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Impact of the COVID-19 pandemic on transplantation by income level and cumulative COVID-19 incidence: a multinational survey study

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ABSTRACT

Objectives The COVID-19 pandemic significantly affected the provisions of health services to necessary but deprioritised fields, such as transplantation. Many programmes had to ramp-down their activity, which may significantly affect transplant volumes. We aimed to pragmatically analyse measures of transplant activity and compare them by a country's income level and cumulative COVID-19 incidence (CCI).

Design, setting and participants From June to September 2020, we surveyed transplant physicians identified as key informants in their programmes. Of the 1267 eligible physicians, 40.5% from 71 countries participated.

Outcome Four pragmatic measures of transplant activity.

Results Overall, 46.5% of the programmes from high-income countries anticipate being able to maintain >75% of their transplant volume compared with 31.6% of the programmes from upper-middle-income countries, and with 21.7% from low/lower-middle-income countries (p<0.001). This could be because more programmes in high-income countries reported being able to perform transplantation/s (86.8%%–58.5%–67.9%, p<0.001), maintain prepandemic deceased donor offers (31.0%%–14.2%–26.4%, p<0.01) and avoid a ramp down phase (30.9%%–19.7%–8.3%, p<0.001), respectively. In a multivariable analysis that adjusted for CCI, programmes in upper-middle-income countries (adjusted OR, aOR=0.47, 95% CI 0.27 to 0.81) and low/lower-middle-income countries (aOR 0.33, 95% CI 0.16 to 0.67) had lower odds of being able to maintain >75% of their transplant volume, compared with programmes in high-income countries. Again, this could be attributed to lower-income being associated with 3.3–3.9 higher odds of performing no transplantation/s, 66%–68% lower odds of maintaining prepandemic donor offers and 37%–76% lower odds of avoiding ramp-down of transplantation. Overall, CCI was not associated with these measures.

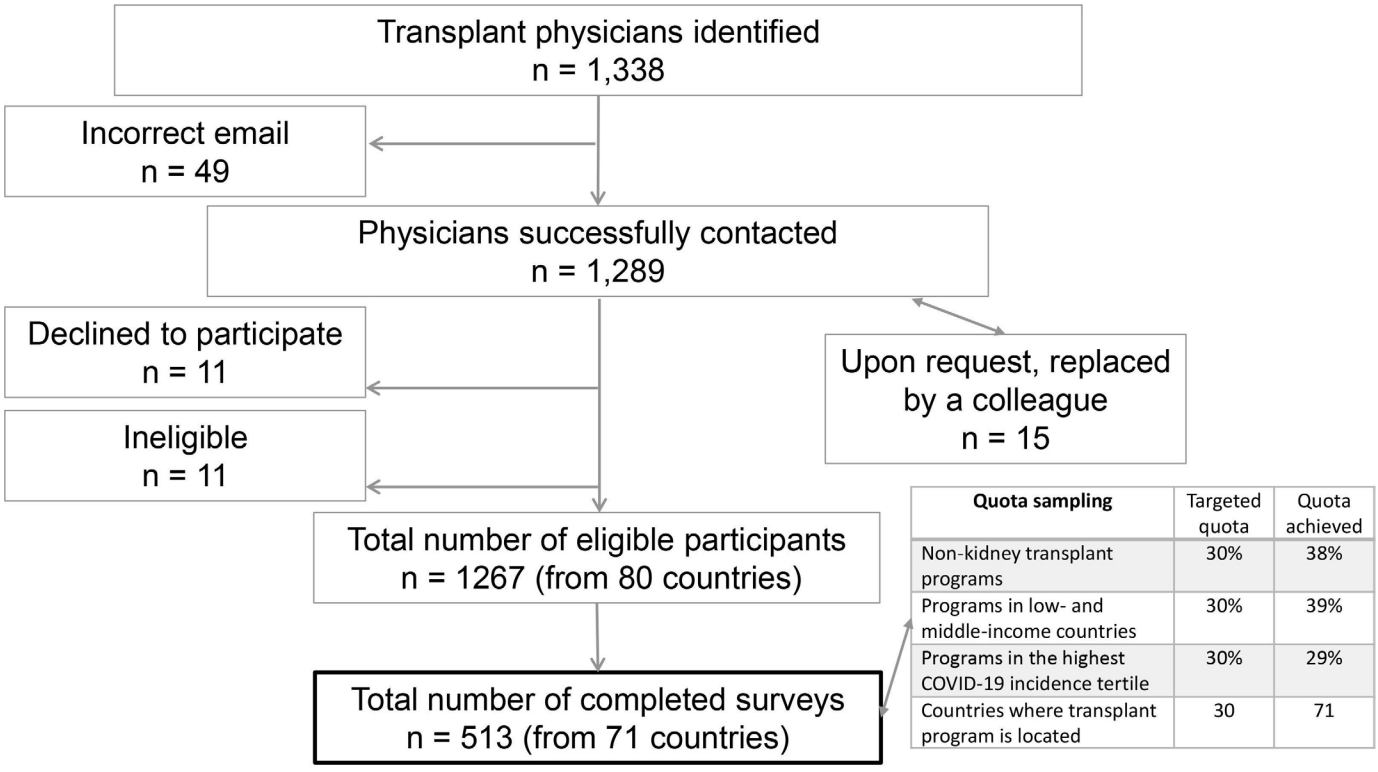
Conclusions The impact of the pandemic on transplantation was more in lower-income countries, independent of the COVID-19 burden. Given the lag of 1–2 years in objective data being reported by global registries, our findings may inform practice and policy. Transplant programmes in lower-income countries may need more effort to rebuild disrupted services and recuperate from the pandemic even if their COVID-19 burden was low.

Strengths and limitations of this study

- This study pragmatically analysed four measures of transplant activity to capture the state of transplantation globally.
- Responses were compared by a country's income level and cumulative COVID-19 incidence.
- We were able to mobilise transplant leadership from 71 different countries to take our survey and attain a good response rate amid a pandemic.
- The income level of a country is a surrogate measure of the vulnerabilities of a healthcare system.
- We could not obtain adequate representation from certain regions, such as East Asia and Africa.

INTRODUCTION

The COVID-19 pandemic has globally impacted and overwhelmed healthcare systems and as a consequence, non-COVID medical fields have suffered significant collateral harm;[1–3] this includes the field of solid organ transplantation. Following the WHO announcement declaring COVID-19 a pandemic, many transplant programmes reported cutting down on their activity due to multiple reasons.[4–7] There was a redirection of services and resources to COVID-related care, lower procurement of organs from deceased donors, and cancellation of non-urgent surgeries, such as living donor transplantations.[8–11] Also, there were initial concerns that transplant recipients with COVID-19 are at a higher risk of adverse outcomes.[12–17] Management of immunosuppressive medications in transplant recipients and the pathogenesis of the SARS-CoV-2 in an immunosuppressed host were also largely unclear.[18] Thus, as a precautionary measure, many centres closed their transplant programmes or cut down on their activity.[9 10] This phase was referred to as the 'ramp-down' phase.



Quota sampling	Targeted quota	Quota achieved
Non-kidney transplant programs	30%	38%
Programs in low- and middle-income countries	30%	39%
Programs in the highest COVID-19 incidence tertile	30%	29%
Countries where transplant program is located	30	71

Figure 1 Study flow diagram.

Evidence from the initial weeks showed a substantial decrease in measures of transplant activity.[4–7 19] For example, the overall reduction in deceased donor transplantation was 90.6% in France, and 51.1% in the USA.[4] Following this, some studies reported that the burden of COVID-19 was a major determinant of some of these measures of activity.[5 7 20] However, much of this work came from resource-rich countries that also reported a high burden of COVID-19. Transplant leadership initially recommended that resource-poor countries prioritise efforts towards resolving the pandemic.[11 21] Thus, it remains to be seen if the impact of the pandemic to transplantation varied in regions with lower baseline healthcare resources and higher health system vulnerabilities.

Responses to and decision making during global threats, such as a pandemic, are influenced by a country's baseline healthcare systems.[8 22–24] A country's wealth or income level, as defined by the World Bank, provides a surrogate measure for a country's expenditure in health and the ability to cope with the social and economic disruption caused by a global threat.[23–27] Prepandemic, the WHO reported significant differences in healthcare spending between low-income and high-income countries.[26] During the pandemic, the economic impact of the pandemic may be more in some developing countries compared with resource-rich countries.[28] Thus, income level serves as a good measure of baseline resources and health system vulnerability to a pandemic, and to what extent a non-COVID clinical service, such as transplantation, is affected.

We aimed to demonstrate that the collateral damage of the pandemic to a non-COVID clinical service varied by a country's income level. Many countries have well-established data repositories that capture transplant numbers and outcomes and then report them to the WHO's Global Observatory on Donation and Transplantation database. However, there is a lag of 1–2 years before this data becomes publicly available. Thus, we instead focused on some pragmatically identified measures of transplant activity and compared them by income level and cumulative COVID-19 incidence (CCI) of the region. We also aimed at comparing how physicians across different CCI and income-level perceived resources, finances and disease/patient-related factors as current and anticipated risks to their programmes.

METHODS

From June to September 2020, we conducted a multinational cross-sectional survey of transplant programmes (attached as a online supplemental file).

Survey design

The survey was designed using an iterative process by our team composed of transplant professionals and research methodologists. First, we pragmatically identified four simple measures that would successfully capture the transplant activity of a programme. These were (1) anticipating that the total number of transplantations, that is, transplant volume, will be >75% of the programme's baseline volume; (2) performing transplantation/s during the initial months of the pandemic; (3) reporting declines in organ transplant offers from deceased donors when

Table 1 Baseline characteristics of the transplant programme

Solid organ, n (%)	
Heart	44 (8.6)
Kidney	285 (55.6)
Liver	102 (19.9)
Lung	42 (8.2)
Pancreas/Islet	8 (1.6)
Multiple	32 (6.2)
Age group of transplant recipients, n (%)	
Adult only	329 (64.1)
Paediatric only	56 (10.9)
Both	128 (25.0)
Baseline transplant volume*, n (%)	
<20	142 (27.6)
21–100	231 (45.1)
>100	140 (27.3)
Health system, n (%)	
Public	210 (40.9)
Private	9 (1.8)
Mix of both	293 (57.1)
Other	1 (0.2)
Country's income level†, n (%)	
Low income	4 (0.8)
Lower-middle-income	80 (15.6)
Upper-middle-income	118 (23.0)
High income	311 (60.6)
Cumulative COVID-incidence (CCI)‡, n (%)	
Low (<2031/M)	176 (34.3)
Medium (2032–5400/M)	190 (37.0)
High (>5400/M)	147 (28.6)

*Self reported number of transplants performed annually prior to the pandemic.
†As defined by the World Bank at https://www.worldbank.org/.
‡Per 1M population, calculated from 13 March 2020 to 15 July 2020 as reported by the Johns Hopkins COVID-19 Map, supplemented by covidindia.org. Reported in person per million population. For the USA, Canada, Australia, India and China, CCI was calculated by states/provinces, and for the rest by country.

compared with the prepandemic era and (4) having a ramp-down phase following the WHO announcement declaring the COVID-19 outbreak a pandemic.

We then used several best practices in survey creation to design our survey instrument.[29–31] Following modifications and multiple rounds of revisions the final survey was created and then reviewed by the executive committee of The Transplantation Society. It was self-administered electronically using the Qualtrics XM platform. The survey was pilot tested using 10 participants who represented four different countries of varied income level. Minor modifications to the survey were made, and these 10 responses were included in the data analysis. Additionally, the survey included sections on immunosuppression practices; results of which will be reported separately in a transplant specific journal.

Recruitment

Our recruitment goal was 500 different solid organ transplant programmes. This number was chosen keeping feasibility in mind and that the sample size would be large enough to detect differences between responses. One transplant centre can have up to five different solid organ transplant programmes (heart, kidney, liver, lung and pancreas/islet); hence, up to five participants from one centre could be contacted. We recruited a convenience sample of transplant physicians who were identified as key informants in their programmes using publicly available data (congress web pages, programme websites) and with the help of regional organisations and individuals (see the Acknowledgements section). We were able to obtain the names and contact emails of 1338 physicians from 80 different countries; of these 209 physicians had directly reached out to us with interest in participating in our study. Of the 1267 that were eligible and successfully contacted, 513 physicians from 71 different countries completed the survey for a response rate of 40.5%. To ensure we achieved a heterogeneous sample, we had predetermined quotas of baseline characteristics of the programmes as outlined in figure 1; we successfully met all these quotas.[32]

Exposures and main outcomes

The main outcomes of interest were the four aforementioned measures of transplant activity. Exposures were the type of solid organ transplant, patient age group (adult or paediatric), baseline transplant volume, type of health system (public, private, or a mix of both), income level of the country, and CCI of the region where the programme was located. The first four variables were captured in the survey and were self-reported. Income level was assigned as per the 2020 World Bank Classification.[33] CCI was calculated from 13 March 2020 to 15 July 2020, using the Johns Hopkins COVID-19 Map and supplemented with data reported from India.[34 35] For the USA, Canada, Australia, India and China, CCI was calculated by state/province.

Other outcomes

Two other outcomes of interest were as follows. Earlier literature suggested that transplant programmes prioritise the need for an organ by individually assessing each patient's need for an organ as being urgent or emergent. Thus, we asked programmes to rate the likelihood of performing these types of transplants (urgent, emergent, non-urgent and living donor, if applicable) on a Likert scale of 1–5, 1 being unlikely and 5 being very likely. We also aimed to analyse and compare subjective perception of the risks to transplantation. We first conducted a needs assessment review of the literature and identified current and anticipated risks to transplantation.[19 36–45] We diligently followed all real-time data related to COVID-19

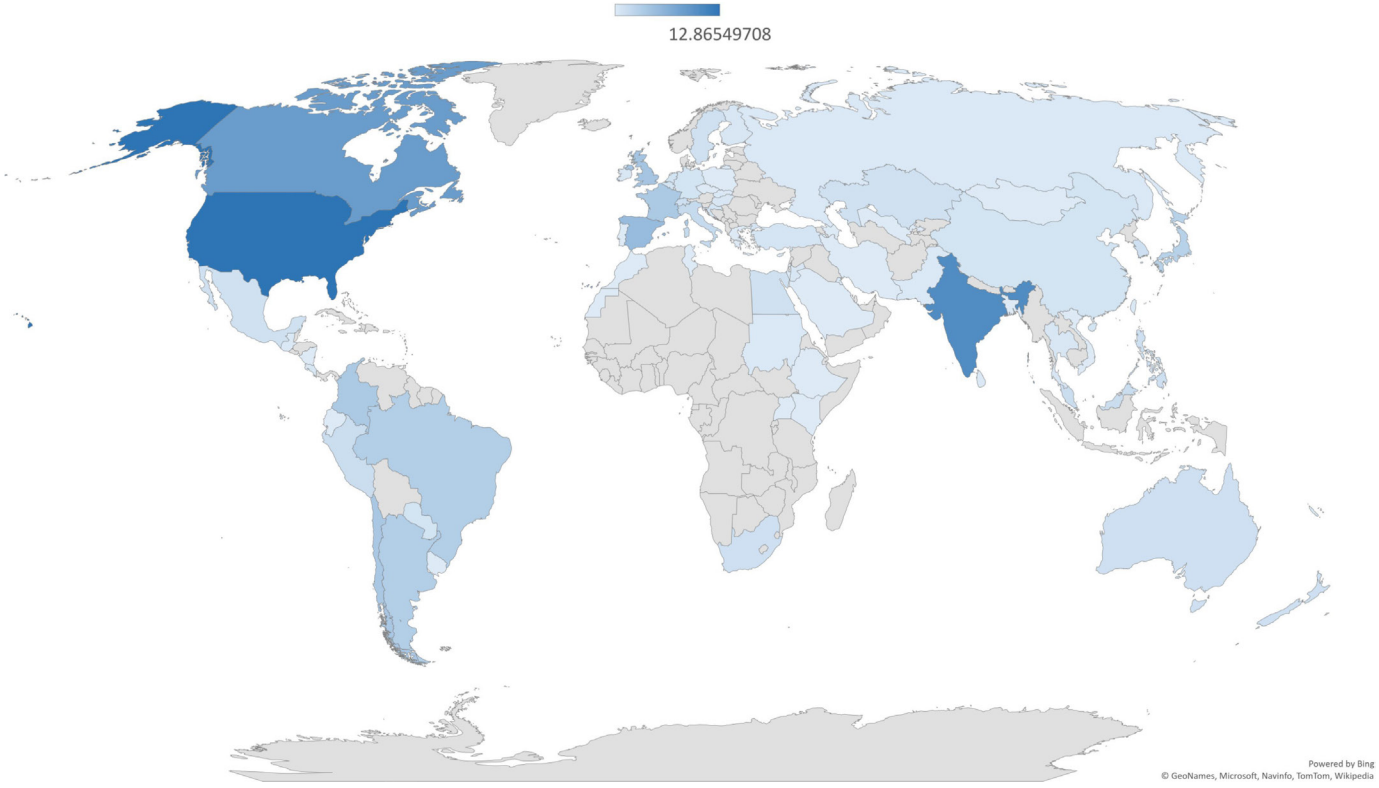


Figure 2 Geographical representation of the transplant programmes that participated in this study (depth of blue indicating the proportion of programmes from that country and grey indicating no representation).

that was being collectively captured by two major transplant orders on their online portals and web messaging services: the American Society of Transplantation and The Transplantation Society. We then constructed statements outlining these risks and asked respondents to rate their level of agreement on a Likert scale whether these statements were risks to their programmes. We segregated responses by the CCI and income level to compare the percentage of respondents in each sub-stratum of CCI and income level who agreed or strongly agreed with these statements.

Data analysis

Each transplant programme, hence, each survey response was treated as a unit of analysis. Descriptive statistics (frequencies, means) were used as appropriate to collectively describe survey responses. Fisher's exact tests were used for univariate comparison of four measures of transplant activity (anticipating transplant volume >75% of the norm, performing no transplantation/s, maintaining prepandemic deceased donor offers, avoiding ramp-down of transplantation) across programme characteristics. Logistic regression was used to determine the association between programme characteristics (income level, CCI, organ type, patient age group, baseline transplant volume, health system) and these four measures in a multivariable framework. Bartlett's test of homogeneity of variances was used to examine variances in the likelihood of performing specific types of transplants. The response 'do not know' was excluded from the comparative analyses. All analyses were performed using Stata V.16.0/MP for Linux and significance level using $p<0.05$ was reported. All CIs are 95% CIs and are reported as per the method of Louis and Zeger.[46]

Patient and public involvement statement

This research was designed and performed without active patient or public involvement.

RESULTS

Baseline characteristics

Survey participants listed their primary roles as transplant surgeons (28.8%), medical transplant specialists (67.1%), administrators (1.6%), infectious disease specialists (0.6%) or others (1.9%). The majority had been in practice for over 10 years; 5.5%<5 years, 16.2% 5–10 years, 35.7% 11–20 years and 42.5%>20 years. The characteristics of the transplant programmes they represented are listed in table 1 and the location is illustrated in figure 2.

Measures of transplant activity

When compared with the norm, only 38% of transplant programmes anticipate that their transplant volume will be >75% of the norm. However, 3.9% anticipate an increase in volume, due to an increase in donor referrals and closure of or refusal by other programmes in their region. Also, while 76.8% of the programmes were able to perform transplantation/s, only 24.9% reported being able to maintain pre-pandemic deceased donor offers

Table 2 Measures of transplant programme activity during the early months of the pandemic

When compared with the norm, anticipated change to the programme's transplant volume, n (%)	
No transplantations (0%)	9 (1.8)
<25% of the norm	67 (13.1)
25%–50% of the norm	103 (20.1)
50%–75% of the norm	127 (24.7)
75%–100% of the norm	95 (18.5)
No change (100%)	80 (15.6)
>100% of the norm	20 (3.9)
Do not know	12 (2.3)
Programme performed transplantation/s, n (%)	
Yes	394 (76.8)
No	117 (22.8)
Do not know	2 (0.4)
When compared with the norm, change in deceased donor offers to the programme during the pandemic, n (%)	
Fewer/much fewer	357 (69.6)
No change	89 (17.3)
More/much more	39 (7.6)
Do not know	28 (5.5)
Programme decided to ramp-down transplantation following the WHO announcement on 13 March 2020, n (%)	
Yes	386 (75.2)
No	126 (24.6)
Do not know	1 (0.2)

(no change or more offers) and 75.2% reported a ramp-down phase (table 2).

Measures of transplant activity by income level

A significantly higher number of transplant programmes in high-income countries anticipate their transplant volume will be >75% of the norm (high-income:46.5%, upper-middle-income: 31.6%, low/lower-middle-income:21.7%, p<0.001). This can be attributed to the fact that within these income brackets, high-income countries were more likely to perform transplantation/s (86.8%, 58.5%, 67.9%, p<0.001), maintain pre-pandemic deceased donor offers (31.0%, 14.2%, 26.4%, p<0.01), and avoid ramp-down of transplantation (30.9% vs 19.7% vs 8.3%, p<0.001), respectively.

Logistic regression analysis of the measures of transplant activity

Income level

In multivariable analyses, lower income level was negatively associated with all these measures of transplant activity. When compared with programmes from high-income countries, the odds of anticipating transplant volume to be >75% of the norm was significantly lower for programmes in upper-middle-countries (adjusted OR (aOR)=0.47, 95% CI 0.27 to 0.81) and for those in low/lower-middle-income countries (aOR0.33, 95% CI 0.16 to 0.67)). Also, programmes in low/lower-middle-income countries had higher odds of being unable to perform transplantation/s (aOR 3.33, 95% CI 1.49 to 7.43), but lower odds of maintaining prepandemic deceased donor offers (aOR 0.34, 95% CI 0.16 to 0.71) and avoiding a ramp-down phase of transplantation (aOR 0.24, 95% CI 0.09 to 0.64). For upper-middle-income countries, similar trends were noted, except for avoiding ramp-down of transplantation, which was not statistically different (aOR 0.63, 95% CI 0.33 to 1.19) (table 3).

Cumulative COVID-19 incidence

The CCI of a particular region was not associated with any of these measures except for maintaining prepandemic deceased donor offers. When compared with transplant programmes from regions with low CCI, transplant programmes located in a region with medium CCI had lower odds of maintaining prepandemic deceased donor offers (aOR 0.38, 95% CI 0.21 to 0.68). A programme in a region with high CCI also had lower odds for this measure, however, it did not reach statistical significance (aOR 0.55, 95% CI 0.30 to 1.00) (table 3).

Other exposures

In adjusted analyses, adult vs paediatric programmes did not determine any of these four measures and neither did the type of health system. Kidney/pancreas transplant programmes and programmes that normally perform fewer transplants also appear to be disproportionately affected by the pandemic. (table 3).

Types of transplants

The mean likelihood score of performing an urgent transplantation was 3.98±1.57, an emergent transplantation was 3.82±1.61, a non-urgent transplantation was 3.25±1.66, and living donor (if applicable) transplantations was 2.92±1.74. Transplant programmes from low/lower-income and middle-income countries had a significantly lower likelihood of performing urgent but not emergent transplantations. Type of solid-organ programme and CCI were associated with the likelihood of performing both urgent and emergent transplantations (table 4).

Risks to transplantation

Overall, the top-rated current risk to transplantation was the increased utilisation of hospital resources (66.3%). For anticipated risks, the top four rated statements were the burden of COVID-19 (76.2%), lack of deceased donors (64.5%), lack of a vaccine for COVID-19 (57.3%) and resources being redirected to others (54.4%). CCI did not seem to change the percentage of respondents that agreed with these statements being risks to their programmes, except for the burden of COVID-19 as a current and an anticipated risk. However, after segregating responses by income level of the country where the programme is located, these percentages were

Table 3 The adjusted OR for the measures of transplant activity by programme characteristics (significant values in bold)

	Anticipating transplant volume >75% of the norm	Performing no transplantation	Maintaining pre-pandemic deceased donor offers	Avoiding ramp-down of transplantation
Income level*				
High	Ref	Ref	Ref	Ref
Upper-middle	0.27 **0.47** 0.81	2.16 **3.94** 7.17	0.17 **0.32** 0.62	0.33 0.63 1.19
Low/lower-middle	0.16 **0.33** 0.67	1.49 **3.33** 7.43	0.16 **0.34** 0.71	0.09 **0.24** 0.64
Cumulative COVID-19 incidence†				
<20	Ref	Ref	Ref	Ref
20–100	0.51 0.85 1.43	0.94 1.78 3.39	0.21 **0.38** 0.68	0.33 0.59 1.07
>100	0.53 0.92 1.62	0.76 1.52 3.06	0.30 0.55 1.00	0.33 0.62 1.19
Type of solid-organ programme§				
Kidney/Pancreas	Ref	Ref	Ref	Ref
Liver	1.51 **2.47** 4.05	0.13 **0.27** 0.55	0.67 1.17 2.03	2.42 **4.26** 7.50
Heart	0.55 1.15 2.41	0.07 **0.17** 0.50	0.23 0.58 1.47	2.20 **4.89** 10.85
Lung	0.92 1.92 4.00	0.07 **0.23** 0.76	0.41 0.91 2.01	2.95 **6.44** 14.09
Age group of recipients				
Adult programme	Ref	Ref	Ref	Ref
Paediatric programme	0.71 1.41 2.78	0.38 0.84 1.88	0.48 0.93 2.26	0.91 1.91 3.99
Baseline transplant volume‡				
Low	Ref	Ref	Ref	Ref
Moderate	0.48 0.80 1.34	0.13 **0.23** 0.43	0.65 1.18 2.12	0.58 1.05 1.88
High	0.42 0.78 1.47	0.06 **0.12** 0.25	1.02 **2.01** 3.95	0.90 1.89 3.95
Health system				
Mixed/private	Ref	Ref	Ref	Ref
Public	0.41 0.64 1.01	0.61 1.07 1.87	0.41 0.67 1.11	0.39 0.66 1.11

*As defined by the World Bank at https://www.worldbank.org/.
†Calculated from 13 March 2020 to 15 July 2020 as reported by the Johns Hopkins COVID-19 Map, supplemented by covidindia.org. Calculated in person per million population, we divided this variable into tertiles: low: <2031, medium: 2032–5400, high: >5400.
‡One response excluded as respondent picked 'do not know'.
§Excluding those who listed multiple organs as their scope of practice.

dramatically different. A much higher percentage of physicians from low/lower-middle-income countries identified resources, finances and disease/patient-related factors as risks to their programme. For statements related to finances, the percentage of respondents who identified these as risks were threefold to fivefold more in low-income/lower-middle-income countries (table 5).

DISCUSSION

In this global survey of 513 solid-organ transplant programmes from 71 different countries, we report that the collateral damage of the pandemic to transplantation varied by a country's baseline resources and health system vulnerability, as measured by the income level. Programmes from higher-income countries were more likely to anticipate that their transplant volume will be >75% of the norm, and being able to perform transplantation/s, maintain prepandemic deceased donor offers and avoiding a ramp-down phase. Lower income level was negatively associated with all these measures of transplant activity even after adjusting for the CCI of the region. To our knowledge, this is the first global study to objectively demonstrate that transplant programmes in lower-income countries may have incurred more disruption from the pandemic even if their region's COVID-19 burden was low.

Earlier data suggested that most global cases of confirmed COVID-19 were seen in higher-income countries and lower-income countries may have been spared.[34] However, lower-income countries are more vulnerable to disruptions of natural and manmade disasters, such as pandemics.[24] Thus, many expressed concerns on the collateral damage of the pandemic to other clinical services in these countries.[1–3] Most of these were commentaries or entailed modelling studies. Also, they pertained to infectious diseases that are endemic in these regions,

Table 4 The likelihood of performing specific types of transplantations during the early months of pandemic rated on a scale of 1–5 (1 being unlikely and five being very likely) by programme characteristics (mean score and SD reported)*

	Urgent 3.98±1.57	Emergent 3.82±1.61	Non-urgent 3.25±1.66	Living donor 2.92±1.74
Income level†	P=0.002	P=0.08	P=0.57	P=0.46
Low/lower-middle	3.74±1.62	3.62±1.71	2.66±1.56	3.35±1.59
Upper-middle	3.33±1.76	3.26±1.72	2.73±1.70	2.53±1.71
High	4.29±1.38	4.07±1.49	3.60±1.58	2.94±1.78
Cumulative COVID-19 incidence‡	P=0.001	P=0.02	P=0.90	P=0.66
Low	3.71±1.66	3.61±1.71	3.13±1.69	3.19±1.67
Medium	3.88±1.63	3.67±1.65	3.23±1.65	2.74±1.79
High	4.44±1.26	4.23±1.37	3.42±1.63	2.80±1.75
Type of solid organ	P<0.001	P=0.02	P=0.47	P=0.42
Kidney/pancreas	3.71±1.67	3.51±1.69	3.02±1.69	3.01±1.69
Liver	4.29±1.42	4.23±1.40	3.46±1.61	2.86±1.85
Heart	4.59±1.02	4.59±1.02	3.47±1.58	NA
Lung	4.38±1.27	4.19±1.35	3.89±1.40	NA
Multiple	4.03±1.62	3.88±1.66	3.52±1.67	3.53±1.72
Baseline transplant volume	P=0.93	P=0.66	P=0.99	P=0.83
<20	3.92±1.57	3.70±1.61	3.11±1.67	2.62±1.67
20–100	4.00±1.56	3.91±1.57	3.23±1.66	2.80±1.76
>100	4.02±1.60	3.78±1.68	3.44±1.65	3.33±1.72

*Bartlett's test of homogeneity of variances was used to examine variances across survey responses by these programme-level factors (do not know responses were excluded).
†As defined by the World Bank at https://www.worldbank.org/.
‡Calculated from 13 March 2015 to 15 July 2020 as reported by the Johns Hopkins COVID-19 Map, supplemented by covidindia.org.
Calculated in person per million population, we divided this variable into tertiles: low: <2031, medium: 2032–5400, high: >5400.
NA, not applicable.

such as, HIV, tuberculosis and malaria. The differential impact of a specific clinical service across different regions are largely unexplored. We found only one survey study in the field of oncology, where authors reported that the severity of the pandemic on some aspects of cancer care were worse in centres from lower-income countries.[47] However, they did not adjust for the COVID-19 burden of the region.

It is well recognised that social constructs, public health response and politics are playing a big role in determining COVID-19 trajectories and burden. We believe that CCI over the initial 4 months of the pandemic is a good measure of the COVID-19 burden as it considers variabilities in responses to the pandemic. Our study shows that it is not the COVID-19 burden per se, but the health system's vulnerability and baseline resources, as measured by the income level, that is, more important in determining measures of transplant activity. The field of solid organ transplantation requires the coordination of 'staff, space, stuff and systems'.[48] Redirection of services and resources to COVID-19-related care was the morally and ethically right thing to do.[8 11] We now objectively demonstrate that this has led to a significant more impact to solid organ transplantation in lower-income countries. Recently, some data from lower-income countries did report that while patient and graft outcome of kidney transplants done during the COVID-19 pandemic were acceptable, the incidence of COVID-19 was 13.8% with a high case fatality ratio.[21]

Some other findings merit discussions. Similar to others,[36 44] we report that kidney transplant programmes are disproportionately affected by the pandemic. This is because due to the availability of dialysis, kidney transplantation is sometimes considered less urgent than heart, liver or lung transplantation. Second, transplantations are generally considered emergent if without them the patient will die in a few days. Thus, it is important to note that emergent transplantations had a similar likelihood of being performed across countries of all income level. Third, a higher proportion of physicians from lower-income countries perceived resources, finances and disease/patient-related factors as risks to their programmes. For example, screening methods for donors and recipients are well outlined in the literature[9]; yet, 47.0% of the programmes from low-income/lower-middle-income countries agreed with the statement 'we do not know how best to screen recipients and donors' as being a risk to their programme. Thus, emerging

Table 5 Percentage of respondents who agreed or strongly agreed with these statements as risks to their transplant programmes segregated by the cumulative COVID-19 incidence of the region and country's income level

	Cumulative COVID-19 incidence*			Income level†		
	Low n=176	Medium n=190	High n=147	Low/lower-middle n=84	Upper-middle n=118	High n=311
Current risks (% of agree/strongly agree responses)						
Resources						
There is a shortage of COVID-19 tests	30.3	27.1	33.6	35.7	41.4	24.3
We do not have enough personal protective equipment	20.6	18.5	21.1	26.2	26.5	15.8
Transplant entails increased utilisation of hospital resources	61.9	71.4	65.3	79.8	65.8	63.0
ICUs in my area are overwhelmed	41.5	53.4	47.6	66.7	62.4	37.0
Disease/patient						
The burden of COVID-19 patients is high	34.4	45.4	51.0	63.9	48.7	35.6
The sensitivity of the COVID-19 tests is suboptimal	37.7	33.7	41.8	56.0	39.7	31.5
We do not know how best to screen recipients and donors	27.4	22.9	30.6	47.0	29.3	20.3
Anticipated risks (% of agree/strongly agree responses)						
Resources						
Being unable to travel to procure organs	51.9	39.6	43.7	62.0	61.6	34.7
Lack of deceased donors	70.7	66.5	63.9	78.9	81.7	59.0
Resources being redirected to others	52.8	55.1	57.5	75.9	61.7	46.9
Administrative issues	42.4	35.2	36.1	56.6	51.8	27.5
Lack of access to clinical trials	27.8	20.8	15.3	42.5	25.0	14.7
Disease/patient						
Lack of vaccine to COVID-19	63.8	56.7	56.2	82.9	66.7	49.8
The burden of COVID-19	67.2	84.2	81.0	91.6	87.1	69.9
Poor outcomes in transplant recipients with COVID-19	35.0	29.6	28.4	44.3	29.4	28.1
Lack of good quality evidence to treat COVID-19	54.0	45.9	46.2	68.7	52.7	42.0
Patient preference	47.7	42.1	50.7	73.2	50.9	37.8
Finances						
Financial issues—institution related	30.9	27.6	26.5	46.4	45.7	16.9
Financial issues—patient related	41.7	21.3	32.2	76.2	42.6	15.1

*Calculated from 13 March 2020 to 15 July 2020 as reported by the Johns Hopkins COVID-19 Map, supplemented by covidindia.org. Calculated in person per million population, we divided this variable into tertiles: low: <2031, medium: 2032–5400, high: >5400.
†As defined by the World Bank at https://www.worldbank.org/.
ICU, Intensive care unit.

literature may not be universally applicable, and recommendations may not to be adapted to the local context. Leadership in each region is best suited to develop and shape contextually relevant interventions, while drawing on international partners as needed.[3]

A strength of this study is that we were able to mobilise transplant leadership from 71 different countries to take our survey and attain a good response rate amid a pandemic. We have identified four pragmatic and simple measures of transplant activity that have reliably captured the state of transplantation globally. These may serve as benchmarks for progress, improvements, and responses to intervention. Our work in transplantation serves as a surrogate for the impact of the pandemic on several other clinical services where access to timely care is necessary but was deprioritised, such as oncology and infectious diseases.

We, however, acknowledge the following limitations. The income level of a country is a good surrogate measure of a country's expenditure in health and the overall vulnerabilities of a healthcare system to a global pandemic.[23 25–27] Yet, there are large variations among countries of similar incomes in healthcare spending,[26] and we recognise that other health system factors, such

as health financing and health workforce/capacity, may be relevant. We also acknowledge that the incidence of COVID-19 may be under-reported by many countries; however, the Johns Hopkins COVID-19 Map is the best data source for determining the COVID-19 burden and we supplemented it with data from a source from India. We could not obtain adequate representation from certain regions, such as East Asia and Africa,[49 50] but our sample size was large enough to enable a comparative analysis and draw plausible conclusions. Many lower income countries rely more on living donation than deceased donation and we acknowledge that this was not accounted for. However, both deceased and living donation were impacted during the early days of the pandemic. The former because donor procurements were affected by availability of intensive care unit (ICU) beds, the latter as non-emergent surgeries were cancelled to accommodate for the COVID-19-related care. As with any survey study, our findings are at risk of subjective bias. However, as noted in table 2, most survey questions used in the present analysis had binary responses or were rated on a Likert scale; thus, the risk for subjective and acquiescence bias was low.

Regardless, our findings are extremely important as the COVID-19 pandemic has led to severe disruptions in the field of transplantation. Transplantation is a life-saving procedure in those with end-organ failure. The WHO's Task Force on Donation and Transplantation of Human Organs and Tissues reported that during the prepandemic period 17 transplantations were performed every hour and globally over 130 000 solid-organ transplants were performed annually.[51] This is estimated to represent less than 10% of the global need for a solid organ transplant,[51] and the gap likely widened significantly during the pandemic. If all transplant programmes closed for 1 week only, 2856 fewer organs will be transplanted. Thus, the pool of patients waiting for an organ transplant and dying while waiting for one has likely increased significantly during the pandemic, more so in lower-income countries.

In conclusion, we report that most transplant programmes globally have incurred significant collateral damage from the COVID-19 pandemic. However, the impact of the pandemic was much more in lower income countries, independent of the CCI. Health systems in lower-income countries will likely need more effort to rebuild disrupted services and recuperate from the pandemic even if their COVID-19 burden was low. Our results can inform practice and policy to mitigate some of the ongoing effect of the pandemic on non-COVID medical fields.

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