Received: 11 May 2020 | Revised: 29 May 2020 | Accepted: 14 June 2020

DOI: 10.1111/tid.13373

LETTER TO THE EDITOR

WILEY

Haddon matrix for kidney transplantation during COVID-19 pandemic: A problem solving framework for present and future

To the EditorNovel coronavirus disease 2019 (COVID-19) pandemic is a public health emergency with several million worldwide and a quarter of a million and soon half a million deaths including a third in the United States alone (as of May 10, 2020).[1] It affects kidney transplantation and has caused mortality in waitlist dialysis and transplant patients.[2,3] This inevitably raises questions about the practicality and direction of transplant surgeries during this critical period.

Haddon matrix is a framework used for injury prevention and response strategies (Table 1). It has also been used with previous pandemics including influenza and SARS,[4,5] and may be applied to transplantation during the current COVID-19 pandemic. The matrix investigates host and environmental factors (physical and sociocultural) during three time points: pre-event, event, and post-event.[6] The proposed application of the Haddon matrix during current COVID-19 pandemic by considering host, agent (SARS-CoV-2), and environmental factors from pre-transplant through post-transplant periods is shown in the Table 1.

The Haddon matrix paradigm primarily guides providers to identify strategies to minimize COVID-19 infections amongst their transplant patients. In a broader context, it can be applied to the transplant community at large and facilitate strategic relationships between transplant centers. For example, centers located in highly impacted areas will have reduced healthcare resources and transplantation may be temporarily halted while healthcare resources are pooled for critically ill patients.[7] A strong relationship with a center that has not yet been affected or has overcome the largest anticipated spike may allow some patients from the struggling center to be transplanted at the sister facility rather than waiting for their center to re-open.

The risk of death from COVID-19 versus the risk of remaining on dialysis for patients with ESRD must be carefully considered.[8] Although highest fatality from COVID-19 is among individuals aged ≥85 years (10%-27%), the mortality ranges from <1% to 1%-3% among persons aged 20-54 and 55-64 years, respectively.[9] Additionally, under detected cases likely overestimate reported fatality. In comparison, the mortality of patients with ESRD is 20%-25% after 1 year of dialysis and their survival rate at 5-years is only 35%.[10] Notably, kidney transplant waitlist candidates are generally healthier (even pre-transplant) than the overall dialysis population and do not have as high mortality at 1 year or low survival rate at 5-years on dialysis. Despite this transplant still significantly reduces their overall mortality. In the setting of an evolving pandemic with little information on current kidney transplant outcomes, the decision to postpone transplantation should be based on other factors. These include availability of healthcare resources, the risk of infection to the patient, the extent of community spread, the risk of transmission to healthcare providers, and the availability of suitable transplant candidates.

Although applying the Haddon matrix framework to transplantation can be helpful, some unmodifiable factors including our limited understanding of SARS-CoV-2 may limit its' utility in efforts to prevent and control COVID-19. SARS-CoV-2 is highly contagious and has a wide spectrum of clinical presentations making it difficult to detect all cases when screening occurs by symptoms in each transplant phase. The accuracy of the diagnostic methods for SARS-CoV-2 both RT-PCR and antibody testing in transplant recipients needs further study.[11] Moreover, prioritized healthcare resources for emergency or critically ill patients during the pandemic may decrease the number of kidney transplantations and may further limit availability of resources to optimize the control of COVID-19 in immunosuppressed patients during the post-transplant phase. Implementation of the Haddon Matrix cannot be achieved unless it is integrated into an institutions policies and procedures that can be modified as this disease continues to evolve.[4]

Applying this matrix is a dynamic process and by its nature requires the provider to re-visit and re-evaluate the ever-changing situation. The information gathered during this pandemic will help preemptively identify future problems and better prepare the transplant community for future unprecedented infectious outbreaks.

ACKNOWLEDGEMENTS

Authors would like to thank Dr Joseph Bressler from the Department of Environmental Health Sciences at the Johns Hopkins University Bloomberg School of Public Health and the Kennedy-Krieger Institute as well as Dr Daniel Barnett from the Department of Environmental Health Sciences and the Department of Health Policy and Management at the Johns Hopkins University Bloomberg School of Public Health for their teaching in the classes and motivating the first author to create this work.

CONFLICT OF INTERESTS

KKZ has received honoraria and/or grants from Abbott, Abbvie, Alexion, Amgen, DaVita, Fresenius, Genzyme, Keryx, Otsuka, Shire, Rockwell, and Vifor, the manufacturers of drugs or devices and/or providers of services for CKD patients. KKZ serves as a physician

Abbreviations: COVID-19, Coronavirus disease 2019.

TABLE 1 Application of Haddon matrix to organ transplantation during COVID-19 pandemic

Epidemiologic dimensions			Environment	
Event dimensions	**Host factors**	**Agent**	**Physical**	**Sociocultural**
Pre-transplantation	• Minimize organ contamination and shipping • Minimize recipient travel • Provider training in infection control • Individualized donor selection to minimize anticipated DGF necessitating post-transplant dialysis • Recipient selection to minimize anticipated DGF • SAR-CoV-2 screening in donors and recipients	• Contagiousness of COVID-19 viruses • Virulence of COVID-19 viruses	• Infection control infrastructure • Availability of donor and recipient COVID-19 testing • Availability of PPE • Plan for increased capacity for COVID-19 cases	• Societal attitudes toward COVID-19 • Provider adherence to infection control policies • Resource allocation and prioritization
Transplantation	• Underlying co-morbidities • Healthcare providers' practice • Risk communication to patient and staff	• Mode of COVID-19 transmission during	• Capacity to quarantine if indicated • Designated area for COVID-19 cases • Medical equipment and potential effective anti-viral therapies	• Practical and ethical considerations for organ transplantation • Budgets for resource utilization • Patients and family adherence to infection control policy • Appropriate communication about COVID-19 to patients
Post-transplantation	• Post-infection management and surveillance	• Persistent COVID-19 in the environment • COVID-19 virus mutation • Research pertaining to treatment, immunization	• Post-infection decontamination • Patient transportation availability	• Psychological support • Financial support for transplant centers and hospitals affected by COVID-19 • Support for patients and their communities affected by COVID-19

Abbreviations: COVID-19, coronavirus disease 2019; DGF, delayed graft function, PPE, personal protective equipment, SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

in the US Department of Veterans Affairs medical centers with or without compensation or is a part- or full-time employees of a US Department of Veterans Affairs medical centers. Opinions expressed in this paper are those of the authors' and do not represent the official opinion of the US Department of Veterans Affairs.

AUTHORS CONTRIBUTIONS

ET participated in designing of topics and detail of manuscript, writing of the manuscript, and preparing the table. UGR, AJF, HI, DCD, and KKZ participated in editing and reviewing of the manuscript.

Funding information

Supported by research grants from the National Institute of Diabetes, Digestive and Kidney Disease of the National Institutes of Health K24-DK091419 and Philanthropic grants from Mr Louis Chang and Dr Joseph Lee.

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REFERENCES

1. Center for Disease Control and Prevention. National Center for Immunization and Respiratory Diseases (NCIRD), Division of Viral Diseases. Cases of Coronavirus Disease (COVID-19) in the U.S. https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html. Accessed on April 22, 2020.
2. Ferrey AJ, Choi G, Hanna RM, et al. A case of novel coronavirus disease 19 in a chronic hemodialysis patient presenting with gastroenteritis and developing severe pulmonary disease. *Am J Nephrol*. 2020;51(5):337-342.
3. The Columbia University Kidney Transplant Program. Early description of coronavirus 2019 disease in kidney transplant recipients in New York. *J Am Soc Nephrol*. 2020;31(6):1150-1156.
4. Barnett DJ, Balicer RD, Lucey DR, et al. A systematic analytic approach to pandemic influenza preparedness planning. *PLoS Medicine*. 2005;2(12):e359.
5. Barnett DJ, Balicer RD, Blodgett D, Fews AL, Parker CL, Links JM. The application of the Haddon matrix to public health readiness and response planning. *Environ Health Perspect*. 2005;113(5):561-566.
6. Haddon W Jr. The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based. *Am J Public Health Nations Health*. 1968;58(8):1431-1438.
7. Michaels MG, La Hoz RM, Danziger-Isakov L, et al. Coronavirus disease 2019: implications of emerging infections for transplantation [published online ahead of print, 2020 Feb 24]. *Am J Transplant*. e15832. https://doi.org/10.1111/ajt.15832
8. Kumar D, Manuel O, Natori Y, et al. COVID-19: a global transplant perspective on successfully navigating a pandemic [published online ahead of print, 2020 Mar 23]. *Am J Transplant*. e15876. https://doi.org/10.1111/ajt.15876
9. Bialek S, Boundy E, Bowen V, et al. Severe outcomes among patients with coronavirus disease 2019 (COVID-19) — United States, February 12–March 16, 2020. *MMWR*. 2020;69(12):343-346.
10. United States Renal Data System. *2018 USRDS Annual Data Report: Epidemiology of Kidney Disease in the United States*. Bethesda, MD: National Institute of Diabetes and Digestive and Kidney Diseases; 2018.
11. Sethuraman N, Jeremiah SS, Ryo A. Interpreting diagnostic tests for SARS-CoV-2. *JAMA*. 2020;323(22):2249.