ORIGINAL ARTICLE

Assessing Countries' Deceased Organ Donation and Transplantation Performance

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ABSTRACT

Introduction: Donors per million population and transplantations per million population are standardized, widely used indicators to assess and compare countries' performance in organ donation and transplantation. This study aims to investigate these two particular metrics of organ donation and transplantation performance, and to introduce a new index, namely, 'transplantations per patients on the waiting list'. **Methods:** Secondary analyses of data on 23 countries in 2016 were used to construct the transplantations per patients on the waiting list indicator for kidney, liver, pancreas, heart, and lung transplantation, as well as for the transplantation of any of the five aforementioned organs. **Results:** According to the transplantations per patients on the waiting list, the best-performing countries in terms of organ donation and transplantation are Belarus for kidney transplantation, Finland for liver and pancreas transplantation, Australia for heart transplantation, and France for lung transplantation. Considering all five organs together, Sweden, Australia, Finland, Austria, and Poland were the top five best-performing countries, followed by Spain in the sixth position. **Conclusion:** The deceased transplantations per patients on the waiting list can be an alternative indicator to assess performance, along with the widely-used donors and transplantations per million population, but still has its limitations in certain scenarios.
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INTRODUCTION

In comparing countries' performance in terms of deceased organ donation and transplantation (ODT), the number of donors per million population (DPMP) or the number of transplantations per million population (TPMP) have been the most widely-used metrics, finding Spain as the world's most successful country (1-9). The excellent performance by countries such as Spain in having high rate of deceased organ donation was a lesson to be followed by other countries. The new metrics that we are proposing is by no mean to challenge the status quo of the already established metrics, but additive in nature that will complement the existing metrics.

DPMP compares countries' success in recruiting donors. However, this does not necessarily translate to providing a higher number of transplantations. The primary objective is to be able to provide transplantations for patients' needs, and not to merely recruit a high number of donors. In 2016, Sweden and Belarus had a similar population size (10). During that same year, 195 donors were recruited in Sweden, and 222 were recruited in Belarus, resulting in a higher DPMP in Belarus (23.3) compared to Sweden (19.5) (11). However, Sweden performed 637 transplantations (290 kidneys, 197 livers, 24 pancreases, 64 hearts and 62 lungs), about 33% higher compared to the 478 transplantations performed in Belarus (366 kidneys, 64 livers, 2 pancreases, 44 hearts and 2 lungs) (11). The DPMP indicator thus suggests Belarus to be more successful than Sweden in Organ Donation and Transplantation (ODT), where in fact, Sweden was able to provide more transplantations to patients in actual need.

Although the TPMP indicator avoids the abovementioned fallacy of the DPMP indicator, it suffers from another

bias, since it uses countries' overall population size as a reference. In reality, transplantation is only necessary for those who are in need of organs, and not the general population. Moreover, this demand for transplantation varies across countries (12). Therefore, using TPMP to compare countries' ODT performance ignores these particular variations.

Portugal and Sweden also had a rather similar population size in 2016. A total of 637 transplantations were performed in Sweden that year, which is lower than the 784 in Portugal (434 kidneys, 257 livers, 25 pancreases, 42 hearts, and 26 lungs), resulting in a higher TPMP in Portugal (74.8) compared to Sweden (63.9). However, the number of patients in need of transplantation was significantly higher in Portugal than in Sweden (3,105 vs. 1,214 patients respectively) (12), which means that Sweden satisfied 52.5% of the needed transplantations compared to only 26.0% of those in Portugal. This example could very well highlight this particular flaw in the TPMP as an indicator of countries' ODT performance. This work offers an alternative indicator to compare countries' performance in organ transplantation: transplantations per patients on the waiting list (TPWL), and employs it as an indicator across a sample group of countries. Each metric gives a slightly different view of the performance of transplantation activity in listed countries. Given the complexity and nature of transplant activities, we need all three metrics (DPMP, TPMP and TPWL) to inform health practitioners the factors that influence the donation and transplant rate in certain countries. The countries involved as well will have opportunities to improve on factors influencing all metrics.

MATERIALS AND METHODS

In this work, the number of transplants refer to those that receive only deceased donor allografts. TPWL is defined as:

$$\text{TPWL} = \frac{\text{Tr}}{\text{Tr} + \text{PWLE}}$$

where Tr refers to the total number of transplantations performed in a year, while PWLE represents the total number of patients on the waiting list at the end of the same year. The number of transplantations was added to the denominator, as it represents patients who were on the waiting list during the year, but were removed after receiving transplantation. Obviously, TPWL ranges from 0 to 100%, and represents the fulfilled proportion of demand for transplantation per year in a particular country. A higher TPWL indicates better ODT performance. This work employs the above formula to construct TPWL for kidney, liver, pancreas, heart, and lung transplantations, as well as for transplantations of any of these five organs.

Data on donation and transplantation were drawn from the International Registry of Organ Donation and Transplantation (11). As in prior work (9), data on the number of patients awaiting organ transplantations were taken from the Transplantation Newsletter (12) published by the Spanish National Transplant Organization in collaboration with the European Directorate for the Quality of Medicines (12). Data on country populations were extracted from the World Development Indicators database of the World Bank (10). All data were 2016 observations measured at the country level. Complete data on the number of patients awaiting kidney, liver, pancreas, heart, and lung transplantations were available for only 23 countries, and most of these were developed countries.

Note that the denominator, which is the number of patients on the waiting list, did not specify whether the waiting list data was based on actively waiting patients, or those who have been suspended from the waiting list. All procedures and studies have been performed in accordance with the ethical standards laid down in The Helsinki Declaration, as well as The Declaration of Istanbul on Organ Trafficking and Transplant Tourism.

RESULTS

Table I presents the TPWL index for kidney, liver, pancreas, heart, and lung transplantations, as well as the transplantations of any of these five organs. The results indicate that from among the 23 countries, Belarus performed the best in kidney donation and transplantation, satisfying about 49.1% (TPWL = 0.491) of those in need of transplantation. Argentina, on the contrary, had the lowest score (TPWL = 0.106). Spain satisfied 38.1% of its needs for kidney transplantations, and was ranked eighth after Belarus, Poland, Finland, Australia, the Netherlands, Sweden and Austria.

When it comes to liver and pancreas transplantation, Finland met 91% and 87.1% of its needs, respectively, ranking first compared to the other countries considered. Argentina (TPWL = 0.197) and Belarus (TPWL = 0.034) ranked last in satisfying the demand for liver and pancreas transplantations respectively. Spain ranked 10th for liver (TPWL = 0.637) and seventh for pancreas (TPWL = 0.495) transplantations.

Australia led the 23 countries in heart transplantations, providing 74.0% of the needed transplantations on the waiting list. On the contrary, about 79.3% of the need for heart transplantations was unmet in Poland, which ranked last among the 23 countries. Spain had its best ranking in heart transplantations in fifth, compared to other organs, satisfying 64.9% of its needs.

France satisfied about 80.3% of its needs for lung transplantations and ranked first, whereas Belarus ranked last with 93.6% unmet lung transplantations. Spain's performance for lung transplantations significantly

Table I: Transplantations per patient on waiting lists (TPWL index) in 23 countries, 2016 data

Country	Kidney	Liver	Pancreas	Heart	Lung	All*
Argentina	**0.106**	**0.197**	**0.762**	**0.424**	**0.147**	**0.137**
Australia	0.436	0.696	0.391	0.740	0.721	0.519
Austria	0.383	0.752	0.743	0.509	0.550	0.473
Belarus	0.491	0.403	0.034	0.396	0.074	0.434
Belgium	0.362	0.595	0.261	0.374	0.514	0.422
Brazil	0.177	0.605	0.213	0.568	0.345	0.234
Canada	0.358	0.590	0.795	0.595	0.584	0.442
Denmark	0.277	0.728	0.438	0.644	0.509	0.368
Finland	0.436	0.910	0.871	0.492	0.375	0.497
France	0.320	0.651	0.427	0.674	0.803	0.400
Germany	0.160	0.417	0.261	0.291	0.457	0.226
Hungary	0.292	0.407	0.207	0.547	0.708	0.333
Israel	0.133	0.422	0.632	0.242	0.360	0.206
Italy	0.208	0.543	0.211	0.264	0.298	0.275
Netherlands	0.404	0.540	0.301	0.257	0.272	0.389
Norway	0.355	0.855	0.417	0.600	0.436	0.448
Poland	0.486	0.647	0.442	0.207	0.380	0.464
Portugal	0.178	0.700	0.424	0.712	0.306	0.260
Spain	0.381	0.637	0.490	0.649	0.515	0.448
Sweden	0.394	0.776	0.649	0.681	0.667	0.525
Switzerland	0.265	0.457	0.407	0.423	0.716	0.345
UK	0.307	0.627	0.466	0.445	0.307	0.364
USA	0.191	0.392	0.473	0.507	0.783	0.279

*Calculated based on the total number of kidney, liver, pancreas, heart, and lung transplantations.
Abbreviation: TPWL, transplantations per patients on the waiting list.

Table II: Comparison of ODT performance of the 23 countries based on the TPWL, DPMP, and TPMP indicators, 2016 data

	Score (Ranking)		
Country	**TPWL**	**DPMP**	**TPMP**
Sweden	0.525 (1)	19.6 (14)	63.9 (10)
Australia	0.519 (2)	20.8 (13)	62.4 (11)
Finland	0.497 (3)	24.7 (7)	68.5 (8)
Austria	0.473 (4)	24.9 (6)	81.5 (5)
Poland	0.464 (5)	14.1 (19)	39.0 (19)
Spain	0.448 (6)	43.4 (1)	95.6 (1)
Norway	0.448 (7)	20.8 (12)	70.4 (7)
Canada	0.442 (8)	20.9 (11)	65.4 (9)
Belarus	0.434 (9)	23.3 (9)	50.2 (14)
Belgium	0.422 (10)	31.1 (3)	82.4 (4)
France	0.400 (11)	28.7 (5)	91.0 (3)
Netherlands	0.389 (12)	14.7 (17)	41.5 (18)
Denmark	0.368 (13)	17.1 (16)	47.5 (16)
UK	0.364 (14)	21.4 (10)	57.9 (12)
Switzerland	0.345 (15)	13.3 (20)	46.4 (17)
Hungary	0.333 (16)	18.5 (15)	47.9 (15)
USA	0.279 (17)	31.0 (4)	94.3 (2)
Italy	0.275 (18)	24.3 (8)	57.4 (13)
Portugal	0.260 (19)	32.6 (2)	75.8 (6)
Brazil	0.234 (20)	14.6 (18)	33.1 (22)
Germany	0.226 (21)	10.4 (22)	37.0 (20)
Israel	0.206 (22)	10.0 (23)	34.1 (21)
Argentina	0.137 (23)	11.8 (21)	28.6 (23)

Source: The author constructed the TPWL. Data on donation and transplantation are taken from the International Registry of Organ Donation and Transplantation.

Abbreviations: ODT, organ donation and transplantation; TPWL, transplantations per patients on the waiting list; DPMP, donors per million population; TPMP, transplantation per million population.

better than that of other organs, with only 51.5% of its needs satisfied, ranking ninth among the 23 countries considered in this study.

Table II compares countries' ranking for the TPWL (all organs) with the DPMP and TPMP indicators. According to TPWL, Sweden, Australia, Finland, Austria, and Poland were the top five best-performing countries, followed by Spain in the sixth position.

Countries' rankings vary significantly across the three indicators. For instance, Portugal ranked second by DPMP and sixth by TPMP, but was 19th using TPWL. Sweden, the top- performing country according to TPWL, ranked 14th according to DPMP, and was 10th based on TPMP. Moreover, Spain, which had the highest DPMP (43.4) and TPMP (95.6) globally, was ranked sixth by the TPWL indicator.

DISCUSSION

The DPMP and TPMP indicators have been commonly used to assess countries' overall ODT performance. However, although these two indicators reflect some aspects of such performance, they may not be viable to capture trends of countries' progress in fulfilling the needs in ODT. If the primary goal of organ transplantation is to provide quality transplants to patients, a more accurate assessment of countries' performance should not be limited to the number of recruited donors per million population (PMP), or to transplants PMP. The TPWL indicator measures the proportion of fulfilled transplantation demand. However, some issues should be taken into consideration when using this indicator, as explained hereafter.

Access to transplant therapy

The TPWL indicator relies on a country's reported number of patients on the waiting list, a figure which may not, however, reflect the actual number of patients in actual need of transplantation. Some patients in certain countries may not have access to transplantation therapy (13). A better version of the TPWL could thus be achieved by weighing the indicator with the number of patients who lack access to transplant therapy (i.e., using the actual need for organ transplantation). However, such statistics are currently unavailable.

Another limitation in using the TPWL indicator is that some countries may limit the number of patients who can be on the waiting list for transplantation. Our search revealed that only Italy has such a policy, where the number of listed patients should not exceed 20% of the number of transplantations performed per year (14). Such a policy would hold TPWL almost steady (around 20% in the case of Italy), and thus render it useless. Moreover, the waiting list is a dynamic in itself, patients come on and off – some get better, some get sicker and some pass away. It would be useful to 'deep dive' on the individual type of organ to better understand the severity and performance of each country. Again, considering the actual number of patients in need of transplantation would overcome this limitation, if such data is readily available.

In this new metric, the denominator plays a major role in determining the percentage of TPWL. Different countries may have different policy in putting patients on waiting list. Some patients may already be listed when the eGFR reach 20 mls/min/1.72m3, while some other countries may only list patients after they have started dialysis. In the available data for our study, it was not mentioned whether the number of patients on the waiting list was based on active patients only, or they would have included patients on suspended list as well. These limitations reflect the importance of having standardisation of wait list criteria to ensure a fair comparison between countries.

Intra- and inter-country comparison

The TPWL is useful to track a country's progress in ODT over time, often yearly. However, to compare ODT performance across countries using this indicator would assume similar inclusion and exclusion criteria for patients on waiting lists in the compared countries. In practice, countries' criteria may vary. Thus, the TPWL indicator alone may be insufficient to make inter-country comparisons. Since DPMP and TPMP could also be indicators with their very own limitations, as discussed earlier, considering the three indicators in combination seems to be the optimal method for inter-country comparison.

Quality of transplantation

Similar to DPMP and TPMP, TPWL is a quantitative indicator. None of these indicators consider the quality of transplantation. Weighting TPWL with a quality modifier, such as the transplant recipients' quality of life or survival rate, would make it a more accurate indicator. Unfortunately, comparable data on such a modifier is unavailable for most countries included in this study. Another limitation in accessing the overall transplant activity and quality is that TPWL does not take into account the impact of living donation on the waiting list. Living donation affects the waiting list and thus the shortage of deceased donors.

The proposed metric in this study (i.e. TPWL) looked at a different component. Having to incorporate data on patients who are already on dialysis as compared to those who are not — on the transplant waiting list — may provide beneficial information. In this work, in order to keep the formula simple and straightforward, this information was disregarded. Our proposed new metric relies on the number of patients on waiting list and number of deceased donations. We do not include living donations (including pre-emptive transplantation), which other metrics would have looked into.

One of the difficulties in our proposed metric is the dynamism of the transplant waiting list. There will be patients who deteriorate and die while on the list, and these patients may not be reflected in the number of patients on waiting list at the end of the year. The number can be significant in patients waiting for heart transplant, as 1-year survival while on waiting list may be as low as 34.1%, though this number has improved significantly to 67.8% of recent period (15). Patients waiting for kidney transplant are less affected by death compared to other waitlist, with 1-year mortality rate between 5-10% (16). Future studies should explore this particular matter as well as the other limitations of this study.

CONCLUSION

In sum, the widely-used indicators of DPMP and TPMP

have their own limitations in assessing countries' ODT performance. This work introduces TPWL, an indicator that avoids some of those limitations. While TPWL is a useful measure for assessing countries' overall ODT performance, it has its own limitations, nonetheless. In many cases, it is better to be used alongside DPMP and TPMP for comparison. The new metric will allow the policy maker to focus on proper development of standardised waiting list criteria. Combining all the three metrics (TPMP, DPMP and TPWL) will inform the relevant parties factors influencing the donation and transplant rate, as well as patients on the waiting list in their countries.

As the waiting list becomes the denominator for our metric, one may find that those countries with excellent waiting list performance may be penalized by the new proposed metric. Hence, it is vitally important to have a standardized wait-list criteria. Can the patient be included in the waiting if the essential investigations have not been completed? What do we do when a patient was taken off temporarily from the active waiting list because of infection – do we include such patient in our new metric? This is an opportunity for international organization to standardize such differences.

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