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Method Article

NOA method – three dimensions in the governance of kidney transplantation: *Need-Opportunity-Accessibility*, how to engage them? ☆

Paulo Filipe Severino [a,b,*], Catarina Bolotinha [c], Ana Luísa Papoila [a,e], Carlos Brás-Geraldes [d,e], Alexandrina Dos Santos [c], Vanda Rute Patrício Palmeiro [c], Ana Paula Fernandes [c], Ana Franca [c]

[a] *NOVA Medical School/Faculdade de Ciências Médicas, Universidade Nova de Lisboa, Portugal*
[b] *Department for Quality in Health, Directorate-General of Health/Departamento da Qualidade na Saúde, Direção-Geral da Saúde, Portugal*
[c] *National Transplant Coordination/Coordenação Nacional da Transplantação, Instituto Português do Sangue e da Transplantação, IP, Portugal*
[d] *Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa, Portugal*
[e] *Centre of Statistics and its Applications/Centro de Estatística e Aplicações, Universidade de Lisboa, Portugal*

A B S T R A C T

Background: Despite all efforts, the demand for organs increases. New and better strategies are still needed, critical in a crisis like pandemics.
Methodology: A mathematical approach that integrates need, *Opportunity*, and Accessibility to kidney transplantation, was created. NOA method, corresponds to the lateral surface area of a trigonal pyramid with the need, *Opportunity*, and Accessibility as axis, resulting in an intuitional chart output (NOA chart) and a percentage score (NOA score). Higher NOA scores are associated with larger NOA chart areas.
Method Application: We found some natural variability among the European Member States regarding *Need, Opportunity*, and Accessibility to kidney transplantation, concomitant with NOA scores. In 2019, in the European Union, 129 patients pmp on the waiting list for a kidney transplant were registered, 47 kidneys pmp were procured, and 36 kidneys pmp were transplanted, corresponding to 25% of kidney transplantation's response capacity.
Conclusion: Transplantation is frequently the better treatment for end-stage kidney failure. NOA method may be, in the future, an indicator for evaluating the overall transplantation performance regarding the need for it and a tool for policy definition. With NOA method we seek to contribute for:

☆ Direct Submission or Co-Submission: Direct Submission

* Corresponding author at: NOVA Medical School/Faculdade de Ciências Médicas, Universidade Nova de Lisboa, Portugal.
E-mail address: pauloseverino@dgs.min-saude.pt (P.F. Severino).

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- *A transplantation overall performance normalizing score;*
- *Transplantation response capacity evaluation.*

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Specifications table

Subject Area:	Medicine and Dentistry
More specific subject area:	*Transplantation*
Method name:	*NOA method*
Name and reference of original method:	*NOA method is an original method.*
Resource availability:	*Data:* • *Number of patients ever active on the waiting list for kidney transplantation;* • *Number of kidneys procured;* • *Number of kidney transplanted patients.* *Software:* • *No specific graph making software.*

Introduction

When Otto Lanz stated, in 1894, a treatment "*which aims to replace the organ that has lost its function in the organism*", it seemed pure speculation and science fiction. However, transplantation became one of the 20th century's most outstanding achievements. Organ transplantation is, nowadays, recognized as the best and frequently the only life-saving therapy for end-stage organ failure [1]. Recent data from the World Health Organization – WHO (*at*: https://www.who.int/transplantation/donation/taskforce-transplantation/en/) and the Global Observatory on Donation and Transplantation – GODT (*at*: http://www.transplant-observatory.org/contador1) announces more than 153,000 solid organ transplants worldwide annually. Despite this, number estimates represent less than 10% of the global need. Moreover, there is a huge gap in the availability and access to transplantation, with organ donation and transplantation rates varying widely between WHO regions (*at*: https://www.who.int/transplantation/knowledgebase/en/). Tremendous efforts to combat organ shortage remain a significant obstacle, imposing restrictions for the patients who can benefit from transplantation [2,3]. Although organ transplantation saves thousands of lives and ameliorates the quality of life of thousands more, many people will die because organ supply is scarce. Organ transplantation systems still need to improve resource use, particularly under budget constraints and more demanding circumstances like the current Pandemic. Accordingly, optimizing organ donation is one of the leading global goals for self-sufficiency. Geographic populations are heterogeneous, and differences in Donation-Transplantation activities among countries rely on population profiles, health, social and political systems [4]. Transplantation must also reflect equity, and to attain this, transparency and accountability are crucial [5]. Performance assessment is a crucial driver to quality improvement in transplantation. Donation and transplantation activities' indicators are often used to assess their performance, contributing to enhancing transparency [6]. Donation and Transplantation data, presented in terms of population rates: *per million of the population – pmp*, are currently the reference analysis approach. Nevertheless, there is still a need for a consensual assessment of the transplantation system [7]. Effectively, when thinking on the Portuguese experience, despite the

favorable rates of donation and transplantation, our perception, based on the waiting lists, is still of concern. Regardless of all efforts in fighting organ shortage, the gap between the waiting lists and transplantation is still a drawback. Then, some questions arise:

- How to recognize the relevance of the need for kidney transplantation?
- How to respond to patient's needs for kidney transplantation?
- How to measure the overall patients' need for kidney transplantation responsiveness?

Bearing in mind these questions, we propose the NOA method, which integrates *Need, Opportunity,* and *Accessibility* to kidney transplantation.

Methodology

Design and setting

NOA method integrates the following three fundamental dimensions: *Need (N), Opportunity (O),* and *Accessibility (A)* to kidney transplantation is conceptually designed as the following equation:

$$NOA\% = \left(\frac{O \times N + (O \ + \ N \ ) \times A}{3 \ \times N^2} \right) \times 100\%$$

This equation gives a percentage score – NOA score, reflecting the combination of the paired effectiveness areas *Need-Opportunity, Opportunity-Accessibility,* and *Need-Accessibility*. These areas can be presented in a three-dimensional *Kiviat* diagram with the *Need, Opportunity,* and *Accessibility* dimensions as axis – NOA chart. Higher NOA scores and greater NOA chart areas correspond to higher overall performance of kidney transplantation regarding the need for it.

Populations and samples

Target populations:

- Patients *pmp* ever active on the waiting list (eaWL), yearly, for kidney transplantation.
- Yearly kidney donors (actual deceased and living kidney donors) *pmp*.
- Yearly kidney transplanted patients *pmp*.

Accessible populations:

- Patients *pmp* eaWL, yearly, for kidney transplantation from European Member States (EU MS).
- Yearly kidney donors *pmp* from EU MS
- Yearly kidney transplanted patients *pmp* from EU MS.

Sampling:

- Patients *pmp* eaWL, during 2019, for kidney transplantation from EU MS.
- 2019 kidney donors *pmp* from EU MS.
- 2019 kidney transplanted patients *pmp* from EU MS.

Data collection, analysis, and procedure

Data regards kidney activities, between 2004 and 2019 in EU MS, published in the *Transplant Newsletter – International Figures on Donation and Transplantation* of the *European Directorate for the Quality of Medicines* (EDQM) and in the GODT.

Population subsets were converted into the variables: *Need, Opportunity,* and *Accessibility* to kidney transplantation as follows:

- *Need* – number of patients listed yearly for kidney transplantation corresponds to the number of patients eaWL.
- *Opportunity* – number of yearly kidneys procured from deceased and living donors for transplantation. When the number of kidneys from deceased donors was not available, it was assumed as twice the number of the deceased donors, giving the natural duplicity of this organ. We also envisaged the kidneys donated under exchange programs and cross-border programs. Every kidney allocated to a second country represents an intention to transplant, and donated kidneys received from a second country represent, effectively, an opportunity gain.
- *Accessibility* – number of yearly kidney transplants.

These variables represent the three fundamental dimensions of the NOA method. We assumed that *Opportunity* is never higher than *Need.* On the other hand, *Accessibility* is never higher than *Opportunity*, considering that there is no transplantation without a procured organ (accounted for the *Opportunity* value). In this sense, the NOA method is free from identifiability issues (different dimensional values conducting to equal NOA scores).

Variables and NOA scores were calculated for the period 2004–2019, as described, for each EU MS 2019 subset of data, are presented in bar charts along with NOA charts allowing the perception of NOA method intuitiveness.

Method application

Timelines of the *Need, Opportunity,* and *Accessibility* to kidney transplantation between 2004 and 2019 (Fig. 1), displayed variability reflecting the natural variability of waiting lists, kidneys procured, and transplants over time, along with the NOA score variability. When applying NOA method to the European Union population, NOA chart (Fig. 2) shows 2019 values of *Need* – 129 patients *pmp* waiting for a kidney transplant, *Opportunity* – 47 kidneys *pmp* procured, *Accessibility* – 36 kidneys *pmp* transplanted and the corresponding NOA score of 25%, corresponding to kidney transplantation's response capacity. By discriminating each European Member State, it's shown detailed 2019 NOA scores (in bars on the left side of Fig. 3), overlapping *Need, Opportunity*, and *Accessibility pmp* values, together with NOA charts (on the right side of Fig. 3). Heterogenous results are shown among countries, nevertheless, it's shown that higher NOA scores are associated with smaller gaps between *Need, Opportunity*, and *Accessibility* values pairwise and correspond to larger areas on NOA charts.

Discussion

Successful kidney transplantation is associated with significant survival and quality of life and substantial cost savings with dialysis. Despite the shortage of organ donation, a solid message for the health plan should include the intensification of the transplant programs and the optimization of the shift from dialysis to transplantation, whenever applicable [8]. When analyzing the whole health situation in terms of better treatment for end-stage renal patients (ESRF), strengthening governance and the interaction between donation and transplantation through health professionals and policymakers could reduce the time for a kidney transplant and increase patients' wellbeing [9]. Effectively, these policies lead to better outcomes and cost reductions; according to the kidney transplantation rates, WHO reports severe inequities in access to transplantation. That is why we reflected on this problem, aligned with WHO initiatives, which draws together international governmental and professional organizations with the mission of advancing the safe, effective and ethical practice of transplantation for all patients in need. To achieve this goal, one can rely on recommendations, build and support partnerships, improve the quality of information supported by digital materials, and develop educational models, such as those on living donor evaluation and transplant recipient's care [7]. Aiming to contribute to enhancing the assessment of transplantation implementation, we propose the use of the NOA score and its graphical representation and existing performance measures. High-level metrics for measuring the status of a transplant system, such as supply to demand ratios (O/N); procured kidney utilization rates (A/O); and transplantation rates (A/N), are valuable and essential metrics used in the field. NOA score and NOA *Kiviat*-based graphical

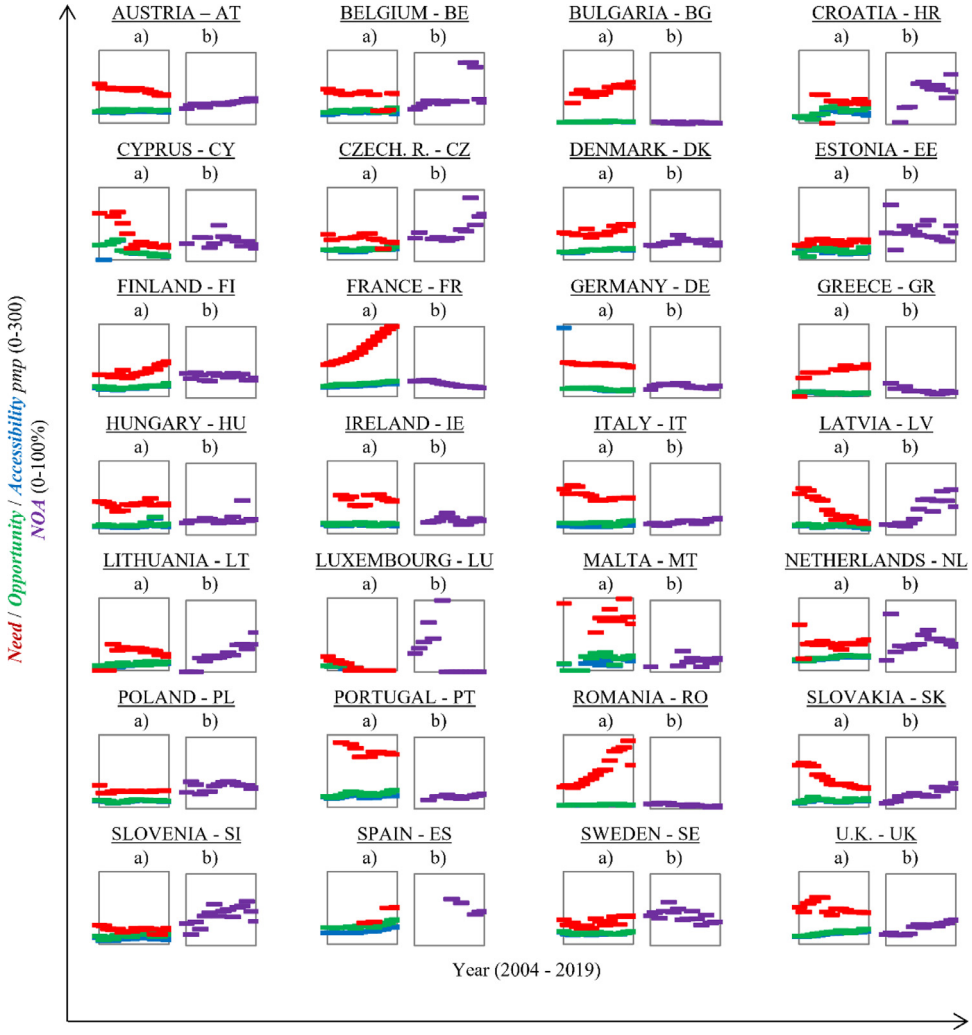

Fig. 1. Timelines of (*a) Need* (number of patients ever active on waiting list *pmp* in red), *Opportunity* (estimated number of donated kidneys *pmp* in green) and *Accessibility* (number of kidney transplants *pmp* in blue), and *b) NOA* scores (in purple) for kidney transplantation among the EU Member States between 2004 and 2019.

assessment improve upon these traditional high-level metrics by giving an integrated overview of the response capacity to transplantation need, and at the same time, by allowing to guide on which sub-metrics should be a priority for action-targeted measures. For instance, one country with a lower NOA score might have high A/O rates requiring action on O/N ratios; on the other hand, this country might present high O/N ratios requiring action on the A/O rates. In the present study, we found a discrepancy between NOA scores and the *Need*, the *Opportunity*, and the *Accessibility pmp* values, reinforcing that NOA infers the donation-transplantation response to the Need for transplantation. It can be evident also by the NOA chart of larger areas corresponding to higher NOA scores. According to each country's characteristics, supported by this conceptual model and in other areas, we can have an integrated and relative overview, despite the different needs for transplantation, resources, and approach. The NOA score is normalized over *Need*, allowing us to compare different national realities.

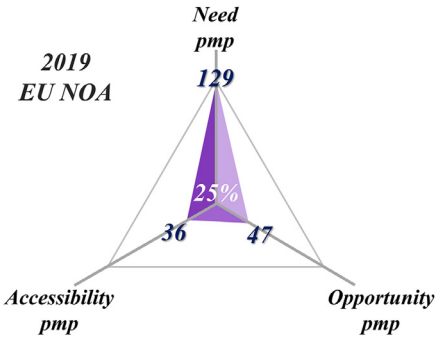

Fig. 2. European Union 2019 NOA chart.

Additionally, its graphical representation, based on existing published data, will enable a better understanding and, eventually, highlight potential improvement opportunities in each countries transplantation system. The NOA chart overcomes the natural limitation of a "score" as an abstract number by emphasizing dimension information in the corresponding axes. Ideally, there should be a balance between the three graphical faces of the triangular pyramid, meaning that the best answer to the citizens' Need for a kidney transplant and their quality of life improves. Even though the number of ESRF patients under dialysis represents a comprehensive and heterogeneous population in Europe, we can only consider the number of patients on the waiting list for the NOA method. Specifically, we believe the ever-active patients on the waiting list throughout the year, once this is the recognized need for transplantation, in each country.

Considering the Portuguese 2019 results (a country with ten million inhabitants), it ranked among EU MS as 2nd on deceased organ donation and 6th on kidney transplantation while holding the 20th NOA score for the same period. Portugal is the 2nd country with a higher waiting list *pmp* for kidney transplantation. According to European Renal Association - European Dialysis and Transplant Association (ERA EDTA, 2018), it has one of the highest incidences of patients starting renal replacement therapy in Europe. Paradigmatic cases like this validate that, despite higher rates of *Opportunity* and *Accessibility* within EU MS, new and improved strategies still need to be addressed for a better response to patients on waiting lists, evidenced by tremendous efforts, with scarce results in some countries [10]. Noa method could allow countries with similar health systems to benchmark their NOA results and move forward with new and proper strategies for improving transplantation and patient outcomes.

Limitations and future perspectives

This method doesn't consider the cases of dual kidney transplantation. Theoretical higher number of these cases would result in fewer patients being transplanted without contributing for higher discard rates. However, these cases, when existing, are not significant. Also, from its application point of view, NOA method doesn't recognize differing population more specific characteristics (*e.g.*, death rates, age distribution at death, comorbidities that may rule out donation and successful transplantation), and for this reason, when considering applying this method, other than focus on the NOA weakest axis, efforts must be made in the sense of correctly identify relevant population characteristics that can be empowered, and those that are naturally limiting the transplantation system. Additionally, NOA method relies on accountability and completeness of the data. Great efforts among EU MS are going on to harmonize data collection and report. We foresee more accurate data, in the near future, namely the precise number of procured kidneys among the European Member States.

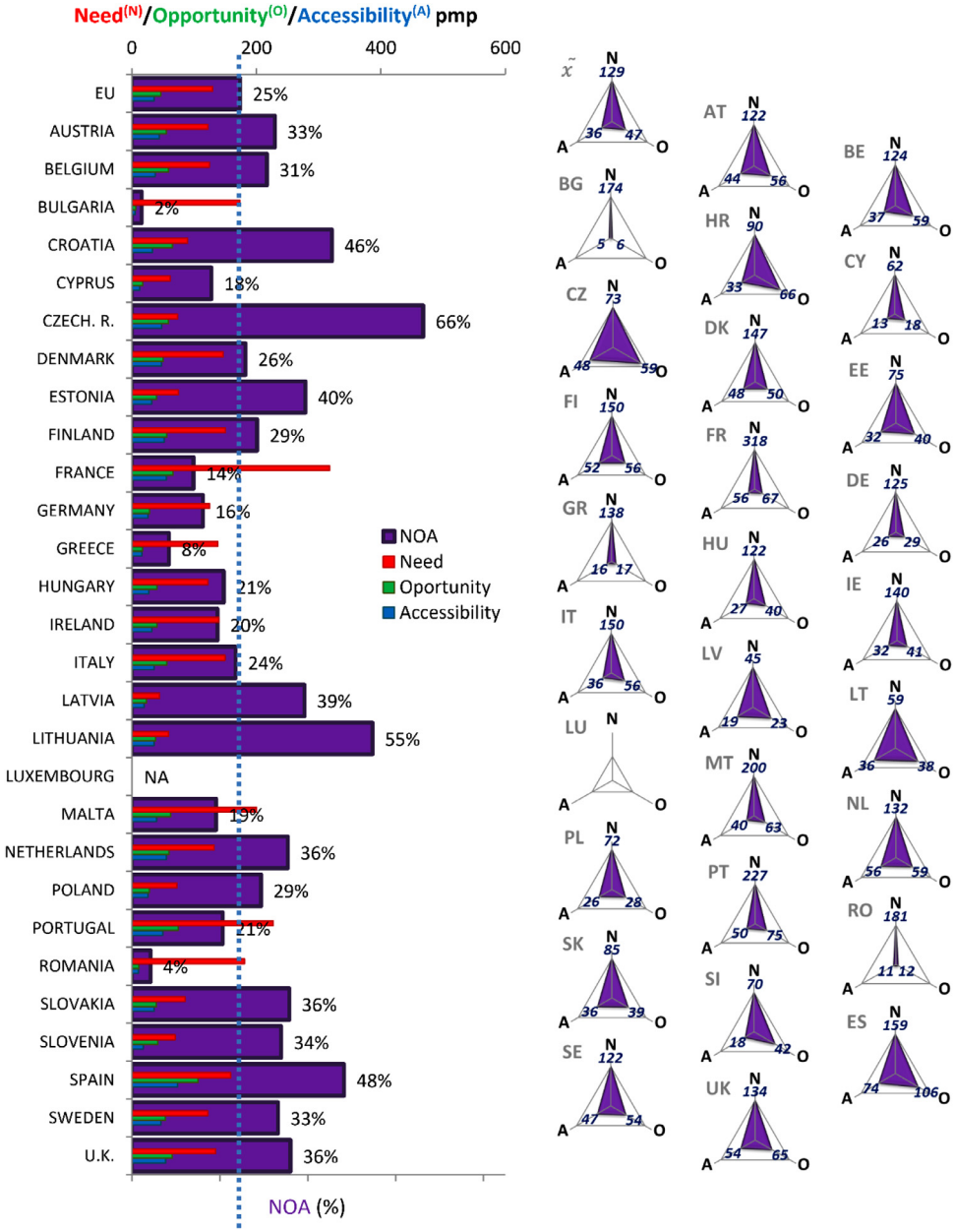

Fig. 3. NOA scores (purple bars), *Need* (red bars), *Opportunity* (green bars), and *Accessibility* (blue bars) among the EU Member States in 2019 (left), and corresponding NOA charts (right).

Conclusion

Transplantation systems are complex. Relating donation and transplantation rates between countries is essential and helpful but may not give an integrated overview for each country, specifically what concerns the waiting lists. However, by integrating three essential dimensions for organ transplantation – the *Need* (patients ever active in waiting list), the *Opportunity* (kidneys procured), and the *Accessibility* (kidney transplants), a methodology is proposed for assessing the performance of the donation-transplantation activities regarding the Need for transplantation, using an intuitional chart output – NOA chart and a percentage score – NOA score. Complementing the already existing metrics can be an added value tool for kidney transplantation management and policy definitions within each country and seen as an efficiency indicator.

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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.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.mex.2021.101542.

References

[1] T. Schlich, The origins of organ transplantation, Lancet 378 (9800) (2011) 1372–1373 Elsevier B.V., doi:10.1016/S0140-6736(11)61601-2.
[2] M. Manyalich, H. Nelson, F.L. Delmonico, The need and opportunity for donation after circulatory death worldwide, Curr. Opin. Organ Transplant. 23 (1) (2018) 136–141 Lippincott Williams and WilkinsFeb. 01, doi:10.1097/MOT.0000000000000486.
[3] M. Smith, B. Dominguez-Gil, D.M. Greer, A.R. Manara, M.J. Souter, Organ donation after circulatory death: current status and future potential, Intensive Care Med. 45 (3) (2019) 310–321 Springer VerlagMar. 13, doi:10.1007/s00134-019-05533-0.
[4] L.R. Thacker, What is the big deal about populations in research? Prog. Transplant. 30 (1) (2020) 3 SAGE Publications Inc.Mar. 01, doi:10.1177/1526924819893795.
[5] S. Benatar, T. Sullivan, A. Brown, Why equity in health and in access to health care are elusive: insights from Canada and South Africa, Glob. Public Health 13 (11) (2018) 1533–1557 Nov., doi:10.1080/17441692.2017.1407813.
[6] M.M. Siqueira, C.A. Araujo, B. De Aguiar Roza, J. Schirmer, Efficiency indicators to assess the organ donation and transplantation process: systematic review of the literature, Rev. Panam. Salud Pública 40 (2) (2016) 90–97. https://pubmed.ncbi.nlm.nih.gov/27982363/.
[7] J. Weiss, et al., Evolution of deceased organ donation activity versus efficiency over a 15-year period: an international comparison, Transplantation 102 (10) (2018) 1768–1778 Oct., doi:10.1097/TP.0000000000002226.
[8] J. Augustine, Kidney transplant: new opportunities and challenges, Clevel. Clin. J. Med. 85 (2) (2018) 138–144 Feb., doi:10.3949/ccjm.85gr.18001.
[9] R. Vanholder, et al., How to increase kidney transplant activity throughout Europe - an advocacy review by the European kidney health alliance, Nephrol. Dial. Transplant. 34 (8) (2019) 1254–1261 Oxford University PressAug. 01, doi:10.1093/ndt/gfy390.
[10] E.J. See, et al., Global coverage of health information systems for kidney disease: availability, challenges, and opportunities for development, Kidney Int. Suppl. 8 (2) (2018) 74–81 Elsevier B.V.Feb. 01, doi:10.1016/j.kisu.2017.10.011.