impact of direct-acting antiviral agents on liver and kidney transplant costs and outcomes, American Journal of Transplantation, 18(10):p 2437-82. https://doi.org/10.1111/ajt.14895.

[45] Welch CM. March 10, 2020. Hepatitis C Treatment History Timeline. Retrieved on November 12, 2023, from https://www.hepmag.com/blog/hepatitis-c-treatment-history timeline#:~:text=1991%3A%20FDA%20approved%20the%20first,be%20the%20only%20treatment%20available.

[46] S. Department of Health and Human Services. November 30, 2022. Hepatitis C Basic Information. Retrieved on November 12, 2023, from https://www.hhs.gov/hepatitis/learn-about-viral-hepatitis/hepatitis-c-basics/index.html#:~:text=Effective%20Treatments%20Are%20Available%20for%20Hepatitis%20C,-New%20medication%20to&text=These%20treatments%20are%20much%20better,in%208%20to%2012%20weeks.

[47] Cannon RM, Locke JE, Orandi BJ, Anderson DJ, Davis EG, Mackelaite L, Dave H, Eng M, Jones CM. (2020). Impact of Donor Hepatitis C Virus on Kidney Transplant Outcomes for Hepatitis C-positive Recipients in the Direct-acting Antiviral Era: Time to Revise the Kidney Donor Risk Index? Transplantation. 104(6):1215-28. doi: 10.1097/TP.0000000000002949.

[48] Potluri VS, Goldberg DS, Mohan S, Bloom RD, Sawinski D, Abt PL, Blumberg EA, Parikh CR, Sharpe J, Reddy KR, Molnar MZ, Sise M, Reese PP. (2019). National Trends in Utilization and 1-Year Outcomes with Transplantation of HCV-Viremic Kidneys. J Am Soc Nephrol.(10):1939-51. doi: 10.1681/ASN.2019050462.

[49] Cannon RM, Locke JE, Orandi BJ, Anderson DJ, Davis EG, Mackelaite L, Dave H, Eng M, Jones CM. (2020). Impact of Donor Hepatitis C Virus on Kidney Transplant Outcomes for Hepatitis C-positive Recipients in the Direct-acting Antiviral Era: Time to Revise the Kidney Donor Risk Index? Transplantation. 104(6):1215-28. doi: 10.1097/TP.0000000000002949.

[50] Potluri VS, Goldberg DS, Mohan S, Bloom RD, Sawinski D, Abt PL, Blumberg EA, Parikh CR, Sharpe J, Reddy KR, Molnar MZ, Sise M, Reese PP. (2019). National Trends in Utilization and 1-Year Outcomes with Transplantation of HCV-Viremic Kidneys. J Am Soc Nephrol.(10):1939-51. doi: 10.1681/ASN.2019050462.

[51] See OPTN Minority Affairs Committee meeting summary. September 18, 2023. https://optn.transplant.hrsa.gov/media/wogcgpiq/20230918_mac_summary.pdf.

are African American/Black or HCV positive.[52] A more accurate determination of KDPI supports candidates being matched with donor kidneys that aligns with the priority rankings outlined in OPTN Policy. To develop this proposal, the OPTN Minority Affairs Committee convened the Refit KDPI without race and HCV Workgroup (the Workgroup) which consisted of experts and stakeholders with representation from the OPTN Kidney Transplantation, Disease Transmission Advisory (DTAC), and Patient Affairs Committees (PAC) in addition to members of the National Kidney Foundation (NKF) and the American Society of Nephrology (ASN). This Workgroup developed a data request for the SRTR, reviewed results, and made the following recommendations to the OPTN Minority Affairs Committee.

Refit KDPI

The Committee proposes the KDRI calculation be refit without the race and HCV donor characteristics.[53]

The Committee considered three options:

- Refit the KDRI model without race and HCV
- Zero out race and HCV in the KDRI model
- Replace race in KDRI model with APOL1

Refitting KDRI without race or HCV involves removing these two coefficients and recalculating the model as though they were never included. When the model is refit, the weights of the eight remaining donor characteristics will shift to account for the absence of race and HCV. This reweighting of donor characteristics may help mediate the effects of confounding variables and will show the true weight of each donor characteristic and its relation to others in the KDRI calculation. The Committee also considered using the "zero out" method to remove race. Removing race and HCV coefficients from the KDRI calculation with the "zero out" method involves changing the hazard ratios associated with race and HCV status to zero but keeping all ten variables in the model, with their hazard ratios unchanged.

The Committee briefly discussed the possibility of replacing the race variable in the KDRI model with APOL1.[54] While the results of the APOL1 Long-term Kidney Transplantation Outcomes (APOLLO) Consortium have potential to provide evidence for the replacement of race with APOL1, the completion of the study is not expected until Fall 2025.[55] The Committee determined that currently there is not enough evidence regarding APOL1's efficacy to include it in this policy, but expressed interest in reassessing it as an option when additional data is available.[56]

The Committee discussed that while some of the reviewed literature used the "zero out" method, a refit of the model, which would account for confounding variables, would be the most thorough of the three options.[57] Additionally, supporting literature by Miller et al. used SRTR data to recalculate KDRI without race using the refit method demonstrating that the option the Committee found to be the most comprehensive was also feasible from a modeling perspective.[58]

[52] Ibid.
[53] Ibid.
[54] See OPTN Minority Affairs Committee meeting summary. February 27, 2023. https://optn.transplant.hrsa.gov/media/13pkeofk/20230227_mac_summary.pdf.
[55] NIH US Clinical Library of Medine. June 5, 2023. APOL1 Long-term Kidney Transplantation Outcomes Network (APOLLO). Retrieved on November 12, from https://classic.clinicaltrials.gov/ct2/show/NCT03615235.
[56] See OPTN Minority Affairs Committee meeting summary. February 27, 2023. https://optn.transplant.hrsa.gov/media/13pkeofk/20230227_mac_summary.pdf.
[57] Ibid.
[58] Miller J, Lyden GR, McKinney WT, Snyder JJ, Israni AK. (2023). Impacts of removing race from the calculation of the kidney donor profile index. American Journal of Transplantation, 23(5):636-641. https://doi.org/10.1016/j.ajt.2022.12.016.

Impact of Removing Race and HCV on KDPI Calculation

In the early stages of the project, the Committee sought to understand what, if any greater impact refitting the model without race and HCV variables would have on the KDPI calculation. Before proceeding the Committee confirmed that their proposed changes would not alter the scale of KDRI or KDPI. This means that KDRI will still map to 100% and the number of donors in each KDPI sequence will be roughly the same, but which donors are in each KDPI sequence will change. For example, the number of donors moving to KDPI less 85% would be offset by an almost equal number of donors moving to KDPI greater than 85%. The result of this policy will not impact the overall meaning of KDPI percentages. A kidney with a KDPI of 86% today reflects that the kidney has a worse estimated graft survival than 86% kidneys recovered from the previous year's donors, and this will not change with this update.

SRTR KDPI Modeling Data Request

The Workgroup requested the SRTR recalculate the coefficients used to calculate KDPI, excluding the Black race and HCV positive donor variables, using an updated cohort of transplants.[59] The Workgroup's request to the SRTR was grouped into three categories: cohort, change in coefficients, and donor movement between KDPI sequences (**Table 1**).

Table 1. Summary of SRTR KDPI Modeling Data Request

Cohort	Change in Coefficients	Donor movement between KDPI sequences
• **Cohort dates** • **Cohort size** • **Donor and recipient demographics**	• **New coefficients** • **Coefficients with biggest change** • **Most heavily weighted coefficient** • **Model fit and summary statistics**	• **General demographics of each KDPI sequence for refit KDPI and original KDPI** • **Average change in KDPI per donor** • **Total number or percent of people moving between KDPI sequences**

Cohort

The Workgroup requested the SRTR identify the cohort of transplants used for calculating the updated KDRI coefficients. Specifically, the Committee requested information regarding cohort dates, size, and donor and recipient demographics. The Committee suggested the SRTR might consider the innovation and increased availability of HCV treatment in 2017 when selecting the cohort.[60]

[59] See Refit KDPI without Race and HCV Workgroup summary. July 27, 2023. https://optn.transplant.hrsa.gov/media/tcml4nuq/20230727_kdpi_summary.pdf.
[60] See Refit KDPI without Race and HCV Workgroup summary. July 27, 2023. https://optn.transplant.hrsa.gov/media/tcml4nuq/20230727_kdpi_summary.pdf.

Change in coefficients

The Workgroup requested the SRTR analysis include the weight shift for the remaining donor characteristics when the KDRI model is refit without race and HCV.[61] The Workgroup posed questions regarding which coefficients displayed the biggest change and are the most heavily weighted. The Committee also asked for model fit and summary statistics.

Donor movement between KDPI sequences

The Workgroup requested the SRTR analysis include the donor movement between KDPI sequences. This includes general demographics of each KDPI sequence for the refit KDPI and the original KDPI, average change in KDPI per donor, and the total number or percent of donors moving between KDPI sequences. The Committee had particular interest in donor movement in the top two KDPI sequences given an increased risk of graft non-use for donor kidneys with KDPI greater than 85%.[62]

SRTR KDPI Modeling Data Results

Cohorts

Using exclusion criteria similar to the original (Rao 2009) analysis, this updated KDRI model was fit on adult, deceased donor, kidney alone, first transplants from January 1, 2018, to December 31, 2021, and applying the additional exclusion criteria from the original analysis. The model fit cohort was chosen to only include the era after HCV+ donor to HCV– recipient transplants became more common. Therefore, the cohort window is only 4 years, compared to the 11-year window in the original analysis. A sensitivity analysis was conducted calculating model coefficients and global model fit statistics on a 10-year cohort to ensure that coefficient inferences were not substantially changed.

Table 2 displays the model fitting cohort which included 50,769 kidney transplants between January 1, 2018, and December 31, 2021. The mean donor age among these transplants was 40.06 years, 13.44% of donors were Black and 10.72% of donors were HCV positive (either antibody, NAT, or both).

[61] Ibid.
[62] Ibid.

Table 2. Model Fitting Cohort Characteristics

Variable	
n	50769
Dates	2018-01-01 to 2021-12-31
Donor Age (years): mean (sd)	40.06 (14.89)
Donor Race: n (%)	
Asian	1281 (2.52%)
Black	6824 (13.44%)
Hawaiian/Pacific Islander	137 (0.27%)
Native	396 (0.78%)
White	41904 (82.54%)
Multiracial	227 (0.45%)
Donor HCV Status: n (%)	
Positive: NAT and Antibody	3206 (6.31%)
Positive: NAT Only	103 (0.2%)
Positive: Antibody Only	2139 (4.21%)
Not Positive	45321 (89.27%)
Recipient Age (years): mean (sd)	54 (13.24)
Recipient HCV: n (%)	1904 (3.75%)
Recipient Race: n (%)	
Asian	4053 (7.98%)
Black	17830 (35.12%)
Hawaiian/Pacific Islander	288 (0.57%)
Native	484 (0.95%)
White	27658 (54.48%)
Multiracial	456 (0.9%)

1

Global Model Fit

Global model fit was calculated using discrimination (concordance, also known as the C-statistic) and calibration (Brier score). Discrimination refers to how frequently the model correctly assigns higher risk to a patient who experiences graft failure when compared with a patient who did not. A C- statistic of 1 means that the model correctly classifies outcomes 100% of the time, while .5 means the model correctly classifies outcomes 50% of the time. For models that estimate when a certain patient would have graft failure, calibration describes how far the estimate is from when the patient actually had graft failure.

Global model fit results showed that concordance and Brier scores do not change substantially in either the HCV era cohort (transplants from 2018 through 2021) or the 11-year cohort (transplants from 2011 through 2021). Model concordance for HCV positive donors, which is particularly poor in the 11-year cohort, is substantially improved when using the 2018 through 2021 HCV era cohort. Among African American/Black donors, the concordance is lower in the HCV era cohort than in the 11-year cohort, but this difference is small when compared to the improvement in concordance among HCV positive donors in moving from the 11-year to the HCV era cohort. The Committee and the SRTR agreed that when comparing the two cohorts, a greater concordance in the HCV era supported using this cohort for estimating updated KDRI coefficients. They also discussed that in the HCV cohort overall, internal concordance was about 0.6 and did not change substantially when race and HCV status variables were removed from the model fitting.

Change in Coefficients

When recalculating the original KDRI models on the HCV era cohort (transplants from 2018 through 2021), the donor Black race coefficient was only slightly lower. Donor HCV positive status coefficient was substantially lower and became slightly protective (had a negative coefficient) but was not statistically significant. This non-significance of HCV status can be attributed to the change in treatment of recipients of HCV positive kidneys. When the donor Black race and donor HCV status variables were removed, only the two HLA DR mismatch coefficient changed more than 10% (making a change from 0.0103 to 0.0139). All coefficients for donor specific variables that would be used in the calculation of allocation KDRI changed less than 10%.

Table 3 displays the variables retained in the final model, compared to the original coefficients calculated by Rao (2009), donor diabetes status and donor DCD status were notably stronger in the HCV era (2018 through 2021) cohort. The donor diabetes status and donor DCD status coefficients were not as strong in the updated 11-year cohort (2011 through 2021).

Table 3. Original and updated KDRI coefficients

Variable	Original Coefficients	Recreation of Original Coefficients	Recreation without Race and HCV Variables	Percent Change without Race and HCV
Donor Age Less than 18 spline	-0.0194	0.0125	0.0113	-9.68
Donor Age	0.0128	0.0097	0.0092	-5.41
Donor Age greater than 50 spline	0.0107	0.0063	0.0067	5.87
Donor Black Race	0.1794	0.1534		
Donor Creatinine	0.2198	0.1962	0.2128	8.43
Donor Creatinine greater than 1.5 spline	-0.2093	-0.2027	-0.2199	8.48
Donor Hypertension	0.1262	0.1017	0.1106	8.82
Donor Diabetes	0.1301	0.2528	0.2577	1.91
Cause of Donor Death: Stroke	0.0881	0.0685	0.0743	8.53
Donor Height	-0.0464	-0.0571	-0.0557	-2.37
Donor Weight less than 80 spline	-0.0199	-0.0332	-0.0333	0.35
Donation after Cardiac Death	0.1329	0.2022	0.1966	-2.77
Donor HCV Positive	0.2403	-0.0405		
Zero HLA-B mismatches	-0.0766	-0.0693	-0.0759	9.43
One HLA-B mismatch	-0.0610	-0.0543	-0.0542	-0.19
Zero HLA-DR mismatches	-0.1300	-0.0683	-0.0698	2.14
Two HLA-DR mismatches	0.0765	0.0103	0.0139	33.96
Cold Ischemia Time	0.0055	0.0094	0.0093	-0.53
Enbloc Transplant	-0.3640	-0.1915	-0.1925	0.53
Double Kidney Transplant	-0.1480	-0.2338	-0.2208	-5.56

Donor movement between KDPI sequences

Table 4 shows that among Black donors, the probability of being classified as KDPI less than 20 increased notably and the probability of being classified as KDPI greater than 85 decreased notably when the Black race and HCV variables were removed from the model after recreating the original coefficients. Among HCV positive donors, there were notable decreases in the probability of being classified as KDPI less than 20 when the Black race and HCV variables were removed from the model after recreating the original coefficients.

Table 4. Donor characteristics by KDPI sequence for the original coefficients and fit without race.

Variable	Recreation of Original Coefficients: Mean KDRI	Recreation without Race and HCV Variables: Mean KDRI	Recreation of Original Coefficients, KDPI <= 20: n (%)	Recreation without Race and HCV Variables, KDPI <= 20: n (%)	Recreation of Original Coefficients, KDPI 21 to 35: n (%)	Recreation without Race and HCV Variables, KDPI 21 to 35: n (%)	Recreation of Original Coefficient, KDPI 36 to 85: n (%)	Recreation without Race and HCV Variables, KDPI 36 to 85: n (%)	Recreation of Original Coefficients, KDPI > 85: n (%)	Recreation without Race and HCV Variables, KDPI > 85: n (%)
Overall	1.325393	1.303475	8451 (18.31%)	8451 (18.31%)	6606 (14.31%)	6598 (14.29%)	23484 (50.88%)	23445 (50.79%)	7618 (16.5%)	7665 (16.61%)
Race										
Black Donor	1.494399	1.296553	448 (6.58%)	1455 (21.36%)	907 (13.32%)	949 (13.93%)	3501 (51.4%)	3205 (47.06%)	1955 (28.7%)	1202 (17.65%)
Non-Black Donor	1.296139	1.304673	8003 (20.34%)	6996 (17.78%)	5699 (14.48%)	5649 (14.36%)	19983 (50.79%)	20240 (51.44%)	5663 (14.39%)	6463 (16.43%)
HCV Status										
HCV NAT and Antibody Donor	1.169778	1.202222	735 (27.27%)	481 (17.85%)	601 (22.3%)	606 (22.49%)	1160 (43.04%)	1390 (51.58%)	199 (7.38%)	218 (8.09%)
HCV NAT Only Donor	1.112407	1.144338	34 (36.96%)	25 (27.17%)	17 (18.48%)	18 (19.57%)	37 (40.22%)	45 (48.91%)	4 (4.35%)	4 (4.35%)
HCV Antibody Only Donor	1.311541	1.297358	262 (14.2%)	239 (12.95%)	330 (17.89%)	314 (17.02%)	994 (53.88%)	1024 (55.5%)	259 (14.04%)	268 (14.53%)
HCV Not Positive	1.336580	1.310671	7420 (17.87%)	7706 (18.56%)	5658 (13.62%)	5660 (13.63%)	21293 (51.28%)	20986 (50.54%)	7156 (17.23%)	7175 (17.28%)

The Committee discussed that movement of African American/Black donors out of the KDPI greater than 85 group into lower KDPI groups was an expected result that reflects the over-representation of African American/Black and HCV positive deceased donor kidneys in high KDPI sequences. When looking at the results for HCV positive donors, the Committee discussed the movement of HCV positive kidneys from the KDPI less than 20 group into higher sequences reflects what happens when HCV is included in the model with a more recent cohort and then removed.

Overall, the results of the data request found that coefficients from an updated KDRI model refit on transplants from 2018 through 2021 and removing the donor HCV status and donor Black race variables resulted in more racially equitable KDPI distributions. Based on review of these results, the Committee confirmed the presented evidence provided substantial rationale to move forward with this proposal to refit KDPI without race or HCV.

Post-Public Comment Discussion

The Committee reviewed and discussed the results of public comment and concluded the public sentiment supports sending the proposal to the Board with no changes.[63] Based on public comment feedback, the Committee submitted and reviewed an additional, more detailed modeling request for global model fit analyses and reporting of all recipient coefficients from the recalculation of KDRI **(Appendix A)**. The Committee also reviewed additional donor data to assess the size of potential impact of removing HCV

[63] https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/

from the KDPI calculator on the pediatric population. Rationale for retaining the policy as proposed and details on the additional efforts mentioned above can be found in the discussion on themes.

Overall Sentiment from Public Comment

The Committee requested public comment feedback, including input on the following questions:[64]

- Do community members support the Committee's proposal to refit the KDPI model rather than using the "zero out" method or Apolipoprotein L1 (APOL1) testing?
- Do transplant professionals believe this policy change will impact acceptance behavior when using KDPI to assess deceased donor kidneys for transplant?
- Do patients and donor families support the proposed solution?
- Do community members have feedback on the SRTR modeling results related to the updated cohort, change in coefficients, or donor movement between KDPI sequences?

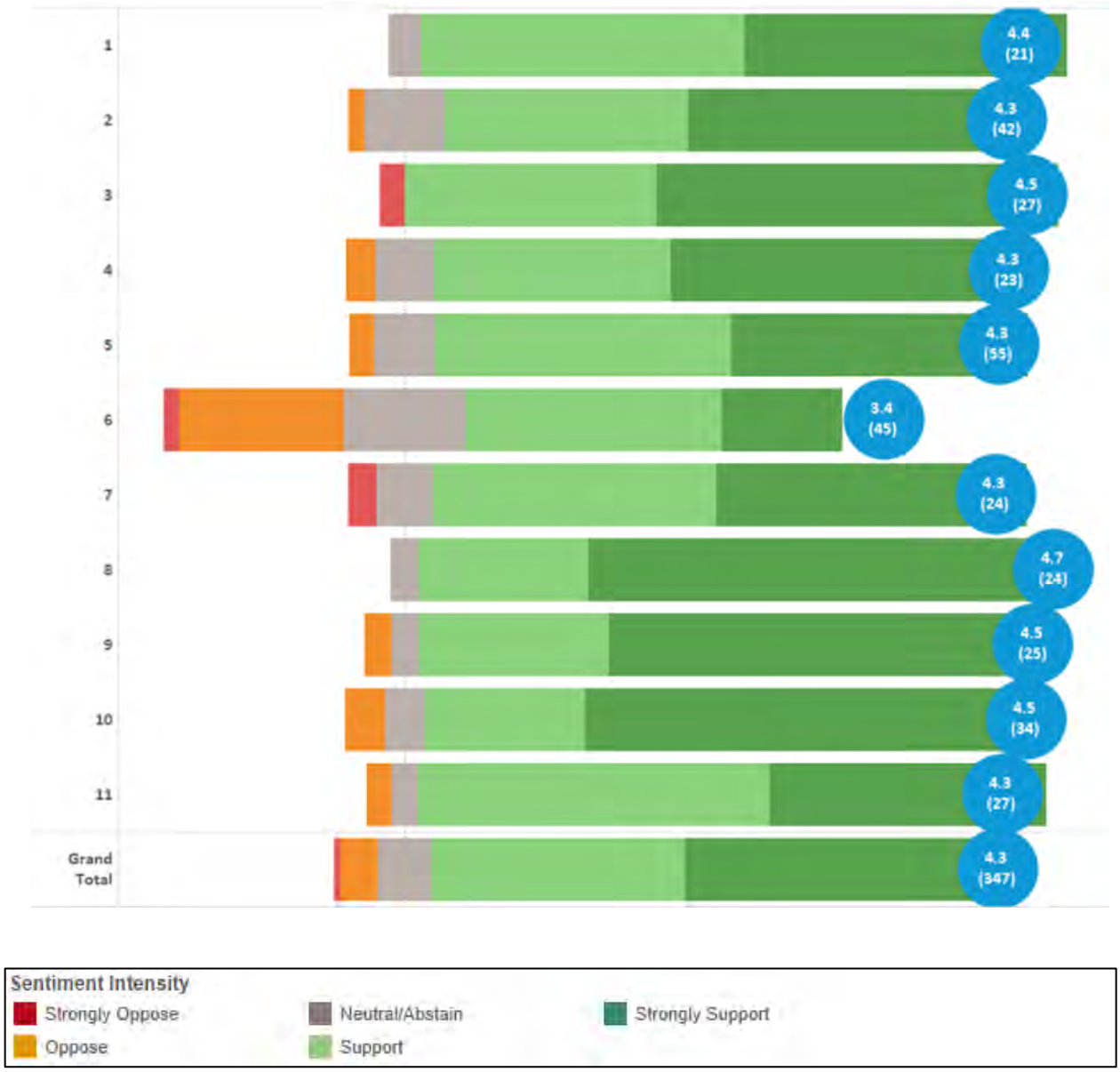
The Committee presented the proposal to all 11 OPTN regions and eight committees for feedback and posted a video presentation describing the proposal to the OPTN website. The proposal received 367 comments, including 71 substantive, written comments from all member types including 14 professional societies and patient advocacy groups. Sentiment by member type and region are shown below in **Figures 4** and **5**.

Figure 4 shows sentiment received from each of the 11 regions.[65] Overall, sentiment was supportive, as indicated by a total sentiment score of 4.3. Opposition was raised in all but 2 regions, but most regions either supported or strongly supported the proposal. Out of the 11 regions, region 6 had the most opposing sentiment. The opposing sentiment was related to concerns regarding the removal of HCV from the KDPI calculation on the pediatric population. Additional details on the potential impact on the pediatric population can be found in the discussion on themes.

[64] Public Comment Proposal, Refit Kidney Donor Profile Index without Race and Hepatitis C Virus, https://optn.transplant.hrsa.gov/media/ekkfxy4t/mac_kdpiracehcv_pcjan24.pdf

[65] Sentiment is collected from participants who submit an individual public comment and from regional meeting participants. Participants are asked to provide their feedback on "What is your opinion of this proposal?" There are five Likert scale response choices with 1 representing strongly oppose up to 5 representing strongly support.

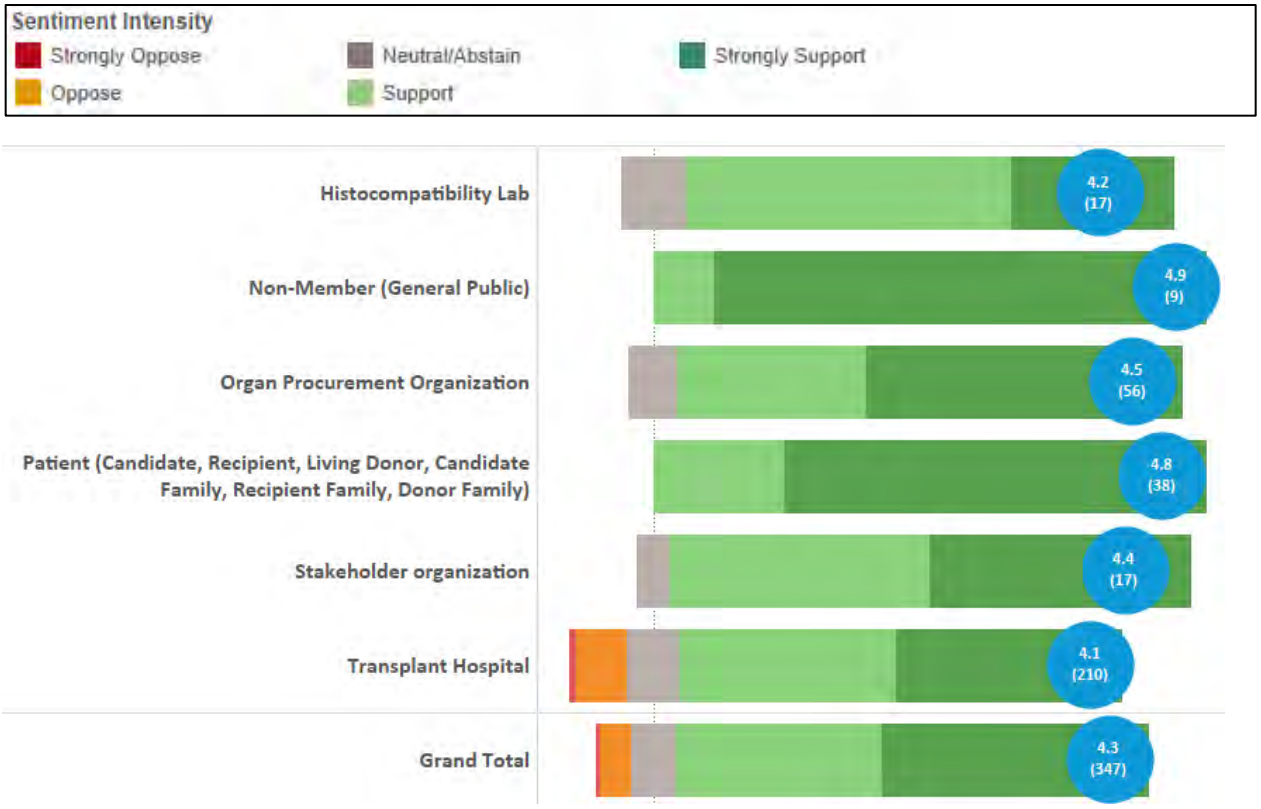
Figure 4. Sentiment by Region, *Refit Kidney Donor Profile Index without Race and Hepatitis C Virus*, 2024[66]



[66] The circles after each bar indicate the average sentiment score and the number of participants in is in the parentheses.

Figure 5 shows sentiment received from all respondents (regional meeting, online, and email) by their stated member type. There was overall support for the proposal from all member types, demonstrated by a sentiment score of 4.3. Patients were particularly supportive of this proposal with a sentiment score of 4.8. Although transplant programs were the only member type to show opposition and strong opposition, the overall 4.1 sentiment score from this stakeholder group demonstrates support for this proposal.

Figure 5. Sentiment by Member Type, *Refit Kidney Donor Profile Index without Race and Hepatitis C Virus*, 2024 [67]



A summary of grand total sentiment in **Figure 4** and **Figure 5** are displayed in **Table 5.**

Table 5. Summary of Grand Total Sentiment

Sentiment intensity	Number of sentiment votes	Percentage of sentiment votes
Strongly Support	168	48.41%
Support	129	37.81%
Neutral/Abstain	28	8.07%
Oppose	19	5.48%
Strongly Oppose	3	.86%

1

[67] The circles after each bar indicate the average sentiment score and the number of participants in is in the parentheses.

Themes in public comment

Respondents submitted 71 substantive, written public comments.[68] Responses were submitted by members of the public at large, as well as on behalf of regions and committees. Commenters covered many different topics, including the following themes:

- Support for the removal of race & HCV from KDPI
- Mixed feedback regarding SRTR modeling
- Concerns regarding potential impact on pediatric population
- Support for substituting APOL1 testing for race

The Committee discussed each of these themes and provided additional data and rationale when necessary.[69]

Support for the removal of race & HCV from KDPI

The paper asked transplant professionals and patients for feedback on the proposed solution to refit the KDPI calculation without race and HCV variables. The most common theme throughout public comment was support for the removal of race, removal of HCV, or the removal of both race and HCV from KDPI. Respondents highlighted that over 90,000 individuals are awaiting a life-saving kidney donation and the current inclusion of both race and HCV does not accurately measure the quality and post-transplant survival of kidneys from African American/Black and HCV positive deceased donors. These comments expressed that the KDPI calculation should be based on medical history, current scientific research, and evidence-based practice, as opposed to social constructs and outdated data. Comments from patients/donor families and patient advocacy groups supported the proposed change and expressed that it will increase equity and transparency in the organ allocation system.

Mixed feedback on SRTR modeling

The paper asked for community feedback on the SRTR modeling results related to the updated cohort, change in coefficients, or donor movement between KDPI sequences. Comments related to this theme discussed 1) concerns with modeling approach and 2) preference to rework the whole KDPI model.

Respondents that expressed concerns with the modeling questioned if the refitting would impact the predictive ability of KDPI. Comments also requested additional global model fit analyses and reporting of all recipient coefficients from the recalculation of KDRI. Comments that discussed preference to rework the KDPI model in its entirety favored use of the updated cohort and all available donor variables to run a new stepwise regression to observe which variables should or should not be included in the model. Comments in this theme also highlighted the limitations of KDPI, such as the exclusion of recipient factors.

Post Public Comment Committee discussion

In response to comments that expressed concerns with the modeling approach, the Committee made an additional addendum request to the SRTR to further examine the models, including additional global model fit analyses and reporting of all recipient coefficients from the recalculation of KDRI. **(Appendix A).** The SRTR presented these results during a Committee meeting on April 4, 2024. Results of this additional

[68] OPTN Public Comment, Refit Kidney Donor Profile Index without Race and Hepatitis C Virus, https://optn.transplant.hrsa.gov/policies-bylaws/public-comment/refit-kidney-donor-profile-index-without-race-and-hepatitis-c-virus/

[69] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/

request showed no substantial changes in the magnitude of the coefficients for the recipient variables when donor race and HCV status are removed from the model. The full report can be found in Appendix A. While the Committee understands some community members' support for reworking the whole KDPI model, the Committee maintains that this request is out of scope for the project.[70] During the development of this project, the MAC discussed a variety of options with the Kidney Transplantation Committee and determined that while there are other areas of the KDPI calculation that should be changed, race and HCV variables are the priorities to be removed from the calculation as a first step.[71] A complete rework of KDPI would require additional resources and a lengthier timeline but could be considered by the OPTN Kidney Transplantation Committee in the future.

Concerns regarding potential Impact on Pediatric Population

A theme that emerged throughout public comment was discussion surrounding potential unintended consequences of removing HCV from KDPI on the pediatric population. Pediatric candidates are given high priority in kidney allocation, but that priority is restricted to those donor kidneys with a KDPI of 0-34%. Some community members expressed concerned that when HCV status is removed, a number of formerly greater than 35% KDPI HCV positive kidneys will enter the 0-34% sequences, while a similar number of formerly 0-34% KDPI HCV negative kidneys will enter the greater than 35% sequences. Current drugs for HCV are only approved for children three years old and up and generally parents of pediatric candidates do not consent for HCV + kidneys, therefore HCV+ kidneys in the 0-34% sequences may not be acceptable for pediatric candidates.

Post Public Comment Committee discussion

The Committee reviewed the data shown in **Figure 6** to assess the potential impact of removing HCV from KDPI on the pediatric population.[72] **Figure 6** shows donors recovered between 2018-2021 stratified by HCV status and KDPI sequence. The SRTR report grouped KDPI sequences differently than the OPTN, but that should have a minimal effect as the difference is only 1%. The top portion of the table shows the current KDPI as it stands now using the Rao modeling. These numbers were pulled from the OPTN website on 3/12/2024. The OPTN website only includes HCV antibody testing, so those NAT only donors are missing, but those numbers tend to be small. Below the top portion are two groups pulled directly from the SRTR report, one shows KDPI using a new updated cohort with donors recovered from 2018-2021, and the other shows that updated cohort with the removal of race and HCV from the model.

[70] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/
[71] See OPTN Minority Affairs Committee meeting summary. February 27, 2023. https://optn.transplant.hrsa.gov/media/13pkeofk/20230227_mac_summary.pdf.
[72] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/

Figure 6. Donors Recovered 2018-2021 by HCV Status and KDPI

Donors Recovered 2018-2021 by HCV Status and KDPI				
Current KDPI (Rao Modeling, cohort from 90's to mid-2000's)	**KDPI 0-20%**	**KDPI 21-34%**	**KDPI 35-85%**	**KDPI 86-100%**
HCV Antibody Positive	24	326	3159	1295
Not Positive	8375	5948	21662	8240
KDPI with Updated Cohort (SRTR Modeling, cohort 2018-2021)	**KDPI 0-20%**	**KDPI 21-35%**	**KDPI 36-85%**	**KDPI 86-100%**
Total Positive Any Test	1031	948	2,191	462
HCV NAT and antibody donor	735	601	1160	199
HCV NAT only donor	34	17	37	4
HCV antibody only donor	262	330	994	259
Not Positive	7420	5658	21293	7156
KDPI with Updated Cohort Removal of Race and HCV (SRTR Modeling, cohort 2018-2021)	**KDPI 0-20%**	**KDPI 21-35%**	**KDPI 36-85%**	**KDPI 86-100%**
Total Positive Any Test	745	938	2459	490
HCV NAT and antibody donor	481	606	1390	218
HCV NAT only donor	25	18	45	4
HCV antibody only donor	239	314	1024	268
Not Positive	7706	5660	20986	7175

*Data pulled from the OPTN site on 3/12/2024 and is subject to change based on future data submission or correction.

When SRTR updated the cohort there was an increase in HCV positive donors in the lower two KDPI sequences. This effect is due to the cohort update, not the removal of race and HCV. When race and HCV were removed, it had a slightly mediating effect, and some of those HCV positive donors move into higher KDPI sequences.

In the addendum SRTR modeling **(Appendix A)** after the removal of race and HCV, there are roughly 15,049 donors in the 0-34% group and 1,683 (roughly 11%) have any type of HCV positive test, with most donors in those groupings remaining negative.

After reviewing these data, the Committee determined that the overall potential for unintended consequences were small when compared to the potential benefit of removing race and HCV from KDPI. The Committee will monitor the distribution of HCV positive donors (as well as African American/Black donors and other demographics) to ensure the impact on the pediatric population does not exceed the expected range.[73]

Support for Substituting APOL1 Testing for Race

The community discussed APOL1 testing during public comment. Respondents agreed that race is a poor proxy for genetic difference and supported the inclusion of APOL1 testing in its place to account for potential genetically related post-transplant impacts. Some commenters requested that the OPTN consider the inclusion of APOL1 testing for all deceased donors, but the majority recommend that the Committee continue to monitor further developments in this research and reassess the potential value of its future inclusion.

[73] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/.

Post Public Comment Committee discussion

During development of the proposal, the Committee discussed replacing the race coefficient with APOL1 testing in the KDPI calculation.[74] The Committee determined that there is limited access to APOL1 testing, as it is not the standard of care at this time and there is currently not enough evidence to support its inclusion, but the results from the ongoing APOLLO study might provide the necessary data at a future date.[75]

Compliance Analysis

NOTA and OPTN Final Rule

The Committee submits this proposal for consideration under the authority of the National Organ Transplant Act of 1984 (NOTA) and the OPTN Final Rule. NOTA requires the Organ Procurement and Transplantation Network (OPTN) to "establish … medical criteria for allocating organs and provide to members of the public an opportunity to comment with respect to such criteria."[76] The OPTN Final Rule states the OPTN "shall be responsible for developing … policies for the equitable allocation for cadaveric organs."[77] The proposal to refit KDPI without race or HCV affects allocation in that a more accurate reflection of the quality and post-transplant survival of kidneys from deceased donors who are African American/Black or HCV positive may impact which candidates receive the offers of these kidneys. If the KDPI of these donor kidneys is more accurate, candidates are more likely to get the kidney that best aligns with their priority ranking.

The Final Rule requires that when developing policies for the equitable allocation of cadaveric organs, such policies must be developed "in accordance with §121.8," which requires that allocation policies "(1) Shall be based on sound medical judgment; (2) Shall seek to achieve the best use of donated organs; (3) Shall preserve the ability of a transplant program to decline an offer of an organ or not to use the organ for the potential recipient in accordance with §121.7(b)(4)(d) and (e); (4) Shall be specific for each organ type or combination of organ types to be transplanted into a transplant candidate; (5) Shall be designed to avoid wasting organs, to avoid futile transplants, to promote patient access to transplantation, and to promote the efficient management of organ placement;…(8) Shall not be based on the candidate's place of residence or place of listing, except to the extent required by paragraphs (a)(1)-(5) of this section."[78] This proposal:

- **Is based on sound medical judgment**[79] because it is an evidence-based change relying on the following evidence:
    - Data showing the high efficacy of DAAs as treatment for HCV [80]

[74] See OPTN Minority Affairs Committee meeting summary. February 27, 2023. https://optn.transplant.hrsa.gov/media/13pkeofk/20230227_mac_summary.pdf.
[75] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/
[76] 42 USC §274(b)(2)(B).
[77] 42 CFR §121.4(a)(1).
[78] 42 CFR §121.8(a).
[79] 42 CFR §121.8(a)(1).
[80] Welch CM. March 10, 2020. Hepatitis C Treatment History Timeline. Retrieved on November 12, 2023, from https://www.hepmag.com/blog/hepatitis-c-treatment-history timeline#:~:text=1991%3A%20FDA%20approved%20the%20first,be%20the%20only%20treatment%20available.

  - Literature showing that KDPI overestimates risk and underestimates quality of HCV positive deceased donor kidneys [81, 82]
  - Published literature showing that race should not be used in clinical decision making because it is not a proxy for genetic difference[83]
  - Literature showing that the APOL1 gene, not African American/Black race, had an increased risk of graft failure[84]
  - Modeling and analysis estimating that a refit of KDPI without race of HCV donor characteristics would result in more racially equitable KDPI distributions
- **Seeks to achieve the best use of donated organs[85]** by ensuring organs are allocated and transplanted according to medical urgency and post-transplant outcomes.
  - This proposal intends to increase the accuracy of KDPI for African American/Black and HCV positive deceased donors. Deceased donor kidneys that were previously mischaracterized with a higher KDPI due to these donor factors, will have a lower KDPI that is more reflective of their quality, post-transplant survival, and suitability for transplant. As such, these kidneys may be offered to candidates with higher priority rankings, which aligns with the best use of a donated organ.
- **Be designed to … promote patient access to transplantation[86] by** giving similarly situated candidates' equitable opportunities to receive an organ offer.
  - Due to HLA matching, African American/Black donor kidneys are more likely to match with African American/Black recipients. Decreases in the KDPI of African American/Black donor kidneys could result in more of the lower KDPI donor kidneys being available for African American/Black candidates. These lower KDPI donors' kidneys may have a greater chance of being accepted by transplant programs for their African American/Black candidates and contribute to a decrease in the waiting time disparity.[87]

Although the proposal outlined in this briefing paper addresses certain aspects of the Final Rule listed above, the Committee does not expect impacts on the following aspects of the Final Rule:

- Shall be designed to avoid wasting organs, to avoid futile transplants, and promote the efficient management of organ placement.
  - Non- use is impacted by many factors other than KDPI and the degree to which each factor contributes to non-use is not well defined. For these reasons, the Committee was not able to estimate exactly how transplant rates may change.
- This proposal is not based on the candidate's place of residence or place of listing.

[81] Cannon RM, Locke JE, Orandi BJ, Anderson DJ, Davis EG, Mackelaite L, Dave H, Eng M, Jones CM. (2020). Impact of Donor Hepatitis C Virus on Kidney Transplant Outcomes for Hepatitis C-positive Recipients in the Direct-acting Antiviral Era: Time to Revise the Kidney Donor Risk Index? Transplantation. 104(6):1215-28. doi: 10.1097/TP.0000000000002949.

[82] Potluri VS, Goldberg DS, Mohan S, Bloom RD, Sawinski D, Abt PL, Blumberg EA, Parikh CR, Sharpe J, Reddy KR, Molnar MZ, Sise M, Reese PP. (2019). National Trends in Utilization and 1-Year Outcomes with Transplantation of HCV-Viremic Kidneys. J Am Soc Nephrol.(10):1939-51. doi: 10.1681/ASN.2019050462.

[83] Vyas DA, Einstein LG, Jones DS. Hidden in Plain Sight — Reconsidering the Use of Race Correction in Clinical Algorithms. The New England Journal of Medicine. 2020. 383(9): 874-882.

[84] NephCure. (2023). Understanding APOL1 Kidney Disease Among Black Americans. Retrieved on November 12, 2023, from https://nephcure.org/understanding-apol1-kidney-disease-among-black-americans/.

[85] 42 CFR §121.8(a)(2).

[86] 42 CFR §121.8(a)(5).

[87] Miller J, Lyden GR, McKinney WT, Snyder JJ, Israni AK. (2023). Impacts of removing race from the calculation of the kidney donor profile index. American Journal of Transplantation, 23(5):636-641. https://doi.org/10.1016/j.ajt.2022.12.016.

Potential Impact on Select Patient Populations

The refit of KDPI without race and HCV has the potential to impact minority candidates. Those who identify as African American/Black make up 13% of the national population, but about 30% of the national waiting list. Since African American/Black patients are more likely to receive kidneys from African American/Black donors, removal of the race coefficient from KDRI could help to decrease the waiting time disparity for African American/Black candidates and non-use of organs from African American/Black deceased donors. When considering the impact on the assignment of donors to allocation sequence groups, the zero-sum nature of this policy change means that the number of donors moving between allocation sequence groups will be equal. For example, the number of African American/Black donors moving to KDPI less than 85% would be offset by an almost equal number of non-African American/Black donors moving to KDPI greater than 85%. After implementation, there could be an increase of African American/Black kidney candidates transplanted and conversely, a decrease of non-African American/Black candidates transplanted. Since non-use may be impacted by many factors besides KDPI, and the degree to which each factor contributes to non-use is not well defined, the Committee was not able to estimate exactly how transplant rates may change based on race. During development, the Committee considered the potential shift in transplant rates for these populations an expected outcome, as the intent of this policy is to increase equity in access to transplant.[88]

OPTN Strategic Plan

This proposal aligns with the strategic plan goal to improve equity in access to transplants. By removing race and HCV variables from KDPI, this proposal aims to better reflect the likelihood of graft failure for kidneys from African American/Black and HCV positive deceased donors. Decreases in the KDPI of African American/Black donor kidneys could result in more lower KDPI donor kidneys being available for African American/Black candidates. These lower KDPI donor kidneys may have a greater chance of being accepted by transplant programs for their African American/Black candidates and contribute to a decrease in the waiting time disparity.

Implementation Considerations

Member and OPTN Operations

This proposal would impact transplant hospitals, Organ Procurement Organizations, and the OPTN but would not impact histocompatibility laboratories.

OPTN

Operational Considerations

The OPTN would need to update the OPTN Computer System with the refit KDPI calculator so that appropriate values display in the OPTN Donor Data and Matching System and the OPTN Waiting List.

Resource Estimates

It is estimated that 2,175 hours would be needed to implement this proposal. Implementation would involve updates to the OPTN Computer System to refit the KDRI calculation without race or HCV and

[88] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/

update the KDPI calculation. Additionally, implementation would involve cross-department work on training and communication with members and the public. The refitted calculations would update to the new values in the OPTN Donor Data and Matching System and the OPTN Waiting List. It is estimated that 345 hours will be required for ongoing support. Ongoing support includes post-implementation evaluation and answering member questions.

Transplant Programs

Operational Considerations

While no action is required by transplant hospitals, members would need to be aware of the changes to the KDPI calculator.

Fiscal Impact

This proposal is not anticipated to have a fiscal impact on transplant hospitals.

Organ Procurement Organizations

Operational Considerations

While no action is required by OPOs, members would need to be aware of the changes to the KDPI calculator.

Fiscal Impact

This proposal is not anticipated to have any fiscal impact on OPOs.

Histocompatibility Laboratories

Operational Considerations

This proposal is not anticipated to affect the operations of histocompatibility laboratories.

Fiscal Impact

This proposal is not anticipated to have any fiscal impact on histocompatibility laboratories.

Post-implementation Monitoring

Member Compliance

The Final Rule requires that allocation policies "include appropriate procedures to promote and review compliance including, to the extent appropriate, prospective, and retrospective reviews of each transplant program's application of the policies to patients listed or proposed to be listed at the program."[89]

[89] 42 CFR §121.8(a)(7).

This proposal will not change the current routine monitoring of OPTN members. The OPTN may review any data entered in the OPTN Computer System, and members must provide documentation as requested.

Policy Evaluation

The OPTN Minority Affairs Committee considers the non-use of kidneys and transplant rates as the key metrics to assess the outcome of the proposed change to KDPI. Metrics will be compared pre- to post-implementation.

Metrics to be evaluated include:

- Demographics within each KDPI sequence, including race/ethnicity, HCV status, and others as needed
- Demographics of transplanted candidates, including race/ethnicity, HCV status, and others as needed
- Transplant rates by KDPI sequence, race/ethnicity, and HCV status
- Non-use of kidneys by KDPI sequence, race/ethnicity, and HCV status
- Delayed graft function by KDPI sequence
- Survival by KDPI sequence
- Others subsequently requested by the committee

These metrics will be reviewed at approximately six months, one year, and two years post-implementation. Rates and survival analyses will be provided only at one- and two-years post-implementation to allow for sufficient follow-up time.

Conclusion

The Committee confirms that modeling results from the SRTR, supplemented by peer-reviewed literature, provide rationale to refit the KDRI calculation without race and HCV donor characteristics. Removing these donor characteristics by refitting the KDRI and subsequently the KDPI model aim to better reflect the likelihood of graft failure for kidneys from African American/Black and HCV positive donors. The Committee reviewed and discussed the results of public comment and concluded the public sentiment supports sending the proposal to the Board of Directors with no changes.[90]

[90] OPTN Minority Affairs Committee, https://optn.transplant.hrsa.gov/about/committees/minority-affairs-committee/

Policy Language

Proposed new language is underlined (example) and language that is proposed for removal is struck through (example). Heading numbers, table and figure captions, cross-references, and footnotes affected by the numbering will be updated as necessary.

8.4.B: Deceased Donor Classifications

Kidneys from deceased donors are classified according to the Kidney Donor Profile Index (KDPI). The KDPI score is derived directly from the Kidney Donor Risk Index (KDRI) score. The KDPI is the percentage of donors in the reference population that have a KDRI less than or equal to this donor's KDRI.

The donor characteristics used to calculate KDRI are provided in *Table 8-5* below.

Table 8-5: KDRI Factors

This deceased donor characteristic:	Applies to:	KDRI score component:
Age (integer years)	All donors	~~0.0128~~ 0.0092*(age-40)
	Donors with age < 18	~~-0.0194~~ 0.0113*(age-18)
	Donors with age > 50	~~0.0107~~ 0.0067*(age-50)
~~Race~~	~~African American donors~~	~~0.1790~~
Creatinine (mg/dL)	All donors	~~0.2200~~ 0.2128*(creatinine - 1)
	Donors with creatinine > 1.5	~~-0.2090~~ -0.2199*(creatinine -1.5)
History of Hypertension	Hypertensive donors	~~0.1260~~ 0.1106
History of Diabetes	Diabetic donors	~~0.1300~~ 0.2577
Cause of Death	Donors with cerebrovascular accident as cause of death	~~0.0881~~ 0.0743
Height (cm)	All donors	~~-0.0464~~ -0.0557*(height -170) / 10
Weight (kg)	All donors with weight < 80 kg	~~-0.0199~~ -0.0333*(weight - 80) / 5
Donor type	DCD donors	~~0.1330~~ 0.1966
~~HCV status~~	~~HCV positive donors~~	~~0.2400~~

To calculate KDRI, follow these steps:

1. Sum each of the applicable KDRI score components in *Table 8-5*
2. Apply the antilog (base e) function to this sum
3. Divide the KDRI by the median KDRI value of the most recent donor reference population
4. Determine the KDPI using the OPTN's KDRI-to-KDPI mapping table

The KDPI score is rounded to the nearest integer.

The KDPI used for allocation is based on the most recent values of donor characteristics reported to the OPTN before executing a match run.

The reference population used to determine the KDRI-to-KDPI mapping is reviewed annually by the Kidney Transplantation Committee and updated by the OPTN on or before June 1 of each calendar year.

#

Appendix A: Addendum to Removing Black Race and HCV Coefficients from Calculation of the Kidney Donor Risk Index

Table of Contents

Date: March 28, 2024

Prepared By: Jon Miller, PhD, Grace Lyden, PhD, Bryn Thompson, MPH, Dave Zaun, MS, Jon Snyder, PhD, Ajay Israni, MD, MS

Timeline

Committee met: February 21, 2024

Request submitted: March 11, 2024

1 Analysis plan submitted: March 12, 2024

2 Final report submitted: March 29, 2024

3 Next committee meeting: April 4, 2024

Background

In August 2023, the Organ Procurement and Transplantation Network (OPTN) Minority Affairs Committee (MAC) requested a recalculation of the KDRI excluding the Black race and HCV status variables. Analysts at the Scientific Registry of Transplant Recipients recalculated the KDRI using the same variables, exclusion criteria and modeling method as the original 2009 calculation of KDRI in a cohort that included 50,769 kidney transplants between January 1, 2018, and December 31, 2021. The KDRI was calculated with and without Black donor race and HCV status variables to understand the impact of removing both race and HCV status variables.

During public comment in February of 2024, additional global model fit analyses and reporting of all recipient coefficients from the recalculation of KDRI were requested.

Strategic Goal

Increase equity in access to transplants

Data Request: Additional model fit and coefficient reporting from race- and HCV-free KDRI

In response to the August 2023 MAC data request, the SRTR provided analyses of the updated KDRI calculated with and without the race and HCV status variables to answer, among other questions:

1. How are the coefficients changing?
    a. What are the new coefficients?
    b. Which coefficients had the biggest change?
    c. Which coefficient is now the most heavily weighted?
    d. Model fit and summary statistics

The coefficients examined were the donor and transplant coefficients reported in the original 2009 analysis and recipient specific coefficients were not reported. Model fit statistics were reported overall and by black donor/non-black donor strata and by HCV positive/HCD negative strata. In response to public comments during February 2024, the MAC additionally requests:

1. Comparison of the recipient specific coefficients

2. Model fit statistics, including calibration plots, for these additional subgroups:
    a. Male recipients; Female recipients;
    b. Recipients in each quartile of age;
    c. Recipients of kidneys from Black donors; Recipients of kidneys from White donors; Recipients of kidneys from non-Black, non-White donors;
    d. Recipients of kidneys with allocation KDPI >= 85; Recipients of kidneys with allocation KDPI <=20;
    e. Recipients of kidneys from HCV RNA+ kidneys.

Analysis Plan

The analyses presented in this addendum apply to the model-fitting component of the initial data request and will therefore use the same study cohort and same models created for the initial data request.

Additional Covariate Comparisons

Table 4 from the analysis report for the initial data request will be expanded to also include the coefficients for the recipient specific covariates that were included in the updated KDRI model that was fit on the entire study cohort.

Additional Global Model Fit Analyses

The original external global model fit analyses were conducted with models fit on an 80% training sample of the entire study cohort and fit metrics were assessed in the 20% test sample of the entire study cohort. These were presented in Appendix Table 3 in the analysis report for the initial data request. For this addendum request, Appendix Table 3 will be updated to include only comparisons for the 2018 through 2021 cohort that was used for the final models, and will include additional subgroups. Specifically we will calculate concordance and the integrated Brier score in the 20% held-out test set of the 2018 through 2021 cohort, and in the following subgroups:

1. Male recipients;
2. Female recipients;
3. Recipients in the each quartile of age;
4. Recipients of kidneys from Black donors;
5. Recipients of kidneys from White donors;
6. Recipients of kidneys from non-Black donors;
7. Recipients of kidneys from non-White donors;
8. Recipients of kidneys with original allocation KDPI >= 85;
9. Recipients of kidneys with original allocation KDPI <=20;
10. Recipients of kidneys from HCV positive (stratified on nucleic acid test, antibody test or both) donors.

In addition, we will present calibration plots for the 20% held-out test set of the 2018 through 2021 cohort as well as all the subgroups listed above. Specifically, the calibration plot will compare observed and predicted probabilities of graft failure by the maximum follow-up time in the test sample (ie, up to 5 years) using the nearest neighbor of the model-predicted survival method with a bin width of 0.1 and observed survival estimated by the Kaplan-Meier method.

Results

Full Comparison of Coefficients

There are not any substantial changes in the magnitude of the coefficients of the recipient variables when donor race and HCV status are removed from the model. While the coefficient on the indicator for transplant year 2019 does change by more than 10%, this coefficient was very small to begin with and the absolute change in the coefficient (-0.0033 to -0.0063) is quite small (Table 1).

Table 1: Original and updated KDRI coefficients

Variable	Original Coefficients	Recreation of Original Coefficients	Recreation without Race and HCV Variables	Percent Change without Race and HCV
Donor Age Less than 18 spline	-0.0194	0.0125	0.0113	-9.68
Donor Age	0.0128	0.0097	0.0092	-5.41
Donor Age greater than 50 spline	0.0107	0.0063	0.0067	5.87
Donor Black Race	0.1794	0.1534		
Donor Creatinine	0.2198	0.1962	0.2128	8.43
Donor Creatinine greater than 1.5 spline	-0.2093	-0.2027	-0.2199	8.48
Donor Hypertension	0.1262	0.1017	0.1106	8.82
Donor Diabetes	0.1301	0.2528	0.2577	1.91
Cause of Donor Death: Stroke	0.0881	0.0685	0.0743	8.53
Donor Height	-0.0464	-0.0571	-0.0557	-2.37
Donor Weight less than 80 spline	-0.0199	-0.0332	-0.0333	0.35
Donation after Cardiac Death	0.1329	0.2022	0.1966	-2.77
Donor HCV Positive	0.2403	-0.0405		
Zero HLA-B mismatches	-0.0766	-0.0693	-0.0759	9.43
One HLA-B mismatch	-0.0610	-0.0543	-0.0542	-0.19
Zero HLA-DR mismatches	-0.1300	-0.0683	-0.0698	2.14
Two HLA-DR mismatches	0.0765	0.0103	0.0139	33.96
Cold Ischemia Time	0.0055	0.0094	0.0093	-0.53

Table 1: Original and updated KDRI coefficients

Variable	Original Coefficients	Recreation of Original Coefficients	Recreation without Race and HCV Variables	Percent Change without Race and HCV
Enbloc Transplant	-0.3640	-0.1915	-0.1925	0.53
Double Kidney Transplant	-0.1480	-0.2338	-0.2208	-5.56
Recipient Black Race		0.1286	0.1347	4.73
Recipient Diagnosis: Diabetes		0.2669	0.2685	0.62
Recipient Diagnosis: Glomerulonephritis		0.1702	0.1708	0.31
Recipient Diagnosis: Hypertension		0.1410	0.1426	1.11
Recipient Diagnosis: Other		0.2802	0.2806	0.14
Recipient Sex: Male		0.0779	0.0773	-0.84
Recipient Weight		0.0047	0.0047	-0.43
Recipient cPRA		0.1904	0.1983	4.12
Recipient Years on Dialysis		0.0458	0.0467	1.93
Recipient PVD		0.2634	0.2630	-0.17
Recipient Age		0.0092	0.0092	0.93
Transplant Year: 2019		-0.0033	-0.0063	93.37
Transplant Year: 2020		0.1717	0.1697	-1.18
Transplant Year: 2021		0.0982	0.0959	-2.31

Additional Global Model Fit Analyses

Removing donor race and HCV status from the model estimating KDRI does not have a substantial impact on model fit statistics - neither model discrimination (concordance) nor model calibration (Brier score) - when assessed on the overall test cohort or within any of the donor or recipient subgroups (Table 2).

While the calibration plots highlight some of the limitations of the overall KDRI/KDPI measure - in particular that the model tends to overestimate the risk in the 'highest' risk donors - there is no evidence from the comparison of the calibration plots that removing donor race and HCV

status would have any substantial impact on the goodness of the model fit, either overall or in any of the donor or recipient subgroups (Figures 1-6).

Table 2: External Global Model Fit for HCV Era Cohort

Cohort	Concordance: Original Coefficients	Concordance: Removed Race and HCV	Brier Score: Original Coefficients	Brier Score: Removed Race and HCV
All Donors	0.5934687	0.5899492	0.10836814	0.10848734
Recipient Sex				
Male Recipients	0.5915991	0.5876197	0.11227312	0.11241253
Female Recipients	0.6074803	0.6070866	0.10236348	0.10245591
Recipient Age				
Age: Less than 45	0.6155855	0.6055725	0.07899732	0.07905075
Age: 45 through 55	0.5834018	0.5809367	0.09274382	0.09280775
Age: 56 through 63	0.5996800	0.5907200	0.11924747	0.11941374
Age: 64 or greater	0.5781570	0.5765643	0.13720327	0.13738405
Donor Race				
Black Donors	0.5381679	0.5419847	0.12566206	0.12640889
Non-Black Donors	0.5912563	0.5906062	0.10574987	0.10577648
White Donors	0.5921510	0.5912817	0.10685881	0.10688207
Non-White Donors	0.5605769	0.5557692	0.11174754	0.11209443
Donor Allocation KDPI				
KDPI <= 20	0.5580247	0.5481481	0.06371112	0.06366935
KDPI >= 85	0.5476879	0.5419075	0.15964777	0.16016884
Donor HCV Status				
HCV NAT Positive Donors	0.6250000	0.6052632	0.09634418	0.09652010
HCV Antibody Only Positive Donors	0.4920635	0.5238095	0.11094988	0.11126510
HCV Not Positive Donors	0.5930985	0.5894699	0.10901454	0.10916555

Overall Calibration Plots

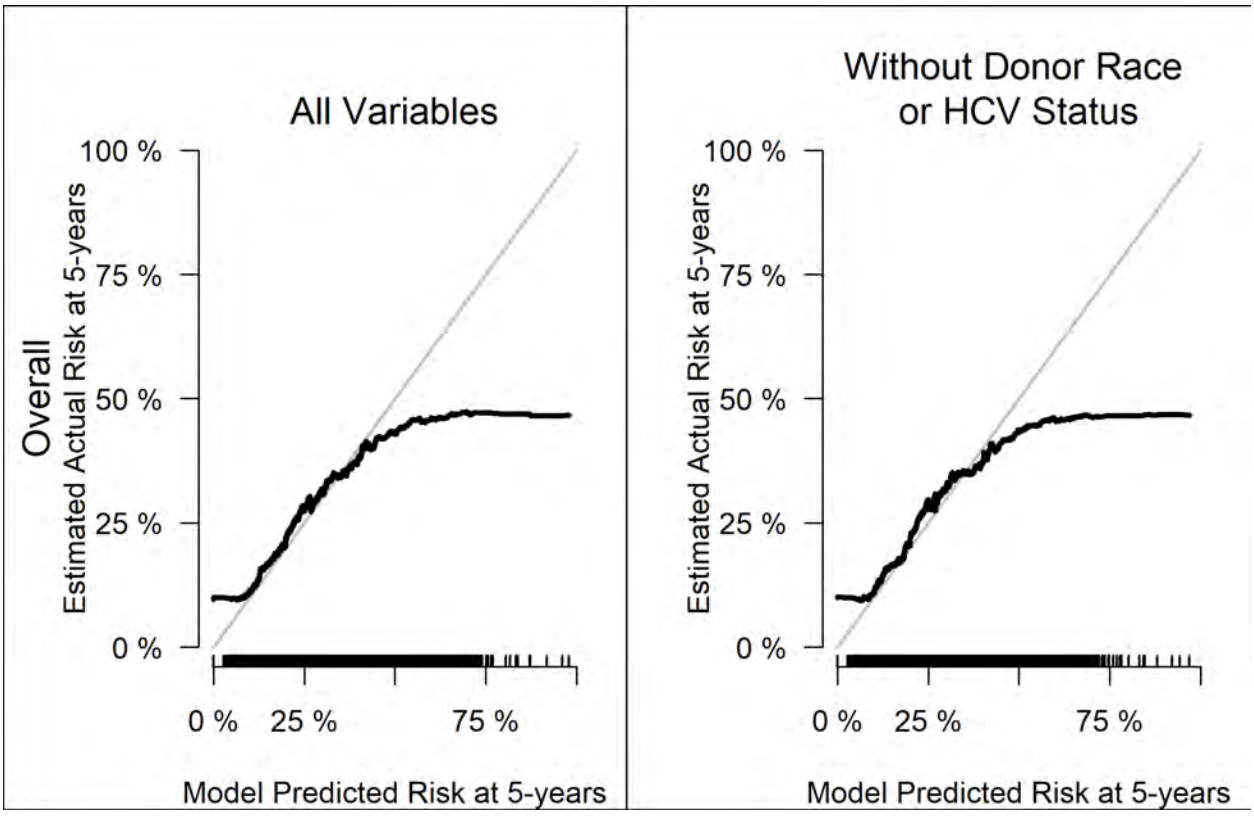


Figure 1: Overall calibration plots for model with all variables and model with donor race and HCV status excluded

Recipient Sex Calibration Plots

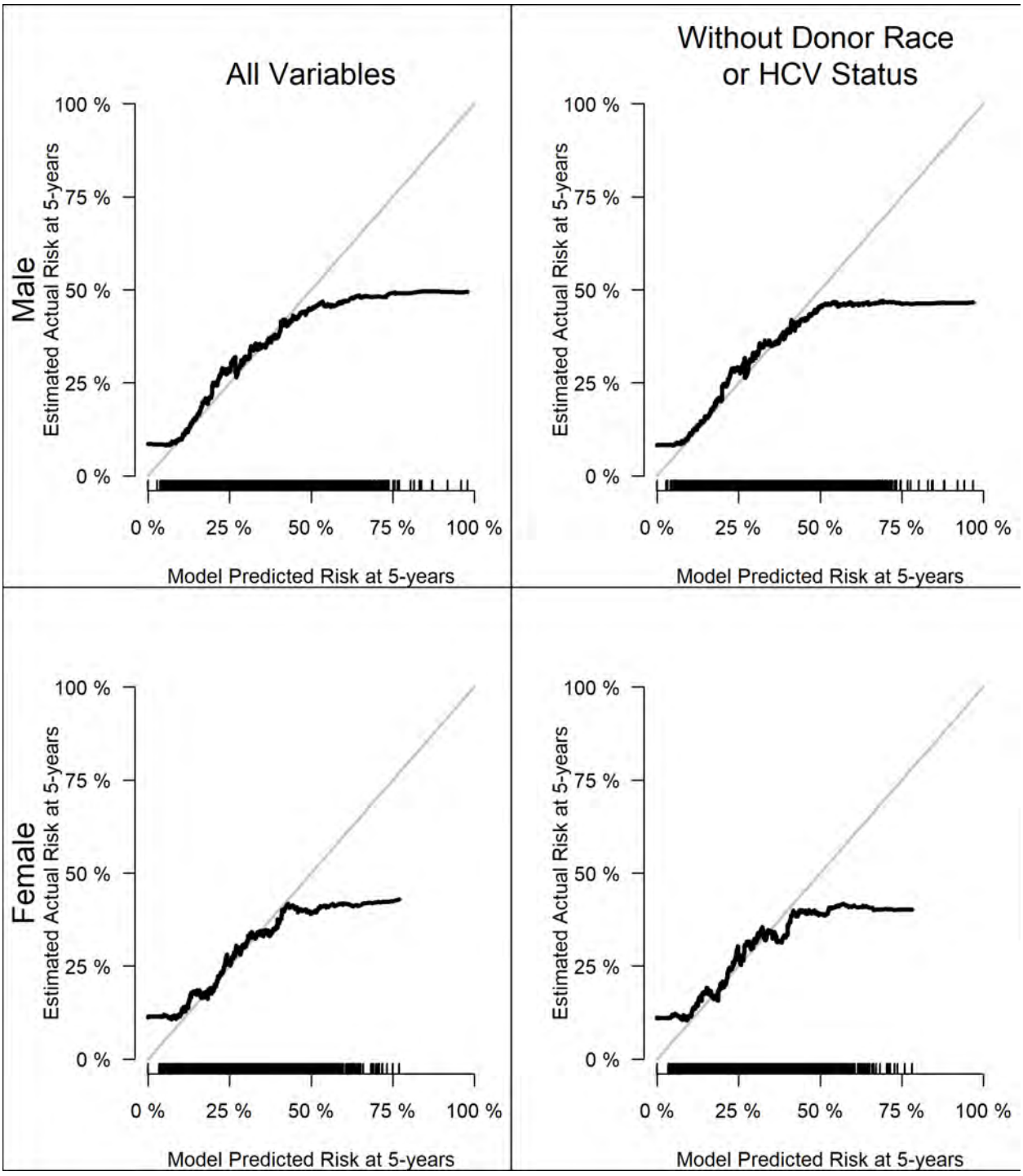


Figure 2: Calibration plots by recipient sex for model with all variables and model with donor race and HCV status excluded

Recipient Age Calibration Plots

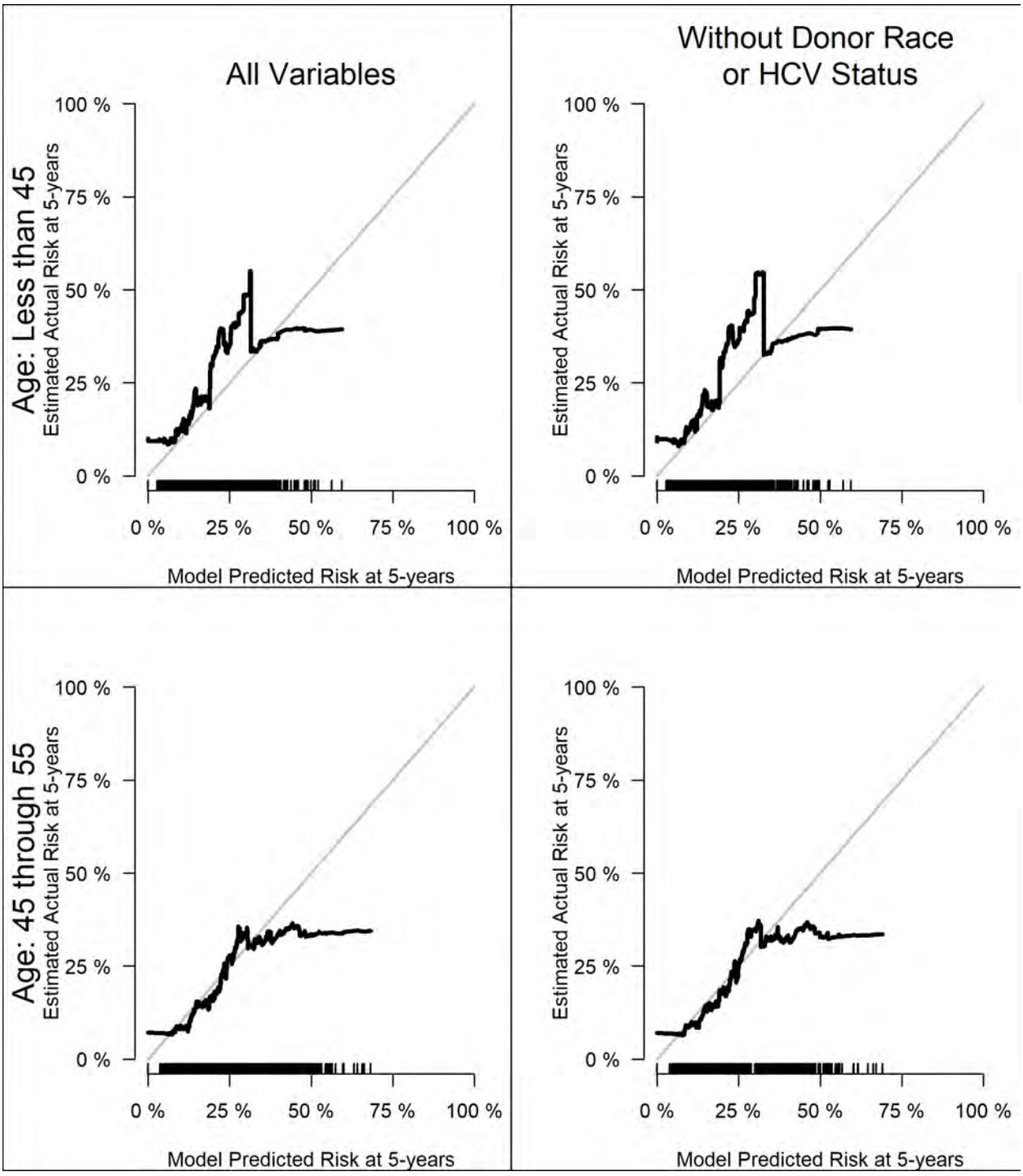


Figure 3: Calibration plots by recipient age for model with all variables and model with donor race and HCV status excluded

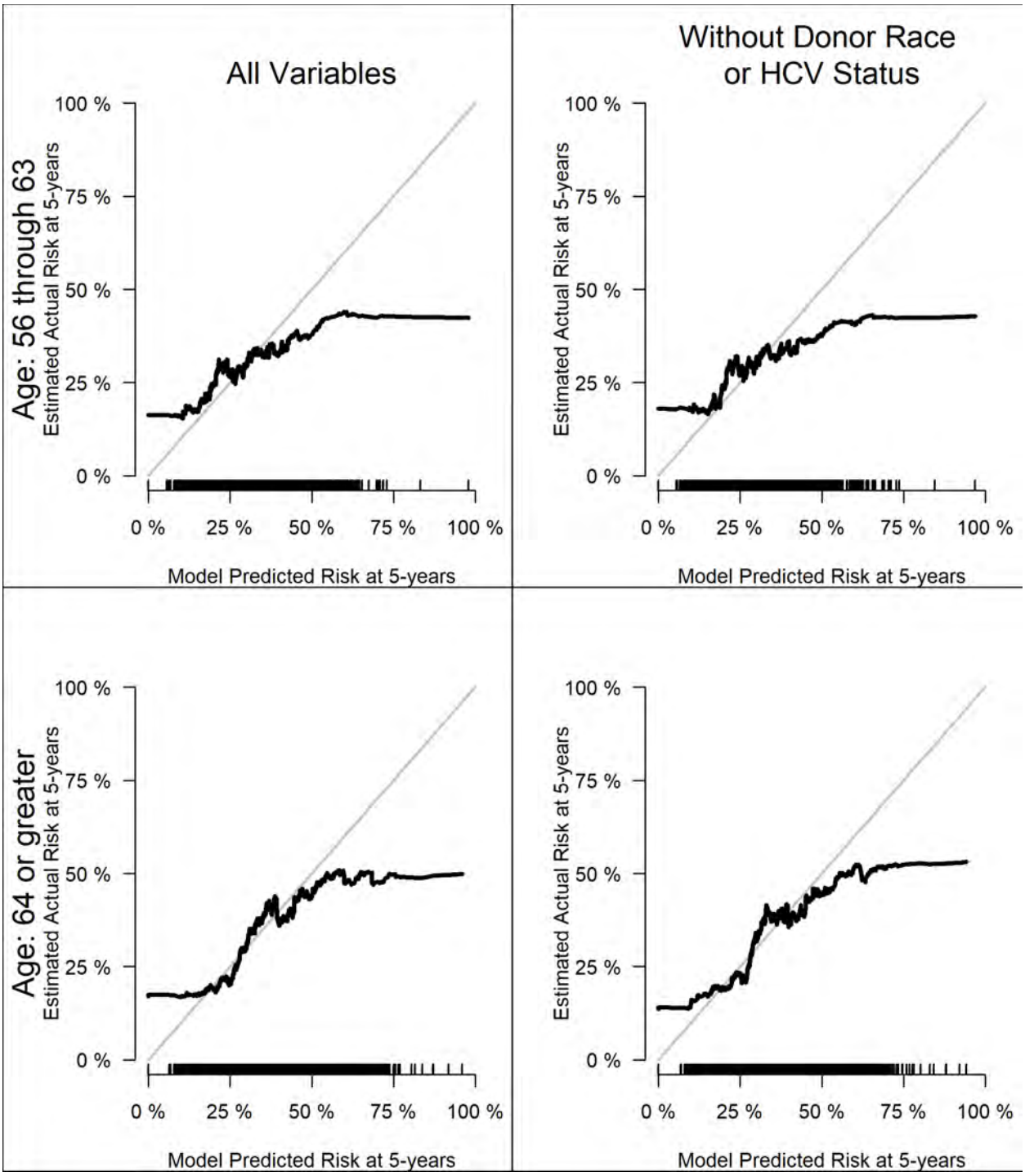


Figure 3: Calibration plots by recipient age for model with all variables and model with donor race and HCV status excluded

Donor Race Calibration Plots

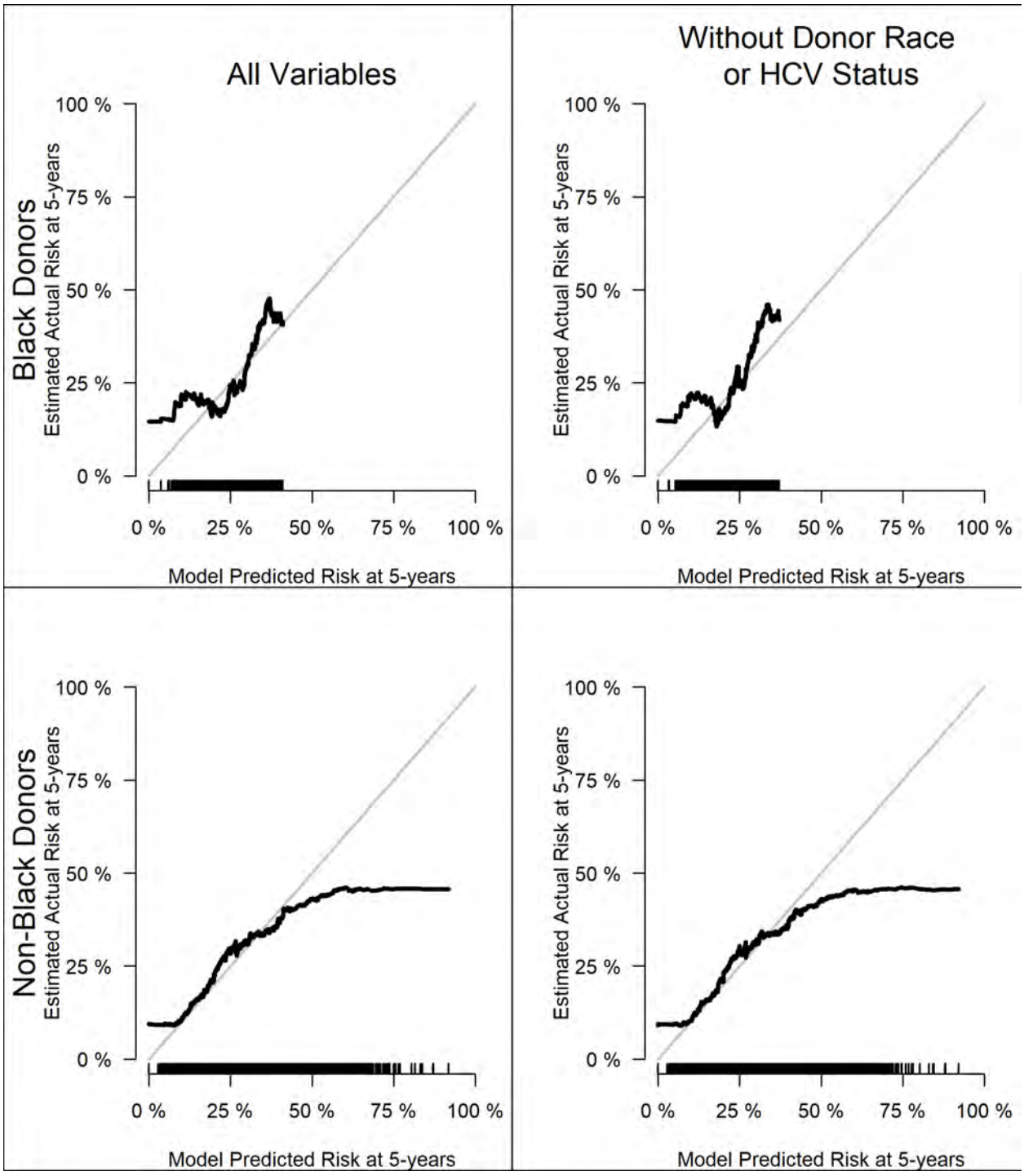


Figure 4: Calibration plots by donor race for model with all variables and model with donor race and HCV status excluded

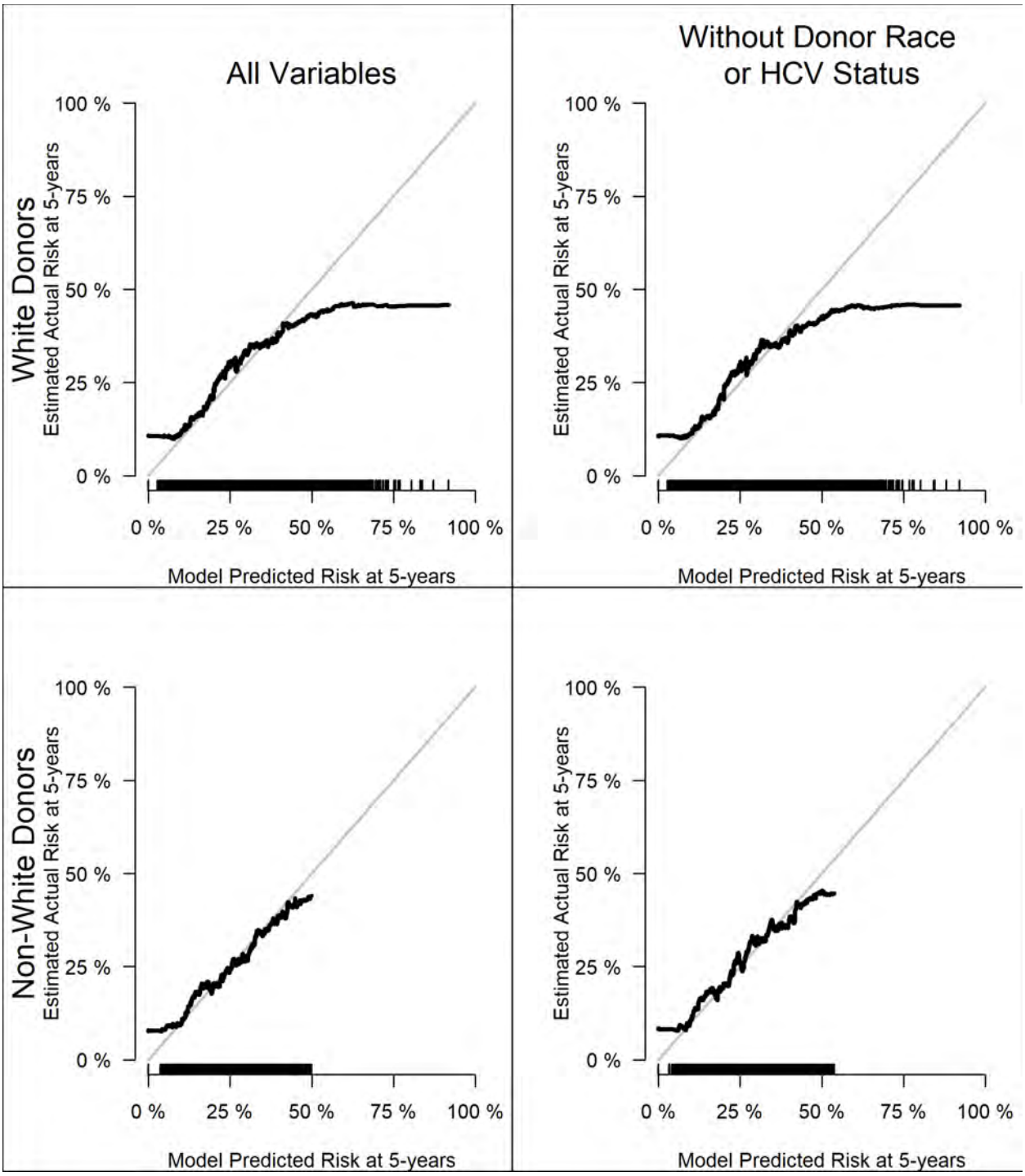


Figure 4: Calibration plots by donor race for model with all variables and model with donor race and HCV status excluded

Donor KDPI Calibration Plots

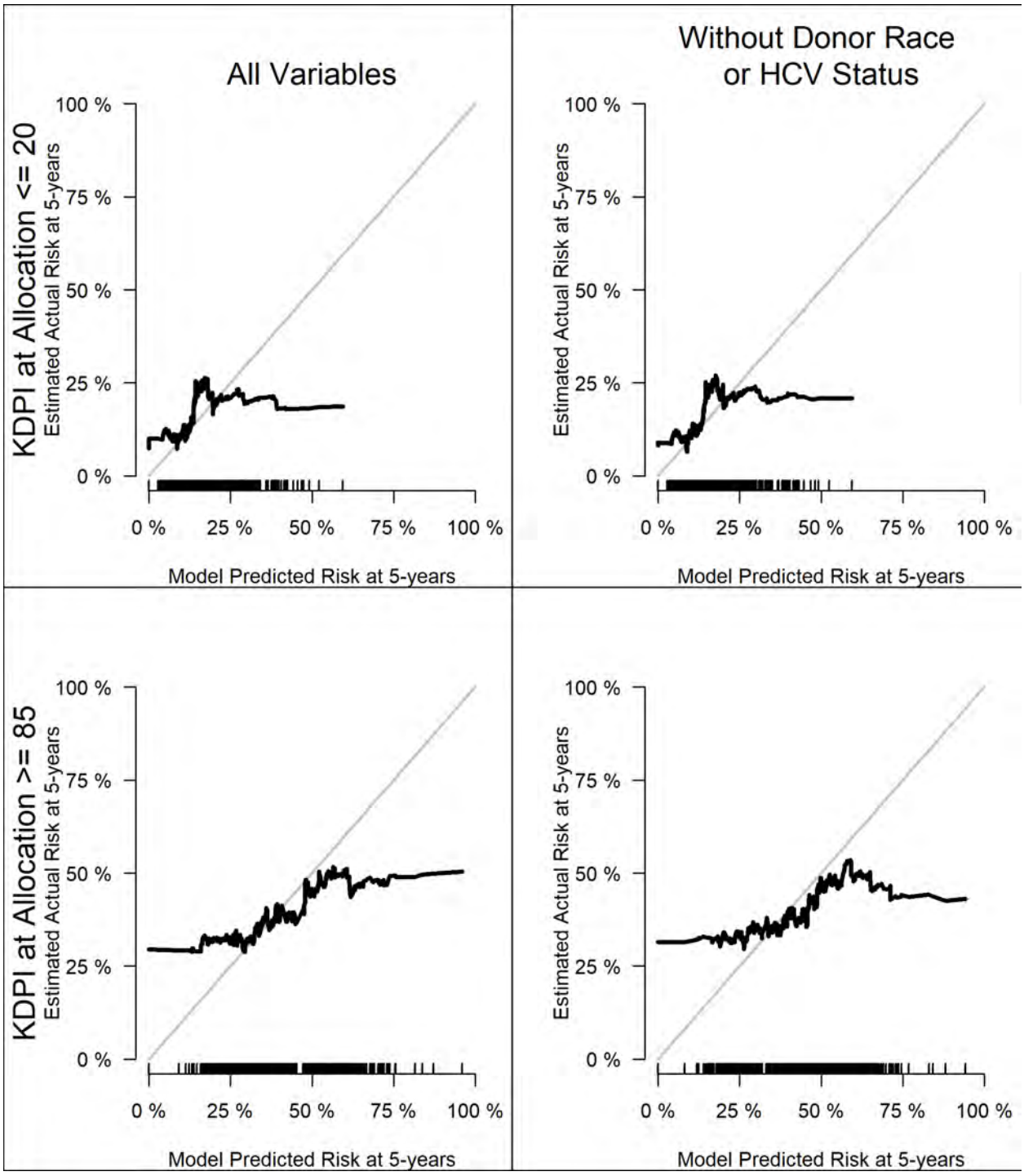


Figure 5: Calibration plots by donor KDPI for model with all variables and model with donor race and HCV status excluded

Donor HCV Status Calibration Plots

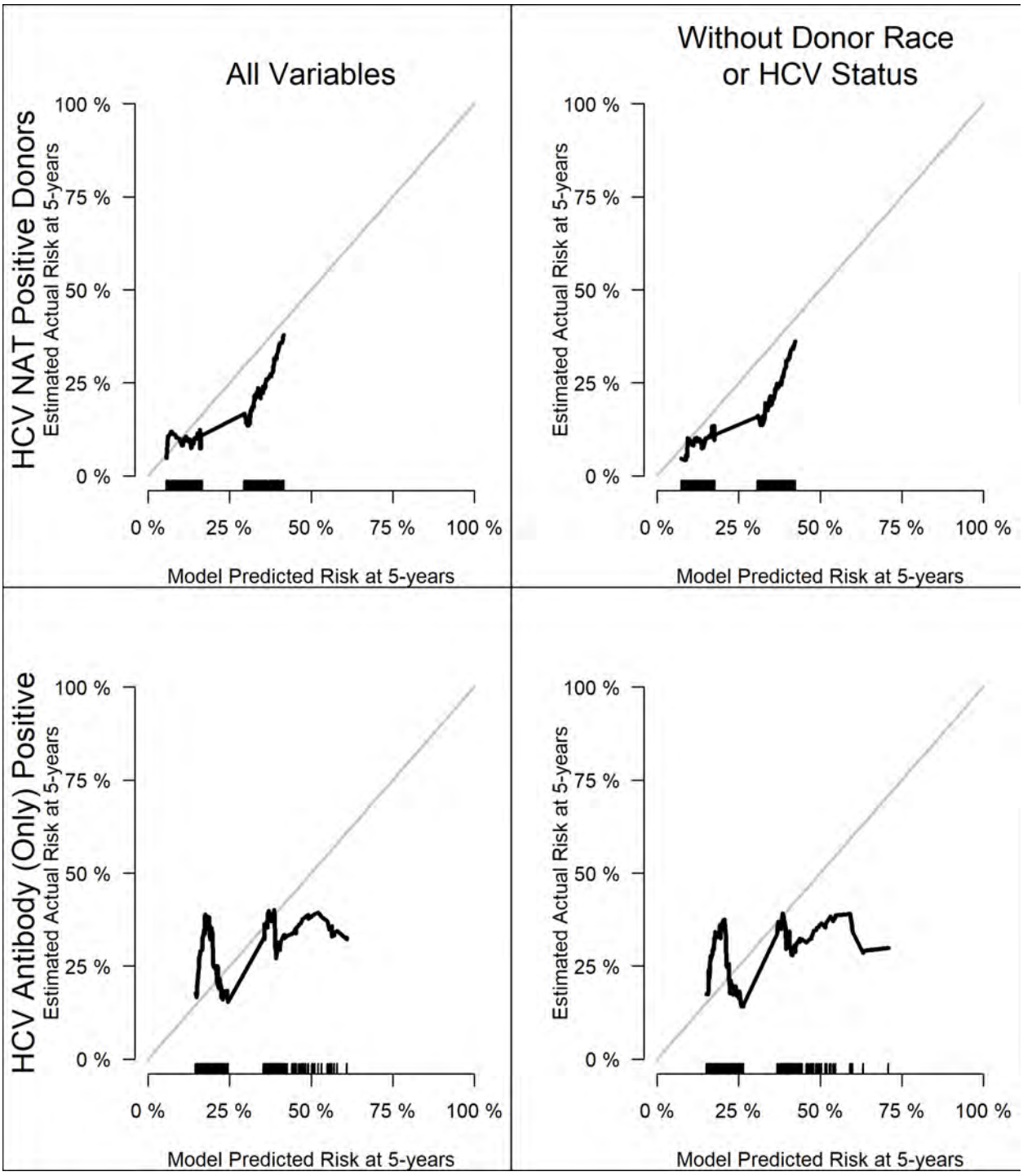


Figure 6: Calibration plots by donor HCV status for model with all variables and model with donor race and HCV status excluded

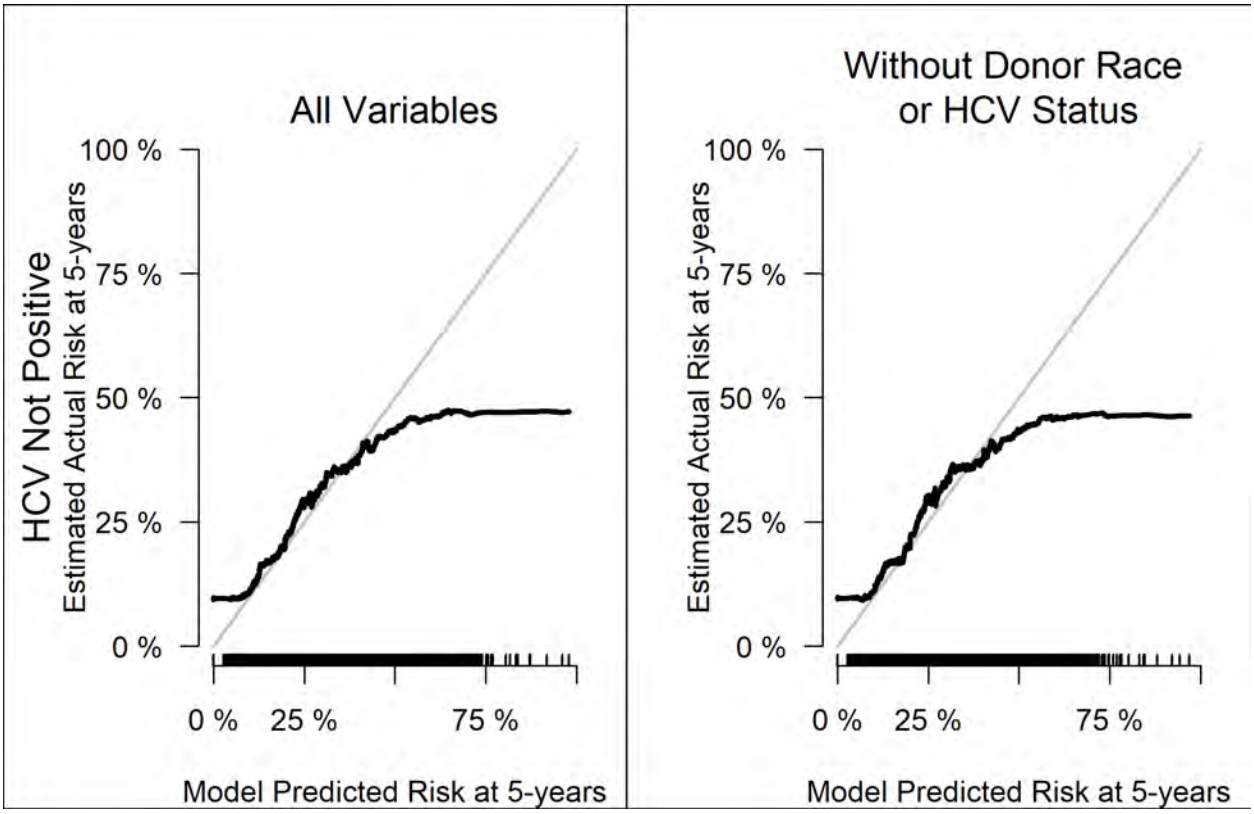


Figure 6: Calibration plots by donor HCV status for model with all variables and model with donor race and HCV status excluded