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Research article

The learning curve of COVID-19 and organ donation: Potential missed opportunities in the COVID era

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ABSTRACT

Background: Early in the COVID-19 pandemic, positive COVID-19 status often disqualified potential organ donors due to perceived risks, despite limited evidence. Subsequent studies have clarified that the COVID-19 status of donors, particularly when incidental and not the cause of death, does not adversely affect non-lung transplant outcomes. This study quantifies the potential loss of eligible organ donors and the corresponding impact on organ availability during the initial phase of the pandemic.
Methods: In this retrospective analysis, we examined deceased donor referrals to a major organ procurement organization from June 2020 to January 2022. Referrals were categorized as All Referrals, Medically Ruled Out (MRO), or Procured Donors (PD). We used Chi-square tests for categorical comparisons and logistic regression to model additional donors and organs, contrasting COVID-negative and positive cases within age-matched cohorts.
Results: Among 9478 referrals, 23.4 % (2221) were COVID-positive. Notably, COVID-positive referrals had a substantially higher MRO rate (80.6 % vs. 29.6 %, $p < 0.01$) and a markedly lower PD rate (0.2 % vs. 8.2 %, $p < 0.01$). Potential missed donations of 103 organs from COVID-positive referrals were identified.
Conclusion: This OPO-level study demonstrates a substantial impact of COVID-19 status on organ donation rates, revealing significant missed opportunities. Improved management of donor COVID-19 status could potentially increase organ donations nationwide, taking into account evolving evidence and vaccine availability changes.

1. Introduction

The advent of coronavirus disease 2019 (COVID-19) at the close of 2019 notably disrupted the sphere of solid organ

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List of abbreviations

COVID-19	Coronavirus Disease 2019
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
OPO	Organ Procurement Organization
MRO	Medically Ruled Out
PD	Procured Donors
STA	Southwest Transplant Alliance
UNOS	United Network for Organ Sharing
OPTN	Organ Procurement Transplant Network
NAAT	Nucleic Acid Amplification Tests
ICH	Intracerebral Hemorrhage
SRTR	Scientific Registry of Transplant Recipients
IRB	Institutional Review Board
IQR	Interquartile Range

transplantation, particularly during the initial phase of the global health crisis. Such disruption led to significant disturbances in the procedures for organ donation and procurement. As the medical community's comprehension of the virus expanded, protocols for organ acceptance underwent substantial revisions. This progression informed the updated guidelines issued by the United Network for Organ Sharing and the Organ Procurement Transplant Network (UNOS/OPTN) [1]. Recent evidence, encompassing a broad array of successful transplants from donors infected with SARS-CoV-2 to uninfected recipients without subsequent viral transmission, has been established [2–4]. The guidelines evolved from a complete prohibition of COVID-19-positive donors at the beginning of the pandemic to nuanced criteria by April 2022, differentiating between recent infection and prior exposure [1].

Despite these updates, a combination of overburdened healthcare facilities, limited access to hospital services, and the infection status of donors contributed to a sustained reduction in organ transplant activities. Many transplant centers have navigated this new landscape on a case-by-case basis, often treating a positive COVID test as a disqualifying factor for donation at the outset of the pandemic, leading to a significant drop in transplantation activities relative to pre-pandemic figures [5]. This response was largely shaped by individual OPOs within the regulatory frameworks and advisories provided at both federal and state levels, which did not mandate but rather guided the handling of COVID-19 positive donors.

While emerging studies suggest that the presence of SARS-CoV-2 in donors does not singularly determine the success of organ transplants, the persistent cautious practices likely continue to suppress overall transplantation rates [6].This research was conducted to analyze the referrals of deceased donors to a major organ procurement organization in Texas, aiming to evaluate the potential missed opportunities for organ donations from individuals excluded based on their SARS-CoV-2 status during the early phase of the COVID-19 pandemic.

While diverse international approaches, such as those in the UK and Australia, offer valuable perspectives on utilizing COVID-19-positive donors, this study specifically focuses on data from an OPO based in Texas. Our analysis is centered on local donor data to provide detailed and context-specific insights. Nevertheless, the lessons learned from international contexts could indeed inform future research and policy-making efforts aimed at enhancing organ donation rates during pandemic situations and other crises within and beyond our area of investigation.

2. Methods

2.1. Ethical compliance

This study involved analyzing anonymized data from deceased organ donors, which precludes the identification of individual subjects. Consequently, it falls under the exempt category of research involving non-identifiable existing data, as per IRB guidelines.

2.2. Study design

Our study entailed a retrospective cohort analysis focused on referral patterns to the Southwest Transplant Alliance (STA), a major organ procurement organization in Texas. STA, collaborating with 10 transplant centers, manages a significant portion of the state's organ donations [7]. The protocol for deceased donor organ transplantation begins with a detailed assessment of potential donors by the OPO, which involves evaluating medical histories and conducting comprehensive clinical assessments to ascertain organ viability. Following donor authorization, the OPO coordinates with transplant teams to facilitate the organ recovery process, which includes organ preservation and subsequent matching with recipients based on medical compatibility criteria. During the period from June 1, 2020, to January 31, 2022, we analyzed de-identified data, tracking the progression of donor referrals through the various stages of STA's organ procurement process. Referrals were systematically classified into 'All Referrals', 'Medically Ruled Out' (MRO) for those not meeting medical criteria, and 'Procured Donors' (PD) for those whose organs were harvested. Furthermore, the study documented causes of death, categorizing them into established medical classifications. This approach provided a platform to critically assess the impact of COVID-19 on the organ donor selection process and to identify possible missed opportunities for organ donation due to SARS-CoV-2 positivity.

2.3. Referral triggers

Referrals to the OPO are typically triggered by hospital reports of potential donors following clinical or brain death assessments, in line with national regulations and local practices that dictate the criteria for referral to organ procurement organizations.

2.4. Classification of medical data

During the period from June 1, 2020, to January 31, 2022, we tracked donor referrals through STA's organ procurement process. Referrals were systematically categorized as 'All Referrals', 'Medically Ruled Out' (MRO) for those failing to meet medical criteria, and 'Procured Donors' (PD) for those whose organs were procured. Causes of death were documented according to established medical classifications, which will be available in a supplementary appendix.

2.5. Study population

We focused on individuals referred for potential organ donation during the intense early phases of the COVID-19 pandemic, defined by the periods of high hospitalization and mortality rates due to the virus. We included only those referrals that provided comprehensive clinical data, such as admission reasons, cause of death, SARS-CoV-2 test results, and eventual organ procurement outcomes, totaling 9478 candidates. These candidates underwent a thorough eligibility assessment to ensure accurate documentation and family consent for organ donation [8]. All candidates who met the inclusion criteria were considered. Records missing any of these details were excluded to maintain data integrity.

2.6. SARS-CoV-2 status assessment

Assessments of the SARS-CoV-2 infection status in donor candidates occurred post-admission, based on nucleic acid amplification tests (NAAT) from respiratory samples from tracheal aspirates or obtained during bronchoscopy.

2.7. Determination of MRO and PD rates

We quantified the influence of SARS-CoV-2 infection on donor organ viability by calculating the proportions of MRO and PD among the total referrals. Specifically, the MRO rate reflected the subset of referrals excluded from further consideration due to medical criteria, while the PD rate pertained to those who met all criteria and whose organs were procured. Serology or antibody testing was not incorporated due to data unavailability.

2.8. Statistical procedures

The study used medians and interquartile ranges for continuous data, and proportions for categorical data. We conducted descriptive statistical analyses to explore participant characteristics and the prevalence of SARS-CoV-2 among the cohort. Chi-square tests, with Yates' correction for small sample sizes, were applied to determine the significance of associations, with a p-value threshold of less than 0.05 indicating significance.

Additionally, MRO and Procured Donors rates were calculated based on the population size of each SARS-CoV-2 cohort. Potential additional donors and organs were modeled by applying MRO and donation rates from SARS-CoV-2-negative referrals to SARS-CoV-2-positive within matched age groups. All statistical analysis was conducted using Prism GraphPad (Version 9.4.1).

2.9. Epidemiological contextualization

During the study period from June 2020 to January 2022, we closely monitored and integrated updates from the United Network for Organ Sharing and the Organ Procurement and Transplantation Network (UNOS/OPTN) into our analysis. These updates were pivotal in shaping organ procurement practices at a major organ procurement organization in Texas, particularly in response to evolving pandemic conditions [9].

Significant policy changes during this time included.

- March 17, 2020: Implementation of emergency policies by OPTN in response to COVID-19, affecting routine transplant operations and donor management.
- April 26, 2021: OPTN issued revised policies on organ recovery from donors with a history of COVID-19, providing detailed guidelines that influenced donor eligibility assessments.

Our analysis focused on the implementation of these guidelines within the local OPO's practices and how they impacted the eligibility and utilization of donors, particularly those testing positive for SARS-CoV-2. This context was crucial for understanding shifts in organ donation and procurement rates during key phases of the pandemic, as well as for assessing potential delays in adopting new national advisories, which could have influenced donor selection processes and outcomes.

2.10. Modeling missed opportunities

A conservative approach was adopted to model missed donor opportunities attributable to SARS-CoV-2 status. We extrapolated the donation rates of SARS-CoV-2-negative donors within the 13–40 age cohort to their positive counterparts to estimate additional donor potentials. This model multiplied the number of suitable SARS-CoV-2-positive donors by the average number of organs recovered per donor (excluding lung procurement), based on data from the Scientific Registry of Transplant Recipients (SRTR) [7].

3. Results

3.1. Referral Overview

From June 2020 to January 2022, the OPO received 9572 organ donor referrals. After excluding incomplete records, 9478 referrals were considered in the analysis (n = 9478). A summarized demographic analysis (Table 1) reveals that males represented the majority of referrals at 59.4 %, with a median age of 62 years (IQR: 23). Among these, 23.4 % (n = 2221) tested positive for COVID-19. The prevalent causes of death included cardiovascular incidents (30.54 %, n = 2977) and intracerebral hemorrhage/stroke (ICH/stroke, 14.4 %, n = 1402). Notably, only 1.9 % (n = 41) of COVID-19-positive patients succumbed to ICH/stroke. Traumatic causes accounted for 8.4 % (n = 814) of all referrals, with only one individual testing positive for COVID-19. This low incidence of COVID-19 positivity among trauma referrals may reflect specific practices or selection criteria of the OPO during this period, a detail that points to a broader discussion on regulatory practices in the era of a novel virus. Of note, a considerable proportion of the reported causes of death fell under the category 'Other'. This diverse classification likely includes a range of medical conditions and circumstances not captured by standard reporting categories. During the study period, characterized by rapidly updating clinical guidelines and reporting practices, these 'Other' classifications signify the broad spectrum of causes that did not conform to typical categorizations.

3.2. Exclusion due to medical criteria (MRO)

Out of the potential donors, 42 % (n = 4015) were medically ruled out prior to the determination of their donor status as brain dead or circulatory dead, which are classifications typically applied during the recovery phase (Table 2). The median age in this group was 65 years (IQR: 19), closely aligning with the overall referral median. The highest exclusion rates were for cardiovascular causes at 16.6 % (n = 665), and 93.4 % (n = 129) for donor candidates with cancer. Notably, the SARS-CoV-2-positive individuals were significantly more likely to be medically ruled out (44.6 %) than their negative counterparts (23.4 %, p < 00.05). This exclusion occurred

Table 1
Demographic and clinical characteristics of all organ donor referrals by COVID-19 status.

All Referrals[a]				
	All, N (% of total)	COVID+, N (% of total)	COVID-, N (% of total)	p-value
	9478 (100 %)	2221 (23.34 %)	7257 (76.57 %)	<0.01
Cause of Death	**All, N (% of total)**	**COVID+, N (% of total COVID+) (1)**	**COVID-, N (% of total COVID-) (1)**	**p-value**
Cardiovascular	2977 (30.54 %)	419 (18.87 %)	2558 (33.98 %)	<0.01
Respiratory	821 (8.42 %)	398 (17.92 %)	423 (5.62 %)	<0.01
ICH/stroke	1402 (14.38 %)	41 (1.85 %)	1361 (18.08 %)	<0.01
Trauma	814 (8.35 %)	0 (0 %)	814 (10.81 %)	<0.01
Drug Intoxication	189 (1.94 %)	0 (0 %)	189 (2.51 %)	<0.01
Cancer	138 (1.42 %)	4 (0.18 %)	134 (1.78 %)	<0.01
Other	3137 (32.18 %)	1359 (61.19 %)	1778 (23.62 %)	<0.01
Age:	**All, N (% of total)**	**COVID+, N (% of total COVID+)**	**COVID-, N (% of total COVID-)**	**p-value**
0–5	219 (2.31 %)	6 (0.27 %)	213 (2.94 %)	<0.01
6–12	47 (0.50 %)	3 (0.14 %)	44 (0.61 %)	<0.01
13–20	199 (2.10 %)	13 (0.59 %)	186 (2.56 %)	<0.01
21–40	1092 (11.52 %)	137 (6.17 %)	955 (13.16 %)	<0.01
41–60	2925 (30.86 %)	737 (33.18 %)	2188 (30.15 %)	<0.01
60+	4996 (52.71 %)	1328 (59.79 %)	3668 (50.54 %)	<0.01
Sex	**All, N (% of total)**	**COVID+, N (% of total COVID+)**	**COVID-, N (% of total COVID-)**	**p-value**
Male	5633 (59.43 %)	1371 (61.74 %)	4262 (58.73 %)	<0.05
Female	3845 (40.57 %)	850 (38.27 %)	2995 (41.27 %)	
Median Age	62	64	61	
IQR	23	18	26	

[a] Percentage is defined as the proportion of patients in each subgroup out of the total number of patients sharing the COVID-19 status.

Table 2
Comparison of medically ruled out organ donor referrals by COVID-19 status.

Medically Ruled Out[a]				
	All, N (% of total MRO)	COVID+, N (% of total MRO)	COVID-, N (% of total MRO)	p-value
	100 % (4015)	44.58 % (1790)	55.32 % (2225)	<0.01
Cause of Death	**All, N (% of total MRO)**	**COVID+, N (% of total COVID + MRO)**	**COVID-, N (% of total COVID- MRO)**	**p-value**
Cardiovascular	665 (16.56 %)	164 (9.16 %)	501 (22.52 %)	<0.01
Respiratory	487 (12.13 %)	340 (18.99 %)	147 (6.61 %)	<0.01
ICH/stroke	285 (7.10 %)	36 (2.01 %)	249 (11.19 %)	<0.01
Trauma	70 (1.74 %)	0 (N/A)	70 (3.15 %)	N/A
Drug Intoxication	105 (2.62 %)	0 (N/A)	105 (4.72 %)	N/A
Cancer	129 (3.21 %)	4 (0.22 %)	125 (5.61 %)	<0.01
Other	2274 (56.64 %)	1246 (69.61 %)	1028 (46.20 %)	<0.01
Age:	**All, N (% of total MRO)**	**COVID+, N (% of total COVID + MRO)**	**COVID-, N (% of total COVID- MRO)**	**p-value**
0–5	111 (2.76 %)	4 (0.22 %)	107 (4.18 %)	<0.01
6–12	6 (0.15 %)	1 (0.06 %)	5 (0.22 %)	0.19
13–20	33 (0.82 %)	7 (0.39 %)	26 (1.17 %)	<0.01
21–40	258 (6.43 %)	96 (5.36 %)	162 (7.28 %)	<0.05
41–60	1141 (28.42 %)	505 (28.21 %)	636 (28.58 %)	0.80
60+	2466 (61.42 %)	1177 (65.75 %)	1289 (57.93 %)	<0.01
Sex	**All, N (% of total MRO)**	**COVID+, N (% of total COVID + MRO)**	**COVID-, N (% of total COVID- MRO)**	**p-value**
Male	2391 (59.55 %)	1097 (61.28 %)	1294 (58.26 %)	0.05
Female	1624 (40.45 %)	693 (38.72 %)	931 (41.84 %)	0.05
Median Age	65	66	63	
IQR	19	17	21	

[a] Of total referrals, zero COVID-19-positive patients were reported with Trauma or Drug Intoxication as the Cause of Death.

Table 3
Profile of successful organ donors by COVID-19 status.

Procured Donors				
	All, N (% of total Procured Donors)	COVID+, N (% of total Procured Donors)	COVID-, N (% of total Procured Donors)	p-value
	100 % (621)	0.81 % (5)	99.19 % (616)	<0.01
Cause of Death	**All, N (% of total Procured Donors)**	**COVID+, N (% of total COVID + Procured Donors)**	**COVID-, N (% of total COVID- Procured Donors)**	**p-value**
Cardiovascular	86 (13.85 %)	1 (20.00 %)	85 (13.80 %)	0.69
Respiratory	23 (3.70 %)	0 (0 %)	23 (3.73 %)	0.66
ICH/stroke	218 (35.10 %)	2 (40 %)	216 (35.06 %)	0.85
Trauma	184 (29.36 %)	0 (0 %)	184 (29.87 %)	0.15
Drug Intoxication	42 (6.76 %)	0 (0 %)	42 (6.82 %)	0.55
Cancer	1 (0.16 %)	0 (0 %)	1 (0.16 %)	0.93
Other	67 (10.79 %)	2 (40 %)	65 (10.55 %)	<0.05
Age:	**All, N (% of total Procured Donors)**	**COVID+, N (% of total COVID + Procured Donors)**	**COVID-, N (% of total COVID- Procured Donors)**	**p-value**
0–5	2.09 % (13)	0 % (0)	2.11 % (13)	0.74
6–12	1.13 % (7)	0 % (0)	1.14 % (7)	0.81
13–20	8.21 % (51)	0 % (0)	8.28 % (51)	0.5
21–40	35.75 % (222)	20 % (1)	35.88 % (221)	0.46
41–60	42.67 % (265)	80 % (4)	42.37 % (261)	0.09
60+	10.14 % (63)	0 % (0)	10.23 % (63)	0.45
Sex	**All, N (% of total Procured Donors)**	**COVID+, N (% of total COVID + Procured Donors)**	**COVID-, N (% of total COVID- Procured Donors)**	**p-value**
Male	57.81 % (359)	0 % (0)	58.28 % (359)	<0.01
Female	42.19 % (262)	100 % (5)	41.72 % (257)	0.1
Median Age	42	46	42	
IQR	27	5	27	

independently of the subsequent classification into brain dead or circulatory dead donors, affirming that the initial medical evaluation phase, rather than the recovery phase classifications, was the critical determinant in the exclusion process.

3.3. Procured donor analysis (PD)

Out of all referrals, 6 % (n = 621) were approved as donors and their organs were procured for transplantation (Table 3). These individuals had a notably lower median age of 42 years (IQR: 27) compared to those medically ruled out. The leading causes of death for donors were ICH/stroke (35.3 %) and trauma (29.8 %). SARS-CoV-2-positive donors represented a mere 0.81 % (n = 5) of this group.

3.4. Comparison of MRO and PD rates

The study identified that 42.36 % of all referrals were medically ruled out, with cardiovascular incidences (16.56 %) and respiratory failures (12.31 %) being the leading reasons. A marked disparity was noted in MRO rates when stratified by COVID-19 status: 80.6 % for positive versus 30.7 % for negative referrals. ($p < 0.05$). This pattern held true across causes of death, with marked differences in exclusion rates between COVID-19-positive and -negative individuals, particularly for cardiovascular causes (76.8 % vs. 33.3 %, $p < 0.01$) and stroke (46.9 % vs. 17.5 %, $p < 0.01$).

The disparities extended to the rates of successful donor procurement. The proportion of referrals proceeding to organ donation was dramatically lower for COVID-19-positive patients, with only 0.2 % of such individuals becoming donors, in contrast to 8.5 % of COVID-19-negative individuals ($p < 0.05$). Trauma and drug intoxication emerged as the most common causes of death among the successfully procured donors, with high procurement rates of 22.60 % and 22.22 %, respectively. Age also played a critical role; those aged 13 to 40 had the highest donor procurement rate at 21.15 %, with no significant differences observed between genders. This data underscores the profound impact that COVID-19 status had on the donor selection process during the study period, reflecting a potential hesitancy to proceed with donors who tested positive for the virus.

3.5. Epidemiological trends

In plotting the temporal trends of the pandemic, our analysis mapped the trajectory of new COVID-19 cases in Texas against the timeline of SARS-CoV-2-positive donor referrals to the OPO (Fig. 1). A synchronous escalation was observed in both the number of reported cases and positive donor referrals, with a notable intensification starting in June 2021 and reaching a crescendo in August 2021. This upsurge coincided with the advent of the delta variant, which dominated the infection landscape during this time, marking the third significant wave of the pandemic in the region [10]. While the increase in SARS-CoV-2-positive donor referrals mirrored the general rise in COVID-19 cases, it was observed that the referrals peaked slightly later, suggesting a lag in the impact of community transmission rates on the organ donation process.

3.6. Missed donation opportunities

In examining missed opportunities, the lowest MRO and highest PD rates were within the SARS-CoV-2-negative cohort aged 13–40 years (16.4 % and 21.15 %, respectively). By applying these rates to the corresponding COVID-positive cohort, we identified a potential increase of 35 donors. When factoring in the average number of organs recovered per donor (OPO-specific ORPD excluding

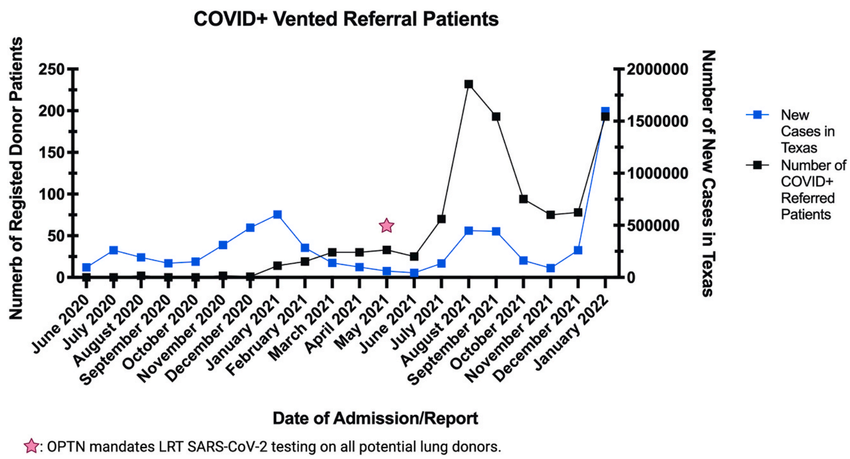

Fig. 1. The number of new COVID-19+ cases in Texas and the number of COVID-19+ registered donor patients referred to the organ procurement center [11].

lungs of 2.96), an estimated 103 additional organs could have been available from SARS-CoV-2-positive donors [7,11,12].

4. Discussion

Our analysis of over 9400 deceased donor referrals at the OPO level from June 2020 to January 2022 revealed significant challenges in donor selection due to COVID-19 status. This period, the first 18 months of the pandemic in the United States, was a critical time when the pandemic's trajectory and response strategies were rapidly evolving. During this time, we observed a delay in the utilization of SARS-CoV-2-positive donors, corresponding with the initial surges in COVID-19 cases and before the establishment of refined transplantation protocols. Notably, the initial surge of the pandemic in the summer and winter of 2020 did not correlate with SARS-CoV-2-positive referrals until January 2021, signaling a considerable delay in recognizing the potential of these donors. This lag could likely be a reflection of the uncertainties that clouded the medical community's understanding of the virus, particularly with respect to organ transplantation safety. Professional transplant organizations initially advised the suspension of living donor transplants in high-risk areas and recommended against utilizing SARS-CoV-2-positive donors due to concerns about viral transmission risk [13–16].

In the span from June 2020 to January 2022, although SARS-CoV-2-positive individuals constituted over 23 % of all donor referrals, a mere fraction, less than 1 %, proceeded to become actual donors. This substantial gap is largely due to the markedly higher rates of medical disqualification for SARS-CoV-2-positive referrals, which were more than twice that of negative ones (80.6 % vs. 30.7 %, $p < 0.01$). Notably, the lack of detailed data on the reasons for medical disqualification precludes a deeper understanding of this discrepancy. However, even within the prime donor age group of 13–40 years, where the influence of comorbid conditions is presumably lower, the disparity in exclusion rates based on COVID-19 status remained significant, with 68 % of positive referrals ruled out compared to 16 % of negative ones.

The limited use of SARS-CoV-2-positive individuals as donors, constituting less than 1 % of referrals, was attributed to a stringent medical disqualification criterion, reflective of a healthcare system grappling with the novel virus's complexities. This heightened level of caution was undoubtedly influenced by concerns regarding complications like sepsis and multi-organ failure, which were prevalent in COVID-19 fatalities [17]. It's reasonable to suggest that these factors, associated with COVID-19-related deaths, contributed to the categorization of 'respiratory failure', highlighting a major challenge in data categorization during an unprecedented crisis.

While we adopted a conservative approach to estimating an additional 35 donors and 103 organs that could have been procured from the SARS-CoV-2-positive cohort, these figures represent a substantial resource that could potentially alleviate the organ shortage crisis. The impact of such an increase becomes even more profound when projected across multiple OPOs nationwide, offering a considerable expansion of the donor pool for patients on transplant waiting lists.

This study is not a retrospective critique of the decisions made during an emergent health crisis. Instead, it seeks to understand the possible opportunities for organ donation that may have been overlooked due to the precautionary disqualification of COVID-19 positive donors. The initial guidelines recommended by professional transplant organizations were crucial for ensuring patient safety, yet this retrospective analysis suggests the potential for revising organ donor assessment protocols in light of emerging evidence, possibly increasing organ availability without compromising donor safety. We acknowledge the initial necessity for prudence during an emergent infectious outbreak. However, our findings prompt a discussion about how rapidly evolving guidelines and research could have supported a more responsive approach to donor assessment and utilization. It was indeed a period marked by a dual imperative: to adapt quickly while navigating the operational stresses imposed by the pandemic on the healthcare system. The observed lag in adopting new guidelines into clinical practice highlights the disconnect between policy development and frontline medical action. This suggests a need for more proactive dissemination and integration of emerging research into clinical practice, ensuring timely and informed decision-making.

Nevertheless, the study is not without limitations. Our analysis was constrained by the categorization within the OPO's dataset, which often recorded a singular primary cause of death and did not capture the complexity of cases where multiple factors, such as concurrent drug intoxication and traumatic injuries, might contribute. This simplification, while practical, might mask the intricacies of each case, such as how COVID-19 interplayed with other conditions in medical disqualifications. Particularly, the rejection rates due to COVID-19 alone are challenging to isolate and quantify. The 'other' category, accounting for a significant portion of causes of death, signifies a broad array of unclassified conditions and reflects the challenges in classification precision during a tumultuous period for healthcare systems. Furthermore, the lack of a detailed list of medical exclusion criteria and the apparent variations in recording practices among medical centers could introduce additional confounding variables. These limitations highlight the importance of establishing more robust data collection and reporting protocols that can withstand the demands of a public health emergency and provide clear guidance for future retrospective studies.

5. Conclusion

Over 18 months at the onset of the pandemic, our study revealed SARS-CoV-2's substantial impact on organ donation in Texas, with a sharp decline in donations from positive individuals. This underscores the need for evolved protocols responsive to public health challenges. The data points to a potential increase in organ donations if the 13–40 age group, particularly those without COVID-19, were targeted, which could significantly alleviate organ shortages in emergent situations.

The findings call for policies that can adapt to real-time research, improving organ donation frameworks during pandemics. Although interpreting the direct impact of COVID-19 amidst other factors proved complex, the study highlights a vital opportunity: to enhance donation strategies and support the health system's resilience against future health crises. The insights provided here advocate for the integration of evolving knowledge into clinical practices, with the ultimate goal of saving more lives through transplantation.

Data availability statement

Data will be made available on request.

CRediT authorship contribution statement

Jared R. Zhang: Writing – original draft, Visualization, Investigation, Formal analysis, Data curation, Conceptualization. **Muhammad Mujtaba:** Writing – review & editing, Conceptualization. **Heidi Wagenhauser:** Data curation. **Yvette Chapman:** Data curation. **Trine Engebretsen:** Writing – review & editing. **Heather L. Stevenson:** Writing – review & editing. **Syed Hussain:** Writing – review & editing, Writing – review & editing. **Michael Kueht:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e32086.

References

[1] Summary of evidence report details experience with COVID-19. https://optn.transplant.hrsa.gov/media/kkhnlwah/sars-cov-2-summary-of-evidence.pdf, 2022.
[2] J.R. Zhang, M. Kueht, A.S. Lea, H.L. Stevenson, J. Gosnell, P. Ren, M.C. Nielsen, A. Miller, M. Mujtaba, J. Fair, Multisite biologic tissue SARS-CoV-2 PCR testing in kidney transplantation from a COVID-positive donor, J. Surg. Case Rep. 2022 (2022) rjac314, https://doi.org/10.1093/jscr/rjac314.
[3] R. Romagnoli, S. Gruttadauria, G. Tisone, G. Maria Ettorre, L. De Carlis, S. Martini, F. Tandoi, S. Trapani, M. Saracco, A. Luca, et al., Liver transplantation from active COVID-19 donors: a lifesaving opportunity worth grasping? Am. J. Transplant. 21 (2021) 3919–3925, https://doi.org/10.1111/ajt.16823.
[4] C.E. Koval, M. Eltemamy, E.D. Poggio, J.D. Schold, A.C. Wee, Comparative outcomes for over 100 deceased donor kidney transplants from SARS-CoV-2 positive donors: a single-center experience, Am. J. Transplant. 22 (2022) 2903–2911, https://doi.org/10.1111/ajt.17203.
[5] L. Danziger-Isakov, E.A. Blumberg, O. Manuel, M. Sester, Impact of COVID-19 in solid organ transplant recipients, Am. J. Transplant. 21 (2021) 925–937, https://doi.org/10.1111/ajt.16449.
[6] L.J. Thomas, P. Huang, F. Yin, X.I. Luo, Z.W. Almquist, J.R. Hipp, C.T. Butts, Spatial heterogeneity can lead to substantial local variations in COVID-19 timing and severity, Proc Natl Acad Sci U S A 117 (2020) 24180–24187, https://doi.org/10.1073/pnas.2011656117.
[7] OPO-specific report (OSR) Southwest Transplant alliance, Dallas, TX. https://www.srtr.org/reports/opo-specific-reports/opo?code=TXSB, 2023.
[8] S.T. Alliance, About Us, 2024. https://www.organ.org/about-us.
[9] C.f.D.C.a. Prevention, United States COVID-19 cases and deaths by state. https://data.cdc.gov/Case-Surveillance/United-States-COVID-19-Cases-and-Deaths-by-State-o/9mfq-cb36/data, 2022.
[10] D.J. Sencer, CDC Museum COVID-19 Timeline, 2022 cdc.gov/museum/timeline/covid19.html#:~:text=June%201%2C%202021,during%20the%20summer%20of%202021.
[11] J.M. Miller, Y.S. Ahn, A. Hart, K. Lindblad, C. Jett, C. Fox, R. Hirose, A.K. Israni, J.J. Snyder, OPTN/SRTR 2021 annual data report: COVID-19, Am. J. Transplant. 23 (2023) S475–s522, https://doi.org/10.1016/j.ajt.2023.02.011.
[12] J.M. Miller, Y.S. Ahn, A. Hart, D.L. Segev, D.P. Schladt, K.T. Livelli, K.A. Lindblad, A.K. Israni, J.J. Snyder, OPTN/SRTR 2022 annual data report: COVID-19, Am. J. Transplant. 24 (2024) S489–s533, https://doi.org/10.1016/j.ajt.2024.01.019.
[13] Q.Y. Ho, S.J. Chung, S.C.S. Low, R.C. Chen, S.P. Teh, F.Z.Y. Chan, B.H. Tan, T.Y.S. Kee, Evaluating potential deceased donor renal transplant recipients for asymptomatic COVID-19, Transplant Direct 6 (2020) e559, https://doi.org/10.1097/txd.0000000000001010.
[14] A.E. Woolley, M.R. Mehra, Dilemma of organ donation in transplantation and the COVID-19 pandemic, J. Heart Lung Transplant. 39 (2020) 410–411, https://doi.org/10.1016/j.healun.2020.03.017.
[15] O.S. Kates, B.M. Haydel, S.S. Florman, M.M. Rana, Z.S. Chaudhry, M.S. Ramesh, K. Safa, C.N. Kotton, E.A. Blumberg, B.D. Besharatian, et al., Coronavirus disease 2019 in solid organ transplant: a multicenter cohort study, Clin. Infect. Dis. 73 (2021) e4090–e4099, https://doi.org/10.1093/cid/ciaa1097.
[16] S. Iftimie, A.F. López-Azcona, I. Vallverdú, S. Hernández-Flix, G. de Febrer, S. Parra, A. Hernández-Aguilera, F. Riu, J. Joven, N. Andreychuk, et al., First and second waves of coronavirus disease-19: a comparative study in hospitalized patients in Reus, Spain, PLoS One 16 (2021) e0248029, https://doi.org/10.1371/journal.pone.0248029.
[17] T.A. Santos, J.E. Oliveira, C.D.D. Fonseca, D.A. Barbosa, A. Belasco, C.R.M. Miura, Sepsis and COVID-19: outcomes in young adults in intensive care, Rev. Bras. Enferm. 76 (2023) e20230037, https://doi.org/10.1590/0034-7167-2023-0037.