
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Journal of Cardiothoracic and Vascular Anesthesia 36 (2022) 1662–1669

Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Original Article

# How Should ECMO Be Used Under Conditions of Severe Scarcity? A Population Study of Public Perception

Jason J. Han, MD[*,2], Max Shin, BA[†,2], William L. Patrick, MD[*], Akhil Rao[†], Salim E. Olia, PhD[*], Mark R. Helmers, MD[*], Amit Iyengar, MD[*], John J. Kelly, MD[*], Benjamin Smood, MD[*], Jacob T. Gutsche, MD[*], Christian Bermudez, MD[*], Marisa Cevasco, MD, MPH[*,‡,1]

[*]*Division of Cardiovascular Surgery, Department of Surgery, University of Pennsylvania, Philadelphia, PA*
[†]*Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA*
[‡]*Department of Anesthesiology and Critical Care, University of Pennsylvania, Philadelphia, PA*

*Objective:* To assess societal preferences regarding allocation of extracorporeal membrane oxygenation (ECMO) as a rescue option for select patients with coronavirus disease 2019 (COVID-19).
*Design:* Cross-sectional survey of a nationally representative sample.
*Setting:* Amazon Mechanical Turk platform.
*Participants:* In total, responses from 1,041 members of Amazon Mechanical Turk crowd-sourcing platform were included. Participants were 37.9 ± 12.6 years old, generally white (65%), and college-educated (66.1%). Many reported working in a healthcare setting (22.5%) and having a friend or family member who was admitted to the hospital (43.8%) or died from COVID-19 (29.9%).
*Measurements and Main Results:* Although most reported an unwillingness to stay on ECMO for >one week without signs of recovery, participants were highly supportive of ECMO utilization as a life-preserving technique on a policy level. The majority (96.7%) advocated for continued use of ECMO to treat COVID patients during periods of resource scarcity but would prioritize those with highest likelihood of recovery (50%) followed by those who were sickest regardless of survival chances (31.7%). Patients >40 years old were more likely to prefer distributing ECMO on a first-come first-served basis (21.5% *v* 13.3%, $p < 0.05$).
*Conclusion:* Even though participants expressed hesitation regarding ECMO in personal circumstances, they were uniformly in support of using ECMO to treat COVID patients at a policy level for others who might need it, even in the setting of severe scarcity.


*Key Words:* COVID-19; ECMO; resource allocation; justice; bioethics

CORONAVIRUS DISEASE 2019 (COVID-19) is a potentially lethal infection that may cause respiratory failure requiring hospitalization and, possibly, advanced therapies. During scenarios in which lung-protective mechanical ventilation proves insufficient, extracorporeal membrane oxygenation (ECMO) has been offered selectively as rescue therapy.[1] In a recent analysis of approximately 1,000 patients requiring ECMO from the Extracorporeal Life Support Organization (ELSO) database, 30% were able to be discharged home or to an acute rehabilitation center and 10% to a long-term acute-care center.[2] Based on these findings, current guidelines by

W. L. Patrick is funded by a National Institutes of Health T32 Training Grant (T32HL007843).
[1]Address correspondence to Marisa Cevasco, MD, MPH, Division of Cardiovascular Surgery, Hospital of the University of Pennsylvania, 3400 Spruce St, 6 Silverstein Pavilion, Philadelphia, PA.
*E-mail address:* Marisa.cevasco@pennmedicine.upenn.edu (M. Cevasco).
[2]The first 2 authors contributed equally.

https://doi.org/10.1053/j.jvca.2021.05.058
1053-0770/

ELSO, the World Health Organization (WHO) and the Society of Critical Care Medicine recommend the use of ECMO to manage COVID-19, with contingency plans based on system capacity.[3-6]

The pathophysiology of COVID-19, which requires a potentially prolonged treatment duration on ECMO, combined with scarcity of resources, present uniquely complex clinical and ethicolegal challenges. However, even as guidelines continue to become more sophisticated, understanding of societal preferences regarding the use of ECMO, both as it pertains to the individual as well as to society at large, remains poor. Literature and public discourse on the subject remain scarce. Thus, the purpose of this study was to encourage public involvement, ultimately to help develop fair, transparent, and trustworthy policies surrounding the use of shared healthcare resources. Although some insight into population preferences can be gleaned from individual shared decision-making conversations, the acuity of presentation generally precludes a meaningful discussion with patients and their caregivers prior to its initiation. In this study, the authors surveyed a nationally representative sample to gain a better understanding of the public's preferences regarding the utilization and allocation of ECMO to manage severe COVID-19 infections. These insights may be helpful in informing patients, providers, and policymakers as they must navigate the complex landscape of treating severe cases of COVID-19 with ECMO.

## Materials & Methods

### *Study Design*

A 23-question survey (Supplementary Appendix 1) was created using an electronic survey platform (Qualtrics, Raleigh, NC). Respondents first were provided a background reading that simulated an informed consent discussion and provided relevant information[1] about ECMO, its potential risks and benefits, and general prognosis. The first two questions in the survey were objective in nature and assessed participants on their understanding of the background reading. After personal preferences regarding the utilization of ECMO were evaluated using 10-point Likert scales ranging from 1 (strongly disagree) to 10 (strongly agree), participants then were presented with a scenario describing severe national resource scarcity. They were asked to answer multiple-choice questions on preferred utilization and allocation strategies. Basic demographic information, as well as personal outlooks or experiences with COVID-19, were collected.

### *Survey Enrollment*

Participants were recruited using Amazon (Seattle, WA) Mechanical Turk (MTurk)—a well-established crowdsourcing platform. Previous literature has validated the generalizability of the MTurk community opinions to the broader population.[7,8] Members of this community were offered $0.30 in return for survey completion. Even though ECMO is used more frequently in older and more vulnerable populations, the survey was distributed without restrictions to evaluate societal preferences regarding allocation. Enrollment was limited to 1,200 individuals for budgetary consideration. Enrollment opened at 12:00 PM on 12/4/2020 and was closed at 12:00 PM on 12/5/2020.

### *Statistical Analysis*

The cohort was stratified by age $\leq$ and $>40$, income level ($<100{,}000$ *v* $\geq 100{,}000$), and education level (reporting of a

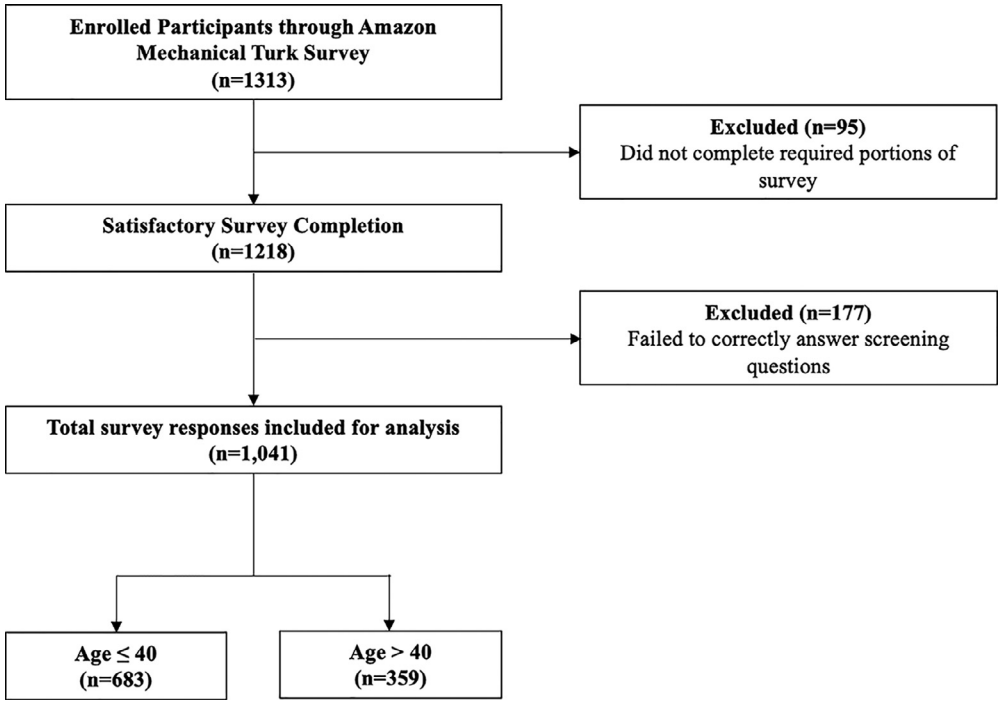


Fig 1. Flowchart illustrating total participants, stratification, and reasons for exclusion.

Table 1
Demographic Information

| Variable | Overall | Age ≤40 | Age >40 | *p* Value |
|---|---|---|---|---|
| Demographics | | | | |
| Number, n (%) | 1041 | 683 (65.61) | 359 (34.39) | - |
| Age (30-49) | 35 (28-46) | 30 (26-35) | 52 (45-58) | - |
| White, n (%) | 674 (64.68) | 395 (57.83) | 279 (77.93) | < 0.001 |
| Female, n (%) | 472 (45.4) | 282 (41.3) | 190 (53.4) | 0.001 |
| Highest level of education, (%) | | | | 0.220 |
| No schooling completed | 3 (0.29) | 2 (0.29) | 1 (0.36) | |
| Some high school, no diploma | 8 (0.77) | 5 (0.73) | 3 (0.84) | |
| High school graduate or GED | 83 (7.97) | 52 (7.61) | 30 (8.38) | |
| Some college credit, no degree | 142 (13.63) | 97 (14.2) | 45 (12.57) | |
| Trade/technical/ vocational training | 39 (3.74) | 31 (4.54) | 8 (2.23) | |
| Associate degree | 77 (7.39) | 43 (6.30) | 34 (9.50) | |
| Bachelor's degree | 496 (47.60) | 334 (48.90) | 162 (45.25) | |
| Master's degree | 194 (18.62) | 119 (17.42) | 75 (20.95) | |
| Employment, n (%) | | | | < 0.001 |
| Self-employed | 182 (17.47) | 123 (18.01) | 59 (16.48) | |
| Employed for wages | 652 (62.57) | 424 (62.08) | 228 (63.69) | |
| Out of work and looking for work | 82 (7.87) | 71 (10.40) | 11 (3.07) | |
| Out of work but not currently looking for work | 35 (3.36) | 28 (4.10) | 6 (1.68) | |
| Homemaker | 41 (3.93) | 28 (4.10) | 13 (3.63) | |
| Military | 3 (0.29) | 1 (0.15) | 2 (0.56) | |
| Retired | 34 (3.26) | 0 (0.0) | 34 (9.50) | |
| Unable to work | 13 (1.25) | 8 (1.17) | 5 (1.40) | |
| Income, n (%) | | | | 0.958 |
| Under $40,000 | 332 (31.86) | 223 (32.65) | 109 (30.45) | |
| $40,000-99,000 | 453 (43.47) | 290 (42.46) | 163 (45.53) | |
| $100,000-149,999 | 146 (14.01) | 97 (14.20) | 48 (13.41) | |
| $150,000-250,000 | 61 (5.85) | 40 (5.86) | 21 (5.87) | |
| $250,000 or more | 22 (2.11) | 15 (2.20) | 7 (1.96) | |
| No response | 28 (2.69) | 18 (2.64) | 10 (2.79) | |
| Religion | | | | |
| I consider myself a religious person. | | | | 0.103 |
| Strongly agree | 173 (18.92) | 99 (14.49) | 74 (20.67) | |
| Agree | 286 (27.47) | 191 (27.96) | 95 (26.54) | |
| Somewhat agree | 183 (17.58) | 116 (16.98) | 67 (18.72) | |
| Neither agree nor disagree | 53 (5.09) | 40 (5.86) | 13 (3.63) | |
| Somewhat disagree | 51 (4.90) | 116 (16.98) | 67 (18.72) | |
| Disagree | 98 (9.41) | 65 (9.52) | 33 (9.22) | |
| Strongly disagree | 197 (18.92) | 134 (19.62) | 63 (17.60) | |
| Healthcare-related experiences | | | | |
| Admitted to hospital in last 5 years | 447 (42.94) | 296 (43.34) | 151 (42.18) | 0.720 |
| Friend or family member admitted to the hospital from COVID-19 | 454 (43.57) | 295 (43.19) | 159 (44.41) | 0.706 |
| Friend or family member passed away from COVID-19 | 310 (29.75) | 203 (29.72) | 107 (29.89) | 0.956 |
| Currently works in a healthcare setting | 235 (22.55) | 161 (23.57) | 74 (20.67) | 0.287 |
| Has conditions that predispose to higher risk of dying from COVID-19 | 329 (31.57) | 185 (27.09) | 144 (40.22) | < 0.001 |

higher education degree). A higher education degree was defined as reporting a bachelor's, master's, professional, or doctorate degree. Baseline characteristics were summarized with descriptive statistics. Categorical characteristics were reported as a number and percentage. Continuous characteristics were reported as mean ± SD if normally distributed or median with interquartile range if not normally distributed. Skewness and kurtosis tests were used to assess normality of variables. In survey questions involving 10-point Likert scales, an answer choice of 5 was designated as neutral. A Wilcoxon rank-sum test was used to compare nonnormally distributed continuous variables. Fisher exact tests or chi-squared tests were used to compare categorical variables where appropriate. A two-sided type I error rate of 0.05 was used to indicate statistical significance. All statistical analyses were performed using STATA/IC 14.2 (StataCorp, College Station, TX).

## Results

### *Total Population*

During the enrollment period, 1,218 participants completed the survey (Fig 1). Of those, 177 respondents failed the screening test for comprehension; thus, 1,041 (85.4%) participants' responses were considered for analysis. The group as a whole was 65% white and 37.9 ± 12.6 years old (Table 1). Of the total, 66% reported a degree in higher education (47.7% had bachelor's and 18.4% had master's, professional, or doctorate degrees). Most (75.4%) respondents reported an average annual income of <$100,000. Also, 22.5% reported working in a healthcare setting, 43.1% reported having been admitted to the hospital in the last five years, and 31.7% reported having condition(s) predisposing to higher risk of mortality from COVID-19. A significant minority (43.8%) reported having a friend or family member who was admitted to the hospital or died from COVID-19 (29.9%). Regarding their baseline beliefs, respondents generally agreed that miraculous recovery in medicine is always possible, and that it is appropriate to remove life support if chances of survival are futile (Table 2).

Table 2
Personal Values and Preferences Regarding Initiation of ECMO for Treatment of COVID-19

| Question Characteristics | Total (N, %) | Age ≤40 (N, %) | Age >40 (N, %) | *p* Value |
|---|---|---|---|---|
| Assessment of values*,† | | | | |
| No matter how unlikely, a miraculous recovery is always possible | 40 (20-62) | 41 (21-64) | 39 (19-59) | 0.007 |
| It is never appropriate to remove life support from a human, even if it seems there is no chance of survival | 65 (40-85) | 63 (43-84) | 67 (34-88) | 0.715 |
| Personal and family preferences for ECMO‡ | | | | |
| Willing to be placed on ECMO | 6.1 ± 3.0 | 6.1 ± 2.9 | 6.1 ± 3.2 | 0.84 |
| Willing to advocate for loved one to be placed on ECMO | 6.4 ± 2.8 | 6.3 ± 2.8 | 6.5 ± 2.9 | 0.13 |

Abbreviations: ECMO, extracorporeal membrane oxygenation; GED, General Education Development.
* Assessed with a continuous scale (0-100) where 0 indicates strongly agree and 100 indicates strongly disagree.
† Values expressed as median (Q1-Q3).
‡ Assessed with a 10-point Likert scale, where 1 indicates strongly against and 10 indicates strongly in favor of.

### *Individual Preferences Regarding ECMO*

Given a hypothetical scenario involving themselves or their loved ones, participants were mildly in favor of initiating ECMO to survive COVID-19 (Table 2). Most respondents (66%) required *at least* a 50% predicted chance of survival (Fig 2) to personally start ECMO (14% requiring >90%, 25.4% requiring >75%, and 26% requiring >50% predicted chance of survival). Of the total, 17.5% wanted to limit their personal time on ECMO to fewer than three days, 23.6% to less than one week, and 16.6% to fewer than two weeks (Fig 3; Table 3).

### *Perceptions Regarding Societal ECMO Allocation*

When presented with a hypothetical condition of extreme national resource shortages (Table 3), an overwhelming majority (96.7%) still advocated for the utilization of ECMO to treat COVID-19 patients. Although most agreed there should be a limit to ECMO under these circumstances, there was no consensus on the duration. The most common response (32%) was that decisions should remain case- dependent. Most advocated for prioritizing ECMO for those with the greatest likelihood of recovery (50.2%), followed by those who are sickest (31.7%).

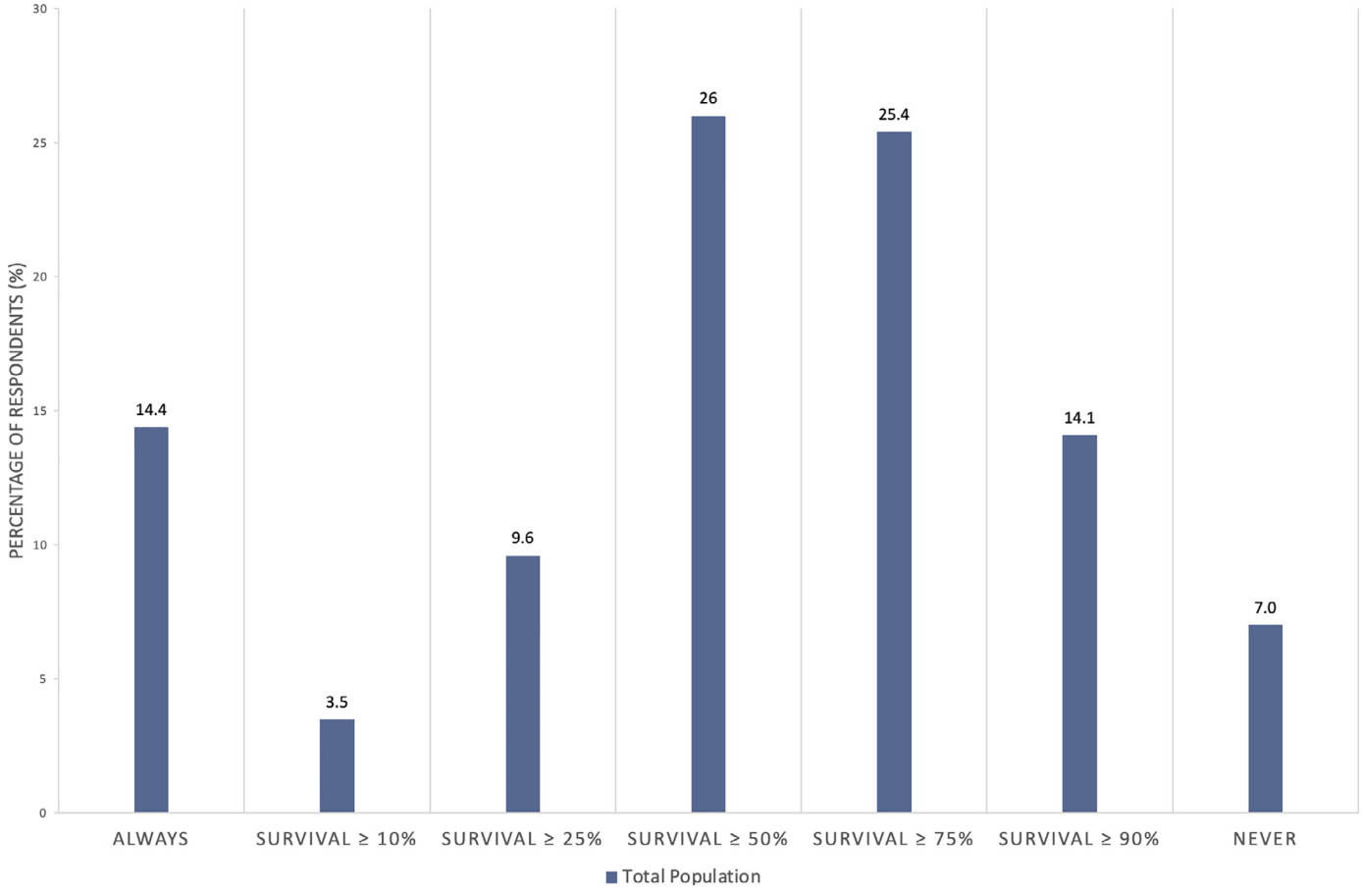


Fig 2. Survival odds needed for respondents to justify being placed on ECMO.

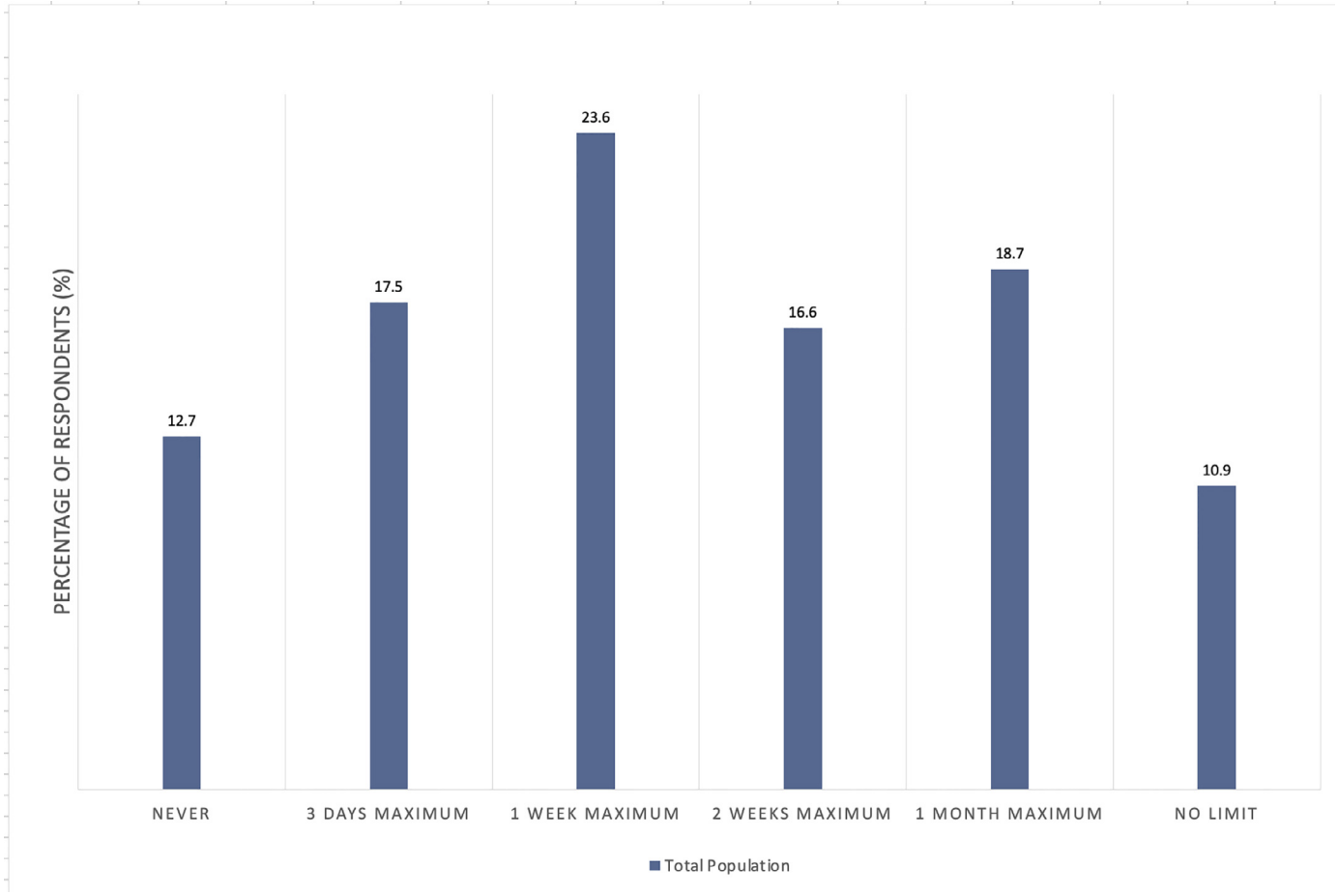


Fig 3. Respondent preferences for durations they would be willing to remain on ECMO without meaningful signs of recovery.

*Age-Stratified Cohort Analysis*

After participants were stratified by age (≤ or >40 years), the older cohort (N = 358; 65.6%) was more white (77.9% *v* 57.8%, p < 0.05) and more likely to have high-risk conditions (44.2% *v* 27.1%, p < 0.05). Younger patients were more optimistic about the possibility of miraculous recoveries (p < 0.05) and were less willing to spend extended amounts of time on ECMO compared to their older counterparts (p = 0.036). Both groups generally were neutral about going on ECMO to survive COVID-19 for themselves (Likert: 6.1 *v* 6.1) and for their loved ones (Likert: 6.3 *v* 6.5).

Yet, at a societal level, both cohorts (96.8% *v* 96.6%) strongly agreed that ECMO should remain an option even during severe resource shortages. Although opinions regarding duration limit were heterogeneous (p = 0.038), the most common response in both groups opposed setting a rigid limit. Both groups agreed that ECMO should be prioritized for those most likely to recover (Fig 4). However, a greater proportion of older respondents (22% *v* 13%) believed ECMO should be distributed in the order they present (p = 0.02).

*Income- and Education-Stratified Cohort Analysis*

There were no significant differences in responses to questions about ECMO allocation and rationing among individuals with incomes <$100,000 compared to those with incomes ≥$100,000 (Supplementary Table 1). Individuals with a bachelor's degree or higher were more likely to advocate for stricter limits for ECMO duration during periods of extreme national shortage (Supplementary Table 2). Additionally, the higher education cohort was more supportive of prioritizing ECMO for those seeking treatment first or those with greater likelihood of recovery.

## Discussion

To the authors' knowledge, this was the first study to investigate public attitudes and preferences regarding the utilization and allocation parameters of ECMO during COVID-19. At an individual level, people were neither in favor nor against the prospect of being placed on ECMO to survive COVID-19. Furthermore, the vast majority of these participants expressed unrealistically stringent conditions for consenting to ECMO, requiring at least a 50% likelihood of recovery and expressing desire to limit their duration on ECMO to fewer than one or two weeks. Even so, when presented with conditions of severe scarcity at a national level, participants overwhelmingly advocated for ECMO to remain an option for patients with COVID-19 without the application of any stringent criteria.

Table 3
ECMO Allocation and Utilization Preferences by Age

| Question | Total Population | Age ≤40 | Age >40 | *P* Value |
|---|---|---|---|---|
| Should ECMO be an option under extreme national resource shortages? | | | | 0.180 |
| Yes | 1007 (96.7) | 661 (96.8) | 346 (96.6) | |
| Always | 378 (36.3) | 232 (34.0) | 146 (40.8) | |
| For those with ≥50% chance of recovery | 463 (44.5) | 316 (46.3) | 147 (41.1) | |
| For those with ≥90% chance of recovery | 166 (16.0) | 113 (16.5) | 53 (14.8) | |
| No | 34 (3.3) | 22 (3.2) | 12 (3.4) | |
| Should there be a limit for how long patients can stay on ECMO under extreme national resource shortages? | | | | 0.038 |
| Yes, 3-day maximum | 105 (10.1) | 67 (9.8) | 38 (10.6) | |
| Yes, 1-week maximum | 206 (19.8) | 147 (21.5) | 59 (16.5) | |
| Yes, 2-week maximum | 186 (17.8) | 107 (15.7) | 79 (22.1) | |
| Yes, 4-week maximum | 106 (10.2) | 78 (11.4) | 28 (7.8) | |
| Yes, but case dependent | 328 (31.5) | 211 (30.9) | 117 (32.7) | |
| No limit | 110 (10.6) | 73 (10.7) | 37 (10.3) | |
| Under extreme national resource shortages, how should we decide who receives ECMO? | | | | 0.002 |
| First come first serve | 168 (16.2) | 91 (13.3) | 77 (21.5) | |
| Those who have the highest likelihood of recovery | 523 (50.2) | 350 (51.2) | 173 (48.3) | |
| Those who are sickest, regardless of survival chances | 330 (31.7) | 225 (32.9) | 105 (29.3) | |
| Future potential for societal contributions | 20 (1.9) | 17 (2.5) | 3 (0.8) | |

Abbreviations: ECMO, extracorporeal membrane oxygenation.

A recent study illustrated the efficacy of ECMO in the setting of COVID-19-related acute hypoxemic respiratory failure. Among 1,035 patients with an average age of 49, the median time on ECMO was 13.9 and 90-day mortality was 37.4%. However, although utilization of ECMO in the setting of COVID-19 is supported by major international organizations (eg, World Health Organization, ELSO, Society of Critical Care Medicine), there are significant clinical and ethical challenges associated with its application. Because it requires a significant amount of financial and human capital, determining candidacy is a highly selective process that must balance the degree of need and the likelihood of recovery. Patients, once placed on ECMO, may require support for a prolonged duration. Moreover, the ability to provide ECMO is highly variable from one setting to another given that it relies on having an established infrastructure.

To this end, the principles guiding the allocation of ECMO during COVID-19 have been described extensively and debated in literature.[9,10] Ramanathan et al. have outlined the importance of balancing the four major ethical principles—beneficence, nonmaleficence, autonomy, and justice—especially by relying on a robust shared decision-making framework.[11,12] Abrams et al. have advocated for the utilitarian allocation principle (ie, maximizing benefits principle), meaning ECMO should be reserved for those who stand to derive the greatest amount of survival benefit.[13] Furthermore, regardless of the principle chosen, Emanuel et al. emphasized the importance of collecting input from all affected parties (ie, the public) to be fair, consistent, and trustworthy.[9] The importance of public involvement has been corroborated in real practice. Cook et al. stated that preserving public trust was an essential factor behind why their triage algorithm was successful in allowing fair allocation in the setting of diminished capacity.[14]

Notably, in this survey of more than 1,000 participants who represented a wide spectrum regarding age, sex, race, and socioeconomic status, the majority responded that they would prioritize the utilitarian principle in the use of ECMO, which is consistent with the recommendation by Abrams et al.[13] However, an interesting caveat was found. Although Abrams et al. proposed ECMO should no longer be an option if and when its operational cost should lead to suboptimal provision of care for all other patients, participants in the study showed nearly unanimous support for continuing to offer ECMO, even during conditions of severe scarcity. Higher degree of education helped somewhat to mitigate this standpoint, as they were more stringent in their limits for ECMO duration at a societal level. Additionally, they appeared to place a greater priority on those with the greatest odds of recovery and less emphasis on those who were sickest.

Conditions of scarcity are not a novel phenomenon. In areas of organ transplantation, mechanical circulatory support, oncology, and more, physicians have had to navigate the challenges of having limited resources.[15] There has not been a uniform solution across the board, as decisions regarding allocation must take into consideration the nuances of each disease process. Such is the case when it comes to managing COVID-19 with ECMO during a pandemic. Although the utilitarian principle seems logical and equitable, one of the challenges of applying it in these circumstances is that prognostication remains an imperfect science. Determining candidacy for ECMO is nuanced and multifaceted. Indeed, given the limited understanding of the pathophysiology of COVID-19, the duration of or the likelihood of recovering from ECMO cannot accurately be prognosticated. Furthermore, the extreme acuity in the presentation of these patients precludes meaningful education or discussion of patients' and

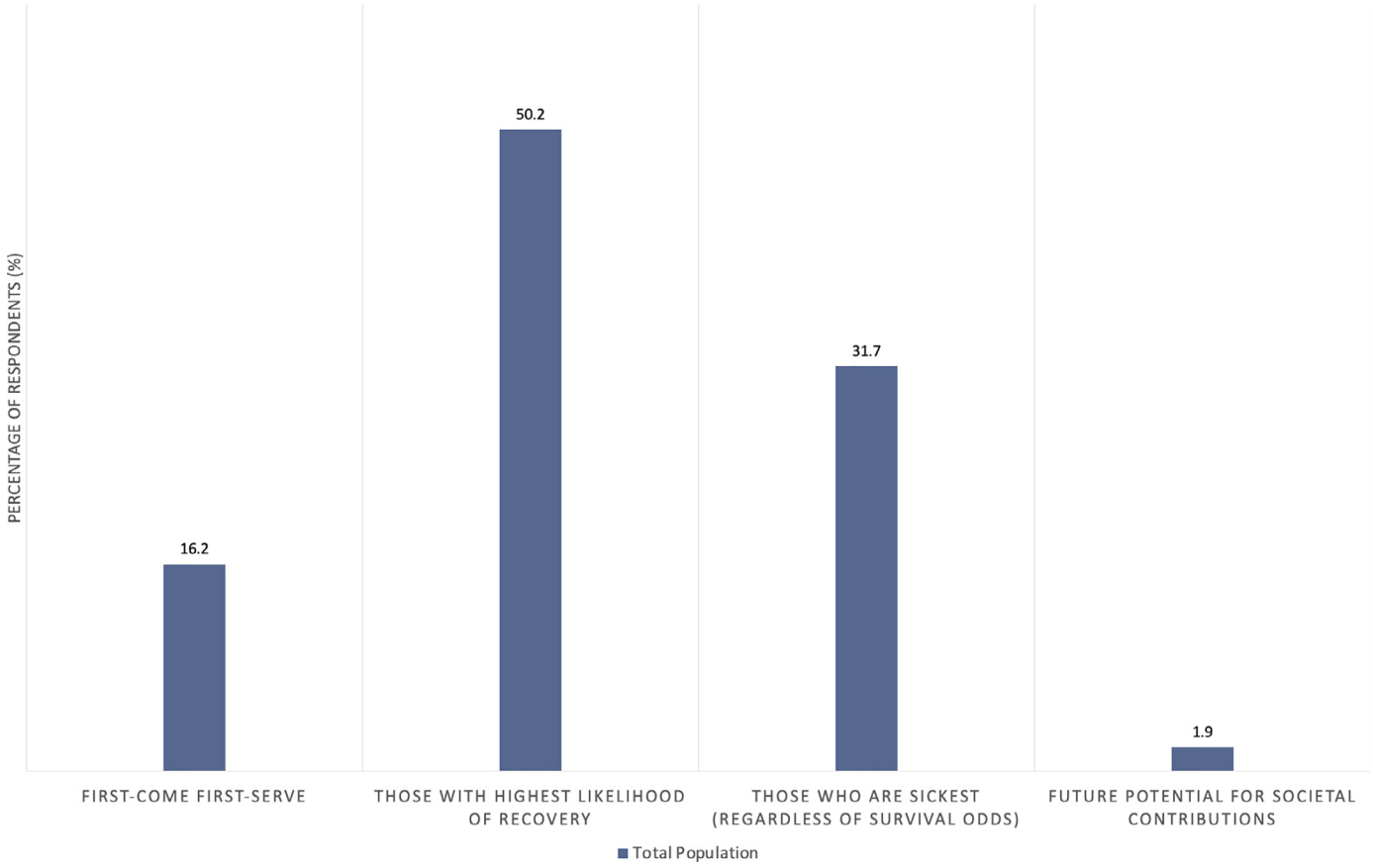


Fig 4. Respondent preferences regarding ECMO allocation during settings of extreme resource shortages.

families' goals prior to initiation. Thus, inevitably, these circumstances lead to difficult decisions for providers at all stages of care, as they must make decisions regarding initiation or withdrawal of ECMO.

Aside from policy implications regarding allocation, this study also revealed areas of discordance between public expectations and the clinical reality regarding ECMO that should inform future national conversations. Most participants expressed a desire to limit their duration on ECMO to one or two weeks, which did not change when presented with conditions of severe national resource shortages. According to Barbaro et al. in the largest cohort study of COVID-19 ECMO patients to-date, the median duration on ECMO was 13.9 days (IQR 7.8-23.3), which signifies that about half of the population likely will exceed their desired duration on ECMO. Such misalignment between what has been observed clinically and what people may expect points to a need for clear, up-front communication among all stakeholders to prevent potential clinical, social, and ethical dilemmas.

This study had several limitations. Even though previous literature has shown that MTurk participants represent a more demographically diverse population than standard internet samples and that the data abstracted from MTurk surveys are of high quality,[16] they tend to be younger, favor liberal social policies, have completed a higher degree of formal education, and have greater access to the internet. Nearly 30% of participants reported experience with a friend or family dying from COVID-19, compared to the national average of 19%, which may limit the generalizability of the findings. Additionally, despite using lay-friendly language to convey key information about ECMO and employing two questions to assess their degree of comprehension, participants' responses inevitably will be limited by the nature of using a survey instrument to simulate real-life decision-making conditions and should be interpreted in this context. Furthermore, although only a minority of the recruited participants (15%) did not pass the initial comprehension screening questions, it highlights the complexity of the technical and ethical components discussed. Lastly, the average age of the cohort was ten years younger than that of the cohort studied by Barbaro et al. (the median age was 49 years old). However, this study intentionally did not limit the survey population based on potential candidacy, since determination of policies regarding its utilization and allocation is equally a social, ethical, and national matter as it is a clinical one. Overall, total public involvement may be informative, valuable, and necessary for the development of fair and transparent practices, and the authors aimed to mitigate this discrepancy by forming a subcohort above age 40.

As the pandemic continues to run its course, there still remains uncertainty regarding the future given the possibility of novel strains and outbreaks. Allocation principles regarding the utilization of ECMO are needed at a policy level to alleviate the burden of decision-making by individual physicians and should include

public opinion to allow for transparency and trustworthiness. Although this study found public agreement with some aspects of utilitarian principles for rationing put forth by previous authors, there also was clear discordance between public perception and clinical reality of ECMO that requires addressing. As the length of time spent on ECMO contributes to resource scarcity, future studies should seek to address the public's opinion regarding appropriate next steps if a patient on ECMO for a prolonged period demonstrates no signs of recovery. As understanding of the pathophysiology of COVID-19 continues to evolve, so too should principles regarding allocation and rationing. Meaningful education of the public regarding ECMO's role in COVID-19 treatment and incorporating informed public opinion are important next steps.

## Conflict of Interest

None.

## Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1053/j.jvca.2021.05.058.

## References


1 Barbaro RP, MacLaren G, Boonstra PS, et al. Extracorporeal membrane oxygenation support in COVID-19: Aan international cohort study of the Extracorporeal Life Support Organization registry. Lancet 2020;396:1071–8.

2 Jacobs JP, Stammers AH, St Louis J, et al. Extracorporeal membrane oxygenation in the treatment of severe pulmonary and cardiac compromise in coronavirus disease 2019: Experience with 32 patients. ASAIO J 2020;66:722–30.

3 Yang X, Cai S, Luo Y, et al. Extracorporeal membrane oxygenation for coronavirus disease 2019-induced acute respiratory distress syndrome: A multicenter descriptive study. Crit Care Med 2020;48:1289–95.

4 Bartlett RH, Ogino MT, Brodie D, et al. Initial ELSO Guidance Document: ECMO for COVID-19 patients with severe cardiopulmonary failure. ASAIO J 2020;66:472–4.

5 Clinical management of severe acute respiratory infection (SARI) when COVID-19 disease is suspected. World Health Organization; 2020.

6 Shekar K, Badulak J, Peek G, et al. Extracorporeal Life Support Organization Coronavirus Disease 2019 Interim Guidelines: A consensus document from an international group of interdisciplinary extracorporeal membrane oxygenation providers. ASAIO J 2020;66:707–21.

7 Levay KE, Freese J, Druckman JN. The demographic and political composition of Mechanical Turk samples. SAGE Open 2016;6.

8 Coppock A, Leeper TJ, Mullinix KJ. Generalizability of heterogeneous treatment effect estimates across samples. Proc Natl Acad Sci U S A 2018;115:12441–6.

9 Emanuel EJ, Persad G, Upshur R, et al. Fair allocation of scarce medical resources in the time of Covid-19. N Engl J Med 2020;382:2049–55.

10 Prekker ME, Brunsvold ME, Bohman JK, et al. Regional planning for extracorporeal membrane oxygenation allocation during coronavirus disease 2019. Chest 2020;158:603–7.

11 Ramanathan K, Antognini D, Combes A, et al. Planning and provision of ECMO services for severe ARDS during the COVID-19 pandemic and other outbreaks of emerging infectious diseases. Lancet Respir Med 2020;8:518–26.

12 Di Nardo M, Dalle Ore A, Starr J, et al. Ethics and extracorporeal membrane oxygenation during coronavirus disease 2019 outbreak. Perfusion 2020;35:562–4.

13 Abrams D, Lorusso R, Vincent JL, et al. ECMO during the COVID-19 pandemic: When is it unjustified? Crit Care 2020;24:507.

14 Cook T, Gupta K, Dyer C, et al. Development of a structured process for fair allocation of critical care resources in the setting of insufficient capacity: A discussion paper [e-pub ahead of print]. J Med Ethics 2020. https://doi.org/10.1136/medethics-2020-106771; Accessed May 12, 2021.

15 Persad G, Wertheimer A, Emanuel EJ. Principles for allocation of scarce medical interventions. Lancet 2009;373:423–31.

16 Buhrmester M, Kwang T, Gosling SD. Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality, data? Perspect Psychol Sci 2011;6:3–5.