

The Future of Kidney Care in Low- and Middle-Income Countries: Challenges, Triumphs, and Opportunities

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CKD affects about 850 million people worldwide and is projected to be the fifth leading cause of death by 2040. Individuals from low- and middle-income countries (LMICs) bear the bulk of CKD. They face challenges including lack of awareness among the general population, as well as health care providers, unique risk factors such as genetic predispositions, infectious diseases, and environmental toxins, limited availability and affordability of diagnostic tests and medications, and limited access to KRTs. The inadequate health system infrastructure, human resources, and financing mechanisms to support comprehensive and integrated kidney care worsen the situation. Overcoming these challenges needs concerted efforts toward early detection, intervention, and multidisciplinary follow-up, policy, collaboration, advocacy, and financing. To achieve this, there is need for individual governments to include kidney health among the key health priorities and build capacity toward resilient health care systems. Integrating kidney care using the roadmaps of well-established management systems for other chronic diseases, such as HIV, has the potential to expedite the widespread adoption of kidney health. The aim of this article is to provide an overview of the current state and future prospects of kidney care in LMICs, highlighting the main challenges, ongoing efforts, and opportunities for improvement. We present case studies of exemplary efforts from three continents of the world with the highest densities of LMICs and propose potential strategies for a sustainable solution.

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Introduction

Kidney care is a vital component of global health, as CKD and AKI affect millions of people worldwide and contribute to significant morbidity and mortality. However, kidney care is not equally accessible and affordable across the globe, especially in low- and middle-income countries (LMICs), where the burden of kidney disease is disproportionately high and the resources to address it are limited, often presenting an ethical challenge.

The effect of CKD has been underestimated in LMICs because of limited infrastructure for population-level surveillance (Box 1). Meanwhile, CKD has been rising through the ranks of the leading causes of mortality globally, at a rate historically only paralleled by HIV, and is further projected to become the fifth leading cause of death globally in another 15–20 years.^{1,2} This rise is not to be discounted as a mere effect of improved longevity from

progress made in communicable diseases control, as there has been a steep rise in the incidence of CKD in LMICs,^{2–4} whereas it has plateaued or declined in high-income countries (HICs).^{5,6}

LMICs, which comprise over two thirds of 195 countries in the world, have approximately 50% of the world's population. These countries carry most of the disability-adjusted life years (DALYs) attributable to CKD,¹ as nearly 80% of the world's population with CKD lives in LMICs where CKD affects younger adults.

In the background of unmet needs for CKD care is a rise in its risk factors, such as diabetes and hypertension, for which there is shortage in capacity and infrastructure for secondary prevention. Although the world is seeing rapid diagnostic and therapeutic advancements to prolong kidney health in these settings, only a fraction of the world's population has access to these benefits. A lack of national

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Box 1.**Significance of the Future of Kidney Care in LMICs**

It has been estimated that low- and middle-income countries (LMICs) will host >70% of patients with ESKD by 2030.⁷ With rapid urbanization and population aging, hypertension and diabetes are on the rise. It is estimated that three quarters of people with hypertension live in LMICs, which will also host >70% of people with diabetes in the next 10–20 years.^{8–10} Annually, over one million people die worldwide due to lack of access to dialysis.^{11,12} It is estimated that by the year 2030 over two thirds of the world's dialysis-requiring population will reside in the lowest sociodemographic index region of the world the sub-Saharan Africa, where only about 1.5% of individuals with ESKD currently have access to dialysis. ESKD, while allotted approximately 1% of the federal budget in a high-income country (HIC) such as the United States, could require as high as 15%–55% of the budget of an LMIC to meet demands.¹³ There is a significant access gap contributing to the disparity in AKI and CKD outcomes between HICs and LMICs. Despite relatively younger age at diagnosis, affected persons in LMICs have poorer prognosis even for reversible kidney dysfunction due to limited access to investigative studies and life-saving care.^{14,15} While the unadjusted 5-year survival of patients on chronic dialysis in HICs ranges from 40% to 60%,¹⁶ it is much lower in most LMICs as out-of-pocket costs force treatment interruptions.

attention and policy and limited infrastructure for tracking and care provision largely contribute to the access gap.

Epidemiology of Kidney Disease in LMICs

The median age of developing CKD was 43.7 years in LMICs, which is approximately 20 years younger than that in HICs (65 years [the United States], 66 years [Japan], and 76.4 years [Denmark]).^{17–19} Deaths attributable to CKD in LMICs are still close to that reported in HICs (2%–3%), imposing a great economic burden on LMICs.²⁰

Africa

Africa is the world's second largest continent, with a population of 1.4 billion (17.9% of the world's population). Most African countries (46/54) are classified as LMICs, with only seven classified as upper middle-income countries (UMICs) and only one (Seychelles) classified as HIC. Most of these countries are experiencing a convergence of communicable and noncommunicable diseases (NCDs).¹

Unique risk factors such as infections (HIV, tuberculosis, and malaria) contribute to the burden of CKD in Africa^{2–4} in addition to unique genetic predispositions (apolipoprotein-1 and sickle cell disease).³

A recent International Society of Nephrology (ISN) survey from respondents representing 92% of the African

population shows an overall CKD prevalence of 4.2% for stages 3–5.⁵ Studies have shown variable CKD stage 3–5 prevalence across the continent ranging from 4.6% to 13.9%,²¹ with 6.6% in West Africa, 6.8% in East Africa,⁶ 6.4%–8.7% in South Africa,⁷ and 6.1% in North Africa.⁸ There is evidence that CKD may be underestimated in Africa because of creatinine-based equations used to estimate kidney function being inaccurate in this population.²²

Latin America

Latin America includes North, South, and Central America and the Caribbean, with an overall population of 666 million (approximately 8.3% of the world's population) spread across 33 countries and dependencies. Most (19) countries are classified as UMICs, whereas five are classified as LMICs (Bolivia, Nicaragua, Honduras, El Salvador, and Haiti).²³ The socioeconomic landscape is widely variable, leading to variability in the availability, accessibility, and quality of kidney care within and between the countries. The latter is a reflection of funding structures of individual countries, adoption of a less resource-intensive dialysis modality (peritoneal dialysis [PD]), and CKD surveillance and management initiatives.^{24–26} A 2023 ISN survey with respondents from 22 Latin American countries representing 96.5% of the region's population²⁵ demonstrated a CKD prevalence of 10.2%, with Puerto Rico (HIC) reporting the highest prevalence (16.8%) and Haiti (low-income country [LIC]) reporting the lowest prevalence (5.8%). CKD in the region is responsible for 3.1% DALYs and one of the highest CKD-attributed death incidences globally (Nicaragua [11.9%], El Salvador [10.2%], and Mexico [9.8%] versus the global average [5.5%]).²⁵

Asia

The epidemiology of kidney diseases in Asia also reflects the unique challenges in delivering kidney care in this region. Except for few countries such as Japan, South Korea, and Hong Kong, the region comprises LICs/MICs. The prevalence of CKD ranges from 6.5% to 11% in South and North/East Asia, with the percentage of DALYs and death attributable to CKD ranging between 1.5%–1.8% and 2.5%–2.6%, respectively.²⁵ South Asia is one of the most densely populated regions of the world with two thirds of population living in rural areas. In the absence of regional or countrywide registries for CKD, dialysis, or kidney transplantation, reliable data on incidence or prevalence of treated kidney failure are not available for most countries.

Status of Kidney Care in LMICs**Current Capacity**

The nephrologist density in LICs is approximately 0.31 per million people (pmp) compared with 28.52 pmp in HICs.²⁷ Dialysis is expensive, and transplant expertise and infrastructure are limited. The estimated average cost of dialysis is approximately Int\$ 30,079.00 per patient per year for hemodialysis and Int\$ 28,592.45 for PD, *i.e.*, approximately 20 times the average gross domestic product of most sub-Saharan countries.²⁸ The lack of financial assistance often drives families into medical impoverishment who will be forced to quit treatment. Often dialysis has to

be rationed to allow only those who can undergo kidney transplants.

Most countries in Africa lack data on KRT. In most countries, treatment is primarily privately funded with only 15 pmp on chronic dialysis (compared with 601 pmp in HICs), leaving up to 90% of patients who need KRT unable to access it.⁵ Most countries in Latin America (59%) fund non-dialysis CKD care through a combination of public and private sources, and care may be free or require a copayment at the point of delivery.^{25,26,29,30} Latin America has chronic hemodialysis services available in all survey participant countries with an average hemodialysis treatment center of 8.32 pmp. Chronic PD services are available in 20 (91%) countries of the region, with an average PD treatment center of 2.68 pmp. Similarly, in Asia, health care services are provided by both publicly and privately funded systems. While services at public sector clinics and hospitals are either free or at nominal charge, the facilities are often understaffed and overburdened. There are no unified electronic databases that link hospitals, clinics, research centers, or diagnostic laboratories and collate data at one place. Most medical records, particularly in public sector hospitals, are handwritten and therefore not readily available. A centrally linked, countrywide data collection that captures every aspect of health care service would be ideal. However, these may not align with immediate health care needs in low-resource settings.

Figure 1 shows the current nephrologist, chronic dialysis, and transplantation capacity in LMIC regions from the 2023 ISN-Global Kidney Health Atlas (GKHA).³¹ Between 2019 and 2023, there was an increase in nephrologist prevalence by 66.7% (Africa), 79.6% (Latin America), and 66.5% (South Asia). In Africa, a 55% increase in chronic hemodialysis and a 44% increase in kidney transplantation were reported albeit through solely an out-of-pocket provision.²⁵

Regarding surveillance, most recent survey data show that hemoglobin A1c testing is available in the primary care setting in only 49% of African countries and 43% of South Asian countries; capacity to report automated eGFR along with serum creatinine is even lower.³¹ Measurement of albuminuria is available in only 36% of African countries and 43% of South Asian countries. The Prospective Urban Rural Epidemiology study, which used a threshold of 20% for household capacity to pay to define potential unaffordability of guideline medications for cardiovascular secondary prevention, showed 25% of households in UMICs, 33% in lower middle-income countries, and 60% in LICs that would find medicines unaffordable compared with 0.14% households in HICs if they were to pay full costs, and the costs were particularly higher for renin-angiotensin system inhibitors and statins.³²

National Prioritization

For diseases covered under national or regional programs (screening, surveillance, and treatment), data are collected and collated at regular intervals to assess the effect of policies that govern such programs. Unfortunately, kidney diseases have not been part of such programs in most LMICs. A 2023 ISN survey with respondents from 167 nations revealed that 68% of participating countries had or/are developing national strategies for NCD care, but

CKD was recognized by the government in only 25% countries and only 19% countries had advocacy groups within the government.³¹ Most of the countries in Africa (79%), Latin America (65%), and South Asia (63%) did not have national guidelines for CKD.^{33,34} Approximately 45% lacked a national strategy for chronic dialysis, 56% lacked a national strategy for improving nondialysis CKD care, and 53% lacked a national strategy for kidney transplantation.³³ Approximately 20% of countries within Africa, North and East Asia, Oceania and Southeast Asia, and South Asia did not have essential cardiometabolic therapy generally available. There have been successful programs in LMICs, such as Sudan and Thailand, with early prioritization of CKD at the national government level with multidisciplinary efforts, advocacy, and research to guide resource allocation. Advocacy groups, including peer/patient advocates and national public health and medical associations and foundations, can play a major role in raising governmental awareness and guiding policy.^{35,36} Less than one fourth of LMICs have advocacy groups for AKI or CKD. In some settings, public-private partnerships have helped cover costs for AKI^{37,38} although sustainability has been a challenge due to lack of national prioritization.

Challenges and Opportunities for Advancing Kidney Care in LMICs

LMICs face many challenges in providing kidney care services, including limited awareness and lack of government attention to combat the rise in CKD and its risk factors (Table 1). Despite the challenges, there are multiple opportunities to improve kidney care.

Embracing Cardiovascular-Kidney-Metabolic Health

With the discovery of cardio-renal therapies such as sodium-glucose transport protein 2 and sodium-glucose co-transporter-2 inhibitors (SGLT2i) to delay CKD and cardiovascular disease progression, embracing the new paradigm of cardiovascular-kidney-metabolic (CKM) health offers an opportunity to address multiple cardiometabolic comorbidities with profound benefits on morbidity and mortality.³⁹ This is highly important as patients with any stage of CKD are already at a high risk of cardiovascular mortality. Therapeutic advancements such as the angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, SGLT2is, and nonsteroidal mineralocorticoid receptor antagonists offer a golden opportunity for LMICs to reverse the trends in CKD. This could mitigate catastrophic health care expenditure and impoverishment and potentially save a significant proportion of countries' budget that would otherwise need to be allocated to KRTs. While grounds for use of these pillar drugs have been laid out by regional nephrology societies, such as the African Society of Nephrology, a concerted effort is needed to lower drug costs and ensure availability to those who would benefit most.^{40,41} Change would thus also require concomitant (1) local and regional campaigns to increase awareness at the population and health care provider level and (2) development of policies to improve access to diagnosis and these essential medications to slow the progression of CKD and cardiovascular disease. An integrated approach to CKM care can be transferred to lower-level health care units to

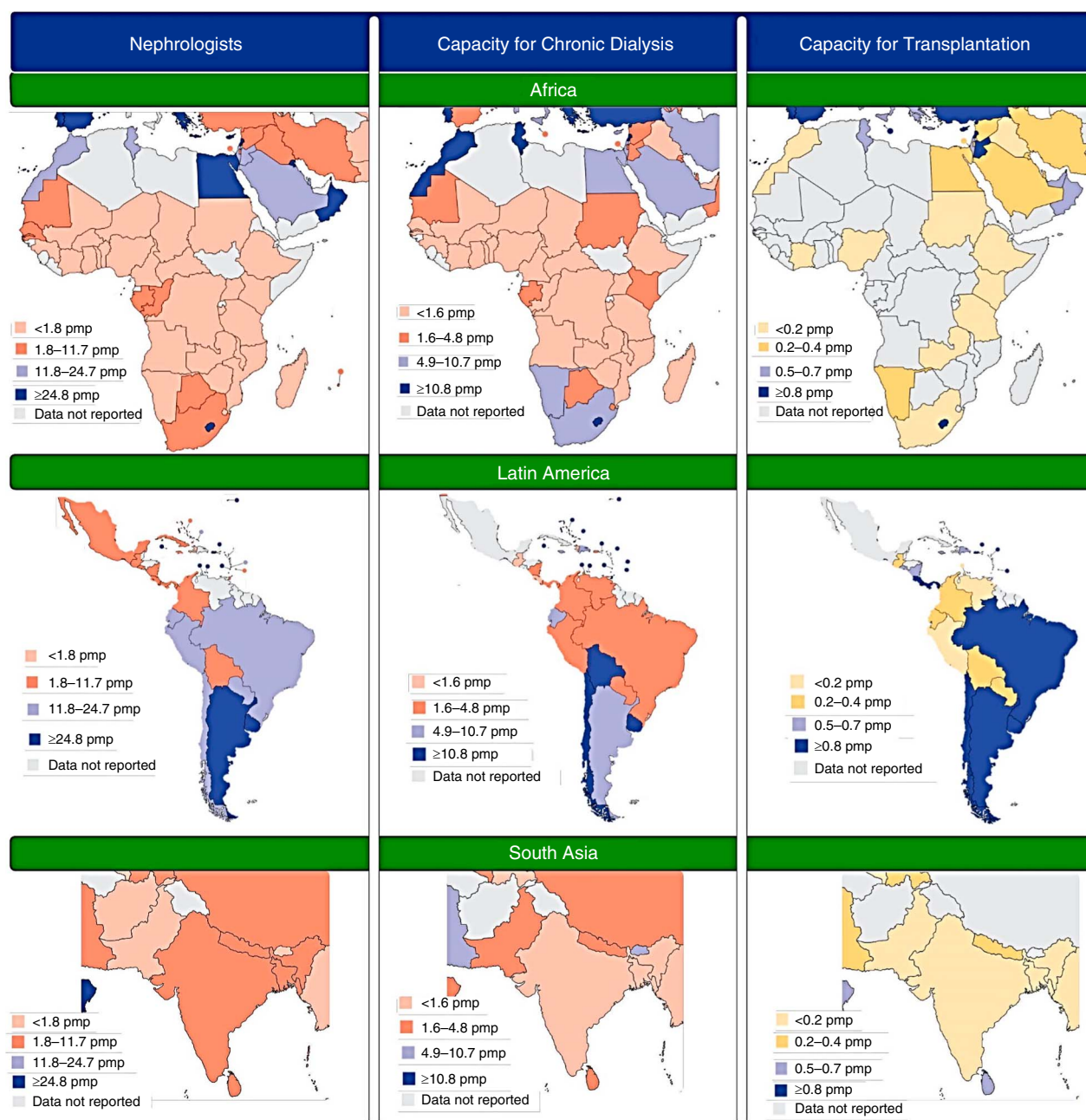


Figure 1. Current work force and kidney care capacity in three LMIC regions. Adapted from the 2023 ISN-GKHA. ISN-GKHA, International Society of Nephrology Global Kidney Health Atlas; LMIC, low- and middle-income country.

serve populations in hard-to-reach areas. Nationwide targeting of at-risk and early CKD groups utilizing primary care providers and allied health care workers can have a significant effect. Risk prediction models for CKD and its progression could assist with cost-effective early detection.⁴² However, existing models require validation in specific populations as we recently learned in the African Research into Kidney Disease (ARK) study.²² Existing kidney function estimating equations developed in HIC cohorts may not be applicable to all populations; for instance, the new CKD Epidemiology Collaboration equation was found to overestimate measured GFR and underestimate CKD prevalence

in a multinational cohort of patients from sub-Saharan Africa.²² Considerations for sustainable infrastructure development for CKM care in LMICs are provided in Figure 2.

Regional/Continental Collaborations

Stakeholders' recognition of challenges countries face is critical to triggering changes and improvements. Regional expert working groups can identify gaps and collaborative solutions. Such groups can identify unmet needs in CKD management, such as timely updating of clinical practice guidelines, regulatory policies, and protocols, as recently underscored by the Latin American Virtual working

Table 1. Major challenges for kidney care in low- and middle-income countries

The Following Make Major Challenges for Kidney Care

- Lack of awareness and screening for CKD among the general population and health care providers
- Rising prevalence of common risk factors for CKD, such as diabetes, hypertension, and unique risk factors such as infectious diseases, environmental toxins, and genetic disorders
- Limited availability and affordability of diagnostic tests, medications, and KRTs such as dialysis and transplantation
- Inadequate health system infrastructure, human resources, and financing mechanisms to support comprehensive and integrated kidney care
- Lack of evidence-based guidelines, policies, and programs tailored to the local context and focused on prevention
- Inadequate emergency preparedness plan to allow continued care in conflicts and other disasters

group.⁴³ National and regional AKI and CKD registries are essential for tracking outcomes and implementing prevention strategies. Furthermore, increased utilization of PD has mitigated the dialysis access constraints in some countries.⁴³ Partnerships and skill transfer on locally sourced materials could improve dialysis equity.

Government-Stakeholder Collaborations

Several LMICs are plagued with financial, infrastructural, and human resource needs and conflicting priorities between

communicable and NCDs. African governments and international partners in particular have for long prioritized infectious diseases over NCDs.⁴⁴ However, in a few countries, dialysis and kidney transplant services have been in existence for decades. For example, South Africa is the oldest of 12 countries in Africa that provide kidney transplantation and the only one utilizing a cadaveric donor program. The University of Cape Town pioneered the first kidney transplantation from HIV-positive donor to recipient. South Africa also runs nephrology programs with training in masters/PhD, a national society of

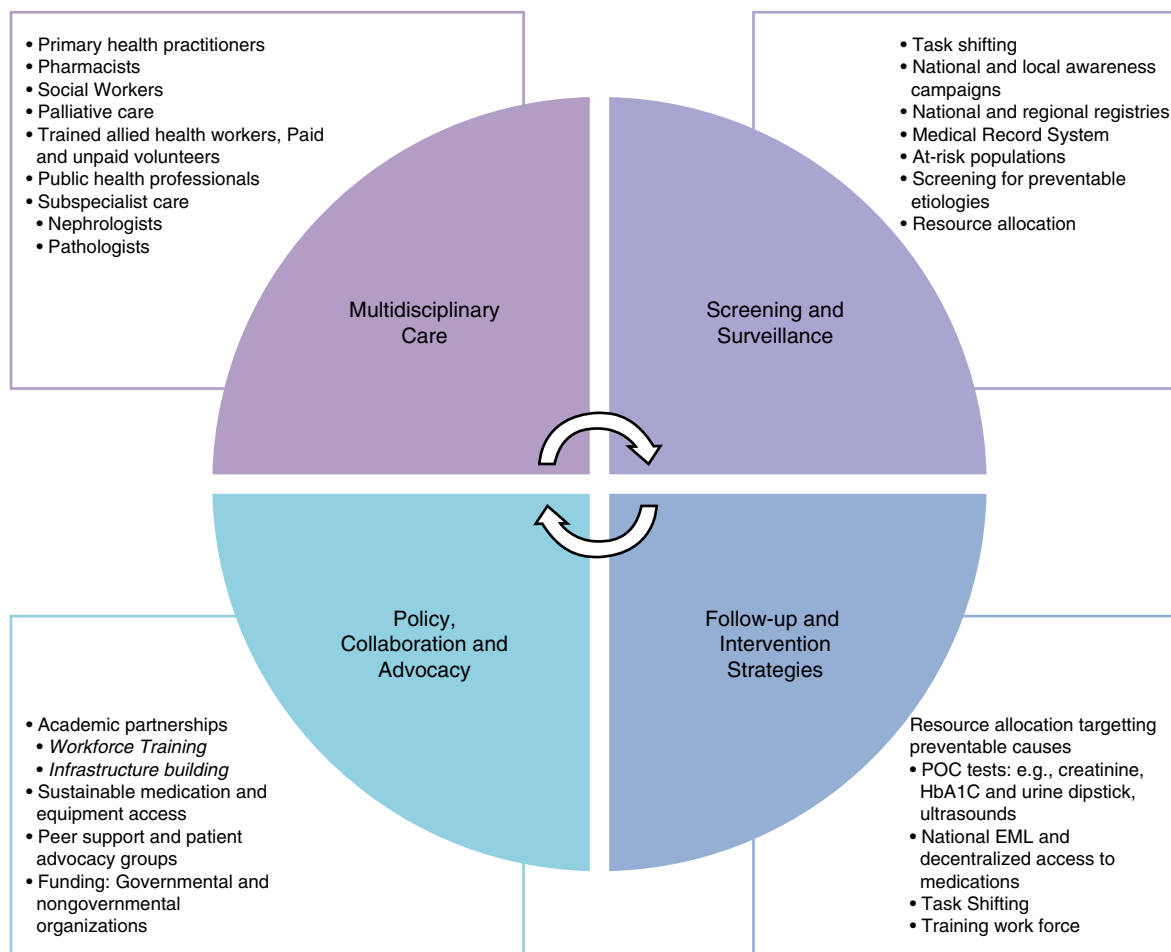


Figure 2. Summary of considerations for sustainable infrastructure development for CKM health management. CKM, cardiovascular-kidney-metabolic; EML, essential medication lists; HbA1c, hemoglobin A1c; POC, point of care.

nephrology established in 1967, and a kidney registry to inform policy and guide service provision.⁴⁵ These are results of successful collaboration between government and key stakeholders, which other LMICs can draw lessons from.

Global Capacity-Building Efforts

Other opportunities come from the enormous support by the ISN working alongside continental and country-specific societies to promote access to knowledge and skills. Collaborations with other LMICs that have devised successful strategies and with academic institutions from HICs can assist with capacity building in the form of training workforce, task sharing, networking, research skills, and counseling on building infrastructure.^{35,46} Inclusion of CKD in the global NCD Action Plan of the World Health Organization (WHO) may help galvanize support at the national level. Involvement of local stakeholders and policy makers to develop continuing educational programs for health care workers will be paramount. Artificial intelligence, social media, and virtual platforms can facilitate information dissemination and education.

Global and Local Initiatives to Improve Kidney Care in LMICs

Various initiatives have been undertaken to promote optimal kidney and comorbid NCD care across the globe by institutions such as the ISN, Kidney Diseases Improving Global Outcomes, and the WHO that have vested interest in all three spheres of care, education, and research.⁴⁷

Health financing has been cited as one of the key factors limiting access to kidney care services across the world. To address this, the WHO has advised on the pooling of resources and setting up Universal Health Coverage (UHC), where “all people have access to the full range of quality health services they need, when and where they need them, without financial hardship.”⁴⁸ The ISN-GKHA (<https://www.theisn.org/initiatives/global-kidney-health-atlas/>)^{49,50}

is a multinational cross-sectional survey launched by the ISN in 2017 as part of its “Closing the Gaps” initiative to assess the current capacity for kidney care. It documents the degree to which key principles of WHO’s UHC (health finance, service delivery and safety, health policy, essential medications and health products, health workforce, health information, and statistics) are available in each country and region.⁵⁰ The ISN further supports over 100 projects annually to assess and support the kidney care needs in the most underserved parts of the world. It has designed extensive support for health care workers operating in resource-limited conditions (Figure 3). Through these initiatives, various approaches to kidney health have been initiated.

Multilevel efforts are essential to raise awareness about AKI and CKD and improve adoption of prevention and control measures.⁵¹ A survey of 735 participants (mean age 38 years) from the general population in Brazil found that only 17.2% understood the concept of CKD; low water intake was the most cited risk factor (79.3%), and diabetes (13.2%) and hypertension (15.1%) were mentioned less frequently.⁵¹ Serum creatinine in Brazil is available for free of cost or <0.25 USD, but it is still underutilized in clinical practice. Capacity for early detection does not always translate to awareness. Exemplary local efforts toward improving CKD care in LMICs are listed in Table 2.

Lessons Learned and Future Directions: Overcoming the Barriers and Harnessing the Potential

Despite ongoing challenges, kidney care providers and respective governments in LMICs have taken strides toward improving kidney health and the care of patients with kidney disease. Local, regional, and global partnerships have been established, focusing on transfer of knowledge and skills to build human resources and infrastructural capacity for surveillance systems, governance bodies, and research to inform decisions.

Building Sustainable Human Resources and Infrastructure

The establishment of local and regional kidney disease registries and the ISN-GKHA surveys have been instrumental in improving kidney disease data and informing policy makers in LMICs. As LMICs build capacity for the future, kidney care providers and research investigators should purposely provide opportunities for trainees to cultivate interest in nephrology.

Existing infrastructures for early detection, management, and surveillance of infectious diseases, particularly HIV, can serve as a blueprint for the design of robust CKD and other NCD care.^{67,68} Screening at-risk populations has been shown to have more diagnostic yield and cost-effectiveness than population screening for CKD.⁶⁹ When accompanied by a checklist system of medical history gathering and an integrated medical record system, it can allow the conduct of epidemiologic studies to identify at-risk populations and target interventions accordingly.⁷ Standardized early detection techniques and population-specific kidney function estimation are also essential to accurately assess prevalence.⁷⁰ Early detection toolkits and management algorithms have been developed by the ISN and can be modified based on regional risk factors.^{3,71} There is continued need for partnerships with international

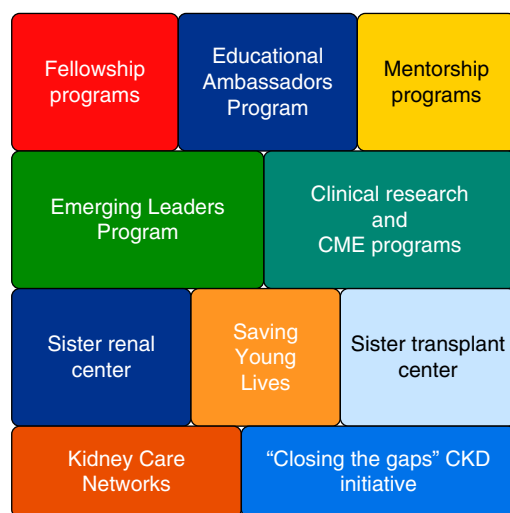


Figure 3. Programs offered by the ISN for capacity building in LMICs. CME, continuing medical education; ISN, International Society of Nephrology.

Table 2. Exemplary steps toward sustainable kidney care

Action Category	Particular Efforts	Outcomes/Future Steps	Lessons Learned
Policy changes	<i>Brazil</i>—Brazil has created a line of care for patients with CKD to allow primary care physicians to know their role in the CKD care up to CKD stage 4 and when to refer to a nephrologist for patients' evaluation and follow-up.⁵² It has been reviewed and individualized by provinces, such as Santa Catarina, with revision of the financial structure for this care.⁵³ This was a huge step to improve the system economic viability for CKD treatment, especially regarding KRT <i>India</i>—under the National Health Mission, the Ministry of Health and Family Welfare, Government of India runs NCD control programmes.⁵⁴ The NPCDCS was launched in 2010 to tackle the increasing burden of major NCDs. However, CKD was not included in this list In 2016, prevention and management of CKD was officially notified to be covered under NPCDCS by the Government of India.⁵⁵ However, it is only recently in 2022 that Medical Officer's manual for prevention and management of CKDs has been published for extensive roll out and implementation⁵⁶	Some countries in Latin America have been reevaluating their policies on kidney care provision, with a focus on identifying specific groups that would benefit from medications such as SGLT2i for free and redefining the role of primary and secondary care on CKD detection, prevention, and management States have modified data collection instruments to be used at primary and community health centers and NCD clinics to ensure collection of data on CKD. A sample of such form (with such changes marked as "new") is available online (https://www.wbhealth.gov.in/NCD/uploaded_files/all_files/NPCDCS_Reporting_Formats_final_NEW_(GOI)_PDF_All.pdf). The ICMR (https://main.icmr.nic.in/sites/default/files/Books/STW_Manual_v1.pdf) and Department of Health Research in India have published STWs (https://stw.icmr.org.in/) for management of various types of kidney diseases at primary, secondary and tertiary care centers	Policy change has potential to improve the system's economic viability for CKD treatment Integrated NCD care is one of the stepping stones toward achieving the goal of UHC Integrated NCD care models could be implemented across different levels of care in LMICs
Facilitating subspecialist care	The "Network Kidney Health Program" was created in 2015 by the Las Higuera Hospital in Talcahuano, a Chilean south province.⁵⁷ This is a computer-based program that starts at the primary care physician's end for a patient's record to be reviewed by a network nephrologist. It aims to reduce referral wait-times, shorten the waiting period for a nephrologist consultation, and prioritize resources between different levels of care. It also provides renal care using a multistakeholder approach (dietitians, psychologists, social workers, nurses, and nephrologists) and includes three KRT modalities		

Table 2. (Continued)

Action Category	Particular Efforts	Outcomes/Future Steps	Lessons Learned
Harnessing technology for education, early detection and monitoring of CKD.	The <i>Renal Health</i>⁵⁸ is a multidisciplinary project developed at the University of Fortaleza, northeast Brazil in 2015, aiming to create novel educational material and technological tools for people with CKD, in different treatment modalities, including dialysis and transplant. One of the products included is an application for smartphones, aiming to help patients in dialysis and transplant with adherence to their treatments <i>mHealth</i>—a mobile Health app was designed to assist the CKD early diagnosis and self-monitoring in North region of Brazil.⁵⁹ The monitoring includes DM and HTN. Users are also able to input and maintain information about prescribed medications, allergies, and test results, and these can be shared with physicians during consultations <i>CASALUD</i>—The CASALUD (https://fundacioncarlosslim.org/english/casalud-100-mexican-digital-health-model-recognized-united-nations-assembly/) program is an innovative digital health care model in Mexico that leverages international best practices and uses innovative technology to deliver NCD care, control and prevention. It aims to bring effect on care of patients with CKD in the country	Contains schedule for medications, with alarms, fluid intake, laboratory test results, dates of medical appointments, and informational material on CKD By promoting self-monitoring of risk factors, it aims to motivate at-risk individuals to keep track of their kidney health CASALUD aims to assure adequate treatment and diagnostic methods, improve professional and practical education, incorporate proactive prevention strategies, and expand early access to health care through the strategic use of technological innovations⁶⁰	Digital health tools are feasible and scalable strategies for patient empowerment that could help increase adherence and improve outcomes for patients with CKD
Improving CKD detection and management	<i>Peru</i>—An exemplary initiative to improve CKD detection and progression prevention is the RHP of Peru. The RHP was implemented in 2013 in Peru, as a secondary prevention strategy to reduce the incidence of ESKD and overall mortality.⁵⁸ The intervention focused on systematic control of eGFR and microalbuminuria for all patients with CKD, comprehensive health care attention to control for comorbidities, and promotion of healthy lifestyles <i>Thailand</i>—A community-based cluster-randomized trial of 442 patients with CKD stages 3–4 in Thailand showed a multidisciplinary team of hospital staff and a community CKD network, including village volunteers, slowed eGFR progression in those living in remote areas²⁷ <i>Cuba, Malaysia, Brazil and Mexico</i>—Nationwide care models developed for those at-risk and with early CKD utilizing primary care providers and allied health care workers were found effective in creating CKD and diabetes registries²⁶ <i>Zambia</i>—To address medication shortage, researchers from Zambia (an LIC) have examined ways to optimize supply chain and found a decentralized distribution system (where clinics directly order and receive medicines from the central agency through a cross-docking arrangement) effective at reducing stockouts of essential medicines⁶³	These interventions demonstrated a 58% reduction in the risk of progression to dialysis^{61,62} <i>These integrated multidisciplinary CKD care models led to improved eGFR progression</i>²⁷ <i>Creation of registries improved albuminuria and diabetes screening, RASi availability, public education and referral to nephrology</i> <i>A decentralized distribution system improved stockouts of essential medicines</i> <i>Future steps should include widespread implementation, knowledge and experience transfer and ensuring sustainability</i>	<i>Multidisciplinary approaches and integrated CKD care models may slow progression of CKD in LMICs</i> <i>Use of local clinics with direct access may improve the supply chain of medicines and increased access to medicines and prevent stock-outs</i>

Table 2. (Continued)

Action Category	Particular Efforts	Outcomes/Future Steps	Lessons Learned
Government efforts	<i>Sudan</i>³⁵—Dialysis expanded in 1980 with support from Ministry of Finance. In 1994, a national call by the government on “how best to do” reforms led to founding of National Center for Kidney Diseases and Surgery. The LSM bill was introduced to cover all citizens for CKD/ESKD care. Funding obtained from the national medical supplies fund and National Zakat Fund, which used the Islamic concept of Zakat, where citizens contribute 2.5% of their annual income to charity. Activities were regularly published to ensure accountability <i>Sri Lanka</i>—Recent efforts have shown promise with respect to establishing sustainable mechanisms for delivery of kidney care. Combined efforts of the professional community and Government have led to the establishment of a CKD and dialysis registry⁶⁴ <i>India</i>—The Indian Government has been funding the ICKD for the past decade.⁶⁵ This is an ongoing, multi-centric, prospective, cohort study of over 4000 participants with early CKD. This initiative was undertaken by the Indian Society of Nephrology. The PMNDP (https://pmndp.mohfw.gov.in/en/about-us) is a program launched in 2016 to provide dialysis services through a public-private partnership model. It has been implemented across India and has ensured availability of dialysis services to people who could not afford it. An electronic portal to create a countrywide registry of patients on dialysis is being implemented. PD is also being promoted <i>Malaysia (UMIC)</i>—The Malaysian Society of Nephrology has been working closely with the Government to maintain the Malaysian Dialysis and Transplant registry since 1992⁶⁶ <i>Pakistan</i>—Another example is the model of free dialysis and transplantation services at the Sindh Institute of Urology and Transplantation in Pakistan³²	<i>Religious-system and value-based interventions such as the National Zakat Fund of Sudan has improved finances for the government to make CKD/ESKD care accessible for citizens for decades</i> <i>Government-supported registries and large prospective studies have led to improved understanding of epidemiology and policy implementation</i> Ongoing work to investigate the CKDu epidemic in regions of Sri Lanka and India exemplifies the strength of regional and international collaborations that are happening in these regions The government-funded ICKD data reveals the average age to be 50 years with two-thirds being male. Diabetic kidney disease and chronic interstitial nephritis are the leading causes of CKD. In approximately 20% of the study population, the cause could not be ascertained. The leading causes of AKI were sepsis and tropical fevers in a large multicentric registry of AKI that reported on outcomes of >3000 patients with community acquired AKI across nine centers in India	<i>Government engagement and involvement is critical for sustainable access to CKD/ESKD services</i> Advocacy for kidney diseases can lead to changes in government policies
CKDu, CKD of unknown origin; HTN, hypertension; ICKD, Indian CKD; ICMR, Indian Council of Medical Research; LIC, low-income country; LMIC, low- and middle-income country; LSM, life-saving medicines; NCD, noncommunicable diseases; NPCDCS, National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke; PD, peritoneal dialysis; PMNDP, Pradhan Mantri National Dialysis Program; SGLT2i, sodium-glucose co-transporter-2 inhibitor; RHP, Renal Health Program; STW, standard treatment workflow; UHC, Universal Health Coverage; UMIC, upper middle-income country.			

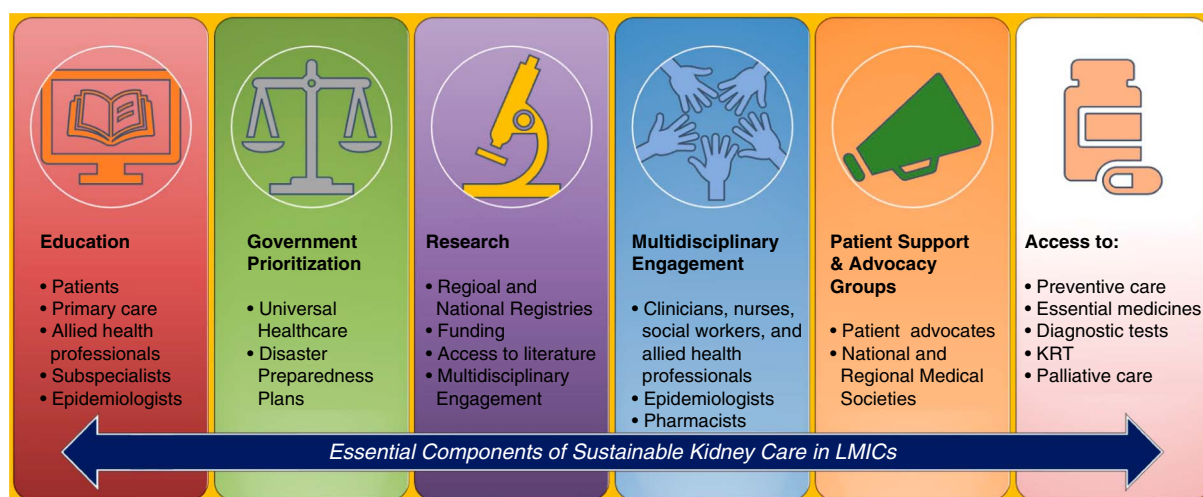


Figure 4. Key components to establishing optimal kidney care in LMICs.

organizations and industry to lower the cost of diagnostics, dialysis, and kidney transplant in LMICs, in addition to provision of training for human resource. There have been global efforts to improve access to dialysis, particularly PD, through programs such as Saving Young Lives, which achieved short-term success.^{72,73} However, uptake of PD as a chronic modality has been limited due to consumable unavailability. There are ongoing efforts to use locally available material to expand access to PD. The more successful and robust PD adoption in Latin American countries highlights an opportunity for collaboration.

Often underappreciated is the effect of disasters on existing infrastructures. Recent and ongoing conflicts and wars (such as in Sudan that had an ESKD care program for over 3 decades with over 4000 kidney transplant recipients and twice as many receiving chronic dialysis)^{35,41} that have led to significant disruption of previously successful programs should ignite concerted efforts to build mechanisms to ensure continued dialysis access during natural disasters/conflicts.⁷⁴ Figure 4 presents a roadmap for sustainable kidney care in LMICs.

Expanding Research Capacity

Research training, partnerships, and webinars offered by international organizations, such as the ISN, as well as fellowships and leadership training programs such as the ISN-Emerging Leaders Program, have been instrumental. The lack of access to peer-reviewed research and insurmountable publication fees, which have been major hurdles for knowledge exchange, are starting to become recognized.

In addition, there have been collaborations to improve research capacity, some of which are highlighted in Table 3. Notably, the CKD-Africa Collaboration is a pan-African initiative designed to better estimate CKD prevalence. The ISN-CKD of unknown origin observatory aims at tracking ongoing studies on CKD of unknown origin and facilitating knowledge exchange. The Human Heredity and Health in Africa (H3Africa) kidney disease network is a collaboration between researchers in Africa and other parts

of the world to understand genomics and environmental determinants of kidney diseases. The ARK is a collaboration between researchers from Malawi, Uganda, South Africa, and England designed to improve kidney function estimation in sub-Saharan Africa.⁷⁵ Genomic databases such as the Uganda Genome Report, which contains genomic data from over 2000 individuals from different ethnographic regions, are promising tools to further kidney disease research.⁷⁶ Assessing the burden of disease and understanding local and regional risk factors is necessary to guide early detection strategies and resource allocation. As such, national registries and strong local research capacity are essential to systematically narrow the equity gap.

Patient participation is also key to strengthening the kidney care and may provide solutions for clinical care and research in low resource settings. Using smartphone-based technologies where the patient's role is expanded from a patient or research participant to active curator of their own data can facilitate care at the individual and population levels.⁷⁷

Improving Early Detection and Prevention

Patients with kidney disease face significant inequities in access to care. There is need for continued lobbying to improve political will, increase health budgets, and move toward UHC. Countries could integrate low-cost tests for kidney disease and its risk factors in nationwide health surveys to generate local data. Early detection strategies and interventions can be designed to target CKD at multiple levels (Table 4). Comprehensive care targeting risk factors for CKD (including nephrotoxins, and glycemic and BP control) can have major effect. Widespread population-level ("upstream") targeting of known modifiable risk factors³⁵ can be achieved through engaging community leaders, mobilizing youth, and using various media platforms.³⁶ Similarly, equitable access to investigative procedures and expertise to interpret tests is necessary not only for prompt and accurate diagnosis but also to avoid unnecessary complications from empiric administration of immunosuppressive therapy.¹⁴ Simultaneous focus on

Table 3. Efforts to expand research capacity

Registries and Regional Bodies	Africa	Latin America	South Asia
Registries ^a	• South Africa 1977–1994, then 2012 to date (est 2012) • Tunisian Dialysis Registry 1990–2011 (est 1990) • Egyptian Renal Data System 1996–2008; 2018 to date • Libya 1980–1996 • Algeria 1981–1997 • Morocco 2006–2008 • African Renal Registry 2015 (seven countries—Botswana, Burundi, Kenya, Ghana, Nigeria, Zambia, and South Africa) but no published report	• Brazilian Registry of Dialysis (est 1998) • Columbia Healthcare Database (est 2008) • Latin American Dialysis and Transplantation Registry (est 1991) • Sociedad Argentina de Nefrologia (est 2004) • Uruguayan Registry of dialysis (est 1981)	None—efforts underway in 3/8 countries (Bangladesh, India, and Sri Lanka)
Consortia and other major research efforts ^b	• CKD-Africa Collaboration (est. 2018) • Initiative to Strengthen Health Research Capacity in Africa (est 2007) • Collaboration for Evidence based Health in Africa (est 2011) • East African Kidney Institute at the University of Nairobi (est 2014) • H3Africa Kidney Disease Network (est 2012) • ARKs—to estimate GFR in Sub-Saharan Africa using established cohorts	SLANH ISN's International Consortium on CKDu Collaborators/ISN i3C working Group	NPCDCS
Regional Nephrology Associations ^c	AFRAN	SLANH	APSN

AFRAN, African Association of Nephrology; APSN, Asian Pacific Society of Nephrology; ARK, African Research into Kidney Disease; CKDu, CKD of unknown origin; i3C, CKDu observatory; ISN, International Society of Nephrology; H3Africa, Human Heredity and Health in Africa; NPCDCS, National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke; SLANH, Latin American Society of Nephrology and Hypertension.

^aRegistries are established to inform policy.

^bCKD-Africa Collaboration: a pan-African initiative designed to better estimate CKD prevalence; International Society of Nephrology-CKDu observatory: established to track ongoing studies on CKDu and facilitating knowledge exchange. The Human Heredity and Health in Africa kidney disease network was established to understand genomics and environmental determinants of kidney diseases in Africa. The African Research into Kidney diseases is a collaboration (Malawi, Uganda, South Africa, and England) designed to improve kidney function estimation in sub-Saharan Africa.

^cAfrican Association of Nephrology, Latin American Society of Nephrology and Hypertension, and Asian Pacific Society of Nephrology are major regional nephrology associations were established with the aim of advancing regional capacity for kidney care including collaborations, setting regional guidelines.

primary and secondary prevention is paramount. Central to this strategy is equitable access to medications to control modifiable risk factors, such as hypertension and diabetes.

This could be made possible by ensuring cardiometabolic therapeutics are part of the national essential medicines list, through local manufacturing of cost-efficient combination pills and strengthening drug cold chains and storage infrastructure to ensure consistent access.

Embracing the CKM Health

With the discovery of cardio-renal therapies such as SGLT2is to delay CKD and cardiovascular disease progression, embracing the new paradigm of CKM health offers an opportunity to address multiple cardiometabolic comorbidities with profound benefits on morbidity and mortality.³⁹ This is highly important as patients with any stage of CKD are already at a high risk of cardiovascular mortality.

Therapeutic advancements, such as the angiotensin-converting enzyme inhibitors/angiotensin receptor blockers, SGLT2is, and nonsteroidal mineralocorticoid receptor antagonists, offer a golden opportunity for LMICs to reverse the trends in CKD. This could mitigate catastrophic health care expenditure to individuals and families, loss of productive human resource, and insurmountable governmental budget allocations toward KRTs. While grounds for use of these pillar drugs have been laid out by regional nephrology societies, such as the African Society of Nephrology, a concerted effort is needed to lower drug costs and ensure availability to those who would benefit most from it.^{40,41} Implementation of these changes would require (1) local and regional campaigns to increase awareness at the population and health care provider level and (2) development of policies to improve access to diagnosis and these essential medications to slow the progression of CKD and cardiovascular disease. An integrated approach to CKM care can be

Table 4. Multipronged approaches to combat CKD and its progression unique to low- and middle-income countries

Screening	Prevention	Management	Capacity Building
> Identify at-risk individuals - Perinatal risk - Pregnant - HIV, TB, Malaria, Schistosomiasis, Dengue and other infectious diseases - Genetic predispositions, e.g., APOL-1, SCD - Malnutrition/underweight - Heat and pollution - Snake bites > Screen those at-risk - BP - HbA1c or fasting glucose - Creatinine/Cystatin-C - Urine dipstick - Urine albumin (ACR) Mechanisms - Engaging local leaders and patient advocates - Task shifting	> Promote healthy habits - Lifestyle modifications - Medication adherence - Nephrotoxin avoidance - Adequate hydration - Salt restriction - Avoidance of illicit drugs, tobacco, and heavy alcohol Mechanisms - Peer support groups - Awareness campaigns (media, phone apps, ads, and utilizing local leaders) - Access to clean water - Regulation of tobacco and ultra-processed food	1. Diet and lifestyle modifications 2. Medications for CKM care: ◦ Glycemic and BP control ◦ Statins ◦ Kidney protective medications—RASi, SGLT2i, MRA 3. Monitoring—BP, kidney function, and HbA1C Mechanisms - Government prioritization - National guidelines and policies - National essential medicines list - Task shifting	> Task shifting > Electronic health record systems > Registries > Research consortia > Infrastructure for drug delivery > Disaster preparedness > Diagnostic tools for prompt diagnosis of reversible etiologies (POC ultrasound, POC labs, Urine microscopy, and Kidney biopsy/pathology) Mechanisms - Government budget re-allocation - Public-private partnerships - Engaging patients in education and their care - Increased taxation on harmful products (tobacco, processed foods) - Collaborations with other countries/institutions - Utilizing social media, virtual platforms for training - Open source platforms for education and research dissemination
ACR, albumin:creatinine ratio; APOL-1, apolipoprotein-1; CKM, cardiovascular-kidney-metabolic; HbA1c, hemoglobin A1c; MRA, mineralocorticoid receptor antagonist; POC, point of care; RASi, renin-angiotensin system inhibitor; SCD, sickle cell disease; SGLT2i, sodium-glucose co-transporter-2 inhibitor; TB, tuberculosis.			

transferred to lower-level health care units to serve populations in hard-to-reach areas. Nationwide targeting of at-risk and early CKD groups utilizing primary care providers and allied health care workers can have a significant effect. Risk prediction models for CKD and its progression could assist with cost-effective early detection.⁴² However, existing models require validation in specific populations as we recently learned in the ARK study.²² Existing kidney function estimating equations developed in HIC cohorts may not be applicable to all populations; for instance, the new CKD Epidemiology Collaboration equation was found to overestimate measured GFR and underestimate CKD prevalence in a multinational cohort of patients from sub-Saharan Africa.²²

Considerations for sustainable infrastructure development for CKM care in LMICs are provided in Figure 2.

Notwithstanding ongoing challenges, the LMIC health care community is no stranger to cost-effective transformative health care solutions in the face of adversity. Widespread efforts are underway by local champions at various levels of health care supported by advocates within international societies to build sustainable expertise and resources capable of progressively narrowing the care gap.^{3,49,71,78} The variability in the degree of access within

regions of similar sociodemographic index^{30,79,80} highlights lessons to be learned and opportunities for collaboration. There are promising efforts to improve data and raise awareness. Reliable governmental support is paramount to the success of these efforts, as lasting solutions can only be achieved through national policies. There are various strides made toward improving kidney care in LMICs. Multidisciplinary collaborations and government buy-in are key for sustainable solutions to curb the global rise in CKD.

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