

# Liver Transplantation in the Time of a Pandemic

## A Widening of the Racial and Socioeconomic Health Care Gap During COVID-19

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**Objective:** During the initial wave of the COVID-19 pandemic, organ transplantation was classified a CMS Tier 3b procedure which should not be postponed. The differential impact of the pandemic on access to liver transplantation was assessed.

**Summary Background Data:** Disparities in organ access and transplant outcomes among vulnerable populations have served as obstacles in liver transplantation.

**Methods:** Using UNOS STARfile data, adult waitlisted candidates were identified from March 1, 2020 to November 30, 2020 ( $n = 21,702$  pandemic) and March 1, 2019 to November 30, 2019 ( $n = 22,797$  pre-pandemic), and further categorized and analyzed by time periods: March to May (Period 1), June to August (Period 2), and September to November (Period 3). Comparisons between pandemic and pre-pandemic groups included: Minority status, demographics, diagnosis, MELD, insurance type, and transplant center characteristics. Liver transplant centers ( $n = 113$ ) were divided into tertiles by volume (small, medium, large) for further analyses. Multivariable logistic regression was fitted to assess odds of transplant. Competing risk regression was used to predict probability of removal from the waitlist due to transplantation or death and sickness. Additional temporal analyses were performed to assess changes in outcomes over the course of the pandemic.

**Results:** During Period 1 of the pandemic, Minorities showed greater reduction in both listing ( $-14\%$  vs  $-12\%$  Whites), and transplant ( $-15\%$  vs  $-7\%$  Whites), despite a higher median MELD at transplant (23 vs 20 Whites,  $P < 0.001$ ). Of candidates with public insurance, Minorities demonstrated an 18.5% decrease in transplants during Period 1 (vs  $-8\%$  Whites). Although large programs increased transplants during Period 1, accounting for 61.5% of liver transplants versus 53.4% pre-pandemic ( $P < 0.001$ ), Minorities constituted significantly fewer transplants at these programs during this time period (27.7% pandemic vs 31.7% pre-pandemic,  $P = 0.04$ ). Although improvements in disparities in candidate listings, removals, and transplants were observed during Periods 2 and 3, the adjusted odds ratio of transplant for Minorities was 0.89 (95% CI 0.83–0.96,  $P = 0.001$ ) over the entire pandemic period.

**Conclusions:** COVID-19's effect on access to liver transplantation has been ubiquitous. However, Minorities, especially those with public insurance, have

been disproportionately affected. Importantly, despite the uncertainty and challenges, our systems have remarkable resiliency, as demonstrated by the temporal improvements observed during Periods 2 and 3. As the pandemic persists, and the aftermath ensues, health care systems must consciously strive to identify and equitably serve vulnerable populations.

**Keywords:** covid-19 ;disparities, liver transplantation, minorities, pandemic (*Ann Surg* 2021;274:427–433)

Disparities in organ access and transplant outcomes endure despite the goal of providing equitable care for patients with end-stage liver disease.<sup>1</sup> Indeed, Minority groups have lower rates of listing<sup>2</sup> and liver transplantation compared to their White counterparts.<sup>3,4</sup> Furthermore, post-transplant outcomes are also worse in Minority groups as a consequence of inequity.<sup>5,6</sup> Importantly, vulnerable populations are especially at risk when stressors are placed on health care systems—during pandemics,<sup>7,8</sup> disasters,<sup>9</sup> and in geographically restricted areas.<sup>10</sup>

During the initial wave of the COVID-19 pandemic many constraints were mandated or self-imposed in health care organizations. As a consequence, patient access to hospital facilities, elective treatments, and outpatient care was restricted. In the first 3 months, elective operations were postponed; however, organ transplantation was classified a CMS Tier 3b procedure, recommending that these cases should not be postponed.<sup>11</sup>

The aim of this study was to examine the effect of the COVID-19 pandemic on the existing health care gap in liver transplantation. The initial difference in rates of candidate listing and transplantation between 2020 (pandemic) and 2019 (pre-pandemic) periods were compared in Minority and White patients. As the pandemic progressed, the rates of waitlist additions, transplant activity, and patient deaths while awaiting transplantation were assessed to determine the impact over time.

## METHODS

### Data Source

This study analyzed the United Network for Organ Sharing (UNOS) Standard Transplant Analysis (UNOS STAR) files which consist of data on all donors, waitlisted candidates, and recipients of solid organ transplantation in the United States. Periodic follow-up (including, but not limited to, graft function and mortality) are reported to the Organ Procurement and Transplantation Network (OPTN) by transplant centers. The information is linked with matched data from the Social Security Death Master File. This study was approved by the University of Texas Southwestern Medical Center Institutional Review Board.

### Study Population

Using UNOS STAR file data, adult waitlisted candidates were identified from March 1, 2020 to November 30, 2020 ( $n = 21,702$ ,

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pandemic) and March 1, 2019 to November 30, 2019 ( $n = 22,797$ , pre-pandemic). Adult waitlisted candidates were further categorized and analyzed by time periods: March 2020 to May 2020 (Period 1), June 2020 to August 2020 (Period 2), and September 2020 to November 2020 (Period 3) (Fig. 1). Comparisons between groups in 2020 and 2019 included: Minority status, demographics, diagnosis, MELD at listing, insurance type, OPTN region, and transplant center characteristics. Minorities included individuals of the following ethnicities: African American, Hispanic, Asian, American Indian/Alaska Native, Native Hawaiian/Pacific Islander, Multiracial.<sup>12</sup>

### Center Analysis

Liver transplant centers ( $n = 113$ ) were divided into tertiles by volume (small, medium, large) based upon the number of liver transplants completed at each center during Period 1 of the pandemic. Center volume classification was held constant for analysis during the ensuing months of the pandemic in Periods 2 and 3.

### Waitlist Analysis

Waitlisted candidates were temporarily inactivated due to a number of reasons. These included: “temporarily too sick,” “candidate work-up incomplete,” “temporarily too well.” On March 18, 2020, UNOS instituted a new COVID-specific code for candidate inactivation: “COVID-19 precaution.” The number of actively waitlisted candidates was calculated as the total number of adult waitlisted candidates eligible to receive organ offers.

### Statistical Analysis

The statistical analyses were performed using Stata 16/MP4 (StataCorp LP, College Station, TX), and  $P$  values  $< 0.05$  (2-tailed) were considered statistically significant. Recipient characteristics were described using mean (standard deviation) for continuous variables and frequencies for categorical variables. Comparisons

between groups were made using the  $t$  test for continuous variables and chi-square tests for categorical variables as appropriate. Differences in new listing, waitlist removal, and transplantation between 2019 and 2020 were compared as relative rates of change year-over-year.<sup>13</sup> Multivariable logistic regression was fitted to assess odds of transplant during the pandemic period. A competing risk regression, the subdistribution hazards approach proposed by Fine and Gray,<sup>14</sup> was used to predict the probability of removal from the waitlist due to an outcome of interest (liver transplantation) at given time for a given patient characteristics (covariates) in the presence of competing risk (too sick/death). This method (using STATA software, the `stcrreg` function) takes into consideration the relationship between the covariates and cumulative incidence function to calculate an individual patient’s risk.

## RESULTS

There were 21,702 adult candidates who were on the waitlist for liver transplant between March 1, 2020 and November 30, 2020. Minorities comprised 6812 (31.4%) of these candidates. In 2019, during the same time period, there were 22,797 adult candidates waitlisted with Minorities comprising 7122 (31.3%) of these candidates.

### Waitlist Additions

A total of 9309 candidates were newly listed for transplant during the study period in 2020, compared with 9687 newly listed candidates in 2019. Initially, during Period 1, listings decreased in Minorities ( $-14\%$ ) and Whites ( $-12\%$ ) relative to 2019 (Fig. 2A). However, candidate listings rebounded in both groups as the pandemic progressed, with Minorities ( $+1\%$ ) and Whites ( $+3\%$ ) returning to 2019 levels in Period 2. Minorities exceeded their 2019 levels in Period 3 ( $+7\%$ ). Overall, across all periods, Minorities comprised 31% of new waitlist listings within the pandemic period compared to 30% of new waitlist listings in the pre-pandemic period.

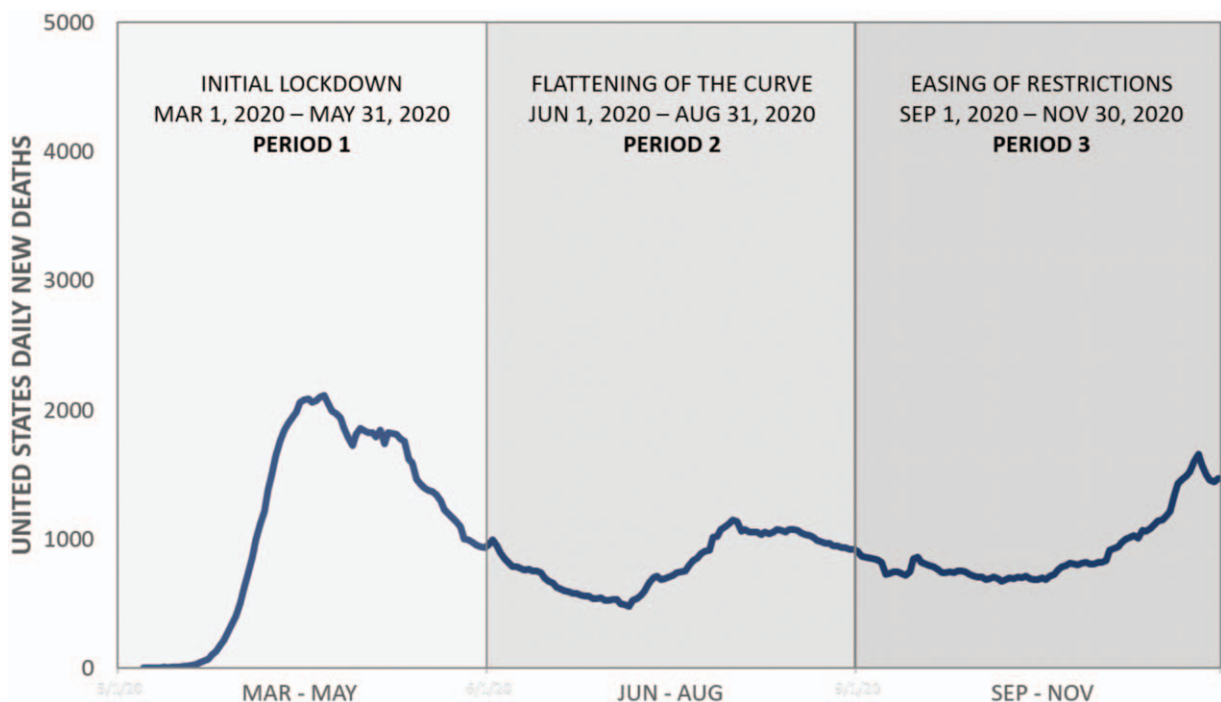
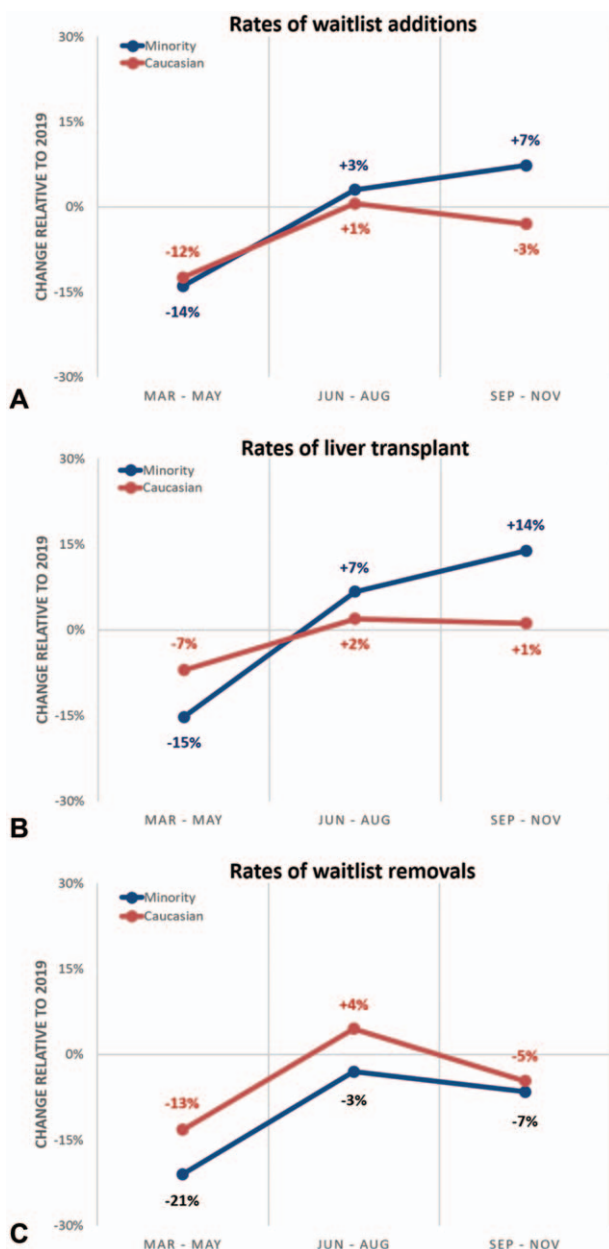


FIGURE 1. United States daily new deaths due to COVID-19 with regard to study time period designations.



**FIGURE 2.** A, Rates of new waitlist listings in 2020 relative to 2019; B, Rates of waitlist removal in 2020 relative to 2019; C, Rates of liver transplant in 2020 relative to 2019.

### Active Waitlist

At the onset of the pandemic (March 1, 2020), the waitlist comprised 12,417 candidates. Of these, 9780 candidates (79%) on the waitlist were active and eligible to receive donor organ offers (Fig. 3A). Minority candidates had a lower baseline level of activation in comparison to Whites (77% Minority vs 80% Whites) and experienced greater numbers of inactivations at the start of the pandemic (-5% active) compared to White (-3% active) waitlisted patients. Additionally, a higher percentage of Minority candidates were inactivated due to “COVID-19 precaution”, and this was responsible for most of the difference in the overall percentage of

inactivation observed between White and Minority groups (Fig. 3B). The relative contribution of the “COVID-19 precaution” reason for all waitlist inactivations was significantly higher for Minorities (8.3%) compared to Whites (5.5%) during the study period ( $P < 0.001$ ). As the pandemic progressed, both groups recovered toward their pre-pandemic levels of percent of active waitlist candidates.

### Liver Transplantation

#### Transplanted Demographics in 2020 (Pandemic) and in 2019 (Pre-pandemic)

From March to November 2020, 6281 deceased donor livers transplants (1885 Minorities vs 4396 White) were performed in adult waitlisted candidates compared to 6321 liver transplants (1867 Minorities vs 4454 White) during the same time period in 2019. Overall, MELD at transplant (21.4 vs 20.2,  $P < 0.001$ ), recipient BMI (29.1 vs 28.8,  $P < 0.001$ ), and Donor Risk Index (1.59 vs 1.51,  $P < 0.001$ ) were significantly greater in 2020 as compared to 2019. Significantly fewer patients with hepatocellular carcinoma as the primary diagnosis were transplanted in 2020 (20.8% vs 24.2%,  $P < 0.001$ ). In addition, Minority recipients transplanted in 2020 were younger (53.9 vs 55.6 years,  $P < 0.0001$ ) and had higher MELD scores (22.3 vs 21.0,  $P < 0.0001$ ) than Whites transplanted in the same period (Table 1). Female candidates, patients in the Midwest and Southwest of the United States, and candidates with lower levels of education were found to have the greatest reduction in transplant rates during the first period of the pandemic relative to the previous year (Table 2).

#### Transplant Rates in Minorities

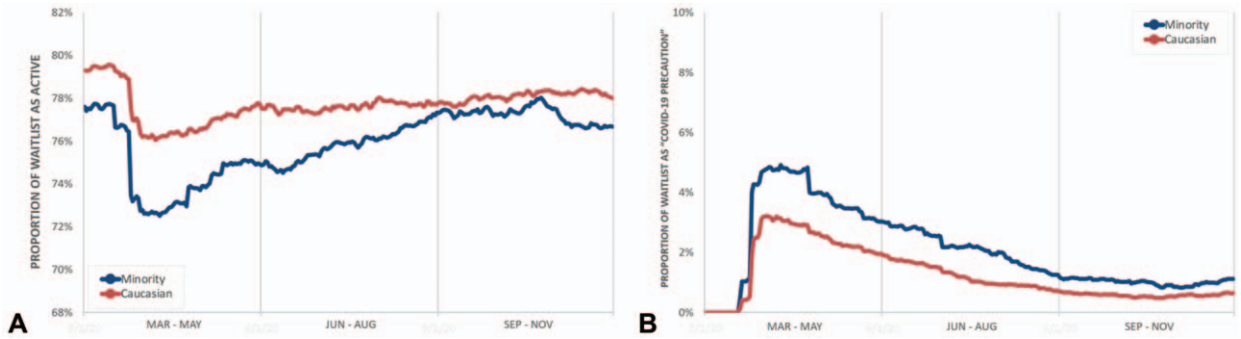
Initially during the pandemic, Minorities experienced a two-fold decrease in transplants compared with Whites (-15% Minorities vs. -7% Whites) relative to transplants done in 2019 (Fig. 2C). This gap appeared to improve as time progressed, with Minorities exceeding their 2019 transplant rates in Period 3 (+14%), whereas White transplant rates remained stable.

#### Transplant Rates in Publicly Versus Privately Insured

In 2020, 51% of candidates transplanted during the study period were privately insured, with similar percentages of Minority and White recipients with public insurance. Privately insured minority and White groups experienced decreased rates of transplantation (-12% vs -10%) in Period 1. This effect recovered in Period 2 (White +0% vs Minority +12%) and Period 3 (White -3% vs Minority +22%). Publicly insured Minorities demonstrated larger decreases in transplant rates compared with White candidates (-18% vs -4%) at the start of the pandemic. However, as with the privately insured, this effect rebounded as the pandemic progressed in Period 2 (White +5% vs Minority +3%) and in Period 3 (White +2% vs Minority +4%).

#### Minority Transplants by Center Size

During Period 1 of the pandemic, volume of liver transplants performed at the largest tertile programs increased (61.5% vs 54.3% pre-pandemic,  $P < 0.001$ ). Despite this increase in overall transplant activity at large centers during Period 1, Minorities comprised significantly fewer transplants at these centers (27.7% vs 31.7% pre-pandemic,  $P = 0.04$ ). The number of Minority transplants at large centers rebounded as the pandemic progressed through Period 2 (29.9% vs 28.9% pre-pandemic) and exceeded 2019 percentages in Period 3 (31.2% vs 28.5% pre-pandemic). Overall, transplant share and transplant volume at large centers was greater in 2020 (3661



**FIGURE 3.** A, Proportion of liver transplant candidate waitlist designated as actively receiving offers; B, Proportion of waitlist inactivated due to UNOS code “COVID-19 Precaution.”

transplants, 58.3% vs 3440 transplants, 54.8%,  $P = 0.005$ ) with a similar overall percentage of Minorities transplanted (29.7% vs 29.6%) (Table 3).

**Odds of Transplant**

Despite the rebound observed in new waitlist listings, removals, and transplants, Minorities had an adjusted odds ratio of transplant of 0.87 [95% confidence interval (CI) 0.78–0.97,  $P = 0.012$ ] during Period 1 of the pandemic and an overall odds ratio for the entire 2020 pandemic period examined of 0.89 (95% CI 0.83–0.96,  $P = 0.001$ ). Female candidates demonstrated significantly decreased odds of transplant relative to male candidates in 2019 [odds ratio (OR) 0.85, 95% CI 0.76–0.94,  $P = 0.001$ ], and 2020 (OR 0.78, 95% CI 0.71–0.87,  $P < 0.001$ ) however, females did not show

significantly decreased odds of transplant in 2020 compared to 2019 (OR 0.93, 95% CI 0.82–1.04,  $P = 0.202$ ). Similarly, publicly insured candidates did not show difference in odds of transplant between 2020 and 2019 (OR 1.0, 95% CI 0.90–1.10,  $P = 0.973$ ). Candidates in the northeast (OR 0.81, 95% CI 0.69–0.94,  $P = 0.009$ ) as well as candidates with some college education (OR 0.85, 95% CI 0.74–0.98,  $P = 0.029$ ) showed significantly decreased odds of transplant in 2020 compared to their odds in 2019.

**Waitlist Removals**

A total of 3566 candidates were removed from the waitlist during the study period in 2020 for reasons other than transplantation. This compared to 3809 removals during 2019. Minorities comprised 31% of these removals during the study period in 2020

**TABLE 1.** Recipient Characteristics

		White 2020, n = 4396	Minority 2020, n = 1885	White 2019, n = 4454	Minority 2019, n = 1867	P
Age, mean (SD)		55.6 (11.4)	53.9 (12.2)	56.0 (11.4)	54.3 (12.1)	<0.0001
Sex, n (%)	Female	1560 (35.5)	725 (38.5)	1533 (34.4)	759 (40.7)	<0.001
	Male	2836 (64.5)	1160 (61.5)	2921 (65.6)	1108 (59.3)	
Primary payer, n (%)	Private	2361 (54.1)	817 (43.7)	2458 (55.2)	768 (41.1)	<0.001
	Public	1989 (45.6)	1041 (55.6)	1973 (44.3)	1088 (58.3)	
	Other	16 (0.3)	13 (0.7)	22 (0.5)	11 (0.6)	
Educational attainment, n (%)	High school or less	1556 (37.2)	1074 (59.8)	1685 (39.0)	1072 (58.9)	<0.001
	Some college	1141 (27.3)	348 (19.4)	1205 (27.9)	399 (21.9)	
	Bachelor’s degree	1482 (35.5)	375 (20.8)	1434 (33.1)	350 (19.2)	
MELD at transplant, mean (SD)		21.0 (10.6)	22.3 (11.6)	20.0 (10.6)	20.6 (13.1)	<0.0001
BMI, kg/m <sup>2</sup>		29.3 (6.2)	28.7 (6.3)	29.0 (5.9)	28.3 (5.9)	0.0008
HCC, n (%)	Yes	845 (19.4)	462 (24.7)	946 (21.2)	585 (31.4)	<0.001
	No	3521 (80.6)	1409 (75.3)	3507 (78.8)	1281 (68.6)	
Donor Risk Index, mean (SD)		1.60 (0.42)	1.59 (0.42)	1.51 (0.42)	1.52 (0.41)	0.528

**TABLE 2.** Change in Transplants, Listings, and Removals During Pandemic Relative to 2019 (Period 1)

Recipient Characteristics		Transplants	Listings	Removals
Sex, %	Female	−10.9%	−15.1%	−20.0%
	Male	−8.9%	−11.5%	−12.9%
Educational attainment, %	High school or less	−10.4%	−20.2%	−10.7%
	Some college	−20.7%	−9.3%	−26.5%
	Bachelor’s degree	−5.4%	−8.0%	−11.9%
Geographic region, %	Northeast	−4.3%	−17.8%	−27.9%
	Southeast	−5.9%	−5.8%	5.2%
	Southwest	−12.0%	−17.7%	−29.8%
	Midwest	−20.3%	−13.4%	−12.0%
	West	−5.4%	−11.2%	−16.8%

TABLE 3. Transplant Center Characteristics

		Pre-Pandemic 2019	Pandemic 2020	P
Center Transplant volume, n (%)	Small	843 (13.4)	729 (11.6)	0.005
	Medium	1992 (31.7)	1885 (30.0)	
	Large	3440 (54.8)	3661 (58.3)	
Minority patients at center, n (%)	Small	238 (3.8)	217 (3.5)	0.143
	Medium	588 (9.4)	587 (9.4)	
	Large	1021 (16.3)	1084 (17.3)	

compared to 32% in 2019. During Period 1, waitlist removals decreased in Minorities (−21%) and Whites (−13%) relative to 2019 (Fig. 2B). Removals increased in both groups as the pandemic progressed. Death as the reason for removal from the waitlist was significantly higher in Minorities (25%) relative to Whites (21%) throughout the pandemic ( $P = 0.026$ ) (Fig. 4). Similarly, a greater percentage of Minority candidates became too sick for transplant (27%) compared to Whites (24%) throughout the pandemic, but this did not reach statistical significance ( $P = 0.055$ ) (Fig. 4B).

### Competing Risk Analysis for Waitlist Removals

Competing risk (subdistribution hazard approach) analysis demonstrated a significantly lower cumulative incidence of transplantation in Minority candidates during the pandemic

compared with White candidates ( $P = 0.001$ , Fig. 5A). Minority candidates with listing MELD score  $>20$  had a significantly lower cumulative incidence of transplant ( $P < 0.001$ , Fig. 5B), whereas candidates with MELD scores  $\leq 20$  had similar cumulative incidence. Subdistribution hazard ratios demonstrated the likelihood of transplant in Minorities was further reduced for those with public insurance [subdistribution hazard ratio (SHR) 0.88, 95% CI 0.81–0.96,  $P = 0.003$ ], those with high MELD score at listing (OR 0.81, 95% CI 0.74–0.89,  $P < 0.001$ , Table 4) and those listed for transplant at a large volume center (SHR 0.81, 95% CI 0.73–0.89,  $P < 0.001$ , Fig. 5C).

### DISCUSSION

The COVID-19 pandemic has exacted an enormous toll worldwide. In the midst of treating those afflicted by the virus

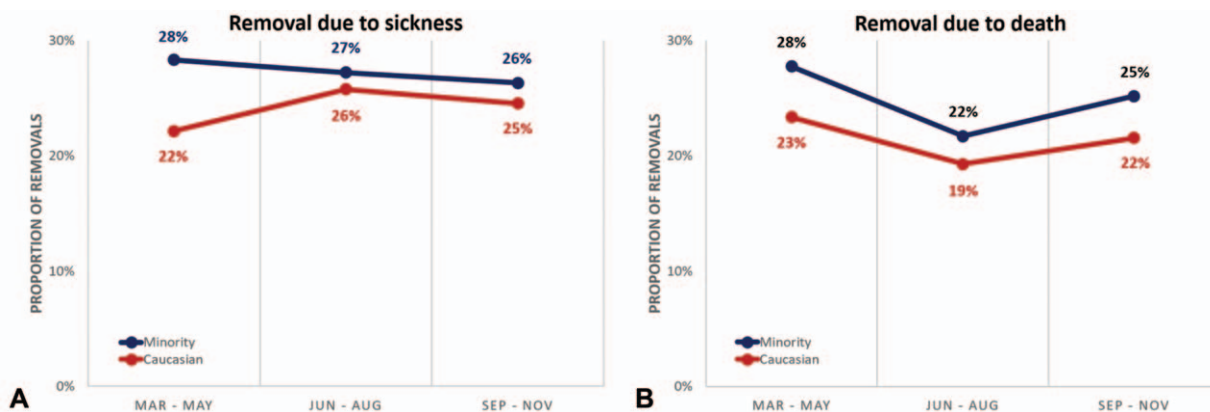


FIGURE 4. A, Proportion of waitlist removals with “death” as reason; B, Proportion of waitlist removals with “too sick to transplant” as reason.

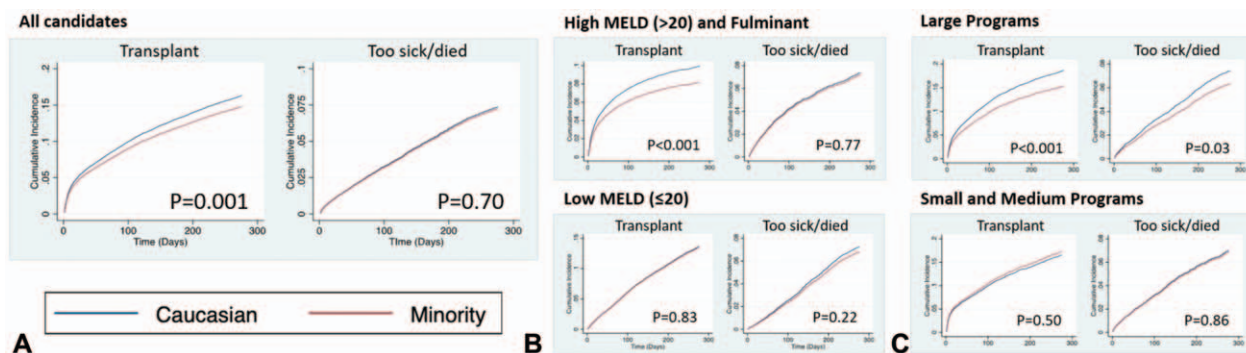


FIGURE 5. Competing risk regression (CRR): subdistribution hazard model analysis comparing Minority and White waitlist candidates where primary event was transplant and competing event was removal from waitlist due to too sick/death. Each subgroup model is adjusted for sex, MELD at initiation of the waitlist, primary diagnosis, insurance status, and region. A, All candidates; B, High MELD group (fulminant or MELD  $>20$ ); C, Low MELD group (MELD score  $\leq 20$ ); D, Candidates at large-volume programs only.

TABLE 4. SHR in Waitlist Candidate Subgroups

	Transplant (Competing risk of Too Sick/Death)					Too Sick/Death (Competing Risk of Transplant)				
	SHR	95% CI		P	SHR	95% CI		P		
All candidates	0.90	0.85	—	0.96	0.001	0.98	0.90	—	1.07	0.700
Subgroups										
Private insurance only	0.92	0.85	—	1.01	0.077	1.00	0.88	—	1.15	0.946
Public insurance only	0.88	0.81	—	0.96	0.003	0.96	0.86	—	1.07	0.438
High MELD	0.81	0.74	—	0.89	<0.001	0.98	0.83	—	1.15	0.772
Low MELD	0.99	0.92	—	1.07	0.830	0.94	0.84	—	1.04	0.223
Large size program	0.81	0.73	—	0.89	<0.001	0.85	0.73	—	0.99	0.031
Medium size program	1.05	0.91	—	1.21	0.500	0.98	0.80	—	1.20	0.860
Small size program	1.12	0.88	—	1.43	0.347	0.91	0.67	—	1.23	0.521
Female candidates	0.90	0.84	—	0.97	0.009	0.92	0.83	—	1.03	0.164
Male candidates	0.89	0.81	—	0.98	0.019	1.08	0.95	—	1.24	0.225

SHR represents likelihood of event in the Minority group compared with the White group. Each subgroup model is adjusted for sex, MELD at initiation of the waitlist, primary diagnosis, insurance status, and region.

and its complications, health care systems throughout the United States struggled to maintain capacity. For patients with end-stage liver disease, in which transplantation is the only life-saving treatment, the initial stages of the COVID-19 pandemic resulted in a widening of existing health care disparities for Minorities and those with public insurance. Specifically, there was a reduction in waitlist candidates actively receiving donor offers, fewer waitlist additions, fewer liver transplants, and lower odds of transplant compared to White candidates awaiting liver transplant. This was most pronounced in the early period of the pandemic, but importantly, with time and adaptation, this disparity gap appeared to improve.

The results described in this study serve to represent a recurring theme displayed during the pandemic—that stress on the healthcare system disproportionately affects vulnerable populations.<sup>15</sup> This finding of widening in disparity levels was not exclusive to transplantation, and was also revealed as disparities in access to testing,<sup>16</sup> as infection rates,<sup>15</sup> and as hospitalizations and deaths<sup>17,18</sup> among Minority groups. In liver transplantation, access to the waitlist is the critical disparity for Minorities, females, poor, and remote-dwelling individuals.<sup>19–21</sup> Drivers of this disparity include actual or perceived gaps in social support and lesser access to referring subspecialties.<sup>22,23</sup> Previous research has also shown waitlist access and survival to be lower for patients dwelling in sociodemographically vulnerable communities and areas with less developed medical infrastructure.<sup>24,25</sup> A system-wide stressor such as the pandemic would be expected to exert greater force on already-marginalized individuals. Notably, although insurance type, sex, and educational attainment were all associated with decreases in new listings, waitlist removals, and transplants, we did not observe a significant pandemic effect on their odds of transplant relative to 2019.

The analyses presented here are derived from large registry data. Additional studies that examine center-specific responses would provide greater clarity and permit causative analysis to be performed. There is of great importance to identify opportunities to lessen the disproportionate burden borne by Minorities and those with public insurance during crisis events. Furthermore, interrogation of upstream effects of the COVID-19 pandemic on access to transplant services for Minorities was not possible within these registry data. It is important to note that procurement numbers of deceased donor livers reached an all-time record in 2020, and together with changes in liver distribution policies that were introduced at the beginning of 2020, are likely to have influenced program-specific behavior during the entire pandemic period.

Improving access to life-saving liver transplantation for all patients is necessary to achieve equitable outcomes for Minority groups. The COVID-19 pandemic disrupted transplantation at multiple levels, but from an equity perspective, it served to illustrate the tenuousness of access to the waitlist for patients in underserved demographics, namely poor, Minority, and remote-dwelling individuals. As the COVID-19 pandemic persists, and future stressors emerge, healthcare systems must consciously strive to identify and equitably serve vulnerable populations.

Despite the uncertainty and challenges, it should be noted that our transplant systems have remarkable resiliency, as demonstrated by the temporal improvements observed. Successful liver transplantation is dependent on the dynamic interplay between organ recovery, donor evaluation, recipient prioritization, and availability of hospital resources. As demonstrated by the initial widening health care gap in liver transplantation in response to the pandemic, it is clear that the COVID-19 pandemic challenged the balance between each of these processes. In addition, disparity was not uniform throughout all regions or transplant centers, suggesting specific actions taken at certain centers were more effective than others. Further detailed study should be of great importance to the field to understand the factors that enabled greater resilience as the pandemic progresses and more center-level responses become publicized. Some strategies, such as the rapid shift toward telemedicine,<sup>26,27</sup> proactive outreach to vulnerable populations, COVID-19 pre-screening tools,<sup>28</sup> and increased local donor recovery,<sup>29</sup> have already shown promise in contributing to more robust transplant practices and ultimately improved organ access and outcomes.

In summary, disparities exist in transplantation and COVID-19 initially exacerbated these inequalities. It is only with continued attentiveness to the development of resilient health care systems that can undergo rapid adaptation, and have sufficient reserve of necessary resources, that equitable care for all with end-stage liver disease will be achieved.

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## DISCUSSANT

### Dr. Jayme E. Locke

I would like to thank the American Surgical Association for the privilege of serving as a primary discussant for this most intriguing work. I would also like to thank the authors for providing both their presentation and manuscript well in advance of the meeting. Drs. MacConmara, Vagefi, and colleagues tackle a pervasive and persistent problem in healthcare – disparities in access to care—and do so in the context of access to liver transplantation during the COVID-19 pandemic. I applaud the authors for keeping health disparities at the forefront of cutting-edge science, and for unapologetically demanding that we as both surgeons and scientists keep the proverbial “foot on the pedal” in our pursuit of equitable access to care. Their findings are both alarming and sobering. The US transplant system was designed to be equitable, and importantly, the National Organ Transplant Act demands it. Can the authors confirm that socioeconomic status was controlled for in their final model? Did the authors examine effect modification in both the additive and multiplicative scale? I ask because if racial disparities persist independent of socioeconomic status, these disparities may not solely be by-products of the lower socioeconomic status that underrepresented minorities disproportionately experience. But rather, we as both surgeons and scientists need and must consider the possibility that these racial disparities may exist within our healthcare system. This paper provides real world data that support our need to critically evaluate, understand, and address structural racism in healthcare.

### Response Dr. Parsia A. Vagefi

Drs. Mcleod and Hawn, American Surgical Association members and guests, we would like to thank you for the privilege of being able to present our work on disparities in access to liver transplantation during the COVID-19 pandemic. In addition, we would like to thank Dr. Locke for her insightful comments. As a leader in investigating health care disparities, Dr. Locke and her University of Alabama team have continued to produce significant contributions in furthering our understanding in this needed area, especially as it relates to disparities in access to organ transplantation.

In regards to the first question related to whether socioeconomic status was controlled for in our final model, we did control for this based upon the surrogate variables utilized - such as insurance status and education level—which are present in the UNOS dataset and which are admittedly limited. Ideally, more granular data should be captured to further enhance our ability to not only investigate, but also minimize these disparities. Variables such as household income or household size would add significant insight to our understanding. It should be noted that collection of these additional variables has been an effort pursued by the United Network for Organ Sharing minority affairs committee, but this has yet to be implemented.

In regards to the second question concerning the examination of effect modification in both the additive and multiplicative scale, this is an important question and one we hope to be able to address with additional analyses in follow up studies.

On behalf of our entire research team, thank you once again for the opportunity to present our work.