Telenephrology: a novel approach to improve coordinated and collaborative care for chronic kidney disease

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ABSTRACT

In this special feature article, we discuss the development of collaborative care models in chronic disease management and the need for such initiatives in chronic kidney disease (CKD). We identify telemedicine as a potential key element to collaborative care in CKD. Telenephrology—as telemedicine would be referred to as it is applied in CKD—would be comprised of various technology platforms and applications, which are described here. We describe a range of scenarios in which telenephrology would facilitate collaborative care in CKD and how it would be the basis for patient-oriented research to assess improvements in outcomes in the future.

COORDINATION OF CARE

Chronic conditions are the leading cause of illness, disability and death in the USA and account for the majority of healthcare expenditures [1]. As the population ages and the number of chronic illnesses per person increases [1, 2], patients more commonly require a multiplicity of providers, resulting often in fragmentation of care [2, 3].

In recognition of the fragmented US healthcare delivery system, policy-makers are advocating for improvements in the coordination of care between healthcare providers [4–6]. Coordination of care refers to the process in which different professional groups work together to positively impact health care’ [7]. Coordination of care and interactive communication between primary care providers (PCPs) and subspecialists is associated with improved health outcomes for patients with diabetes and other chronic illnesses [8]. For patients with chronic kidney disease (CKD) and end-stage kidney disease (ESKD), it is well documented that coordination of care and interdisciplinary care teams confer considerable health benefits to patients with CKD including earlier consultation for nephrology care, reduced morbidity and mortality, and reduced healthcare utilization and costs [9–11]. Greater coordination of care is needed because care for patients with severe CKD by PCPs alone can be suboptimal to PCP care without nephrologist involvement [12–15].

Based on this evidence, clinical practices have implemented numerous approaches to foster coordinated care, including integrating electronic health records (EHRs) and developing multidisciplinary care clinics [16]. Most of these measures are being implemented in the USA and have the potential to improve certain aspects of care coordination. In contrast, telemedicine has received relatively less attention, despite holding great promise for comprehensively improving coordination of care among providers for chronic disease.

In this article, we propose telenephrology as an innovative approach that enables providers to facilitate cohesive and coordinated care between PCPs and nephrologists for patients with CKD. Telenephrology shows promise for...
optimizing patient health care by addressing deficiencies of the underlying healthcare structure contributing to poor patient care. We conclude by highlighting avenues for future research specific to telenephrology and by offering a cautionary perspective about the ethical dimensions of telemedicine.

The need for coordination of care between PCPs and nephrologists

Despite current efforts to enhance coordination of care in the USA, healthcare delivery remains highly fragmented for CKD and ESKD patients [17, 18]. The lack of coordination between PCPs and nephrologists and of a coordinated system of care for patients were identified by nephrologists as factors contributing to poor CKD patient outcomes, including progression of CKD to ESKD [19].

Although patients with mild CKD may be managed adequately by PCPs alone, patients with severe CKD typically require and benefit substantially from the additional care from a nephrologist [12–15, 20]. The nephrology knowledge deficits of PCPs [21], and negative perceptions about communication with nephrologists [22], as well as the relative scarcity of nephrologists, can result in either late, infrequent or absent nephrology care for patients with advanced CKD [23], and limit patients’ access to timely nephrology consultation [24–27]. In two interview studies of PCPs, investigators found that many PCPs perceived poor communication with nephrologists, negative feedback from nephrologists regarding their referral decisions and confusion over; or an uncoordinated approach to; the coordination of patient care with nephrologists as contributing factors to poor referral patterns [22, 28].

Although models of PCP-specialist collaboration for the care of CKD patients have been proposed [29–31], only a few collaborative care models have been implemented [32–34]. A national study of the willingness of PCPs and nephrologists to collaborate in the care of patients with progressive CKD found that most physicians (89%), albeit more nephrologists than PCPs (94 versus 85%), desired collaborative care, with PCPs maintaining a primary role in patient care [32]. A third (29%) desired collaboration at least every 2–3 months. The types of nephrology guidance PCPs desired included (a) confirmation of appropriate clinical evaluation, (b) guidance about additional evaluation and testing, (c) medication regimen advice and (d) nutritional advice [32]. However, the study did not assess PCPs’ preferences of ways to obtain information from nephrologists. These findings suggest that innovative approaches are urgently needed to optimize the use of nephrology resources and to improve the coordination of care.

The role of telemedicine in collaborative care

Telemedicine has been increasingly used over the past decade to promote coordinated and collaborative care, improve patient health outcomes, and address underlying structural problems in healthcare. The American Telemedicine Association (ATA) defines telemedicine as: ‘the use of medical information exchanged from one site to another via electronic communications to improve patients’ health status’ [35]. The World Health Organization identified four defining characteristics of telemedicine:

1. Its purpose is to provide clinical support.
2. It is intended to overcome geographical barriers, connecting users who are not in the same physical location.
3. It involves the use of various types of information and communication technologies (ICTs).
4. Its goal is to improve health outcomes [36].

In this regard, telemedicine provides healthcare providers an opportunity to consult with specialty care on behalf of their patients. Telemedicine may also provide healthcare providers in remote settings with collegial support and relieve feelings of professional isolation.

Telemedicine applications include the use of videoconferencing, transmission of still images, e-health including patient portals, remote monitoring of vital signs, continuing medical education and nursing call centers and application service provider technology [35, 37]. Recognized as constituting a growing set of innovative processes for delivering care as opposed to a single technology [38], telemedicine can be classified into three types of applications (Table 1):

1. ‘Real-time’ videoconferencing [39],
2. Store-and-forward applications, which entail the transmission via email of medical or laboratory data and images to an expert for remote review [37, 40, 41],
3. Remote monitoring and/or care coordination.

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<th>Table 1. Current and potential applications of telenephrology</th>
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<td>Current applications</td>
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<td>E-consults</td>
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<td>Videoconferencing</td>
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<td>Store-and-forward</td>
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Telemedicine has been implemented across diverse forms of subspecialty care, including management of chronic diseases (i.e. diabetes, cancer), pediatrics and disabled veterans [42–44]. According to the American Telemedicine Association, telemedicine has been used for over 40 years [45], with 200 operating networks connecting over 2500 institutions within the USA [46].
Provider–provider telemedicine

Although most research on telemedicine has concentrated on patient–provider communication, much less has focused on provider–provider telemedicine, which has great potential to improve communication and care coordination among providers. Although there have not been any clinical trials of telenephrology interventions, a few descriptive studies of provider–provider telemedicine have generated a host of improved outcomes at the inter- and intra-provider [47, 48] and patient [48, 49] levels. For example, provider–provider telemedicine has been associated with changes in the clinical treatment plan; transfers for definitive diagnosis; a reduction in the number of unnecessary patient transfers or specialist consultations [47, 50], hospital admissions [49] and laboratory examinations; [51] improved metabolic and hemodynamic parameters [49]; improved provider-to-provider communications [47, 48]; and cost-effective care [47, 52]. Moreover, telemedicine facilitates patient-centered care beyond the traditional office or hospital-based setting [53].

An innovation highlighted by Project ECHO (Extension for Community Healthcare Outcomes), a state and privately funded project piloted in New Mexico focusing initially on hepatitis C care, entails the use of technology to ensure that PCPs are as well informed about this disease as possible [54, 55]. The use of information technologies in Project ECHO facilitates and supports the provision of care by ‘disease-specific learning networks’ of PCPs (physicians, nurses, physician assistants) [43]. These learning networks meet weekly with specialists at the University of New Mexico Health Sciences Center via videoconferencing to review and discuss cases as ‘virtual grand rounds’, and learn from brief didactic presentations provided by specialists that address issues emerging from prior videoconferences. In this model, the specialist does not assume care of the patient, but rather jointly manages the patient’s chronic illness using a web-based disease management tool.

The Department of Veterans Affairs (VA) has since spearheaded provider–provider telemedicine with its Specialty Care Access Networks—Extension for Community Healthcare Outcomes (SCAN-ECHO) programs initiated within the Office of Specialty Care under a Transformational Initiative to improve access to and quality of specialty medical services [56]. A Specialty SCAN-ECHO Core Team of health professionals at tertiary medical centers are using telemedicine applications (e.g., videoconferencing) to ensure that PCPs in rural and medically underserved areas have access to specialist expertise in developing clinical treatment plans for patients with diabetes, chronic pain, hepatitis C and chronic heart conditions [43]. Another novel form of telemedicine being launched in VA is electronic-consults (e-consults), which entail non-face-to-face contact between PCPs and specialists within the electronic health record to manage a patient’s chronic disease [57]. The e-consult program entails the PCP placing a consult request in the EMR, which goes to the specialist, who then reviews the patient’s EMR, and then responds with a consultation note in the EMR. The PCP can then review the note at his or her convenience. E-consults and other store-and-forward applications comprise simpler ways in which technology can support collaborative care without requiring providers to coordinate their schedules, which may not always be feasible. E-consults (which can be done sitting at a desk) can be used for ad hoc communications as well as formal consults, but require that PCPs to establish a timeframe for a response from a specialist, e.g. 1 week. As provider–provider telemedicine is still within its infancy, such programs have not been formally evaluated.

The Alaska Federal Healthcare Access Network (AFHCAN) is another noteworthy telemedicine program that provides healthcare services to underserved rural residents in Alaska, USA. AFHCAN uses a ‘store-and-forward’ telehealth platform by linking 248 sites, including 158 village health centers, to facilitate provider–provider consultations within its collaborating network of different health care systems, e.g., VA, Department of Defense (DOD), Department of Transportation, the Department of Homeland Security (USCG), Indian Health Service (IHS), and the Alaska Native Tribal Health Consortium (ANTHC) [58–60].

Survey studies of PCPs and specialists document a high level of satisfaction with the provider–provider telemedicine consultation format, such as interactive videoconferencing [50, 61]. Providers report that telemedicine consults are useful for developing a diagnosis and treatment plan [50], promoting shared decision-making and streamlining patient care [61], making efficient use of provider time [50, 62], and reducing disruptions compared with contacts by telephone or pager [62].

Telenephrology: the unique application of telemedicine to kidney disease

The application of telemedicine to care for CKD and ESKD patients—herein referred to as telenephrology—has been widely adopted in European countries, but its adoption in the USA has been relatively slow [63–71]. Although there are anecdotal reports of some healthcare systems and major medical centers implementing telenephrology programs, these are not well documented in the scholarly literature. A noteworthy example is the use of telenephrology within the Indian Health Service (IHS). This service is led by Andrew S. Narva, MD, director of the National Kidney Disease Education Program (NKDEP), and provides telemedicine consults for patients in the Zuni Indian Health Service (IHS) [46]. The program’s biweekly telenephrology clinics via videoconferencing focus predominantly on patient–provider encounters [72]. Key features of this program’s success are secure access to the patient’s electronic health record and the presence of a case manager (e.g. nurse) on site with the patient, both of which facilitate discussion of patient cases (Andrew Narva, MD, personal communication, 4 March 2012). While provider–provider telemedicine programs have been implemented in the Indian healthcare system for some clinical specialties (e.g. ophthalmology, dermatology, cardiology), telenephrology services have typically focused on secure patient–provider interactions (Mark Carroll, MD, IHS Telehealth Program Coordinator, personal Communication, 21 March 2012).
Telenephrology in chronic kidney disease

The few available provider-provider telemedicine applications that pertain to nephrology (Table 1) do not focus squarely on telenephrology, but rather include nephrology as one of the several clinical conditions served [63, 66, 73–75]. For example, Gómez-Martino et al. [63] arranged for Internet communication followed by real-time videoconferencing between providers and CKD patients in Spain and found that telenephrology is feasible, and reduced the number of hospital visits and in-hospital consultations. In an international program established by Graham et al. [75] in Nepal, doctors used email to specialists detailing patient history, examination and questions. Relevant digital images of diagnostic radiologic studies (e.g. chest X-rays, electrocardiograms, computerized tomography scans) were sent using store-and-forward technology. Specialists were from the USA, UK, Australia, Bangladesh, and specialized in nephrology, respiratory medicine, neurology, dermatology, cardiology and radiology. During 12 months, three consult requests were sent to nephrologists, and the average speed of nephrologist reply was 1 day. Specialists provided help with establishing a diagnosis (57% helpful, 43% very helpful), and making a management plan (77% helpful, 23% very helpful). These studies illustrate that low-cost telemedicine is feasible and effective [75].

Beyond these telemedicine studies, relatively little research has been conducted on the impact of provider-provider communication and coordination on patient care in chronic conditions overall [37]. More broadly, research on telenephrology had a low level of methodological rigor, included few patient- or clinician-related outcome measures, and was based on small numbers of PCPs and nephrologists [65, 74].

Credentiaing, reimbursement, logistics and ethics

In the course of implementing telemedicine, a number of issues dealing with credentialing and licensure need to be addressed. Traditionally, each state and healthcare facility has its own processes and procedures for medical licensure and credentialing. While some states have separate telemedicine licensing, others do not have a formal process to certify a provider in telemedicine. Since telemedicine applications often cross state borders and different facilities, the potential need to obtain licensure and credentialing from several states and facilities can become an obstacle. In an effort to reduce the burden and duplicative nature of these processes, congressional bills and federal policies have attempted to simplify the credentialing process and encourage its flexibility [76, 77].

Policies and procedures for telemedicine reimbursement continue to evolve and remain in transition. The Centers for Medicare and Medicaid Services (CMSs) does not make a distinction between the reimbursement of ‘face-to-face in-person’ physician–patient encounters and the reimbursement of telemedicine provider–patient encounters for a few select specialties (e.g. psychiatry). However, CMS does make this distinction for many other specialties where CMS will not reimburse services unless they are provided in person [78]. While some state Medicaid programs have been more progressive, some programs remain reluctant to pay for telemedicine encounters. Most reimbursements are provided to physicians at both ends of telemedicine services (the hub and spoke sites) through state Medicaid programs on the traditional fee-for-service basis [78]. This applies in Illinois where, for example, Medicaid reimburses physician consultations delivered through interactive video teleconferencing [78]. As an international advocate of telemedicine, the ATA has petitioned the Obama administration to include telenephrology in healthcare reform, and a few state legislatures have included bills to address telemedicine reimbursement [77]. Given that policies have focused on the provider–patient interface, it remains to be determined how provider–provider telemedicine will be reimbursed.

Telenephrology is applicable to academic centers, private practice settings and federal agency settings. In particular, federal agencies such as the IHS have spearheaded the implementation of telemedicine as a cost-effective way to improve access to care for traditionally underserved rural populations [79, 80]. There has also been growing interest and uptake of telemedicine by private groups. Academic centers may have an advantage over private practice settings in terms of conducting research on such applications. Notably, academic centers may have a greater availability of financial resources and higher density of clinicians to better serve as the hub of telenephrology applications. Additionally, the greater infrastructural supports in academic settings may facilitate research that aims to evaluate telenephrology improvements and outcomes.

Before embarking on implementing telenephrology applications, it is important to consider several logistical concerns regarding barriers and facilitators to deploying such applications [70, 81, 82]. Scheduling set times for PCPs and nephrologists for telemedicine interactions may be challenging in busy practice settings where the day-to-day clinical workload is often unpredictable. Moreover, coordinating and scheduling interdisciplinary team meetings among specialists and primary care teams may be difficult. Secondly, while videoconferencing equipment has become more widespread, it is still not sufficiently available and supported within many facilities to enable the sort of rapid access to consultation that a robust provider–provider consultation service requires. Granted, substantial infrastructure may not be in place to support the provider’s use of telemedicine. Notably, favorable reimbursement incentives alone do not enhance adoption; developing habits in telemedicine use is an important determinant of telemedicine adoption. A key cultural factor influencing the use of telemedicine by the providers is beliefs about how to provide good clinical care: more telemedicine nonusers than users believed that a patient’s physical presence is important for diagnosis [70, 81]. Additionally, clinicians should be mindful of the potential unintended consequences of telemedicine on healthcare practices [83, 84], including broad changes in work processes, organizational restructuring and effects on employees not directly involved in telemedicine [83]. Appropriate compensation for provider time and efforts in such clinical interactions will need to be developed.

For nephrologists, concerns remain around responsibility and liability, particularly as it pertains to responses to ad hoc
questions, where a complete review of patient information by the nephrologist has not occurred. In general, clear evidence for the existence of a formal physician–patient relationship is required for professional liability and any malpractice claim. This would likely be applicable in telemedicine applications such as formal case-based presentations by a PCP to a nephrologist where there is a shared understanding among providers and the patient that specific professional services are being delivered for the patient’s care [85]. Although the patient is not present for this interaction, this situation is similar to that of radiologists and pathologists, who frequently render services to patients without contact and are generally perceived liable by courts for failing to act consistent with the standard of care [85]. However, similar to ‘curbside’ or informal consults between PCPs and subspecialists, ad hoc questions in telemedicine would appear not to constitute a formal physician–patient relationship, regardless of the mode of communication; therefore, the malpractice risk would appear to be minimal [85].

Ethical dimensions to telemedicine should be addressed prior to implementation to ensure that it is deployed in an ethically sound manner. Ethical issues for patients that need to be addressed include privacy, confidentiality and informed consent. Relatedly, telemedicine influences the provider–patient relationship, which can bear upon ethical concerns such as the capacity for equitable treatment, cost, quality of life and exploitation [86, 87]. Telemedicine should also promote the equitable access to quality healthcare for all patients [88, 89]. One could argue that concerns about privacy and confidentiality should not hinder efforts to implement telemedicine, considering that the ethical obligation to ensure patient access to care may comprise a greater duty than protecting patients’ privacy and confidentiality once care has been provided.

**Future research in telenephrology**

Based on the evidence from provider–provider applications conducted to date, telenephrology holds great promise for improving the care of CKD and ESKD patients. Research is needed to evaluate telenephrology applications and implementation approaches with the aim of optimizing the delivery of subspecialty nephrology care for patients with CKD in the USA.

A proposed model of one telenephrology application (i.e. videoconferencing) is provided in Figure 1. This model illustrates the set of interactions that would occur between

![Diagram](https://example.com/diagram.png)

**FIGURE 1:** Types of consultation interactions through telenephrology videoconferencing.
### Table 2. Proposed telenephrology outcomes and potential data sources

<table>
<thead>
<tr>
<th>Provider outcomes</th>
<th>Data sources</th>
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<tbody>
<tr>
<td><strong>PCP perceptions/preferences</strong></td>
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<tr>
<td>Competence in patient management</td>
<td>Interview/survey</td>
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<tr>
<td>Interruptions in workday/workflow efficiency</td>
<td>Interview/survey</td>
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<tr>
<td>Access to nephrology consultation and <em>ad hoc</em> questions</td>
<td>Interview/survey</td>
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<tr>
<td>Ease of developing a consensus care plan with nephrologists for patients</td>
<td>Interview/survey</td>
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<tr>
<td>Ease of carrying out a cohesive, unified management plan with nephrologists for patients</td>
<td>Interview/survey</td>
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<tr>
<td>Obtaining timely feedback from a nephrologist about patients</td>
<td>Interview/survey</td>
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<tr>
<td>Quality of the feedback received from nephrologists about referred patients</td>
<td>Interview/survey</td>
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<tr>
<td>Overall quality of coordinated care with nephrologist</td>
<td>Interview/survey</td>
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<tr>
<td>Satisfaction with telenephrology</td>
<td>Interview/survey</td>
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<tr>
<td><strong>Nephrologist perceptions/preferences</strong></td>
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<tr>
<td>Appropriateness of patient referrals from PCPs</td>
<td>Interview/survey</td>
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<tr>
<td>Interruptions in workday/workflow efficiency</td>
<td>Interview/survey</td>
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<tr>
<td>PCPs refer CKD patients to nephrologists on a timely basis</td>
<td>Interview/survey</td>
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<tr>
<td>Coordination of care with PCPs</td>
<td>Interview/survey</td>
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<tr>
<td>Ease of providing feedback to PCPs about their referrals</td>
<td>Interview/survey</td>
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<tr>
<td>Ease of developing a consensus care plan with PCPs</td>
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<td>Ease of carrying out a cohesive, unified management plan with PCPs</td>
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<td>Overall quality of coordinated care with PCPs</td>
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<tr>
<td>Satisfaction with telenephrology</td>
<td>Interview/survey</td>
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<tr>
<td><strong>PCP Knowledge</strong></td>
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<tr>
<td>Knowledge about recognition and management of CKD</td>
<td>Interview/survey</td>
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<tr>
<td>Knowledge about recognition and management of CKD risk factors</td>
<td>Interview/survey</td>
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<tr>
<td>Knowledge about recognition and management of CKD complications</td>
<td>Interview/survey</td>
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<tr>
<td>Knowledge about indications for nephrology referral</td>
<td>Interview/survey</td>
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<tr>
<td><strong>PCP Behavior</strong></td>
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<tr>
<td>Prescriptions of protective renal medicines (ACE-I/ARBs)</td>
<td>MCR</td>
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<tr>
<td>Urine screening for protein</td>
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<td>Frequency of GFR checks</td>
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<td>Frequency of BP checks</td>
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<td>Unnecessary referrals</td>
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<td>Late referrals</td>
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<td><strong>Patient outcomes</strong></td>
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<td>Intermediate outcomes</td>
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<td>BP control</td>
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<td>GFR change over time</td>
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<td>Urine protein change over time</td>
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<tr>
<td>Prevalence and severity of anemia</td>
<td>MCR</td>
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<tr>
<td>Prevalence and severity of secondary hyperparathyroidism</td>
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*All data sources are indicated as Interview/survey or MCR (Medical Chart Review).*
a PCP and nephrologist, including case-based presentation consults, didactic presentations on key nephrologic topics and ad hoc questions. The topics for such interactions would flow primarily from the PCP to the nephrologist, although discussion both ways is to be expected, as well as education from the nephrologist to the PCP. Two additional benefits afforded by videoconferencing are real-time didactic presentations and the dynamic information exchange, e.g. follow-up questions based on response to the initial question. Given that PCPs have previously expressed the desire for more education from nephrologists, e.g. regarding referral criteria, videoconferencing can benefit PCPs through its didactic capacity. Specific examples of content of such interactions are provided in Figure 1. These interactions will address the problem of poor communication that contributes to low referral and poor CKD care by providing PCPs the opportunity to ask ad hoc questions in real-time rather than through chart notes that preclude live discussion. In effect, such interactions are anticipated to improve coordinated and integrated care, increase efficiency of nephrologist clinical practices, improve patient health care and outcomes, and also reduce costs of care. Similarly, didactic lectures through telenephrology are expected to redress knowledge deficits of the PCP. Preliminary evidence of Project ECHO’s effectiveness include the PCP’s perceptions of increased knowledge and expertise in managing the patients’ diseases, and improved patient health [55, 90]. Table 2 outlines current and potential applications of telenephrology.

Provider–provider studies in other chronic diseases utilize several measures that may be worth assessing, including implementation and reach of programs (i.e. number of patients served) [43, 63], provider objective variables (objective knowledge, skills and behavior) [43], provider perceptions (perceived expertise in chronic disease management, connectivity to and respect by academic specialists, and the perception that patients are receiving best-practice care) [55], provider satisfaction [43], treatment behavior change (i.e. use of and adherence to appropriate treatments and diagnostic processes for target conditions) [43], clinical outcomes (i.e. physiologic outcomes, morbidity, mortality and hospitalization) [43] and cost of care [43]. Such measures can be directly adapted to the telenephrology context. We recommend that additional, kidney disease-specific outcome measures be evaluated for telenephrology provider–provider applications, especially in regard to videoconferencing (Table 2). Such measures could be used to evaluate the short- and long-term outcomes of the PCP–nephrologist interactions as proposed in Figure 1. Moreover, a sociocultural analysis of the content and structure of communicative interactions should be
CONCLUSIONS

By improving coordinated and collaborative care between PCPs and nephrologists, telenephrology holds great promise for improving the health of patients with CKD and ESKD. However, relatively little is known about the telenephrology applications that focus on provider–provider interactions. As telemedicine is not experimental, future research should not focus on development within the nephrology context; rather, efforts should be directed towards adapting telemedicine from other clinical specialties to nephrology. However, more research is needed to evaluate implementation strategies that optimize provider–provider interactions and to facilitate coordinated care through the use of telenephrology. Additionally, evaluating the effects of telenephrology on care coordination as well as other clinical practice and clinical outcome parameters may provide important insights into the scope of telemedicine’s potential benefits. As telemedicine applications continue to expand, greater clarity is needed for establishing business-policy models that most effectively support providers in their provision of care to patients.

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CONFLICT OF INTEREST STATEMENT

None declared.

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