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Establishing kidney transplantation in a low-income country: a case in Tanzania

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Abstract

Background Sub-Saharan African countries, including Tanzania, have a high burden of chronic kidney diseases (CKDs) and limited capacity for the provision of services. Tanzania and other countries in the region have made significant improvements in the provision of services for patients with CKD, including hemodialysis. Few countries are offering kidney transplantation services, which is the definitive treatment for patients with CKD and kidney failure. This study was conducted to review the steps taken by Muhimbili National Hospital (MNH) to establish a kidney transplantation service in Tanzania.

Methods This study was based on the review of the activities that were undertaken to establish kidney transplantation services at Muhimbili National Hospital in Dar es Salaam, Tanzania. It was conducted by reviewing key documents developed for kidney transplantation and interviewing key personnel who were involved in the process.

Results Kidney transplantation services at MNH were established in November 2017; several steps were taken in the preparatory phase including training of personnel, infrastructural modifications, and procurement of equipment and supplies. Capacity building was achieved through international collaboration with several international and local institutions, including three Hospitals in India. The transplant team, which included nephrologists, urologists, anesthesiologists, radiologists, nurses, laboratory technicians, a transplant coordinator, and a lawyer, underwent short-term training at BLK Hospital in India. Initial transplant procedures were carried out with support from visiting personnel from BLK, Sakra, and Seifee hospitals. In total, 72 transplant surgeries were conducted, of which 39 (54.2%) were performed with visiting teams and 31 (45.8%) by the local team independently. Of the initial 39 recipients, 56.4% were males and 43.5% were aged above 46 years. About half of the donors were brothers/sisters, and 43.5% had human leukocyte antigen haplomatch. Induction immunosuppression included basiliximab in the majority (64.1%) of recipients, and all recipients received prednisolone, tacrolimus, and mycophenolate mofetil/myfortic.

Conclusions Establishing kidney transplantation in lower-income countries, such as Tanzania, is feasible; however, it requires dedicated efforts. Collaboration with local and international institutions provided an enabling environment for the transfer of skills and access to necessary supportive services.

Keywords Nephrology in Tanzania, Nephrology training, Nephrology in sub-Saharan Africa

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Background

Chronic kidney diseases (CKDs), which are estimated to affect about 12% of the global population, contribute to significant morbidity and mortality; 1.2 million deaths globally were attributed to CKD in 2017 [1, 2]. The burden of CKD has strained health systems in most lower and middle-income countries especially in the sub-Saharan Africa (SSA) region, which has poorly developed infrastructures and human resources for the provision of services [3, 4]. The workforce for care of CKD patients in most lower-income countries is scarce, and there is limited infrastructural capacity for renal replacement therapy, including kidney transplantation [4]. The density of nephrologists per million population is very low (< five per million) in most sub-Saharan African countries, indicating a mismatch between the workforce and the high burden of CKD in the region estimated at 13.9% [3, 5].

Burden of chronic kidney diseases in Tanzania

Tanzania, like other countries in SSA, has a high burden of CKD with a community-based prevalence ranging between 7% and 14% [6–8]. A higher prevalence of CKD is reported in hospitals; Kilonzo et al. reported a prevalence of 69.5% among patients admitted to medical wards at Bugando Medical Centre (BMC) from October 2013 to March 2014 [9]. Similar findings were noted by Mubarakali et al. and Msango et al., reporting CKD prevalence rates of 83.7% and 80% for patients with diabetes mellitus and human immunodeficiency virus (HIV) infection, respectively, at BMC [10, 11]. Diabetes mellitus, hypertension, chronic glomerulonephritis, and viral infections, including HIV, and hepatitis B and C viruses, are known risk factors for CKD in Tanzania [6, 12].

Renal replacement therapy for patients with CKD in Tanzania

Hemodialysis is the predominant modality of renal replacement therapy in Tanzania, and in the last two decades, tremendous improvement has been made in this service. In December 2018, there were 28 hemodialysis units with 933 patients with CKD on maintenance hemodialysis [13] in Tanzania. There has been a steady increase in the number of hemodialysis units in the country operated by both public and private facilities, many regional referral hospitals are setting up facilities for hemodialysis. Despite this increase, there is limited access to these services for many patients in the country with CKD and kidney failure [14, 15].

Acute peritoneal dialysis (PD) is also offered at some facilities in Tanzania, and with the improving coverage of hemodialysis, peritoneal dialysis has largely remained an option for the treatment of children with acute kidney injury [13, 16, 17]. PD is provided using improvised

equipment and supplies and fluids are constituted using intravenous fluids. The type of catheters and dialysate used for PD make this modality only suitable for managing acute kidney injury (AKI), which requires short therapy.

For many decades patients with CKD and kidney failure requiring kidney transplantation were sent overseas. The first ten candidates were transplanted in the UK in the 1980s; subsequently, many patients were transplanted in India, and a few were sent to other countries, including Kenya [13, 18]. More than 200 patients requiring kidney transplantation and their donors were supported by the government through the Ministry of Health for their treatment in India. Most of these patients received their pretransplantation workup and their posttransplantation follow-up at Muhimbili National Hospital [13]. MNH has been providing pretransplantation and posttransplantation care for many years.

The growing number of patients with CKD and kidney failure, some of whom are undergoing hemodialysis, presented the need to establish kidney transplantation services in Tanzania. The cost of a single session of hemodialysis in Tanzania is 240,000–300,000 TShs (\$104–130) amounting to 35–44 million TShs (\$15,000–20,000) annually; this is very expensive and is similar to other reports of cost for this service in the region [19, 20]. Comparatively, kidney transplantation may be cheaper than hemodialysis, although the initial transplant surgery and care may be high. Establishing national kidney transplantation services is a complex process requiring enormous investments in the form of human resources, equipment as well and a legal framework to safeguard the safety of donors, recipients, and the community [21]. This study describes the initiatives undertaken by Muhimbili National Hospital in setting up a kidney transplantation service in Tanzania.

Methods

This study is a review of the actions that were undertaken by Muhimbili National Hospital (MNH) in establishing kidney transplantation. MNH is located in Dar es Salaam, Tanzania, and is the national referral hospital with a 2000 bed capacity, it has the largest hemodialysis unit with 50 hemodialysis machines and one continuous renal replacement therapy (CRRT) machine. MNH is the teaching hospital for Muhimbili University of Health and Allied Sciences (MUHAS). Multiple specialized clinics falling under nephrology unit are offered at MNH, including general nephrology, pediatric nephrology, kidney donors, and kidney recipient clinics.

This study was conducted by interviewing key personnel from departments and units that are involved in the provision of kidney transplantation services and played

a part in establishing transplant services. Departments included in this study included nephrology, urology, a central pathology laboratory, anesthesiology, radiology, critical care, pharmacy, social welfare, and legal services. Key documents that were prepared for kidney transplantation were reviewed including patients' charts for 39 transplant recipients who were transplanted with support from collaborating hospitals from India. Patient charts that were reviewed had information up to 1 month posttransplantation only. This study was approved by the ethical committee of Muhimbili National Hospital with a waiver of consent as no personal information was collected or used in the study.

Results

The information collected in the review process included training of health personnel in kidney transplantation, and improvement of infrastructure, including procurement of equipment, creation of dedicated spaces, and preparation of necessary documents for these services.

Training of health care personnel

In August 2016, a team of doctors, nurses, and laboratory scientists traveled to BLK Hospital in India for 3 months of training, the training was aimed at exposing these practitioners to kidney transplantation services at BLK.

Table 1 indicates the practitioners and the skills acquired at BLK Hospital, India.

Transplantation guideline

The team involved in transplantation at MNH developed a standard operating procedure (SOP) for kidney transplantation. This SOP guides all the procedures involved in the process of transplantation. The SOP also included the evaluation of donors and recipients and the immunosuppression protocol.

Donor and recipient evaluation

Recipients and donors are extensively evaluated before kidney transplantation, this is carried out by taking history for common risk factors and followed by laboratory tests for determining renal and liver functions, screening for medical conditions, and screening for infections and malignancies as indicated in Supplementary documents 1 and 2. Human leukocytic antigens and CDC cross-match are also carried out as the last tests before kidney transplantation. Once all the evaluation is done and before submission of the documents to the kidney transplantation authorization committee, a joint meeting is conducted between the transplant team, including nephrologists, urologists, anesthesiologists, microbiologists, and transplant coordinators. After this meeting nephrologists and urologists discuss with the donor and

Table 1 Training of the MNH transplant team at BLK Hospital

| Practitioners (n) | Duration | Skills acquired |
|--------------------------------|----------|---|
| Nephrologists (3) | 3 months | Donor and recipient pretransplant assessment Donor and recipient posttransplant care Management of early and late-onset graft dysfunction |
| Urologists (3) | 3 months | Preoperative assessment of donor and recipient; graft selection, vessel assessment Graft harvesting from donor, preservation, and pretransplant preparation Graft bed preparation Post-transplant assessment |
| Anesthesiologists (1) | 3 months | Preoperative assessment of donor and recipient Intraoperative management of the recipient |
| Critical care physicians (2) | 3 months | Intensive care unit management of donor and recipient |
| Radiologists (1) | 3 months | Radiological pretransplant assessment of donor and recipients Recipient evaluation for immediate post-transplantation complications |
| Radiographer (1) | 3 months | Doppler ultrasound assessment of the graft |
| Theater nurses (2) | 3 months | Nursing care during graft harvesting, preservation, and transplantation Equipment for graft harvesting Equipment for graft transplanting |
| Intensive care unit nurses (8) | 3 months | Nursing care for donor and recipient: vital sign monitoring and input and output monitoring |
| Laboratory scientists (2) | 3 months | Handling of specimens for transplantation patients Preparation of blood products for transfusion during transplantation Performing human leukocytic antigen (HLA) typing and complement-dependent cytotoxicity (CDC) crossmatch testing |
| Transplant coordinator (1) | 3 months | Coordination of donor selection process Coordination of pretransplant assessment of donors and recipients |
| Lawyer (1) | 2 weeks | Preparation of legal framework for organ transplantation |

recipients to inform them about the procedures and anticipated complications and also to respond to their questions. After this meeting donor and recipient files and their legal documents are submitted to the kidney transplantation authorization committee.

Immunosuppression protocol

The immunosuppression protocol included the following medications.

- i. Induction medications;

Induction medications adopted for MNH guidelines were anti-thymocyte globulin-rabbit (ATG-rabbit) and basiliximab for high-risk and low-risk transplant pairs, respectively.

- ii. Maintenance of immunosuppression drugs;

Maintenance immunosuppressants selected included tacrolimus, mycophenolate mofetil (MMF)/myfortic acid, and prednisolone. Cyclosporine, everolimus, and azathioprine were also included as alternative drugs.

- iii. Prophylaxis;

Post kidney transplant prophylaxis was included in the SOP and prophylaxis is recommended for cytomegalovirus, pneumocystis pneumonia, and oral candida infection. Recommended drugs for prophylaxis are valganciclovir, co-trimoxazole, and clotrimazole/nystatin for cytomegalovirus (CMV), *Pneumocystis carinii* pneumonia (PCP), and oral candidiasis, respectively. Prophylaxis against CMV and PCP is for 6 months while candida is for 3 months.

Laboratory equipment, dedicated spaces, and provision of supplies

The hospital made a dedicated effort to establish infrastructure to support kidney transplantation, these

include the procurement of allocating clinical space, and procurement of supplies and equipment. A transplant ICU was created with three beds, ventilators, monitors, and a reverse osmosis plant for hemodialysis machines. The equipment that was procured included a CRRT machine, plasmapheresis machine, arterial blood gas machine, and crossmatch machine. Other supplies that were procured included induction drugs (basiliximab and anti-thymocyte globulin -rabbit), leukodepletion tubing for blood transfusion, and spirometry.

Collaborating institutions in establishing kidney transplantation at MNH

Several local and international institutions were engaged to facilitate the establishment of the program at MNH, this collaboration offered support in the form of training, clinical support, and laboratory services as indicated in Table 2.

Legal framework to support transplantation

There was no legal framework for organ transplantation in Tanzania, therefore to support kidney transplantation at MNH, the regulations for the legislative act, which established Muhimbili National Hospital in 2000 (Muhimbili National Hospital Act 2000), were changed and clauses for guiding kidney transplantation were included [22]. The MNH Renal Services Regulations 2017 provided the responsibility for regulating the removal, storage, and transplantation of kidneys to avoid commodification and organ trade. The regulation allows the transplantation of kidneys involving near relatives, which include a spouse, child, parent, sibling, grandparent, grandchild, cousin, nephew, niece, uncle, or aunt.

The regulations also provided for the position of transplant coordinator who should be a nurse or social worker appointed by the executive director. The establishment of a transplant authorization committee is prescribed in the

Table 2 Collaborating institutions in establishing transplant services

| Institutions | Area of collaboration |
|--|--|
| <i>Collaboration with Tanzanian institutions</i> | |
| Ocean Road Cancer Institute (ORCI) | Provision of radionuclide studies, including mercaptoacetyltriglycine (MAG 3) and diethylenetriamine pentaacetate (DTPA) |
| Muhimbili University of Health and Allied Sciences (MUHAS) | Provision of laboratory services for HLA testing |
| Jakaya Kikwete Cardiac Institute | Support for cardiac evaluation of donors and recipients |
| <i>International collaboration</i> | |
| University of Bergen & Haukeland University Hospital | Training of neuropathologists under the International Society of Nephrology Fellowship |
| BLK Hospital | Training of kidney transplantation team Support in initial kidney transplantations |
| Sakra Hospital | Supporting kidney transplant procedures |
| Seifee Hospital | Supporting kidney transplant procedures |

regulations. The role of the transplantation authorization committee is to approve the joint application of the kidney donor and recipient for removal and transplantation; seven members of the authorization committee are appointed by the Board of Trustees of MNH. These members include:

- i. Director of medical services—chairperson of the committee
- ii. Two medical doctors appointed by the executive director from within the hospital who are not involved in kidney transplantation
- iii. A senior officer conversant with health matters appointed by the Ministry
- iv. A senior lawyer of high integrity, social standing, and credibility (preferably a retired high court judge).
- v. A doctor from any private hospital in Dar es Salaam
- vi. Two religious leaders, one representing Christians and the other Muslims
- vii. The secretary to the committee shall be the Head of the legal unit of MNH.

Before application to the authorization committee, a medical meeting will be convened to deliberate on the reports of the prospective donor and recipients and members of the medical meeting shall include nephrologists, urologists, transplant coordinators, social workers, the donor, and the recipient.

Process of obtaining donors at Muhimbili national hospital

The renal unit at MNH facilitates the process of identifying donors by holding family conferences in which the

recipient is asked to invite his/her relatives to participate. Participants include potential donors, influential people in the family, and other key members of the family. The conference is facilitated by the transplant coordinator (who is a nurse) and social worker in the renal unit.

During the conference, information discussed with families included the transplant process, program options, risks and benefits (both live donor and deceased donor transplants), medication regimen, lifestyle adjustments, effect of transplantation on existing medical conditions, temporary relocation to Dar es Salaam (if required), and short and long term outcomes of kidney transplantation. At the conference, health information is provided to the family, and all important issues regarding kidney donation are discussed and participants are allowed to ask questions. After the conference, the family is given time to discuss and agree on potential donors who will be evaluated.

Kidney transplantation procedures performed at Muhimbili national hospital

The first kidney transplantation was carried out on 21 November 2017, and until now more than 72 patients with CKD have been transplanted. The initial 39 transplantations were carried out with support from visiting transplant teams from different institutions in India. The visiting teams were bigger in the beginning with different practitioners, their numbers were subsequently reduced with improved local capacity. Table 3, indicates the number of personnel on the visiting team, the number of transplants carried out, and the days spent in Tanzania by the visiting teams.

Table 4 describes the clinical profile of the 39 recipients who were transplanted with the support of the

Table 3 Transplantation procedures conducted at MNH with support from collaborating partners

| Month and Year | Visiting institution details | Member of visiting team | | | | | | | | Number of transplants performed | |
|----------------|------------------------------|------------------------------|-------------------------|----|----|----|----|-----|-----|---------------------------------|----|
| | | Name of visiting institution | Member of visiting team | | | | | | | | |
| | | | NP | UR | AN | IN | VS | TNu | INu | | LS |
| November 2017 | BLK Hospital, India | 1 | 2 | 2 | 1 | 0 | 1 | 2 | 1 | 1 | |
| April 2018 | BLK Hospital, India | 1 | 2 | 2 | 1 | 0 | 1 | 2 | 3 | 4 | |
| June 2018 | BLK Hospital, India | 1 | 2 | 1 | 1 | 0 | 1 | 2 | 3 | 4 | |
| July 2018 | BLK Hospital, India | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 4 | |
| August 2018 | Sakra Hospital, India | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 4 | |
| October 2018 | BLK Hospital, India | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | |
| January 2019 | BLK Hospital, India | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | |
| February 2019 | Seifee Hospital, India | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 4 | |
| April 2019 | Seifee Hospital, India | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 5 | |
| October 2019 | Seifee Hospital, India | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 4 | |

NP: nephrologist, UR: urologist, AN: anesthesiologist, IN: intensivist, VS: vascular surgeon, TNu: theater nurse, INu: ICU nurse, LS: laboratory scientist

Table 4 Clinical profile of transplant recipients

| Variables | Number (%) |
|--|-------------------|
| Sex | |
| Male | 22 (56.4) |
| Female | 17 (43.6) |
| Age (years) | |
| < 18 | 1 (2.6) |
| 18–35 | 15 (38.5) |
| 36–45 | 6 (15.4) |
| 46 and above | 17 (43.5) |
| Relationship with donors | 18 (46.2) |
| Brother/sister | 1 (2.6) |
| Parent | 13 (33.3) |
| Son/daughter | 7 (19.9) |
| Second-degree relatives (Cousins) | |
| HLA matching | |
| 1/6 | 1 (2.6) |
| 2/6 | 6 (15.4) |
| 3/6 | 18 (46.1) |
| 4/6 | 8 (20.5) |
| 5/6 | 3 (7.7) |
| 6/6 | 3 (7.7) |
| Immunosuppression (induction) | |
| ATG | 14 (35.9) |
| Basiliximab | 25 (64.1) |
| Immunosuppression (maintenance) | 39 (100) |
| Tacrolimus + MMF/myfortic + prednisolone | |
| Status at 1 month | |
| Functioning graft | 37 (94.9) |
| Return to dialysis | 1 (2.6) |
| Died | 1 (2.6) |
| Mean serum creatinine at one month | 112.7 μ mol/L |

collaborating teams from India; out of 39 recipients 56.4% were males, and 43.5% were aged above 46 years. Donors included brothers/sisters of recipients (46.2%) followed by sons/daughters (33.3%) and second-degree relatives (19.9%). Haplomatch was noted in 46.1% of donor-recipient pairs and the majority (64.1%) of recipients received basiliximab as induction immunosuppression. The mean creatinine at 1 month was 112 μ mol/L; one recipient returned to dialysis, and one died.

Challenges experienced since the establishment of the kidney transplantation program at MNH

Several challenges were reported by interviewed participants who were involved in the program from the inception of the program. Main challenges included.

- i. Challenges in obtaining supplies for the service include drugs that are not registered in Tanzania, particularly immunosuppressive drugs, graft pres-

ervation fluids, and cross-matching reagents. These had a short shelf life making it difficult to stock adequate supplies.

- ii. Limited financing for kidney transplantation procedures especially for patients who are not subscribed to the National Health Insurance Fund.
- iii. Limited public knowledge and misinformation on transplant procedures resulted in a decline in consent from some donors.

Discussion

Tanzania, like many other countries in sub-Saharan Africa, is faced with a high CKD burden and limited capacity for the provision of services, and many countries in the region have made significant efforts to advance nephrology services. In the last decade Tanzania has made remarkable improvement in the provision of nephrology services, this is noted in the increased number of hemodialysis units [13, 23]. This study aimed to examine steps taken by Muhimbili National Hospital to establish kidney transplantation services in Tanzania and the achievements made in 5 years.

International and local collaboration featured as one of the most important steps in establishing news services and through this collaboration, MNH was able to build capacity in human resources as well as supportive laboratory services. The international collaboration involved three hospitals from India, whereby one hospital provided short-term training for the transplant team. A similar approach was used to support the establishment of kidney transplantation in Ghana [24].

A legal framework is key for the provision of ethical organ transplantation, this was made possible through the adoption of the Istanbul declaration [25] and the amendment of regulation for the act, which established Muhimbili National Hospital. This was an important move to support services at MNH, however, this is a limiting factor for the establishment of similar services in other hospitals in Tanzania. For the sustainability and scaling of organ transplantation services in Tanzania, it is important to prepare organ transplantation legislation that will guide organ procurement, storage, and allocation and address ethical dilemmas.

The cost of transplantation is one of the main challenges for organ transplantation, and efforts to lower the costs are encouraged including using low-cost alternative drugs [26]. The first 39 transplant patients were kept on three immunosuppression drugs including prednisolone, tacrolimus, and mycophenolate mofetil/myfortic. The use of MMF/myfortic instead of azathioprine had financial implications as the price of 100 mg of azathioprine is 0.8 USD while the price of 500 mg of MMF is about 3

USD. The induction immunosuppression drugs used for the transplant recipients included ATG and basiliximab, with the majority of patients receiving basiliximab. The choice of induction drugs was driven by HLA matching, in which the majority of donor–recipient pairs had good HLA matching.

The MNH transplantation guideline was influenced by the practice in the two collaborating institutions, and the drugs included as first line are expensive. It is therefore important for emerging centers in Tanzania to consider cost-effective approaches when establishing organ transplantation and other services to ensure sustainability. To enable patients to meet the costs of medications, it may be necessary to consider switching maintenance immunosuppression drugs from MMF/myfortic to azathioprine.

The number of transplants carried out since the establishment of services at MNH is 72; an average of 14 transplants per year, which is small but encouraging, with 43 transplants being carried out by the local team. The low number of transplantations can be attributed to the difficulties of obtaining drugs, reagents, and other supplies most of which are not registered in Tanzania making their procurement from overseas challenging and time-consuming.

The availability of kidney transplantation services in Tanzania will not only improve access but also reduce the cost of sending patients overseas, which was estimated to cost US \$60,000 as compared with US \$10,000 with local transplantation [21]. National transplantation services will provide a regulatory and legal framework for curbing organ trade which is linked with transplantation services sought overseas [27, 28]. The current authorization process at MNH, which makes use of an authorization committee with nonmedical members, such as religious leaders and attorneys, may be difficult to operationalize in the future with an increase in transplant procedures. The Ministry of Health in Tanzania is currently in the initial process of preparing the bill for organ donation, the experience of MNH will be useful in informing the preparation of this legislation.

The success of carrying out transplantation with a reasonable outcome in 1 month shows the potential for establishing this service in a low-resource setting, and is a good reflection of operationalization of Bamako's resolutions of 2008, which called for emerging centers to establish kidney transplantation services through international and local collaborations [29]. This has also demonstrated feasibility for other countries in the limited resource setting to emulate, and it is high time for the African Association of Nephrology to encourage all countries in sub-Saharan Africa to establish collaborative partnerships to improve services.

Conclusions

Nephrology services in Tanzania have improved dramatically in the past decade with an increasing number of hemodialysis services and the establishment of kidney transplantation services in the last 5 years. International and local collaborative partnership is critical for advancing services in emerging countries, as was demonstrated in this study between MNH and three hospitals from India. Making infrastructural changes, training healthcare providers, and preparing legal framework are essential in supporting kidney transplantation services, and sustaining these services calls for concerted efforts in addressing challenges, including costs of transplantation and shortage of supplies and drugs.

Abbreviations

| | |
|-------|--|
| ATG | Anti-thymocyte globulin |
| CKD | Chronic kidney disease |
| CDC | Complement-dependent cytotoxicity |
| CMV | Cytomegalovirus |
| CRRT | Continuous renal replacement therapy |
| DTPA | Diethylenetriamine pentaacetate |
| HLA | Human leukocytic antigen |
| ICU | Intensive care unit |
| MMF | Mycophenolate mofetil |
| MNH | Muhimbili National Hospital |
| MUHAS | Muhimbili University of Health and Allied Sciences |
| ORCI | Ocean Road Cancer Institute |
| PCP | <i>Pneumocystis carinii</i> pneumonia |
| SOP | Standard operating procedures |

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s41100-024-00545-z>.

Additional file 1: Donor Evaluation Form.

Additional file 2: Recipient Evaluation Form.

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Author contributions

F.F. designed the study, collected data, wrote the report for this study, and drafted the manuscript. J.G.S., P.J.R., J.W.M., and G.V. participated in the study design and data collection. N.K., M.A.M., M.M., N.M., D.B., M.C.M., O.K., H.S., and L.M. critically reviewed the manuscript. All authors have read and approved the final draft of this manuscript.

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Declarations

Ethics approval and consent to participate

This study is based on service data and no personal data are included in the manuscript. The permission to conduct the study was granted by the Directorate of Research and Training of Muhimbili National Hospital.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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References

- Mills KT, Xu Y, Zhang W, Bundy JD, Chen C, Kelly TN, Chen J, He J. A systematic analysis of worldwide population-based data on the global burden of chronic kidney disease in 2010. *Kidney Int.* 2015;88:950–7.
- GBD Chronic Kidney Disease Collaboration. Global, regional, and national burden of chronic kidney disease, 1990–2017: a systematic analysis for the global burden of disease study 2017. *Lancet.* 2020;395(10225):709–33. [https://doi.org/10.1016/S0140-6736\(20\)30045-3](https://doi.org/10.1016/S0140-6736(20)30045-3).
- Crews DC, Bello AK, Saadi G. Burden, access, and disparities in kidney disease. *Nephron.* 2019;141:219–26.
- Naicker S. End-stage renal disease in Sub-Saharan Africa. *Kidney Int Suppl.* 2013;3:161–3. <https://doi.org/10.1038/kisup.2013.4>.
- Stanifer JW, Jing B, Tolan S, Helmke N, Mukerjee R, Naicker S, Patel U. The epidemiology of chronic kidney disease in sub-Saharan Africa: a systematic review and meta-analysis. *Lancet Glob Health.* 2014;2:e174–181.
- Stanifer JW, Maro V, Egger J, Karia F, Thielman N, Turner EL, et al. The epidemiology of chronic kidney disease in northern Tanzania: a population-based survey. *PLoS ONE.* 2015;10(4):e0124506. <https://doi.org/10.1371/journal.pone.0124506>.
- Plath DW, Mbwambo JK, Fonner VA, Horowitz B, Zager P, Schrader R, Fredrick F, Laggis C, Sweat MD. Prevalence of CKD, diabetes, and hypertension in rural Tanzania. *Kidney Int Rep.* 2018;3:905–15. <https://doi.org/10.1016/j.ekir.2018.04.006>.
- Hodel NC, Hamad A, Praehauser C, Mwangoka G, Kasella IM, Reither K, et al. The epidemiology of chronic kidney disease and the association with non-communicable and communicable disorders in a population of sub-Saharan Africa. *PLoS ONE.* 2018;13(10):e0205326.
- Kilonzo SB, Seiffudin AT, Bakshi FA, Gunda DW. Renal dysfunction among adult patients in Mwanza, Tanzania: prevalence, outcomes and associated factors. *Tanzan J Health Res.* 2016. <https://doi.org/10.4314/thrb.v18i3.5>.
- Msango L, Downs JA, Kalluvya SE, Kidenya BR, Kabangila R, Johnson WD Jr, Fitzgerald DW, Peck RN. Renal dysfunction among HIV-infected patients starting antiretroviral therapy in Mwanza, Tanzania. *AIDS.* 2011;25(11):1421–5. <https://doi.org/10.1097/QAD.0b013e328348a4b1>.
- Janmohamed MN, et al. Prevalence of chronic kidney disease in diabetic adult out-patients in Tanzania. *BMC Nephrol.* 2013;14:183.
- Meremo AJ, Masalu MB, Sabi I, Ngilangwa DP, Kapinga J, Tagalile R, et al. Prevalence and risk factors associated with chronic kidney disease among patients presenting at a haemodialysis unit in Dodoma, Tanzania. *East African Health Res J.* 2018;2(1):53–7. <https://doi.org/10.2424/EAHRJ-D-16-00367>.
- Furia FF, Shoo J, Ruggajo PJ, Kilonzo K, Basu G, Yeates K, Varughese S, Svarstad E, Kisanga O. Developing nephrology services in low-income countries: a case of Tanzania. *BMC Nephrol.* 2019;20:378. <https://doi.org/10.1186/s12882-019-1568-7>.
- Pancras G, Shayo G, Anaeli A. Non-medical facilitators and barriers towards accessing haemodialysis services: an exploration of ethical challenges. *BMC Nephrol.* 2018;19:342. <https://doi.org/10.1186/s12882-018-1140-x>.
- Mohamedi S, Moshia IH. Hemodialysis therapy adherence and contributing factors among end-stage renal disease patients at Muhimbili national hospital, Dar es Salaam. *Tanzania Kidney Dial.* 2022;2:123–30. <https://doi.org/10.3390/kidneydial2010014>.
- Kilonzo KG, Ghosh S, Temu SA, Maro V, Callegari J, Carter M, Handelman G, Finkelstein FO, Levin N, Yeates K. Outcome of acute peritoneal dialysis in northern Tanzania. *Perit Dial Int.* 2012;32(3):261–6. <https://doi.org/10.3747/pdi.2012.00083>.
- Kilonzo K, Mathew A, Croome AJ. Establishment of an acute peritoneal dialysis program in Tanzania. *Kidney Int Suppl.* 2013;3(2):186–9.
- Basinda SL, Maro EE, McLarty DG, Young AE, Wing AJ. Ten Tanzanian transplants: problems and perspectives. *Postgrad Med J.* 1988;64(756):778–82.
- Kassa DA, Mekonnen S, Kebede A, Gebremedhin Haile TG. Cost of hemodialysis treatment and associated factors among end-stage renal disease patients at the tertiary hospitals of addis Ababa city and amhara region, Ethiopia. *Clinico Econ Outcomes Res.* 2020;12:399–409.
- Mushi L, Krohn M, Flessa S. Cost of dialysis in Tanzania: evidence from the provider's perspective. *Heal Econ Rev.* 2015;5:28. <https://doi.org/10.1186/s13561-015-0064-4>.
- Kobayashi S, Hidaka S. Can we still ignore renal replacement therapy in sub-Saharan Africa? All living beings are created equal. *Renal Replace Ther.* 2020;6:5. <https://doi.org/10.1186/s41100-019-0243-6>.
- Parliament of Tanzania: Muhimbili National Hospital Act of Parliament number 5 of 2000. <https://www.parliament.go.tz/polis/uploads/bills/acts/1454228796-ActNo-5-2000.pdf>
- Fredrick F, Ruggajo P, Basu G, Svarstad E, Langeland N. Global collaboration bears fruit: Tanzania report. *Kidney Int.* 2015;88(6):1010–213.
- Osofo C, Morton B, Ready A, Jewitt-Harris J, Adu D. Transplantation in Ghana. *Transplantation.* 2018;102(4):539–41.
- International Summit on Transplant Tourism and Organ Trafficking. The declaration of Istanbul on organ trafficking and transplant tourism. *Clin J Am Soc Nephrol.* 2008;3(5):1227–31. <https://doi.org/10.2215/CJN.03320708>.
- Arogundade FA. Kidney transplantation in a low-resource setting: Nigeria experience. *Kidney Int Suppl.* 2013;3:241–5. <https://doi.org/10.1038/kisup.2013.23>.
- Amira CO, Bello BT. Do the benefits of transplant tourism amongst Nigerian patients outweigh the risks? A single-center experience. *Int J Organ Transplant Med.* 2017;8(3):132–9.
- Okafor UH. Transplant tourism among kidney transplant patients in Eastern Nigeria. *BMC Nephrol.* 2017;18:215. <https://doi.org/10.1186/s12882-017-0635-1>.
- Persy VP, Remuzzi G, Perico N, Benganem Gharbi M, Adu D, Jha V, Rizvi A, Ammar MB, Fongoro S, De Broe ME. Prevention and transplantation in chronic kidney disease: what is achievable in emerging countries? *Nephron Clin Pract.* 2010;115(2):122–32. <https://doi.org/10.1159/000312875>.

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