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Potential applications of telenephrology to enhance global kidney care

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ABSTRACT

Chronic kidney disease (CKD) is an important public health issue that increasingly affects more patients globally and is associated with adverse clinical consequences with huge economic impact. Effective management of patients with CKD requires delivery of kidney care in a primary care setting where possible and at a higher level with a nephrologist when necessary to improve outcomes. In many instances and for various reasons, it is not possible to follow this pathway of care delivery. With improving telecommunication technologies worldwide, it is hoped that increasing utilisation of electronic communication devices can be used to facilitate kidney care to improve the quality of care delivered to patients, especially those who live in remote regions. Kidney care and therefore outcomes for patients with CKD is often compromised due to lack of access to a nephrologist, either because of distance or shortage of nephrologists, high proportion of patients being unaware they have CKD, lack of population screening for early detection of CKD and risk factors and prevention programmes and poor patient adherence and absence of appropriate CKD management strategies. Telenephrology can play a significant role in addressing these factors and therefore can be leveraged to improve CKD outcomes globally, especially in low to middle-income countries. This paper provides an overview on the potential role of telenephrology in enhancing access to and quality of care delivered to patients with CKD to improve outcomes.

Key questions

What is already known about this subject?

- Chronic kidney disease (CKD) is an important public health problem that is linked to adverse health consequences and huge economic impact.
- Access to high-quality care for CKD is still low particularly in developing countries and among disadvantaged populations living in high-income nations.

What are the new findings?

- Given the global advancement of telecommunication, telenephrology can improve CKD care particularly in low-income nations.
- This will help to build capacity through addressing global nephrology workforce scarcity. For instance, links with videoconferencing, instant messaging, emails and telephone consults could be formed between primary care, other specialists and nephrologists to communicate clinical information, send laboratory results and discuss appropriate treatment strategies and ongoing monitoring of patients with CKD.

Recommendations for policy

- Telenephrology is an important tool that could be leveraged to provide equitable access to kidney care in all parts of the globe but its important to understand areas of application with the most potential to make impact and the various key implementation barriers.

INTRODUCTION

In the last decades, multiple chronic kidney disease (CKD) care models have been tested in different countries to enhance care and improve patient's outcomes.[1–3] An effective communication system between primary care physicians (PCPs) and kidney specialists is vital for the success of all forms of care delivery models.

Effective management of CKD patients requires that care should be delivered in a primary care setting where possible and at a higher level (secondary or tertiary care setting) when necessary.[4] Although early involvement of nephrologists in CKD care may improve outcomes for certain category of patients,[5] unnecessary referral patterns could deplete resources and may be unsustainable in areas serviced by few nephrologists. Telenephrology is a mechanism that facilitates direct communication between providers (PCPs and kidney specialists) or between patients and providers to exchange information for care delivery.

Telenephrology initiatives are being shown to be widely accepted by practitioners and could offer rapid access to specialist input to care. The impact of provider and patients' experience of care, population health and costs is still unclear. The research in this area is still rudimentary as studies are few and more often observational in nature. A recent systematic review has documented only 22 research studies from surveys and based on only

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utilisation/process measures.[6] There have been no studies yet on impact (efficacy and effectiveness) and costs.

Taking into consideration the role of clinical information system among the six core elements vital for provision of adequate care in chronic disease including CKD,[3] and the global advancement of telecommunication technology, the use of telehealth in nephrology has a great potential to enhance CKD care around the globe.[7] This paper explores the role of telenephrology for improving kidney care with a specific focus on potential applications with greater impact, role in addressing workforce scarcity and limitations and barriers to implementation.

TELENEPHROLOGY AND APPLICATION IN KIDNEY CARE

Telenephrology is a term that refers to the application of telehealth in kidney care.[8] Telehealth uses electronic information and telecommunications technologies to support long-distance clinical healthcare, patient and professional health-related education, public health and health administration.[9] Telehealth services have the capacity to potentially support health systems with growing demands from ageing populations, management of chronic diseases and meeting the growing expectations of patients from healthcare providers.[10]

The different facets of telehealth could be leveraged to optimise kidney care as summarised based on associated advantages and disadvantages (table 1). The use of telenephrology is intended mainly to address various challenges encountered in the provision of kidney care associated with an imploding epidemic of CKD, including: improving access in geographically remote areas; addressing the global shortage of nephrologists, especially in developing countries; increasing ability to continue patient monitoring; reducing cost of care provision; and improving efficiency and patient satisfaction as demonstrated in various studies summarised in table 2.[4 11–20]

Telehealth encompasses a growing variety of applications and services using two-way video, the Internet, email, smart phones, wireless sensors and other forms of telecommunication technology. These applications can facilitate videoconferencing,[15] transmission of still images,[21] use of e-health portals (including patient portals), remote monitoring of vital signs, continuing medical education and nursing call centres (table 1).[22] Due to its diversity and growing innovative processes, telehealth is recognised as constituting an expanding set of services for delivering care as opposed to a single technology with a number of potential applications for optimal kidney care.[23]

Using telenephrology to improve kidney care in developing countries and disadvantaged populations in developed world

Developing countries already face a double burden of disease that comprises communicable diseases (HIV, tuberculosis, malaria, diarrhoeal diseases) and chronic non-communicable diseases, as well as myriad challenges in offering chronic disease care that includes a severe shortage of all cadre of healthcare providers.[24] In addition, they lack the resources to offer the usually resource intensive CKD care including adequate predialysis care, dialysis therapies and kidney transplantation.[25] There is therefore an urgent need for innovative ways to provide effective and quality care using currently available resources to the growing number of CKD patients.

In many developing countries, the rate of growth of digital infrastructure has surpassed that of physical infrastructure, and this minimises cost of applications of telenephrology tools (for example, the use of smartphones that widely is available among patients and care providers even in remotest of places). Affordable connectivity has strong implications for the future of healthcare, in particular where accessibility to specialist care is limited.[26] The ability to communicate through easy-to-use, multiuser applications capable of transmitting audio or video streams, once available only in high-end teleconferencing or telehealth systems, has become an integral part of everyday lives in low and middle-income countries (LMIC). Given this technological environment, it is possible for several small, peripheral centres, typically led by PCPs or nurse practitioners, to be pooled into centrally led virtual nephrology centres. In cases without high Internet connectivity or lacking heavy investment for initial set-up, the relatively cheap e-mail facilities required for 'store and forward' telehealth is more feasible. Using e-mail and digital images consultations has been shown to enable prompt specialist consultation and PCPs support in chronic disease care including nephrology.[27] One practical way in which telehealth has been useful for providing nephrology service in developing countries has been through telepathology; using this means, digital images, including those of renal pathologies, can be transmitted for pathology education, research, diagnosis or consultation.[28] Using iPath, the web-based, open platform developed for telepathology, pathologists from around the world are able to provide diagnostic pathology support as well as pathology education to centres with limited resources.[29] Through this particular initiative, several successful telepathology meetings and pathology projects have been established in developing countries, including Solomon Islands, Egypt, Nigeria, Cambodia and India.[30] This resource, if adequately use, is likely to make a significant and positive impact on the diagnosis and treatment of various glomerular pathologies, especially in Africa where there are few nephropathologists.

The potential for growth of telenephrology in developing countries is enormous. Nephrology support of PCPs and other cadres of healthcare staff in remote communities via teleconsult, through mobile device phone messaging system, e-mail or teleconference has a potential to enhance collaboration and efficiency in CKD care thereby improving diagnosis, testing and

Table 1 Domains of telehealth and specific applications in kidney care delivery

Domain	Definition	Relevant applications	Advantages	Disadvantages
A. Synchronous domains				
- Interactive videoconferencing	Use of real time video and audio for communicating (consulting, teaching, discussing treatment)	- Group clinic sessions to improve compliance - Training of nephrologists/ nurses in LMICs - Promoting appropriate CKD management	- Events take place in'real time' - Questions and answers will reflect real time discussions and can instantly be revisited	- Requires a good Internet and other equipment (TV monitor, computer screen, cables) - May not be effective for practical hands-on demonstrations (eg, renal biopsy, urine microscopy)
- Phone (Mobile Health; mHealth)	Telephone call	- Patient referral - Consultation	- Audio discussions take place in 'real time'	- Cost of long-distance calling
B. Asynchronous domains				
- Store-and-forward	Transmission via email of medical or laboratory data and images to an expert for remote review	- Consultations and referral - Screening/prevention programmes - Training of nephrologists/ nurses in LIC and LMICs - Improving compliance and appropriate CKD management	- Large data (image) can be sent	- Information sent may be too bulky to read in a short time - Needs capacity for storage of data sent - Lack of personal voice interaction
- Phone (mHealth)	Use of SMS or other methods of mobile text messaging for communication	- Screening/prevention programmes - Reminders to attend clinics - Promoting appropriate CKD management	- No need for hospitalisation - Opportunity to provide individualised care	-
- Self-monitoring and management	Involves one or more types of sensors deployed in, on, or around a human body to collect physiological signals	- Management of patients in remote areas - Promoting appropriate CKD management	- No need for hospitalisation - Allows for long-term and continuous monitoring / tracking of health status - Opportunity to provide individualised care	- Need to always carry (wear) a sensing device - Inconvenience of frequent buzzing / beeping sounds - False alarms may be sent due to malfunctioning of device

CKD, chronic kidney disease; LIC, low income countries; LMIC, low middle-income countries; mHealth, Mobile Health.

appropriateness of referral. Moreover, teleconference links between city hospitals to rural hospitals will enhance capacity of the rural hospitals and ensure appropriate and timely referral systems.

Despite spending high amounts of funds on CKD care, there remains a pocket of disadvantaged populations in developed countries who may not have access to kidney care due to geographic barriers. This often means that patients must travel long distances to obtain care, which adds stress, imposes additional costs and may contribute to poor outcome. For instance, Tonelli *et al* have shown that the adjusted rates of death among patients in rural Canada initiating peritoneal dialysis was significantly higher in those living further from the nephrologists than those living within 50 km.[31] In this regard, telehealth may become useful in overcoming the geographic barrier and improve patient's access to specialised CKD care. Patients usually display a high degree of satisfaction when such services are available, and healthcare providers do not have to spend any extra time than usual care.[32] Telehealth has also been shown to be useful for managing remote haemodialysis units from tertiary referral centres with no difference in outcomes compared with patients followed up by an on-site nephrologist in an

Table 2 Utilisation and impact of telenephrology from selected studies

Country (author)	Telehealth platform*	CKD population covered†	Setting‡	Number of patients	Design	Impact§	Identified loopholes and limitations (if any)
Jordan (AlAzab *et al*)[11]	Electronic consults (e-Consult)	Non-dialysis CKD	Regional hospital in remote location	64	Prospective cohort	- Improved access - ↓ cost to patients - Improved patient quality of life	- Small sample (78 patients) - Short follow-up (1 year) - Non-randomised
USA (Ishani *et al*)[12]	Android/iPad, emails	Non-dialysis CKD	Regional care centres, aged patients	600	Randomised clinical trial	- No difference in composite outcomes (death, hospitalisation, emergency department visits) compared with usual care	- Short follow-up period - Small sample size
Spain (Gomez-Martino *et al*)[13]	e-Consult and video conference	Non-dialysis CKD	Regional centre	105	Retrospective descriptive study	- ↓ hospital visits	- Small sample (107 patients) - Short follow-up (27 months)
Netherlands (Scherpbier-de Haan *et al*)[4]	e-Consultation	Non-dialysis CKD	Regional care centres	122	Prospective observational study	- ↓ patient referral to tertiary hospital - ↓ time per consultation	- Short study time - No analysis of actual referrals
UK (Stoves *et al*)[14]	e-Consult	Non-dialysis CKD	General practices and a secondary referral hospital	466	Prospective observational study	- ↓ of paper consults - ↑ satisfaction by GPs - ↑ Clinical Empowerment of GPs	- Short study time - No analysis of actual referrals
USA (Diamantidis *et al*)[43]	SMS PDAs	Non dialysis CKD	Regional hospital	20	Randomised parallel study	- Improved medication safety in CKD	- Small sample size
Russia (Braverman *et al*)[15]	e–Consult	Non-dialysis Paediatric CKD	Open to public (parents of paediatric patients with CKD provided with e-Consult)	141	Retrospective descriptive study	- ↑ patient satisfaction	- None
USA (Berman *et al*)[16]	Teleconference (video)	Haemodialysis	Single hospital, high-risk patients (multiple comorbidities)	44	Prospective observational study	- ↓ hospitalisation and hospital stay - ↓ overall care cost - ↑ quality of life	- Single hospital - Small sample (44 patients)
USA (Bellazi *et al*)	Teleconference	Haemodialysis	Regional hospital	117	Retrospective descriptive study	-↓ patient visit to main hospital -↓ reduced need for doctor travel to satellite unit	- Short study time
Canada (Berstein *et al*)	Teleconference	Haemodialysis	Referral hospitals linked to remote dialysis units (First nations, aborigines)	2663	Retrospective descriptive study	- ↑ 2 and 5 year survival on dialysis	- Socioeconomic status not considered - Comorbidity scare not considered
Spain (Gallar *et al*)[18]	Teleconference	Peritoneal dialysis	Single centre	57	Prospective non-randomised study	- ↓ patient cost of care - ↓ hospitalisation	- Single centre - Small sample (57 patients)
Canada (Alison *et al*)	Teleconference	Peritoneal dialysis	Single centre	8	Randomised parallel design	- ↑ patient satisfaction	- Small sample size
Canada (Sicotte *et al*)[19]	Teleconference	Haemodialysis	2 remote haemodialysis centres serving first nations	19	Prospective observational study	- No difference between virtual patient rounds and telecase reviews with multidisciplinary teams	- Non randomised

Continued

Table 2 Continued

Country (author)	Telehealth platform*	CKD population covered†	Setting‡	Number of patients	Design	Impact§	Identified loopholes and limitations (if any)
USA (Thompson *et al*)[20]	Teleconference	Post -transplant follow-up	Single centre	138	Prospective randomised study	- No difference in usual care regarding post-transplant depression prevalence	- Single centre - Short follow-up
UK (Connor *et al*)	Telephone	Post-transplant	Single centre	30	Prospective observational study	-Improved post-transplant access to care -↓ visit to hospital by patient -↑ cost effectiveness	- Small sample size
USA (Thompson *et al*)[20]	Teleconference	Post -transplant	Single centre	138	Prospective randomised study	-No difference in usual care regarding post-transplant depression prevalence	- Single centre - Short follow-up

*Telephone, video, SMS, Android/iPad technology, email communications, electronic consults (e-Consult), other (outside any of the above platforms).
†Non-dialysis CKD, haemodialysis population, peritoneal dialysis population, transplant population.
‡Single hospital, regional, national, special populations (remote communities, disadvantaged group, etc).
§Accessibility (reduction in wait times), efficiency (time savings for providers and/or patients, cost savings, etc), satisfaction (providers and/or patients).
CKD, chronic kidney disease; GP, general practitioner; PDA, personal digital assistant; SMS, short message service.

urban area, but with the advantage of cost effectiveness, enhanced collaboration and education with the tertiary centre.[19]

Using telenephrology to address the global nephrology workforce shortage

Telenephrology may have its biggest impact in nephrology through addressing global nephrology workforce issues. Links for videoconferencing, instant messaging, emails and consultations via telephone could be formed between PCPs, other specialists and nephrologists to communicate clinical information, send laboratory results and discuss appropriate treatment strategies and ongoing monitoring of patients with CKD, including when a patient needs to be referred to see a nephrologist. Web-based courses have also been used to build capacity for kidney biopsy processing and interpretation for kidney specialists and pathologists in LMICs. Such strategies are already in use to enhance awareness of CKD by organisations such as the National Kidney Disease Education Program (NKDEP), where kidney disease education is promoted via digital media with links to educational topics.[33]

Using telenephrology to improve CKD awareness

Current awareness programmes, including World Kidney Day have become important platforms for community awareness of CKD and have also been used to engage with health authorities to increase their input on CKD-related matters.[34–36] One major problem with such platforms is that they are often one-off activities celebrated on an annual basis with no momentum for sustainability to maximise impact. The asymptomatic nature of kidney disease and complexity of CKD manifestations require that a continuous and sustained process of awareness is used to increase community consciousness of CKD. There is little evidence on the use or effectiveness of telenephrology to improve CKD awareness in the general population. Methods that could increase awareness include use of information blasts as advertisements by the leading advocacy organs such as the International Society of Nephrology (ISN) for at-risk population (people with diabetes, hypertension and cardiovascular disease) to have their kidney functions assessed (other associations like the American Heart Association have used this method) or simple short videos on the ISN or affiliated websites to address the need for kidney disease assessment. The effectiveness of such methods is an area in need of further research.

Using telenephrology to improve the adoption of best practice guidelines for CKD care and patient engagement to their care

Previous decades have witnessed considerable growth in the amount of clinical studies on CKD, and these are being synthesised by international experts into best practice guidelines covering most aspects of CKD care. These guidelines are made easily accessible on Internet but their adoption into practice remains a huge challenge in all parts of the world; telenephrology could be leveraged to enhance adoption of guidelines and capacity building among the care providers.

Patient education and awareness on active involvement in their own care is vital for quality care delivery, and information technology could be leveraged to achieve this objective. Mobile device short message service (SMS) has been used as a reminder to attend clinic appointments in various disciplines and has shown usefulness in improving adherence.[37–40] One systematic review that included 35 randomised controlled trials reporting quantitative outcomes for haemoglobin A1c (HbA1c) in type 2 diabetes subjected to different interventions (telephone call or SMS, video-conferencing and/or informational websites, electronically transmitted recommendations made by clinicians) reported statistically significant lowering of HbA1c following intervention, compared with conventional treatment.[41] Effective patient engagement would enhance adherence to medications and compliance with monitoring and follow-ups that can facilitate quality care and minimise risk of disease progression and related complications.

BARRIERS TO ADOPTING TELENEPHROLOGY

The benefits of telenephrology to improve kidney care have been highlighted; however, various barriers may still make it difficult or nearly impossible to implement it in different parts of the world. For instance, although telecommunication services are growing worldwide, in many LMICs, access to Internet is still very limited, and where it is available, the network or signal strength may be so weak as to render use frustrating and difficult. Hence, telenephrology services that are web-based will not yet be feasible in such places. Another barrier that could hinder the integration of telenephrology into caring for patients with CKD is the level of engagement, knowledge and cultural barriers to adopting new technologies.[42–44] One study that investigated the use of an web-based patient portal for follow-up of patients with diabetes in Northern California found in an adjusted analysis that African-Americans and Latinos had higher odds of never logging on to the site compared with Caucasians, as did those without an educational degree (compared with college graduates (OR 2.3 (1.9 to 2.7)). The study concluded that those most at risk for poor diabetes outcomes may fall further behind as health systems increasingly rely on the Internet and limit current modes of access and communication.[42]

Other factors that have been identified as barriers include a high attrition rate among users (either find more exciting apps or generally lose interest in usage),[45 46] lack of importance given to data in decision making, potential system corruption and insecurity, lack of training and poor infrastructure[47] and remuneration for time spent by physicians and nephrologists for review of electronic results and referrals. Although the importance of these factors will differ from one country to another, the integration of telenephrology into CKD care may only become possible where these barriers have been identified and resources put in place to address them. Finally, exchange of patient information would require a high-level privacy and security requirement that may pose challenges in certain domains of telenephrology as well as geographical settings due to varying or absence of appropriate regulatory frameworks.

CONCLUSION

Burden and consequences of CKD continue pose huge challenges across world nations. Access to and quality of care for CKD remains suboptimal across settings partly due to limited access to appropriate expertise to deliver care. This reality is more evident in LMICs than in developed countries. Telenephrology holds promise to improve, increase or bridge the gap in kidney care in different countries based on current levels of care. Research is required in this area to guide decision making and to point the way forward.

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REFERENCES

1. Stevens PE, O'Donoghue DJ. The UK model for system redesign and chronic kidney disease services. *Semin Nephrol* 2009;29:475–82.
2. Levey AS, Schoolwerth AC, Burrows NR, *et al*; Centers for Disease Control and Prevention Expert Panel. Comprehensive public health strategies for preventing the development, progression, and complications of CKD: report of an expert panel convened by the centers for disease control and prevention. *Am J Kidney Dis* 2009;53:522–35.
3. Bodenheimer T, Wagner EH, Grumbach K. Improving primary care for patients with chronic illness. *Jama* 2002;288:1775–9.
4. Scherpbier-de Haan ND, van Gelder VA, Van Weel C, *et al*. Initial implementation of a web-based consultation process for patients with chronic kidney disease. *Ann Fam Med* 2013;11:151–6.
5. Smart NA, Dieberg G, Ladhani M, *et al*. Early referral to specialist nephrology services for preventing the progression to end-stage kidney disease. *Cochrane Database Syst Rev* 2014;6:Cd007333.
6. Vimalananda VG, Gupte G, Seraj SM, *et al*. Electronic consultations (e-consults) to improve access to specialty care: a systematic review and narrative synthesis. *J Telemed Telecare* 2015;21:323–30.
7. Wootton R. Recent advances: telemedicine. *Bmj* 2001;323:557–60.
8. Gordon EJ, Fink JC, Fischer MJ. Telenephrology: a novel approach to improve coordinated and collaborative care for chronic kidney disease. *Nephrol Dial Transplant* 2013;28:972–81.
9. HealthInformationTechnology. What is telehealth? how is telehealth different from telemedicine? https://www.healthit.gov/providers-professionals/faqs/what-telehealth-how-telehealth-different-telemedicine.

10. WorldHealthOrganization. How can telehealth help in the provision of integrated care? http://www.euro.who.int/__data/assets/pdf_file/0011/120998/E94265.pdf?ua=1.
11. AlAzab R, Khader Y. Telenephrology application in rural and remote areas of Jordan: benefits and impact on quality of life. *Rural Remote Health* 2016;16:3646.
12. Ishani A, Christopher J, Palmer D, *et al*. Telehealth by an Interprofessional Team in Patients with CKD: a Randomized Controlled Trial. *Am J Kidney Dis* 2016;68:41–9.
13. Gómez-Martino JR, Suárez MA, Gallego SD, *et al*. [Telemedicine applied to Nephrology. another form of consultation]. *Nefrologia* 2008;28:407–12.
14. Stoves J, Connolly J, Cheung CK, *et al*. Electronic consultation as an alternative to hospital referral for patients with chronic kidney disease: a novel application for networked electronic health records to improve the accessibility and efficiency of healthcare. *Qual Saf Health Care* 2010;19:e54.
15. Braverman J, Samsonov DV. A study of online consultations for paediatric renal patients in Russia. *J Telemed Telecare* 2011;17:99–104.
16. Berman SJ, Wada C, Minatodani D, *et al*. Home-based preventative care in high-risk Dialysis patients: a pilot study. *Telemed J E Health* 2011;17:283–7.
17. Bernstein K, Zacharias J, Blanchard JF, *et al*. Model for equitable care and outcomes for remote full care hemodialysis units. *Clin J Am Soc Nephrol* 2010;5:645–51.
18. Gallar P, Vigil A, Rodriguez I, *et al*. Two-year experience with telemedicine in the follow-up of patients in home peritoneal Dialysis. *J Telemed Telecare* 2007;13:288–92.
19. Sicotte C, Moqadem K, Vasilevsky M, *et al*. Use of telemedicine for haemodialysis in very remote areas: the Canadian First Nations. *J Telemed Telecare* 2011;17:146–9.
20. Thompson DA, Leimig R, Gower G, *et al*. Assessment of depressive symptoms during post-transplant follow-up care performed via telehealth. *Telemed J E Health* 2009;15:700–6.
21. Cronenberger JH, Hsiao H, Falk RJ, *et al*. Nephropathology consultation via digitized images. *Ann N Y Acad Sci* 1992;670:281–92.
22. AmericanTelemedicineAssociation. What is telemedicine? http://www.americantelemed.org/about-telemedicine/what-is-telemedicine#.V6W8L4N96M8.
23. Wootton R. Telemedicine: a cautious welcome. *BMJ* 1996;313:1375–7.
24. Anyangwe SC, Mtonga C. Inequities in the global health workforce: the greatest impediment to health in sub-Saharan Africa. *Int J Environ Res Public Health* 2007;4:93–100.
25. El Nahas AM, Bello AK. Chronic kidney disease: the global challenge. *The Lancet* 2005;365:331–40.
26. Remuzzi G, Benigni A, Finkelstein FO, *et al*. Kidney failure: aims for the next 10 years and barriers to success. *The Lancet* 2013;382:353–62.
27. Graham LE, Zimmerman M, Vassallo DJ, *et al*. Telemedicine–the way ahead for medicine in the developing world. *Trop Doct* 2003;33:36–8.
28. Hjelm NM. Benefits and drawbacks of telemedicine. *J Telemed Telecare* 2005;11:60–70.
29. Brauchli K, Oberholzer M. The iPath telemedicine platform. *J Telemed Telecare* 2005;11:3–7.
30. Malami SA. Recent advances in telepathology in the developing world. 2010 http://cdn.intechopen.com/pdfs-wm/14332.pdf.
31. Tonelli M, Hemmelgarn B, Culleton B, *et al*. Mortality of Canadians treated by peritoneal Dialysis in remote locations. *Kidney Int* 2007;72:1023–8.
32. Campbell M, Akbari A, Amos S, *et al*. Feasibility of providing nephrology services to remote communities with videoconferencing. *J Telemed Telecare* 2012;18:13–16.
33. Goldstein K, Briggs M, Oleynik V, *et al*. Using digital media to promote kidney disease education. *Adv Chronic Kidney Dis* 2013;20:364–9.
34. Trivedi H, Vanikar A, Patel H, *et al*. High prevalence of chronic kidney disease in a semi-urban population of western India. *Clin Kidney J* 2016;9:438–43.
35. Wachukwu CM, Emem-Chioma PC, Wokoma FS, *et al*. Prevalence of risk factors for chronic kidney disease among adults in a university community in southern Nigeria. *Pan Afr Med J* 2015;21:120.
36. Mastroianni-Kirsztajn G, Bastos MG, Burdmann EA. Strategies of the brazilian chronic kidney disease prevention campaign (2003-2009). *Nephron Clin Pract* 2011;117:c259–c265.
37. da Costa TM, Salomão PL, Martha AS, *et al*. The impact of short message service text messages sent as appointment reminders to patients' cell phones at outpatient clinics in São Paulo, Brazil. *Int J Med Inform* 2010;79:65–70.
38. Hasvold PE, Wootton R. Use of telephone and SMS reminders to improve attendance at hospital appointments: a systematic review. *J Telemed Telecare* 2011;17:358–64.
39. Joo NS, Kim BT. Mobile phone short message service messaging for behaviour modification in a community-based weight control programme in Korea. *J Telemed Telecare* 2007;13:416–20.
40. Krishna S, Boren SA. Diabetes self-management care via cell phone: a systematic review. *J Diabetes Sci Technol* 2008;2:509–17.
41. Zhai YK, Zhu WJ, Cai YL, *et al*. Clinical- and cost-effectiveness of telemedicine in type 2 diabetes mellitus: a systematic review and meta-analysis. *Medicine* 2014;93:e312.
42. Sarkar U, Karter AJ, Liu JY, *et al*. Social disparities in internet patient portal use in diabetes: evidence that the digital divide extends beyond access. *J Am Med Inform Assoc* 2011;18:318–21.
43. Diamantidis CJ, Becker S. Health information technology (IT) to improve the care of patients with chronic kidney disease (CKD). *BMC Nephrol* 2014;15:7.
44. Lorence DP, Park H, Fox S. Racial disparities in health information access: resilience of the Digital divide. *J Med Syst* 2006;30:241–9.
45. Diamantidis CJ, Fink W, Yang S, *et al*. Directed use of the internet for health information by patients with chronic kidney disease: prospective cohort study. *J Med Internet Res* 2013;15:e251.
46. Becker S, Kribben A, Meister S, *et al*. User profiles of a smartphone application to support drug adherence--experiences from the iNephro project. *PLoS One* 2013;8:e78547.
47. Akhlaq A, McKinstry B, Muhammad KB, *et al*. Barriers and facilitators to health information exchange in low- and middle-income country settings: a systematic review. *Health Policy Plan* 2016;31:1310–25.