Access to Kidney Care: Global implications for workforce capacity and use of electronic consultations to facilitate kidney care

by

Mohamed A. Osman

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

Department of Medicine
University of Alberta

ABSTRACT

Chronic kidney disease (CKD) is increasingly recognized as a global public health issue due to rising prevalence, associated adverse health outcomes and substantial economic impact. To address this problem, countries need health system strengthening, and the health workforce is considered the cornerstone of any health care system. An adequately trained and sufficiently staffed workforce is essential to reach universal health coverage. In particular, the nephrology workforce is critical to stem the tide against CKD burden. Nonetheless, there are critical gaps in the evidence on the current global nephrology workforce capacity. The overall objective of this thesis was to research access to kidney care through two separate, yet related, aspects of kidney care delivery namely global nephrology workforce capacity and role of telenephrology.

Three separate studies were conducted to achieve this objective. First, we conducted a multinational cross-sectional survey administered under the auspices of the International Society of Nephrology (ISN). The questionnaire was administered online, and all data were analyzed and presented by ISN regions and World Bank country classification. Overall, 121 countries responded to survey questions pertaining to nephrology workforce. We identified a global nephrologist density of 8.83 per million population (PMP), and we found significant variation in the global density of nephrologists between low-income and high-income countries (0.31 PMP vs. 28.52 PMP) and between ISN regions (lowest density in Africa and South Asia regions).

Secondly, we conducted a review of the literature on health information technologies looking for its potential applications to enhance global kidney care and in workforce specifically. The analysis of the literature identified that telenephrology would

be an indispensable mechanism to close the identified gaps in kidney workforce, particularly in low and middle-income countries.

Finally, we leveraged a local initiative on a specific type of health information technology named electronic consultations (eConsult) to assess the barriers and facilitators to its wider adoption and implementation. We used scoping review synthesis method to identify the factors that favor or hinder eConsult adoption.

This work contributes to the knowledge of current global nephrology workforce capacity and provides potential solutions on how to address identified gaps using telenephrology and eConsult specifically. Although this study was focused on access to kidney care, the findings are potentially useful in other chronic conditions.

PREFACE

The research presented in this thesis is original work conducted by Mohamed Osman under the supervisory committee that included (Dr. Aminu Bello [main supervisor], Dr. Scott Klarenbach [co-supervisor], and Drs Kara Schick-Makaroff and Stephanie Thompson).

Some of the work referred to in this thesis, has been published, is currently under peer-review for publication or is in preparation to be submitted as a publication.

Each of the manuscripts presented here, the first author (Mohamed Osman) was involved in study design, conducted the data collection, data analyses, interpreted the results and wrote the manuscripts. All three studies were completed under the guidance of the supervisors and supervisory committee. All other authors contributed important intellectual content and provided critical reviews of the papers.

Chapter 2: Osman MA, Alrukhaimi M, Ashuntantang GE, et al. Global nephrology workforce: gaps and opportunities toward a sustainable kidney care system. *Kidney Int Suppl*. 2018;8(2):52-63.

Chapter 3: Osman MA, Okel J, Okpechi IG, Jindal K, Bello AK. Potential applications of telenephrology to enhance global kidney care. *BMJ Glob Health*. 2017;2(2):e000292.

Chapter 4: Osman MA, Schick-makaroff K, Thompson S, et al. Barriers and facilitators for implementation of electronic consultations (eConsult) to enhance specialist access to care: a scoping review protocol. (In Press, *BMJ Open*, 2018) .

The research project, of which this thesis is a part, was approved by the University of Alberta Research Ethics Board: (Protocol number: PRO00063121).

DEDICATION

This work is dedicated to

~ First and foremost, to my loving mother

~ To my dear father and inspiration

~ To my best friend, my wife Aisha

~ To my beautiful daughter Asiya

~ To my wonderful siblings Mariam, Fatima, Ali and Hassan

~ To my supervisor, and role model Dr. Aminu Bello

~ And to whoever helped me in my journey

ACKNOWLEDGMENT

I am grateful to Allah for blessing me with the ability and opportunity to undertake this work. Here I would like to show my appreciation to many people how kindly supported me in my masters.

First and foremost, I would like to express my sincere gratitude to my supervisor, Dr. Aminu Bello. Thanks for believing in me and providing this opportunity to do research and grow personally and professionally. Without your continuous support, invaluable feedback and encouragement, this work would not have seen the light. I would also like to thank my co-supervisor, Dr. Scott Klarenbach, for his excellent advice and expertise on my thesis project. I also extend my thanks to the committee members, Dr. Kara Schick-Makaroff and Dr. Stephanie Thompson for their suggestions and review that significantly enhanced my understanding and presentation of this thesis. I feel fortunate to have such supportive and knowledgeable supervisors and committee team as mentors.

I also like to thank the staff at the Alberta Strategy for Patient-Oriented Research (SPOR) Knowledge Translation Platform: Liza Bialy, Dr. Meghan Sebastianski and Robin Featherstone for their tremendous support on the scoping review.

Thanks to Drs David Johnson (University of Queensland) and Ikechi Okpechi (University of Cape Town) for their constructive feedback on the first manuscript as part of their role on the steering committee of the Global Kidney Health Atlas (GKHA) study.

Thanks to all the staff at the Kidney Health Research Group particularly Natasha Wiebe, Sophanny Tiv, Feng Ye and my colleagues for their fantastic support throughout my master's program.

Finally, my sincere appreciation to the Interdisciplinary Chronic Disease Collaboration (ICDC) and the program leads (Drs Brenda Hemmelgarn, Braden Manns and Marcello Tonelli). I also wish to extend my appreciation to Dr. Kailash Jindal (Medical Director of the Northern Alberta Renal Program [NARP]) for providing me with the support to complete my graduate training program in Medicine. The generous funding from the ICDC and NARP provided me with this invaluable training opportunity.

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Chapter 1 : Introduction

1.1 Thesis overview

The overarching goal of this thesis is to research access to kidney care through two separate, yet related, aspects of kidney care delivery namely nephrology workforce capacity and role of telenephrology.

- The two central research questions were:
  1. What is the current capacity for nephrology workforce across the world?
  2. What is the role of telehealth in closing the identified gaps in workforce capacity, as well as key barriers and facilitators for implementation?

- The following aims and objectives guided the answers to these questions:
  Research objectives
  1. To determine the existing global nephrology workforce capacity.
  2. To review the role of health information technology to enhance access to specialist kidney care.
  3. To undertake a broad examination of the eConsult implementation literature, including published and gray literature, focusing on barriers and facilitators to eConsult implementation.

1.2 Thesis structure

The Thesis is divided into three parts: 1) introductory chapter to define concepts and approach, 2) thesis body consisting of three chapters formatted for independent publication and compiled here to form a thesis in conformity with the University of Alberta guidelines on paper-based theses and 3) discussion and conclusions chapter.

Chapter 1 is to set the stage, explore the central concepts that underline the thesis (access to care, universal health coverage, and health care systems), and provide a brief review of health workforce, chronic kidney disease burden, and health information technology in the context of kidney care. Additionally, sources of research data and objectives are described. **Chapter 2** presents the results from the survey administered under the International Society of Nephrology. **Chapter 3** presents the findings from a narrative review of the literature on the role of telenephrology in kidney care. **Chapter 4**

presents the results from the scoping review on factors influencing the implementation of eConsult to enhance access to specialist care. Finally, **Chapter 5** is a discussion of the research findings and the thesis implications for research and practice (**Figure 1.1**).

1.3 Concept of access to care

In both academic research[1,2] and public policy,[3] the fundamental importance of equity in access to health care is recognized. However, "access to care" is not well defined nor used consistently,[1] due in part to using the term synonymously with other distinct terms, such as availability and affordability.[1] Many attempts have been made over the last four decades to conceptualize access to care.[1,4,5]

Access to care was first operationalized in what later became known as the Anderson behavioral model of access to care.[1] In 1974, Anderson and Aday reviewed the literature to create a theoretical framework and provided a recommendation on how to synthesize empirical indicators from their structure (**Figure 1.2**).[1] The authors divided factors influencing access to care under the umbrella of health policy into inputs (process) and outputs (outcome) variables that were connected and interdependent.[1] Five variables made up the framework: 1) health policy; 2) characteristics of health delivery system; 3) characteristics of population at risk; 4) utilization of health services; and 5) consumer satisfaction.[1] The Anderson model recognized three main factors that determine a population's access to care: 1) predisposing factors (e.g., age, sex, race); 2) enabling factors (e.g., income, geographical location); and 3) need factors (e.g., illness level, willingness to seek care). In 1995, Anderson revisited the framework to address critiques of the model and more importantly to further develop it by including factors related to the environment and health outcomes.[6] In addition, Anderson acknowledged that access to care is not linear but an iterative process reflecting the dynamic nature of the real world.[6]

Building on the original Anderson model, in 1981 Penchasky and Thomas theorized the concept of access to care as the degree of "fit" between the customer and customer care provider.[4] The focus of their framework was barriers to health care access. The authors identified and validated five distinct dimensions to measure this general concept: availability, accessibility, accommodation, affordability, and acceptability.[4]

Further development of the concept of access to care incorporated other aspects such as access to specific populations (e.g., rural/remote dwellers)[7] and for different providers (e.g., nurse practitioners).[8] More recently a framework calling for an explicit role of public health systems in health care access was developed.[5] The framework identified the public health role in access to care using the three core functions that underpin public health work, namely assurance (oversight), assessment (monitoring, evaluation), and policy development.[5]

The theoretical framework of this thesis was based on the Anderson model of access to care.[1] The first part of the thesis fits within the process indicator variables, focusing mainly on workforce as an essential input variable in any health delivery system.[1] In the Anderson framework, characteristics of the health delivery system were divided into resources and organization, with resources further subdivided into workforce and finance. The authors described collecting workforce data as a means of measuring access to care especially when a health delivery system is the unit of analysis.[1] The second part of this thesis was a review of the factors that affect implementation of eConsult to enhance access to specialist care. I hypothesized that eConsult fit within the outcome indicator variables of the Anderson framework of access to care as an input variable in health services utilization.[1] I depicted the proposed work to study access to kidney care on the original framework (**Figure 1.2**).[1]

1.4 Universal health coverage

The World Health Organization (WHO) has defined the right to health as containing the four key components of availability, acceptability, quality, and accessibility.[9] Starting in the 1970s, WHO led the earliest global quest to achieve "Health for All"; this was followed notably by the Alma-Ata Declaration of 1978, when world health ministries declared the goal to achieve health for all in the year 2000 and identified primary health care as key.[10] Although this promise was not fulfilled, the declaration provided the foundation for several efforts that followed, most importantly the Millennium Development Goals (MDGs) declared in 2000.[11] While all the MDGs influence health, three of the eight goals specified health care directions (reduce child mortality, improve maternal health, and combat communicable disease).[12] Compared to earlier declarations, the objectives of the MDGs were more precise.[11,13] However, shortcomings of the MDGs relevant to this thesis were that they ignored non-communicable diseases (NCDs), including kidney disease, and the importance of health systems strengthening (HSS) to achieve sustainable developments.[12,13] To address this, the MDGs were followed in 2015 by the more ambitious Sustainable Development Goals (SDGs).[12,14] Under the three broad dimensions of sustainable development (social, economic, environmental), the SDGs contain 17 goals with 169 targets; notably, NCDs were added directly as a separate target and indirectly in many other targets.[12]

Universal health coverage (UHC) represents a central goal of the SDGs.[12] As well, UHC is number one on the list of priorities for the current WHO leadership.[15] A visual concept of UHC was presented in the WHO World Health Report 2010 (**Figure 1.3**).[16] In this "box-within-a-box" representation, the three dimensions are related to: 1) population covered (who); 2) services covered (what); and 3) cost covered (how much). The first two dimensions reflect access to coverage for health services while the third dimension is related to access to care while protecting against catastrophic health care spending.[16] The underlying premise for UHC is the outcome that everyone (populations) has access to needed health care (services) without financial hardship (costs).[16]

All countries strive to achieve UHC for their citizens by applying the same three dimensions;[17] however, because of their different economic development stages, countries can face different sets of challenges that create demand on funds.[17] For instance, in high-income countries (HIC) challenges come from the demographic shift in an ageing population,[18] therefore priorities for UHC include extending more services coverage while working to contain the spiraling cost of care.[17] For low and middle-income countries (LMIC), challenges include the epidemiological transition leading to the double burden of communicable and non-communicable diseases, making their priorities extending essential services to everyone with scarce resources.[17] Even though no single set of interventions exist for counties to deliver UHC optimally, a framework to monitor countries' progress towards UHC was proposed based on measuring levels of interventions coverage and levels of financial protection (outcomes).[17] These outcomes of

UHC are direct results of inputs (polices, finance, workforce) and outputs (available services, pools of funds) of a health care system that together with other social determinants lead to better health (impact) (**Figure 1.4**).[19]

1.5 Health care systems

Globally, there is a considerable developmental assistance aid ($37.6 billion total in 2016) from governments, bilateral agencies and philanthropic donors (e.g., Gates Foundation) spent each year for health.[20] Most of these funds go to specific diseases. In fact, three diseases (HIV/AIDS, malaria and tuberculosis) represent more than one third (35.99% in 2016) of the spending share, while the share for all NCDs combined was less than 2% (1.71% in 2016).[20] It is acknowledged that these three diseases represent a global priority for improving health; however this single disease intervention approach has been criticized as exacerbating the burden on weaken health systems in LMIC.[21,22] Instead, HSS is increasingly considered by many as a more effective approach to improving health outcomes, especially for LMIC.[23,24]

WHO defines health systems as "consisting of all the organizations, institutions, resources and people whose primary purpose is to improve health."[25] For this study of access to kidney care on a global level, the WHO Health Systems Framework was leveraged.[26] This framework is based on six building blocks that together, through their interlinked dynamic relationship, make up a health system: 1) service delivery; 2) leadership and governance; 3) health workforce; 4) health information technology; 5) essential medical products; and 6) health finance.[26] The framework is well validated and used to assess interventions at the health care system level.[27] The WHO framework, however, has been criticized for being too rigid and less flexible to the realities of life.[28] Nevertheless, the framework provides useful standard metrics to measure, evaluate and monitor health care systems.[27] It came out of the need to measure the factors that systematically affect a health care system especially in regard to access and quality of care.[27] The framework allows for robust evaluation of a health care system, taking into account its complexity (rapidly changing, interlinked) and dynamic (non-linear) nature.

Furthermore, this system-level approach allows for the design and evaluation of health care interventions with consideration of all factors important for HSS.[27]

1.6 Workforce

1.6.1 General health workforce

Countries cannot achieve UHC without having an adequate qualified and equitable workforce delivering health care services.[12] Despite the increase in finance for health and rapid developments in information technology, medications and vaccinations, many LMIC have not achieved their MDGs targets.[12] There is growing consensus that this is primarily due to their overwhelmed, fragile and fragmented health systems.[29] In global health research, HSS is becoming the lingua franca to overcome this challenge.[30] And within HSS, the workforce is considered a bottleneck that is preventing the delivery of all the resources available for LMIC to achieve better health outcomes.[29,30]

WHO defines health workforce as "all people engaged in actions whose primary intent is to enhance health."[26] This definition includes both health service delivery staff and administration teams. In the literature, substantial evidence demonstrates the direct relationship between workforce density and better health outcomes.[31] It also shows a relationship between workforce density and achieving essential interventions coverage like vaccinations and skilled birth attendance.[31] Notwithstanding the evidence, many parts of the world and especially LMIC have a significant gap in their current workforce density.[32] The WHO workforce database revealed that HIC have more than three times the physicians and nurses per population as LMIC.[32,33] Furthermore, the gap is more evident in some areas; for instance, it is estimated that in sub-Saharan Africa countries, the projected shortage is more than 700 thousand physicians and 600 thousand nurses.[32]

Several factors are at work in the current situation. First, the capacity for training, for some countries, is insufficient.[32] For countries to produce a qualified workforce, they need investments in the two scarce commodities of time and money.[32] Secondly, even with countries that have adequate production, human resources loss outpaces production capacity. Migration from LMIC to HIC is often cited as a primary reason for the loss.[32] Finally, there is maldistribution in the current workforce; for instance, the maldistribution in skill mix (e.g., high ratios of physicians to nurses in some counties in South Asia and Latin America) and the maldistribution between rural and urban cadre of health workers.[31,32]

In a joint report by the World Bank and the Government of Japan[34] reviewing the experiences of 11 countries at different stages of UHC, the authors found that all 11 countries faced a challenge with human resources to achieve their goals. The challenges included shortage in current workforce production, absence of regulations and quality assurance, and maldistribution of the workforce.[34] They also provided some useful lessons from the countries' experiences with UHC, with examples such as Indonesia's reform of their accreditation process to address a vital segment of their health system workforce (i.e., personnel practicing without qualifications),[34] and the successful attempts by Brazil and Ethiopia to scale up their workforce through community health workers, an approach described as "non-traditional" and "flexible" routes of entry to workforce. The report concluded that a critical lesson from the review was that countries' pledges to UHC should be complemented by an equal pledge to reform workforce policies in terms of creation and retention, especially in countries that are still in the early stages of UHC.[34]

1.6.2 Nephrology workforce

In kidney care, many studies have already examined the state of the nephrology workforce in specific world regions.[35-38] In a review on the global nephrology workforce, Sharif et al. identified multiple factors responsible for a global shortage and suggested detailed and comprehensive nephrology workforce planning backed by government policy and legislation to ensure effective delivery and sustainability of kidney care.[35] Another study examined kidney care structures across 17 European countries and identified limited workforce capacity as a common barrier, among many others, to the care of people with non–dialysis-dependent chronic kidney disease (CKD).[36] However, despite the importance of health workforce for improving health outcomes, there is a lack of comprehensive evidence on the current global nephrology capacity and training, which is the first step towards nephrology workforce planning to meet the growing worldwide burden of kidney disease.

Due to the complexity of CKD management and its associated comorbidities (i.e., hypertension and diabetes),[39] the kidney care continuum ideally requires a diverse, multidisciplinary workforce.[40] Although there is no agreement on what constitutes the multidisciplinary team,[41,42] such a team may include nephrologists, primary care providers (PCPs),[40] nurse practitioners,[40,43] dietitians,[40] renal pathologists, laboratory technicians, social workers,[40] pharmacists,[44] vascular access coordinators,[45] nurse practitioners,[46] psychologists, transplant coordinators, dialysis nurses,[43] and dialysis technicians, working together in different capacities to provide quality kidney care.[40] In this thesis on the access to kidney care, I focused on the narrow yet important access to nephrologists.

1.7 Burden of chronic kidney disease

1.7.1 Prevalence of CKD

The prevalence of CKD is growing in all countries irrespective of their economic development stage.[47] This is in part due to the ageing population but more importantly due to the increasing prevalence of obesity and the two major risk factors for CKD, diabetes[48] and hypertension.[49] Moreover, there is increasing demand for kidney care including renal replacement therapy (RRT) in both HIC and LMIC.[47] On World Kidney Day in 2007, CKD was identified as a “Common, Harmful, and Treatable” condition.[50] This came after the paradigm shift in the understanding of kidney disease (in particular kidney failure) as a result of the introduction of the CKD staging system[51-53] (first in the 2002 Kidney Disease Quality Outcome Initiative [KDQOI],[51] then revised in the 2005 Kidney Disease: Improving Global Outcomes [KDIGO][52] consensus, which was further updated in 2012 to include proteinuria[53]). This staging system was criticized for labelling large segments of the population with disease and not considering specific age groups.[54,55] Nevertheless, it provided the much needed foundational ground to conduct robust epidemiologic studies,[56,57] predict progression to end-stage renal disease (ESRD) using equations,[58] synthesize management and referral guidelines,[59] and advocate for patient care.[60,61]

CKD is defined as structural damage (biopsy-proven or proteinuria [urine protein: creatinine ratio greater than 30 mg/g]) and/or decrease in function (estimated glomerular filtration rate [eGFR] <60 mL/min/1.73 m2 for > 90 days) of the kidneys.[53] Based on this definition, CKD is classified into five different stages.[53] The most recent systematic review and meta-analysis estimated the prevalence of CKD (all stages) at 13.4% of the world's population, or in other words, 1 in 10 people,[62] which represents a significant percentage of world's population. However, ESRD, the last stage of CKD previously known as renal failure, was only present in 0.1% of world's population.[62]

1.7.2 CKD care structure

Although CKD is associated with an increased risk of hospitalization[57] and hospital-acquired complications,[63] most CKD care (i.e., prevention, identification, detection, and treatment)[64] can be provided as ambulatory care.[65] This means the majority of patients (non-dialysis CKD) can be treated in primary care, however early specialist involvement in patient care is essential.[66] Therefore an effective, efficient partnership between the two levels of care is necessary.[67,68]

Kidney care is complex[69] and has characteristics that require a multidisciplinary approach, with the collaboration of PCPs and specialists at the center in patient care.[67,68] This care model is necessary due to many factors. For one, CKD is "Common."[50] The conceptual change in CKD classification and the subsequent estimation of CKD prevalence shed light on the enormous task ahead for kidney care providers. Traditionally nephrologists spend most of their attention and efforts in ESRD; the burden and prevalence of CKD show the importance of involving PCPs in kidney care. For another, CKD is "Harmful."[50] Adverse outcomes associated with CKD underline the importance of PCPs and specialist collaboration in prevention and early detection of CKD. In particular, the significantly high cardiovascular morbidity and mortality associated with CKD, even before reaching ESRD, makes CKD an independent risk factor for heart disease.[70] Furthermore, CKD requires a high index of suspicion in the form of laboratory screening in patients with risk factors[53] and in certain high-risk populations.[71] This is owing to the fact that CKD is a silent disease with no major signs and symptoms until later stages of the disease. CKD is also associated with a tremendous financial burden both at the individual household and health care system levels.[72] In Canada, it's estimated that ESRD care alone cost 1.2% of the total health care expenditure.[73] Similarly, in the United Kingdom, 2% of the CKD population consumed 1.3% of the National Health Service health budget;[74] and in the United States, where ESRD treatment is covered by Medicare, RRT accounted for 7.1% of overall expenditures.[75] Moreover, CKD burden is asymmetrical within and across countries. Globally, most of the CKD burden is found in LMIC,[76] where health care systems cannot meet patient needs for RRT.[47] Within nations, CKD burden was found linked to high deprivation index and low socioeconomic status.[77,78]

Finally, CKD is considered "Treatable",[50] albeit not curable. For patients who reach ESRD stage, there is the option of RRT, however this is prohibited by the high cost of dialysis and limited availability of organs for transplantation.[79] General treatment goals in CKD patient care are both narrowly focusing on slowing the progression of kidney disease (i.e., avoiding acute kidney injury and nephrotoxic drugs) and more broadly controlling risk factors for cardiovascular disease (i.e., diabetes and hypertension) and improving the overall quality of life.[50] Achieving these goals requires the presence of a qualified, multidisciplinary workforce and coordination of care between them.

Recent publications[41,80] have demonstrated the association between multidisciplinary care and reduction in mortality, hospitalization, and progression to ESRD, particularly in the later stages (4-5) of CKD. Although multidisciplinary care was found to be cost-effective in HIC settings,[81] the total cost of this model of care may not be feasible in many LMIC contexts where many demands are competing for a scarce pool of health care funds.[47] However, a recent systematic review on different care models for CKD in LMIC found that care models can be implemented in low resource environments to enhance CKD care.[82] Examples of such care models included task sharing with allied health professional and incorporating CKD care into national NCDs plans.[82]

1.8 Telenephrology

In nephrology, similar to other chronic conditions,[83,84] increased access to specialists is associated with improved outcomes in kidney care.[85] Early (pre-dialysis) care and longer nephrologist care was associated with reduction in mortality,[85,86] better use of appropriate medications,[87] and greater adherence to guidelines.[88] In Canada, timing to nephrologist referral was proposed as one of 17 quality indicators of CKD care in primary care settings.[89]

Since the introduction of eGFR reporting and the subsequent estimation of CKD prevalence, many studies (in HIC) reported increased referrals to nephrologists.[90] Studies also suggested that some of the referrals to specialists may be inappropriate.[91,92] The concentration of specialists in centralized metropolitan centers renders specialist care very limited, especially for remote/rural residents.[93,94] In LMIC, where kidney disease burden is estimated to be growing the most, access to specialist care is even more lacking.[95] In an editorial[96] on a study comparing specialist to non-specialist in kidney care,[88] Blantz identified optimizing the role of nephrologists as the way forward to improving care.

In many countries, specialists provide patient care primarily through referral from PCPs (i.e., family physicians, nurse practitioners), therefore PCPs act as gatekeepers to specialist care.[97] This model of care has the potential advantages of containing the excess costs that tend to be associated with specialist care (charge higher fees, use more resources)[98] and decreasing the wait time to see a specialist (through streamlined appropriate referral),[98] however it can lead to discontinuation and fragmentation of patient care.[98]

In the face of all these challenges, as well as the new emphasis on patient-centered care,[99] many countries have sought to use health information technology (HIT) in the form of telemedicine to extend the reach of specialist care and meet patient care needs.[100,101] Telemedicine is an all-inclusive term for any exchange of health information at a distance to provide and support health care using information technology.[102] Telemedicine has different modalities that include both real-time (synchronous) or store and forward (asynchronous) exchange of information. eConsult is an asynchronous form of telemedicine that involves the transfer of health information between PCPs and specialists through a secure web portal.[103] The application of different telemedicine technologies in kidney care is termed telenephrology.[104] Telenephrology initiatives are being shown to be widely accepted by practitioners and could offer rapid access to specialist input to kidney care. The impact of providers' and patients' experience of care, population health and costs is still unclear.

A recent systematic review intending to investigate the role of interventions affecting the nexus between primary and specialist care in improving access to specialist care found that although no "magic bullet" exists, best evidence was found in process changing interventions (structural changing).[105] Within this category, the most robust evidence was in two types of interventions: a) specialist consultation before referral; and b) electronic referrals.[105] The review pointed out the importance of considering all factors that influence implementation and adoption of any intervention and recognizing the effects of interventions on outcomes in addition to the process of care.[105]

1.9 Sources of data

1.9.1 Surveys

As the first step of the policy development cycle (formulation, implementation and monitoring), it is necessary to ascertain current workforce capacity in nephrology (formulation) to inform policy planning towards strengthening health care systems in kidney care.[106] Diverse methods (e.g., demographic census, labor force surveys, administrative data, and specialized surveys) exist to assess human resources for health.[107] All of these methods have advantages and disadvantages, and since there is no standard method to provides all the informations,[26] WHO recommends using either a single method or a triangulation of several methods to build a database on countries' human resources for health.[26]

WHO developed a core set of indicators that can be used to infer shortages in workforce in terms of numbers, distribution, training, and skill mix.[26] The first of these indicators is workforce density.[26] Density reflects an aggregate of numbers of workforce personnel relative to total population.[26] Although physician and nurse density are currently available in the WHO data repository of the global health workforce,[108] similar information on the nephrology workforce is particularly lacking for many parts of the world. Surveys with a representative response rate and validated questions permit the collection and comparison of workforce data among various countries.

Fortunately for this thesis, a global initiative by the International Society of Nephrology (ISN) to assess global kidney care status, leveraging the WHO Health System Framework, was underway. This allowed focus on the narrow, yet critical, workforce component of kidney care. This data was collected as part of a survey administered under the auspices of ISN using rigors methodology. The survey was administered to 130 countries with ISN affiliate societies; translation into three languages (English, Spanish and French) facilitated an increased response rate. Data was analysed and reported using the 4 World Bank income groups (divided by economic developmental stage) and the 10 ISN regions (divided by geographical and administrative convenience). The workforce part of the survey contained a two-part detailed questionnaire on nephrology workforce capacity and training.

1.9.2 Scoping reviews

Designing new interventions that could potentially disrupt health care delivery is challenging.[109] Furthermore, there is a lack of sustained implementation of new programs, especially in HIT.[110] Innovations in health care have been described as "All Breakthrough, No Follow-Through",[111] mainly due to the gap between available evidence and its implementation in practice. Described as the "knowledge-to-action gap", researchers have outlined several plans to address it, with the most influential of them being Graham and colleagues' Knowledge to Action (KTA) model (**Figure 1.5**).[112]

The KTA model is based on the knowledge translation (KT) concept of a process involving the four elements of "synthesis, dissemination, and exchange and ethically-sound application of knowledge creation."[113] KT is now considered the gold standard when conducting research by many funding agencies, including the Canadian Institutes of Health Research (CIHR).[114] CIHR describes the goal of KT as to "improve the health of Canadians, provide more effective health services and products and strengthen the health care system."[113] The KTA framework has two main parts: knowledge creation (central funnel) and action cycle (outside circle). The central funnel is based on the pyramid of evidence strength.[112] The outer action cycle presents the various steps of moving the created knowledge into action (**Figure 1.5**).

Scoping review is one of multiple different review types described to synthesize knowledge.[115] This synthesis method is increasingly being adopted in health care research as a tool to inform target end users.[116] The scoping review has an explicit methodology first described by Arksey and O'Malley,[117] and later developed by Levac and colleagues,[118] making it more transparent and reproducible than traditional literature reviews. It is also different than a full systematic review in that it enables the answering of broad questions by considering all study designs to map existing literature, identifying areas of focus for a full systematic review, and guiding research through identifying gaps for future work.[116,117]

Scoping reviews have been used to assess barriers and facilitators to knowledge use[119] and implementation.[120] However, it is important to note that knowledge translation is an integral part of the scoping review method itself. Tricco and colleagues found that integrated knowledge translation (i.e., involving end users from the inception of the research) and end-of-grant knowledge translation (i.e., dissemination to end users after completion of the review) was only conducted in 6% and 9% of the scoping reviews respectively.[116]

In this thesis, we conducted a knowledge translation exercise of an HIT to enhance access to specialist care focusing on one component of the KTA circle, namely assessment of barriers and facilitators. When designing and implementing a new health system delivery tool, like eConsult, it is important to identify the factors that favor and hinder its wider uptake by the end users (i.e., PCPs).[121] We leveraged a local initiative on eConsult[122] to determine the factors influencing wider adoption of this intervention to enhance access and quality of kidney care using scoping review methodology.

Figure 1.1: Outline of thesis

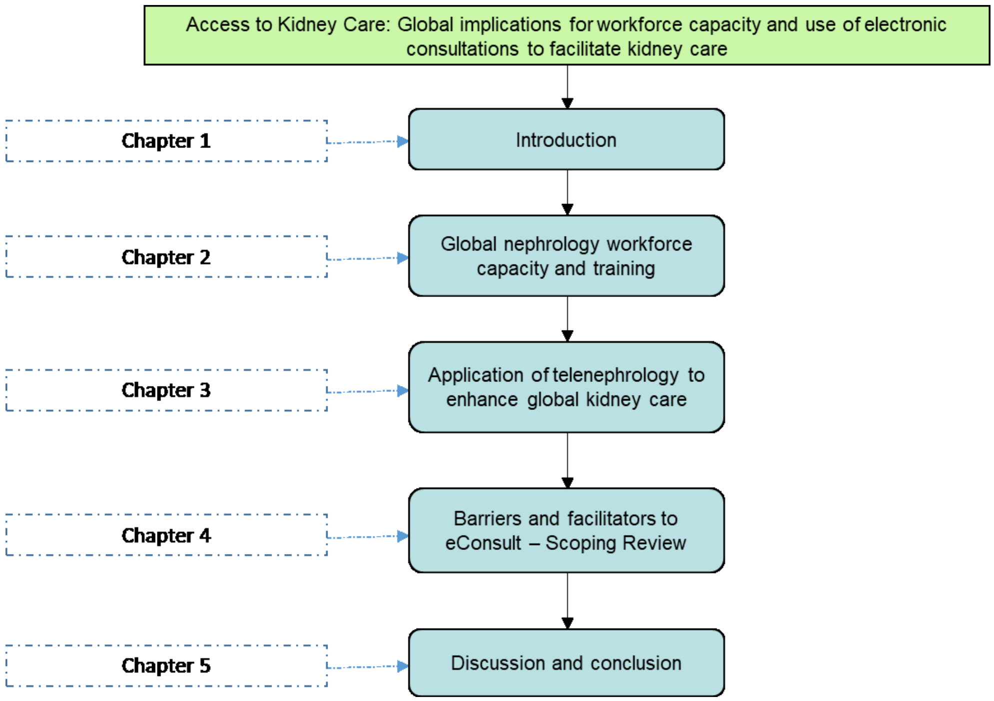
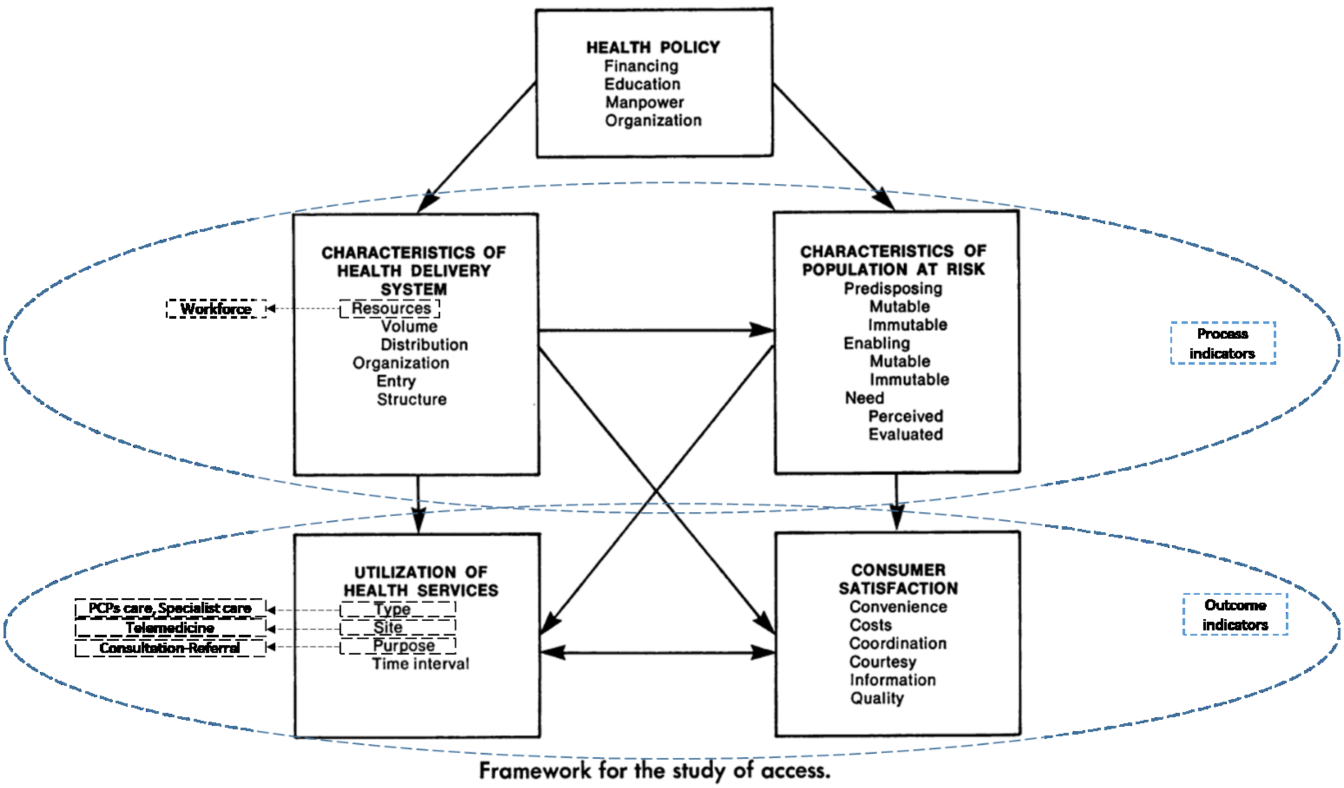
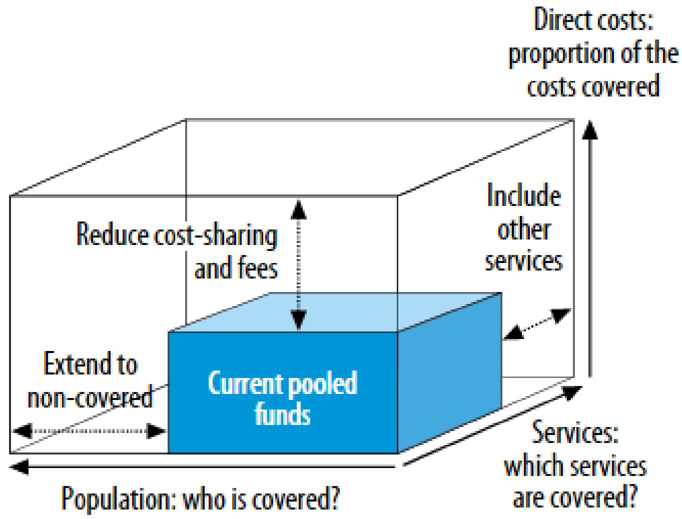


Figure 1.2: Access to care framework



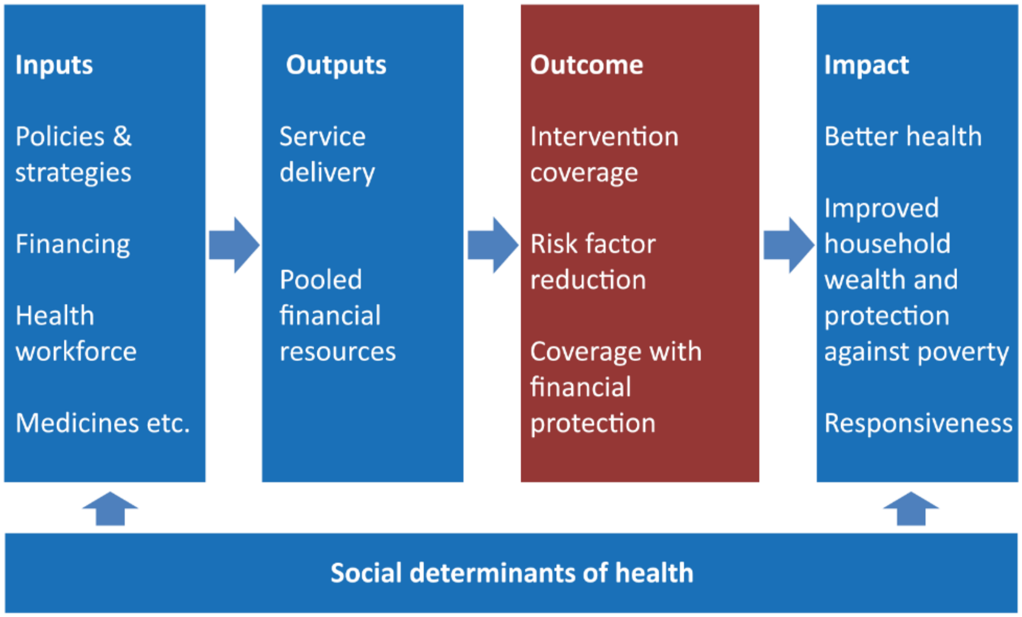
Modified with permission from Aday LA, Andersen R. A framework for the study of access to medical care. Health Serv Res. 1974;9(3):208-220[1]
Solid line (black): original framework
Dash line (blue): modifications to illustrate how the thesis work fits within the framework

Figure 1.3: Universal health coverage concept



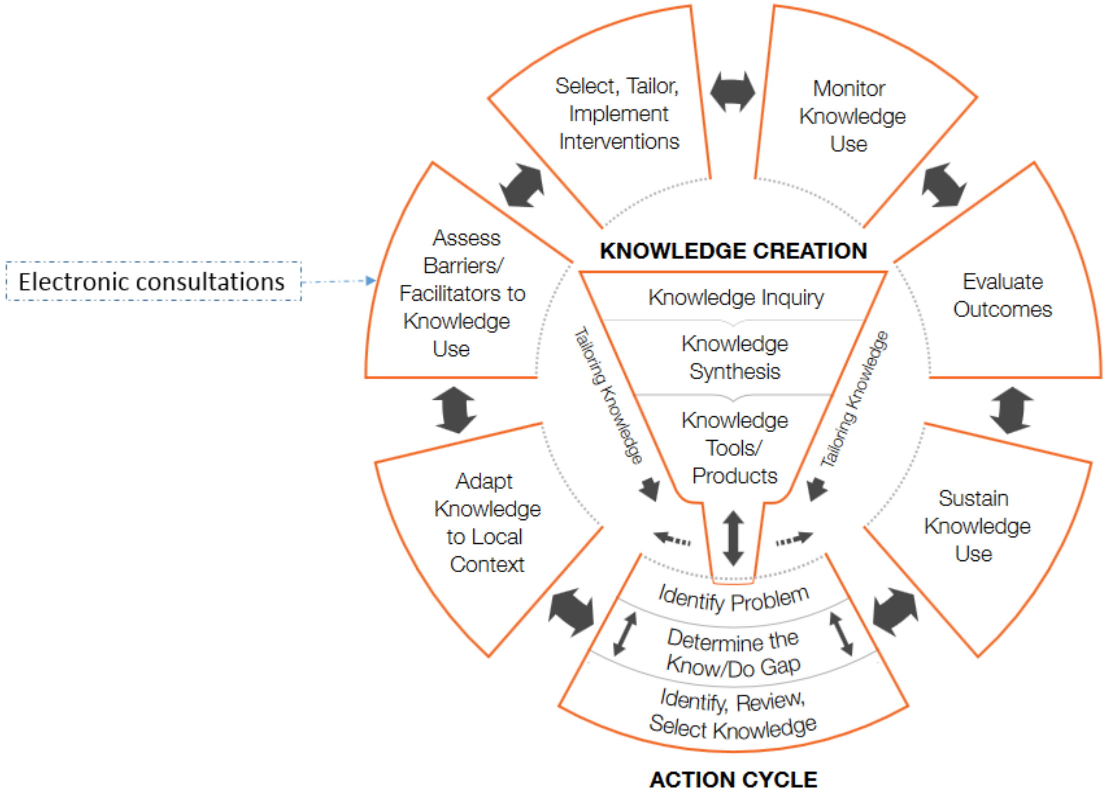
Reprinted with permission from Ref ([16])

Figure 1.4: Monitoring framework for universal health coverage



Reprinted with permission from Ref ([19])

Figure 1.5: Knowledge to action cycle



Modified with permission from Ref ([112])

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Chapter 2 : Global nephrology workforce: gaps and opportunities toward a sustainable kidney care system

(Published) **Osman MA**, Alrukhaimi M, Ashuntantang GE, et al. Global nephrology workforce: gaps and opportunities toward a sustainable kidney care system. Kidney Int Suppl. 2018;8(2):52-63.

2.1 Abstract

The health workforce is the cornerstone of any health care system. An adequately trained and sufficiently staffed workforce is essential to reach universal health coverage. In particular, the nephrology workforce is critical to meet the growing worldwide burden of kidney disease. Despite some attempts, the global nephrology workforce and training capacity remains widely unknown. This multinational cross-sectional survey was part of the Global Kidney Health Atlas project, a new initiative administered by the International Society of Nephrology (ISN). The objective of this study was to address the existing global nephrology workforce and training capacity. The questionnaire was administered online, and all data were analyzed and presented by ISN regions and World Bank country classification. Overall, 125 UN member states responded to the entire survey, with 121 countries responding to survey questions pertaining to nephrology workforce. The global nephrologist density was 8.83 per million population (PMP); high-income countries reported nephrologist density of 28.52 PMP compared to 0.31 PMP in low-income countries. Similarly, global nephrologist trainee density was 1.87 PMP; high-income countries reported 30 times greater nephrology trainee density than low-income countries (6.03 PMP vs. 0.18 PMP). Countries reported a shortage in all care providers in nephrology. 79% of countries had a nephrology training program ranging from 97% in high-income countries to 41% in low-income countries. In countries with a training program, the majority (86%) of programs were 2-4 years, and the most common training structure (56%) was following general internal medicine. We found significant variation in the global density of nephrologists and nephrology trainees and shortages in all care providers in nephrology; the gap was more prominent in low-income countries particularly in Africa and South Asia ISN regions. These findings point to significant gaps in the current nephrology workforce and opportunities for countries and regions to develop and maintain a sustainable workforce.

2.2 Introduction

The health workforce, in general, is the cornerstone of a country's health care system.[1] Countries cannot reach Universal Health Coverage[2] and Sustainable Development Goals[3] without an investment in human resources. To achieve that, countries need adequate numbers of qualified workforce personnel delivering and managing their health care system. The nephrology workforce, in particular, is critical to meet the growing worldwide burden of kidney disease[4-6] and its risk factors, such as diabetes,[7] obesity,[8] and aging population,[9] and the increasing demand of renal replacement therapy (RRT) and kidney care in both high-income and low-income countries.[10] Indeed, nephrologist caseload was found to be associated with mortality of dialysis patients.[11] Various studies have already examined the state of nephrology workforce highlighting the gaps and deficiencies in workforce availability and quality.[12-18] In one review of global nephrology workforce, Sharif et al[12] identified multiple factors responsible for the global shortage in nephrology workforce, and suggested a detailed and comprehensive nephrology workforce planning that is backed by government policy and legislation to ensure effective delivery and sustainability of kidney disease care. Another study that examined kidney care structures across 17 European countries identified limited workforce capacity, among many others, as a common barrier to the care of people with non-dialysis-dependent chronic kidney disease (CKD).[13]

The objective in this cross-sectional survey that was part of the Global Kidney Health Atlas (GKHA) project, a new initiative to assess kidney care in all world regions administered under the umbrella of the International Society of Nephrology (ISN), was to comprehensively examine the existing nephrology workforce in the form of numbers of nephrologists and nephrology trainees, nephrology training capacity in terms of availability, duration and structure, and the perceived shortages in health care providers pertaining to nephrology, across all ten ISN regions[19] and 2014 World Bank country classification[20] as low-, lower-middle-, upper middle-, and high income nations, based on the World Health Organization (WHO) building blocks.[21]

2.3 Methods

This cross-sectional survey was part of the GKHA project, an initiative administered under the umbrella of the ISN to assess kidney care in all world regions. The survey was conducted across all UN member states with a particular focus on the 130 countries with ISN affiliate societies. All 10 ISN Regional Boards (namely: Africa, Eastern and Central Europe, Latin America and the Caribbean, Middle East, North America, North and East Asia, Oceania and South East Asia (OSEA), newly independent states (NIS) and Russia, South Asia, and Western Europe) were sent an invitation letter to participate. Potential survey respondents were identified using a non-probability, purposive sampling approach, and they involved key stakeholders identified by the country and regional nephrology leadership through the ISN, including at least three key representatives per country sourced from national nephrology society leadership; policymakers, including those involved directly with kidney care organization (renal policymakers) and those with a more general scope (non-renal); and patients' organizations, foundations and other advocacy groups. The survey was delivered electronically (via SurveyMonkey).

The GKHA questionnaire was divided into two sections that addressed the core areas of countries and regional capacity for kidney care delivery. The detailed description of all survey sections was described elsewhere.[22,23]

This study focused on the "Health Workforce for Nephrology" module of the GKHA survey. It consisted of nine items subdivided into two components: existing manpower capacity and nephrology training capacity.

Survey respondents were asked about the absolute numbers of nephrologists and nephrology trainees in their country. Density was calculated by measuring the median of absolute numbers of nephrologists/nephrology trainees reported by at least three key representatives of each country and then converting it to Per Million Population (PMP) to estimate numbers relative to the population size. The density overall, and in each ISN region and World Bank income group, was calculated by the total number nephrologists/nephrology trainees divided by the total number of populations. Survey respondents were also asked about any perceived shortages in health care providers essential to the nephrology workforce. Given the list of staff categories, respondents were directed to indicate which ones had shortages; they also had an option to indicate no shortage of any of the staff listed.

Survey respondents were asked about the availability of a nephrology training program (physicians) in their country, and details regarding the duration and structure of training. They were also asked to select the training pathway most relevant to their country from four choices: 1) following general internal medicine; 2) solo training after basic qualification as medical doctor; 3) a mix of 1 & 2 depending on region and/or training center; or, 4) other, with the option to provide details in an open-ended response.

The term “health workforce” was defined as "all people engaged in actions whose primary intent is to enhance health”.[21] It was a holistic definition that encompassed both health service delivery staff and administration staff. The survey focused on nephrology workforce, specifically nephrologists, dietitians, renal pathologists, laboratory technicians, social workers, pharmacists, vascular access coordinators, NPs, counselors/psychologists, transplant coordinators, dialysis nurses, dialysis technicians, general practitioners/PCPs.

2.4 Results

2.4.1 Response rate

Responses were received from a total of 125 of 130 UN member states (96% response rate) across 10 ISN regions and 121 countries answered survey questions pertaining to nephrology workforce. Further details on the response rate and population coverage of the survey have been described elsewhere.[22]

2.4.2 Global density of nephrologists

Overall, the density of nephrologists reported was 8.83 Per Million Population (PMP) **(Table 2.1, Figure 2.1).** There was considerable variation in density of nephrologists among World Bank income groups **(Figure 2.2)** and ISN region countries **(Figure 2.3)**. High-income countries had the highest nephrologist density (28.52 PMP), followed by upper-middle income (7.23 PMP), lower-middle income (2.38 PMP), and low income (0.31 PMP) **(Table 2.1).** Of the ten countries with the lowest nephrologist density, nine belonged to the Africa ISN region, and sub-Saharan Africa specifically.

Yemen, in the Middle East ISN region, was the exception **(Figure 2.4).** In contrast, the countries with the highest nephrologist density were from different ISN regions. Japan (North and East Asia ISN region) reported the highest density followed by Lithuania (Eastern and Central Europe ISN region), Taiwan (North and East Asia ISN region), Greece (Western Europe ISN region), Uruguay (Latin America ISN region), Spain (Western Europe ISN region), Slovenia (Eastern and Central Europe ISN region), Argentina (Latin America ISN region), Germany (Western Europe ISN region) and Oman (Middle East ISN region) **(Figure 2.4).**

Overall, countries in the Africa ISN region reported low density (3.64 PMP) of nephrologists **(Table 2.1).** The lowest numbers were reported from sub-Saharan countries, namely Malawi (0.06 PMP), Mozambique (0.08 PMP), and Ethiopia (0.09 PMP). On the other hand, the highest numbers were reported from North African countries, namely Egypt (21.65 PMP), Tunisia (16.31 PMP), Libya (12.48 PMP), and Algeria (11.38 PMP) **(Appendix 2.1).**

Eastern and Central European countries reported a high density (16.33 PMP) of nephrologists (**Table 2.1**). However, there was wide variation in nephrologist density among the countries in the region. Turkey (6.30 PMP), Moldova (9.02 PMP), and Macedonia (9.54 PMP) reported the lowest densities of nephrologists, while Lithuania (69.34 PMP) and Slovenia (40.33 PMP) reported the highest, a difference of 63.04 between each end of the spectrum **(Appendix 2.1).**

In the Western Europe ISN region, countries overall reported a very high density (21.04 PMP) of nephrologists **(Table 2.1).** All countries in the region reported higher densities than the global average (8.83 PMP). Israel (9.69 PMP) reported the lowest density of nephrologists, while Greece (46.40 PMP) reported the highest **(Appendix 2.1).**

In the OSEA ISN region, countries overall reported low density (3.98 PMP) of nephrologists **(Table 2.1)**. Within the region, Burma (0.37 PMP), Indonesia (0.43 PMP), and Laos (0.43 PMP) reported the lowest densities of nephrologists, while Australia (20.88 PMP), New Zealand (13.07 PMP) and Singapore (9.69 PMP) reported the highest **(Appendix 2.1).**

In the North and East Asia ISN region, countries overall reported a high density (12.37 PMP) of nephrologists **(Table 2.1)**. Japan (78.79 PMP) reported the highest density of nephrologists in the region and globally, followed by Taiwan (61.97 PMP), South Korea (18.32 PMP), Hong Kong (16.31 PMP), and Mongolia (15.04 PMP). Although China reported the highest absolute number of nephrologists globally (mean number of 8500), it had the lowest density within its region (5.12 PMP) **(Appendix 2.1).**

In the North America ISN region, both responding countries reported a density of nephrologists higher than the global average of 8.83 PMP: Canada, 17.81 PMP; and the USA, 24.89 PMP **(Appendix 2.1)**. Furthermore, the region reported the highest density (24.2 PMP) of nephrologists of all 10 ISN regions **(Table 2.1).**

In the Latin America and the Caribbean ISN region, countries overall reported a high density (15.23 PMP) of nephrologists **(Table 2.1)**. However, there was wide variation in nephrologist density among the countries in the region, ranging from Guatemala (3.02 PMP) and Nicaragua (3.72 PMP) with the lowest densities to Uruguay (44.88 PMP) and Argentina (34.54 PMP) with the highest **(Appendix 2.1).**

In the Middle East ISN region, countries overall reported a low density (6.17 PMP) of nephrologists **(Table 2.1)**. Yemen (0.22 PMP), which had one of the lowest densities of nephrologists globally, Iraq (1.03 PMP) and West Bank and Gaza (2.15 PMP) reported the lowest densities of nephrologists in the region, while Oman (30.42 PMP), Lebanon (22.64 PMP), and Saudi Arabia (17.66 PMP) reported the highest **(Appendix 2.1)**.

In the Newly Independent States (NIS) and Russia ISN region, countries overall reported a high density (15.68 PMP) of nephrologists **(Table 2.1)**. Kazakhstan (5.51 PMP) and Armenia (8.18 PMP) reported the lowest densities of nephrologists in the region, while Georgia (23.32 PMP) and Belarus (20.86 PMP) reported the highest **(Appendix 2.1)**.

In the South Asia ISN region, countries overall reported the lowest density (1.17 PMP) of nephrologists globally **(Table 2.1)**. Within the region, Bangladesh (0.65 PMP) and Sri Lanka (0.91 PMP) reported the lowest densities of nephrologists, while Pakistan (2.51 PMP) and India (1.04 PMP) reported the highest **(Appendix 2.1).**

2.4.3 Global density of nephrology trainees

Similar to nephrologist density, there was significant variation in density of nephrology trainees among World Bank income groups and ISN regions **(Table 2.1)**. Overall, the global density of nephrology trainees was 1.87 PMP. The prevalence of nephrology trainees in high-income countries was more than 30-fold that in low-income countries (6.03 vs. 0.18) **(Table 2.1).** The prevalence of nephrology trainees in lower-middle and upper-middle income level countries was 0.78 PMP and 1.19 PMP, respectively. Seven out of the ten countries with the lowest nephrology trainee density were from the Africa ISN region, again sub-Saharan Africa specifically: Ethiopia, Uganda, Tanzania, Burundi, Ghana, Zambia and Malawi. The other three countries were Indonesia and Cambodia (OSEA ISN region) and Ukraine (NIS and Russia ISN region). In contrast, the ten countries with the highest nephrologist trainee densities were from different ISN regions, including three from the Africa ISN region which contrasted sharply with the seven African countries that were in the lowest density list. Japan (North and East Asia ISN region) reported the highest density followed by Kuwait (Middle East ISN region), Libya (Africa ISN region), Croatia (Eastern and Central Europe ISN region), Bahrain (Middle East ISN region), Serbia (Eastern and Central Europe ISN region), Norway (Western Europe ISN region), Greece (Western Europe ISN region), Algeria (Africa ISN region), and Egypt (Africa ISN region).

In the Africa ISN region, all sub-Saharan countries reported trainee densities lower than the global average (1.87 PMP). Ethiopia (0.02 PMP), Uganda (0.05 PMP), and Tanzania (0.06 PMP) reported the lowest densities. North African countries reported the highest densities of trainees, with Libya (18.72 PMP) first followed by Algeria (9.10 PMP), Egypt (8.93 PMP), and Tunisia (5.44 PMP).

In the Eastern and Central Europe ISN region, most of the countries reported trainee densities above the global average, with Slovakia (0.92 PMP) being the exceptions. The highest trainee density was reported by Croatia (13.44 PMP), followed by Serbia (9.75 PMP), Slovenia (7.56 PMP), and Lithuania (6.24 PMP).

In the Latin America and the Caribbean ISN region, Colombia (0.43 PMP) and Peru (0.49 PMP) reported the lowest trainee density, followed by Costa Rica (0.62 PMP) and Chile (0.91 PMP). The highest density was reported by Argentina (5.76 PMP), Uruguay (4.79 PMP), Dominion Republic (3.15 PMP), and Brazil (2.20 PMP).

In the Middle East ISN region, Kuwait (20.62 PMP), Bahrain (13.37 PMP), and Qatar (2.73 PMP) reported the highest trainee densities. Iran (0.26 PMP) and Iraq (0.32 PMP) reported the lowest densities.

In the NIS and Russia ISN region, Armenia (3.44 PMP), Belarus (2.19 PMP), and Russia (2.11 PMP) reported trainee densities higher than the global average. In contrast, Ukraine (0.23 PMP) and Kazakhstan (0.83 PMP) reported trainee densities below the global average.

In the North America ISN region, United States reported nephrology trainees density (1.24 PMP) lower than the average global density. In contrast, Canada (2. 14 PMP) reported above the global density.

In the North and East Asia ISN region, there was the greatest variation in trainee density within a region of all 10 ISN regions. Japan (35.46 PMP) reported one of the highest trainee densities globally, while Taiwan (5.56 PMP), Hong Kong (2.04 PMP), Mongolia (2.00 PMP), and South Korea (1.12 PMP) reported significantly lower densities. China (1.46 PMP) reported second lowest density in the region, yet it reported the highest absolute number of nephrology trainees (n=1667).

In the South Asia ISN region, all countries reported trainee densities below the global average. India (0.24 PMP) and Nepal (0.25 PMP) reported the lowest while Pakistan (1.26 PMP) and Bangladesh (0.71 PMP) reported the highest densities.

In the Western Europe ISN region, all countries reported trainee densities above the global average, except Israel (1.62 PMP). Netherlands (2.51 PMP), Belgium (2.65 PMP), and France (5.26 PMP) reported the lowest trainee densities in the region, while Norway (9.60 PMP), Greece (9.28 PMP), and Spain (7.23 PMP) reported the highest.

2.4.4 Availability of nephrology training programs

Overall, 79% of countries reported the availability of a nephrology training program. Nearly all (97%) of high-income countries and 80% of upper-middle and lower-middle countries reported having a program. Less than half (41%) of low-income countries reported having a program **(Figure 2.5).**

Across the ten ISN regions, all countries (100%) in five ISN regions – North America, North and East Asia, NIS and Russia, South Asia, Western Europe – reported availability of training programs. In the other five ISN regions, the numbers of countries reporting training programs varied: Eastern and Central Europe, 94%; Latin America, 88%; Middle East, 77%; in OSEA, 77%; and Africa, 52% **(Figure 2.5).**

2.4.5 Structure and duration of nephrology training programs

The structure of nephrology training programs varied across countries. Overall, nephrology as subspecialty following general internal medicine was the most reported training structure (56%). The next most reported structure was a mixed system of subspecialty and solo training for nephrology trainee depending on the region and/or training center (27%). Few countries reported solo training alone (9%) or other training arrangements (7%).

Overall, low-income countries reported training structures that were either subspecialty following general internal medicine (86%) or solo training (14%). Within the three other income groups, distribution across the training structure options showed minimum variation; there were similar percentage rates of countries in each income group reporting each of the four different training structure options **(Figure 2.6)**.

Nephrology as a subspecialty following general internal medicine was the most reported training structure across all ISN regions except NIS and Russia (33%), South Asia (40%), and North and East Asia (50%). Solo training was reported in only four ISN regions: Africa, 24%; Eastern and Central Europe, 19%; Latin America, 7%; and NIS and Russia, 17%. A mixed system was reported across all regions except North America, where all countries (100%) in the region reported nephrology training as subspecialty. Other training arrangements were reported in four ISN regions: Africa, 6%; Eastern and Central Europe, 25%; Middle East, 10%; and Western Europe, 10% **(Figure 2.6)**.

Of the countries (79%) that had a nephrology training program, 2% had a less than 2-year program, 86% had a program between 2 and 4 years, and 11% had a program of more than 4 years. Across income groups, the majority of programs were 2-4 years. All (n=6) training programs offered in low-income countries were of this duration. Of the 11 countries that offered programs more than 4 years, 55% were high-income, 18% were lower-middle income, and 18% were upper-middle income. 9% had a program more than 4 years **(Figure 2.7)**.

Overall, most countries in the 10 ISN regions had training programs between 2 and 4 years. Programs more than four years were reported in only four regions: Africa, 18%; Eastern and Central Europe, 25%; Latin America, 14%; and Western Europe, 20%. Programs less than 2 years were reported in only two regions: NIS and Russia (17%) and North and East Asia (17%) (**Figure 2.7).**

2.4.6 Shortages in health care providers in nephrology workforce

A shortage in nearly all health care provider categories essential to nephrology care was identified across all ISN regions and World Bank income groups **(Table 2.1)**. Overall, the largest majority of countries reported a shortage in renal pathologists (86%) and vascular access coordinators (81%). Shortages were also reported by a majority of countries in the following provider categories: dietitians (78%), transplant coordinators (69%), dialysis nurses (69%), counselors/psychologists (67%), social workers (62%), nurse practitioners (NPs) (60%), and dialysis technicians (60%). Shortages of laboratory technicians, primary care physicians and pharmacists were reported by less than 35% of countries. Notably, nearly three quarters (74%) of countries reported a shortage of nephrologists.

Low income countries had renal pathologists and dietitians as the highest reported shortages (100%). Lower-middle income countries had renal pathologists and transplant coordinators as the highest reported shortages, with 94% and 91%, respectively. Upper-middle income countries had renal pathologists (87%), vascular access coordinators (87%), and nephrologists (84%) as the highest reported shortages. In high-income countries, yet again renal pathologists (72%) and vascular access coordinators (72%) were the highest reported shortages. Overall, shortages of all health care providers, with the exception of primary care physicians (NPSs) and pharmacists, were evident across all income groups **(Appendix 2.2)**.

In the Africa ISN region, shortages in all providers were reported by more than 36% of countries. The most frequently reported shortages were of renal pathologists (100%) and dietitians (91%). More than half of the countries reported shortages of vascular access coordinators (88%), transplant coordinators (85%), counselors/psychologists (82%), dialysis technicians (76%) dialysis nurse (76%) and social workers (52%). Less than half of the countries reported shortages of laboratory technicians (42%) and pharmacists (36%). More countries reported shortages of nephrologists (85%) than of NPs (58%) and PCPs (39%) **(Appendix 2.3).**

In the Middle East ISN region, most countries (85%) reported a shortages of nephrologists and renal pathologists. More than three quarters (77%) of countries reported shortages of dialysis nurses, transplant coordinators, and dietitians. More than half (62%-69%) of countries reported a lack of counselors/psychologists, vascular access coordinators and social workers. Less than half of the countries reported shortages of dialysis technicians (46%), pharmacists (46%), and laboratory technicians (23%). More countries reported shortages of NPs (62%) than of PCPs (23%) **(Appendix 2.3).**

In the Latin America and the Caribbean ISN region, all countries (100%) reported a shortage of renal pathologists, while only 25% of countries reported a shortage of pharmacists. More than half of countries reported shortages of vascular access coordinators (94%), dialysis nurses (81%), transplant coordinators (69%) and dialysis technicians (63%). Less than half of the countries reported shortages of dietitians (56%), social workers (44%), counselors/psychologists (44%) and laboratory technicians (38%). More countries reported shortages of nephrologists (88%) than of NPs (75%) and PCPs (38%) **(Appendix 2.3).**

In the North East Asia ISN region, all countries (100%) reported shortages of both vascular access coordinators and social workers. More than half of countries reported shortages of all providers with the exception of pharmacists (17%) and laboratory technicians (17%). More countries reported a shortage of nephrologists (67%) than of NPs (83%) and PCPs (50%) **(Appendix 2.3)**.

In the South Asia ISN region, all countries (100%) reported a shortage of transplant coordinators. Eighty percent of countries reported shortages of all other providers. More countries reported shortages of nephrologists (80%) than of NPs (60%) and PCPs (40%) **(Appendix 2.3).**

In the OSEA ISN region, all countries (100%) reported a shortage of renal pathologists. More than 80% of countries reported shortages of transplant coordinators (92%), vascular access coordinators (92%), dietitians (92%), dialysis technicians (85%), dialysis nurses (85%), counselors/psychologists (85%), social workers (85%) and laboratory technicians (62%). More countries reported shortages of NPs (92%) than of nephrologists (85%) and PCPs (38%) **(Appendix 2.3).**

In the Eastern and Central Europe ISN region, most countries reported shortages of vascular access coordinators (82%), dietitians (76%), social workers (71%), counselors/psychologists (65%), renal pathologists (65%) and dialysis nurses (59%). Less than half of the countries reported shortages of transplant coordinators (47%) and dialysis technicians (35%). Few countries reported shortages of pharmacists (6%) and laboratory technicians (12%). More countries reported shortages of nephrologists (59%) than of NPs (47%) and PCPs (24%) **(Appendix 2.3).**

In the NIS and Russia ISN region, all countries (100%) reported a shortage of dietitians. while no country in the region reported a shortage of pharmacists. More than half of countries reported shortages of counselors/psychologists (83%), transplant coordinators (67%), vascular access coordinators (67%), social workers (67%) and renal pathologists (67%). Few countries reported shortages of dialysis technicians (33%), laboratory technicians (33%), and dialysis nurses (17%). More countries reported shortages of nephrologists (67%) than of NPs (50%) and PCPs (17%) **(Appendix 2.3).**

In the North America ISN region, United states reported a shortage in nephrologists, PCPs, NPs, dialysis technicians, dialysis nurses, and pharmacists. While Canada reported no shortage in any of the listed workforce. Overall, the North American ISN region had the lowest reported shortage in nephrology care providers **(Appendix 2.3).**

In the Western Europe ISN region, renal pathologists (70%) were the most frequently reported shortage. Fifty % of the countries reported shortages of dialysis nurses, vascular access coordinators, social workers and dietitians. Less than half of the countries reported shortages in counselors/psychologists (40%), dialysis technicians (30%), transplant coordinators (20%), pharmacists (20%), and laboratory technicians (20%). More countries reported shortages of PCPs (30%) than of nephrologists (20%) and NPs (20%) **(Appendix 2.3).**

2.5 Discussion

2.5.1 Summary of results and implications

The survey results showed marked inequities in the existing nephrology workforce and training capacities between countries, within regions, and across ISN regions and World Bank income groups. There were significant differences in nephrologist and nephrology trainee densities between high and low-income countries, an absence of nephrology training programs in a large percentage of low-income countries, and shortages of all nephrology care providers in all income groups. Most countries with nephrology training programs reported training durations between two to four years, with few countries reporting more than four or less than two training years. The majority of countries reported their nephrology training structure as subspecialty training following general internal medicine, while the rest reported either solo training after primary medical qualification or a mixed system depending on the region and/or training center.

2.5.2 Gaps, threats, and opportunities towards sustainable provision of nephrology workforce

This study has identified several important gaps in the existing global nephrology workforce and training capacity. A key gap in kidney care was the significant variation in nephrologist density across income groups and ISN regions. This gap was most prominent in low-income countries, which reported a nephrologist density of just 0.31 PMP but accounted for more than half of the world's population. Africa, with more than 1.2 billion in population, and South Asia, home of one fourth of the world's population, had the lowest densities of nephrologists (3.64 PMP and 1.17 PMP, respectively). These highly populated regions face the same increases in demand for health services for noncommunicable diseases as the rest of the world, in addition to the burden of communicable disease.[10] The shortage can be attributed to many factors, such as limited physician training capacity[24] and immigration of skilled workers across and between regions.[25] Some opportunities to address this challenge include increasing workforce retention by providing incentive and opportunities for professional development locally in low-income countries, and adopting policies of fair recruitment in high-income countries.[26] Another opportunity lies in building the scope of PCPs in kidney care management.[27]

There was also a gap in nephrology trainee density. Low-income countries reported trainee density 30 times lower than that of high-income countries. When analyzed by ISN region, seven out of the ten lowest densities were from sub-Saharan Africa, and all countries from South Asia reported trainee densities below the global average. In contrast, all countries from North America and Western Europe reported densities above the global average. Considerable disparity was also found within ISN regions; for example, in the North and East Asia ISN region, China reported a trainee density 30 times lower than that of Japan. Although this study's results showed adequate current nephrology trainee densities in high-income countries, many studies have shown decreased interest in the field.[14,28] Some high-income countries rely on foreign-trained doctors to cover shortages in nephrology manpower. For example, a study from Oman showed that the majority of practicing nephrologists were expatriate physicians, with local doctors representing only 14% of the workforce.[29] In the United States, a recent report showed that international medical graduates represented 47% of active nephrologists and 65% of nephrology trainees.[30] A recent survey from Canada suggested that, although the current nephrologist workforce may have been adequate, the number of trainees may not adequately meet future demand.[31]

Scaling up the current nephrologist workforce may not be feasible, especially for low-income countries, because it requires investment of time and money to produce highly qualified nephrologists. However, countries who are short in supply of nephrologists and face large demands for kidney care may adopt alternative models of care in the short-term. One suggested approach is involving nursing and allied health care professionals through task substitution and sharing to increase efficiency of care and decrease nephrologist workload while maintaining high standards and optimal patient important outcomes.[32,33] Countries may need 9 to 10 years to produce one physician, and many countries with critical shortages of nephrologists cannot afford the time lag, nor possibly the cost of training. An at least partial solution may be found in utilizing allied health care professionals, but it is important that they be held to high standards of accreditation and training in nephrology care to maintain the quality of patient care.

Nephrology training programs were absent in many parts of the world. Almost half of the Africa ISN region reported a lack of nephrology training programs, and only 41% of low-income countries had such training. This gap is a major limiting factor for the abilities of countries to produce the future nephrologist workforce and to achieve self-reliance in providing kidney care to their populations. To scale up their nephrologist workforce, countries need to focus on producing local qualified professionals, ideally through partnerships with other countries and organizations with sufficient resources to help them establish training programs. For instance, as part of its building capacity and outreach initiative, the ISN has a fellowship program for trainees to travel to an advanced center to obtain skills and training and then return to their home country to practice.[34] Since its inception, the program sponsored more than 600 fellows.[35]

Another gap highlighted in this study was a shortage of all nephrology care providers across all ISN regions and World Bank income groups. The most frequently reported shortages were in renal pathologists and vascular access coordinators. Such shortages of health care providers exacerbate the adverse impacts of nephrologist shortages on kidney care that exist in many parts of the world. Health care policies in such countries should ideally cater for and support commensurate scaling up of all nephrology care providers (such as NPs, dialysis nurses and physician assistants) rather than focus narrowly on nephrologists/physicians.

2.5.3 Strengths and limitations of the study

This is the most comprehensive study of the global nephrology workforce and training capacity to date. The study had a large response and adequate representation of the world population (>93%). An established method was used to define and monitor current global nephrologist and nephrology trainee capacities. Specifically, health workforce density was used to estimate health workforce relative to the population size, as recommended by the WHO in its building blocks of health systems handbook.[21] This indicator had the advantages of being simple to calculate and analyze, and being easy to understand and present to a broad audience. However, it did not take into account all dimensions critical for health workforce, such as quality, efficiency, accessibility and geographic distribution of health workforce, and annual output of health care graduates.[21] This may have led to underestimation of the actual capacity of the nephrology workforce and warrants the need for further research. In the present survey, countries provided information on availability, duration, and structure of training. Other important factors in addressing training capacity are quality of training, volume, and location within the country, all of which were beyond the scope of this paper. Physicians who specialize in the management of kidney disorders (nephrologists) are the primary providers of kidney care in many parts of the world. However, depending on the region and health care setting other caregivers such as PCPs may assume the role of nephrologists in providing kidney care. As there is no agreed standard for nephrologist density, the current study used calculated global densities of nephrologists and nephrology trainees to describe each country's and region's current nephrology workforce relative to the rest of the world.

2.5.4 Priorities and recommendations for action

1. Scale up the current nephrology workforce through training qualified providers by implementing evidence-based, competence-based, and community-oriented curriculums.[36,37]
2. Develop robust methodology to collect data and monitor the current and future nephrology workforce.[21]
3. Increase use of allied health professionals to increase efficiency and decrease the load on nephrologists through task substitution/sharing while maintaining high standards and optimal patient important outcomes.[32,33,38-41]
4. Leverage cost-effective technology to increase access to specialist care while building the scope of PCPs and other allied health professionals in managing and improving outcomes of kidney patients.[42-45]

5. Augment research and scholarly activity in nephrology workforce development, management, and maintenance.[46]

2.5.5 Future work

The results of this study show a significant gap in the nephrology workforce. There is a need to move beyond the numbers and conduct more research to ascertain the other factors that influence workforce development and monitoring, such as distribution within countries and regions, demographics and age of the current workforce, and annual graduation rate of nephrologists, PCPs, NPs as well as the rest of the nephrology health care providers. Moreover, there is a pressing need to research how to maximize the roles of PCPs and allied health professionals in sharing the management of kidney disease with nephrologists.

2.5.6 Conclusion

This study involved examining global nephrology workforce and training capacity, an essential component of any country's health care system and especially important in nephrology to face the growing burden of kidney disease globally. With the finding of shortages of nephrologists and all health workforce related to nephrology, it can be concluded that, in most parts of the world, people who need kidney care receive either suboptimal or no kidney care at all. The lack of necessary workforce can have huge implications for the individual person as well as for public health. Countries need to scale up their current nephrology workforce, develop robust methods to collect data on their human resources, and implement short and long-term policies to produce and maintain qualified and equitable nephrology workforce.

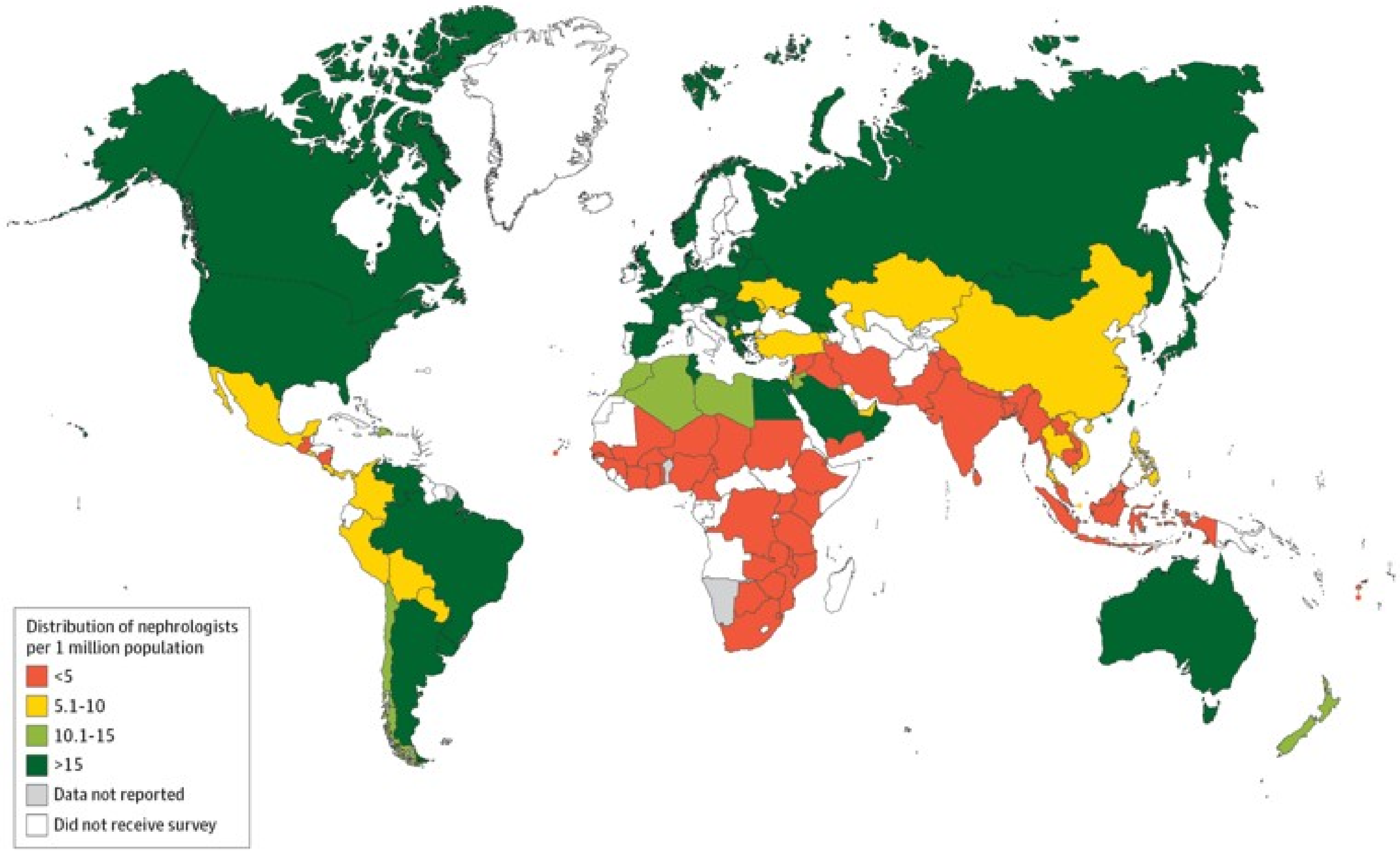
Table 2.1: Density of nephrologists and nephrology trainees and shortage in nephrology care providers in 121 countries

	Total number PMP		Shortage in workforce components (n [%])												
	Nephrologists	Nephrology trainees	Nephrologists	Dietitians	Renal pathologists	Laboratory technicians	Social workers	Pharmacists	Vascular access coordinators	Nurse practitioners	Counselors/ psychologists	Transplant coordinators	Dialysis nurses	Dialysis technicians	primary care physicians
Overall	8.83	1.87	89 (74)	94 (78)	104 (86)	42 (35)	75 (62)	36 (30)	98 (81)	73 (60)	81 (67)	84 (69)	83 (69)	72 (60)	41 (34)
ISN regions:															
- Africa	3.64	1.77	28 (85)	30 (91)	33 (100)	14 (42)	17 (52)	12 (36)	29 (88)	19 (58)	27 (82)	28 (85)	25 (76)	25 (76)	13 (39)
- Eastern & Central Europe	16.33	3.41	10 (59)	13 (76)	11 (65)	2 (12)	12 (71)	1 (6)	14 (82)	8 (47)	11 (65)	8 (47)	10 (59)	6 (35)	4 (24)
- Latin America & the Caribbean	15.23	1.89	14 (88)	9 (56)	16 (100)	6 (38)	7 (44)	4 (25)	15 (94)	12 (75)	7 (44)	11 (69)	13 (81)	10 (63)	6 (38)
- Middle East	6.17	1.22	11 (85)	10 (77)	11 (85)	3 (23)	9 (69)	6 (46)	9 (69)	8 (62)	8 (62)	10 (77)	10 (77)	6 (46)	3 (23)
- NIS & Russia	15.68	1.64	4 (67)	6 (100)	4 (67)	2 (33)	4 (67)	0 (0)	4 (67)	3 (50)	5 (83)	4 (67)	1 (17)	2 (33)	1 (17)
- North America	24.20	1.33	1 (50)	0 (0)	0 (0)	0 (0)	0 (0)	1 (50)	0 (0)	1 (50)	0 (0)	0 (0)	1 (50)	1 (50)	1 (50)
- North & East Asia	12.37	3.62	4 (67)	5 (83)	5 (83)	1 (17)	6 (100)	1 (17)	6 (100)	5 (83)	4 (67)	4 (67)	3 (50)	4 (67)	3 (50)
- Oceania & South East Asia	3.98	0.71	11 (85)	12 (92)	13 (100)	8 (62)	11 (85)	5 (38)	12 (92)	12 (92)	11 (85)	12 (92)	11 (85)	11 (85)	5 (38)
- South Asia	1.17	0.41	4 (80)	4 (80)	4 (80)	4 (80)	4 (80)	4 (80)	4 (80)	3 (60)	4 (80)	5 (100)	4 (80)	4 (80)	2 (40)
- Western Europe	21.04	3.88	2 (20)	5 (50)	7 (70)	2 (20)	5 (50)	2 (20)	5 (50)	2 (20)	4 (40)	2 (20)	5 (50)	3 (30)	3 (30)
World Bank Income Groups:															
- Low income	0.31	0.18	15 (94)	16 (100)	16 (100)	9 (56)	10 (63)	9 (56)	15 (94)	8 (50)	13 (81)	14 (88)	13 (81)	14 (88)	6 (38)
- Lower-middle income	2.38	0.78	28 (80)	29 (83)	33 (94)	14 (40)	20 (57)	9 (26)	28 (80)	24 (69)	26 (74)	32 (91)	24 (69)	23 (66)	11 (31)
- Upper-middle income	7.23	1.19	26 (84)	23 (74)	27 (87)	10 (32)	20 (65)	8 (26)	27 (87)	19 (61)	19 (61)	21 (68)	22 (71)	19 (61)	9 (29)
- High income	28.52	6.03	20 (51)	26 (67)	28 (72)	9 (23)	25 (64)	10 (26)	28 (72)	22 (56)	23 (59)	17 (44)	24 (62)	16 (41)	15 (38)

Abbreviations: ISN - International Society of Nephrology; NIS - national independent states; N – number, PMP – Per Million population;

1. N is the number of responding countries, the proportion is calculated as the number of responding countries divided by the total number of responding countries, overall and by region.
2. PMP is Per Million population density of nephrologists and nephrology trainees, calculated by taking the median of absolute number of nephrologists/nephrology trainees provided by each country respondents, divided by country's population in millions.

Figure 2.1: Global distribution of density of nephrologists PMP from 121 countries*



*Adapted with permission from Bello AK, Levin A, Tonelli M, et al. Assessment of Global Kidney Health Care Status. JAMA 2017; 317(18): 1864. Ref ([22])

Figure 2.2: Density of nephrologists PMP from 121 countries grouped by World Bank income group

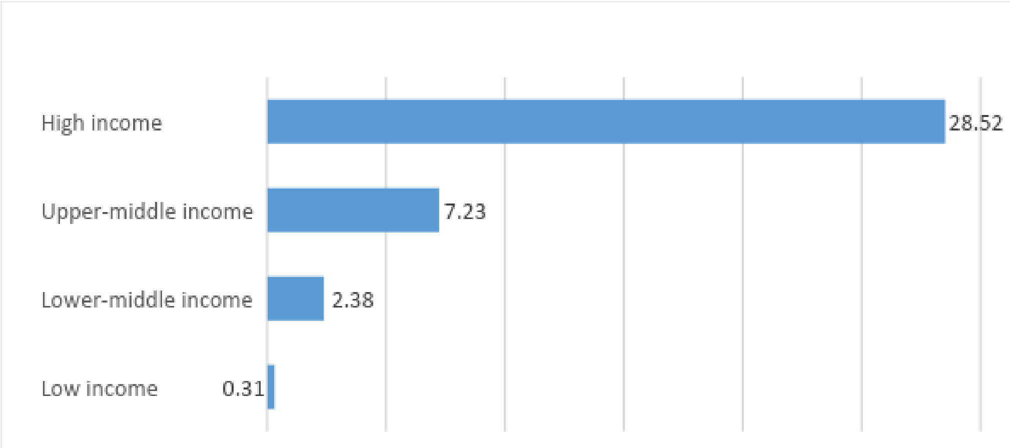


Figure 2.3: Density of nephrologists PMP from 121 countries grouped by ISN region

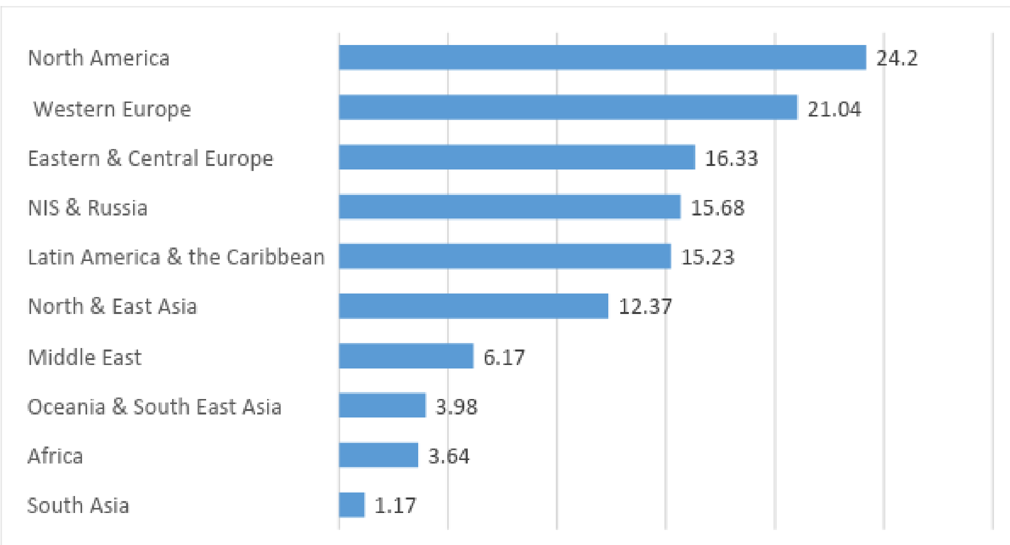


Figure 2.4: Countries with the lowest/highest density of nephrologists PMP from 121 countries

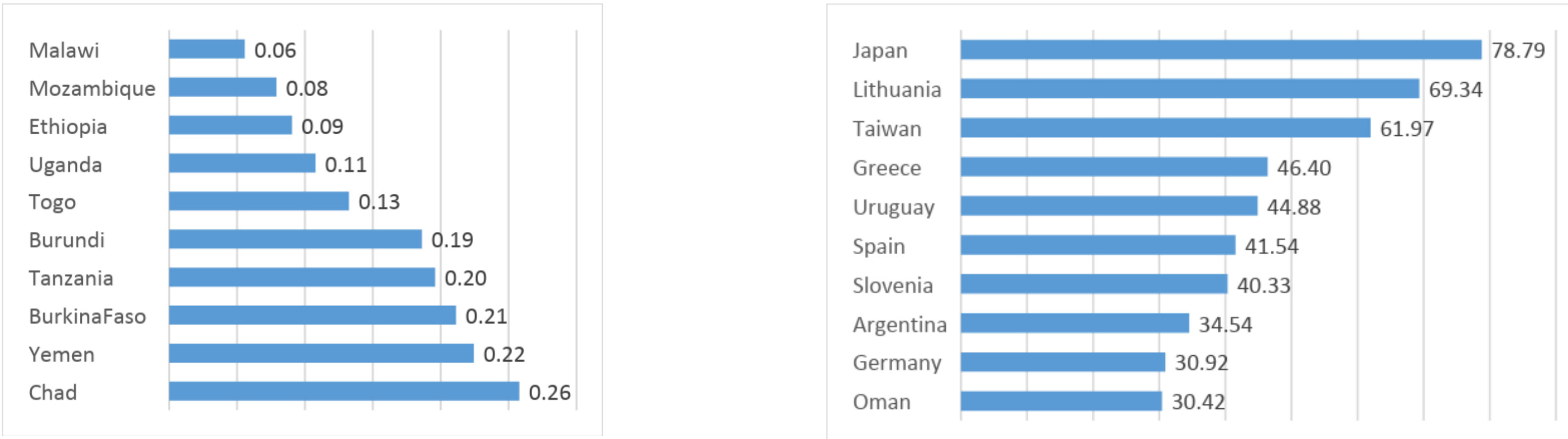
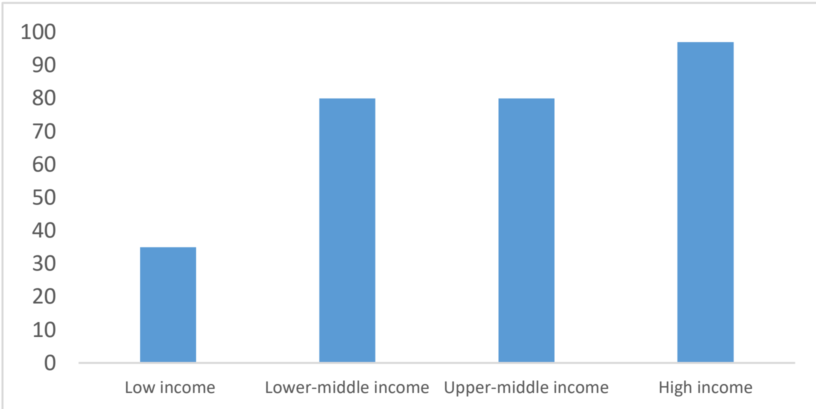
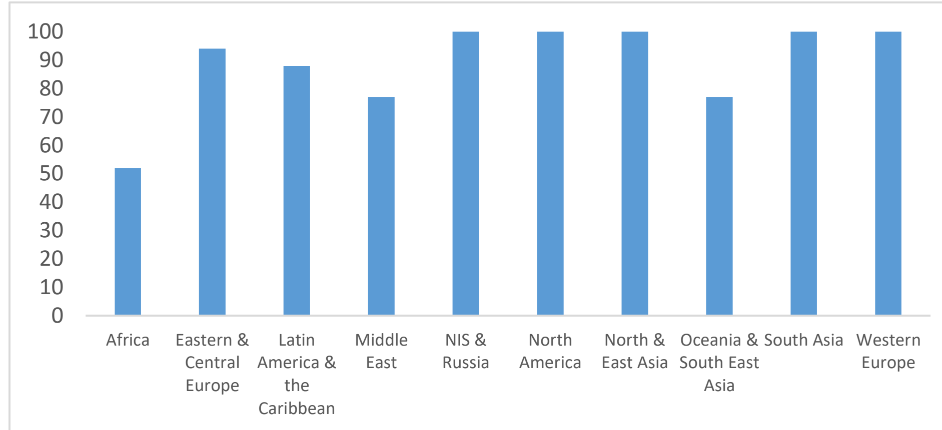


Figure 2.5: Availability of nephrology training programs in 121 countries

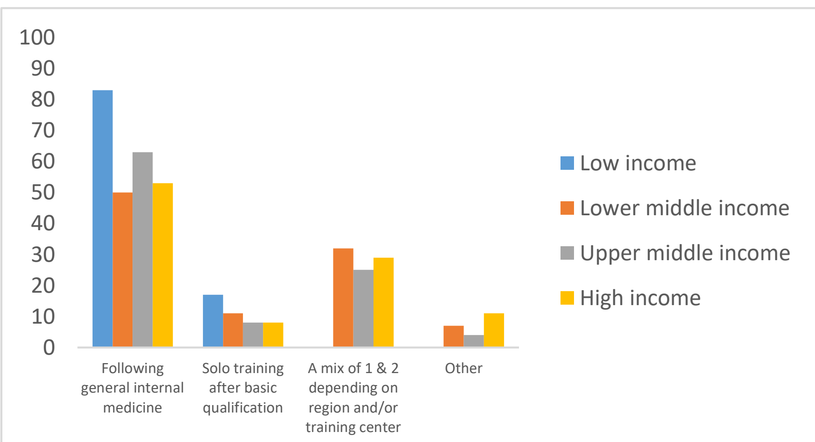


Availability of nephrology training program by World Bank income group

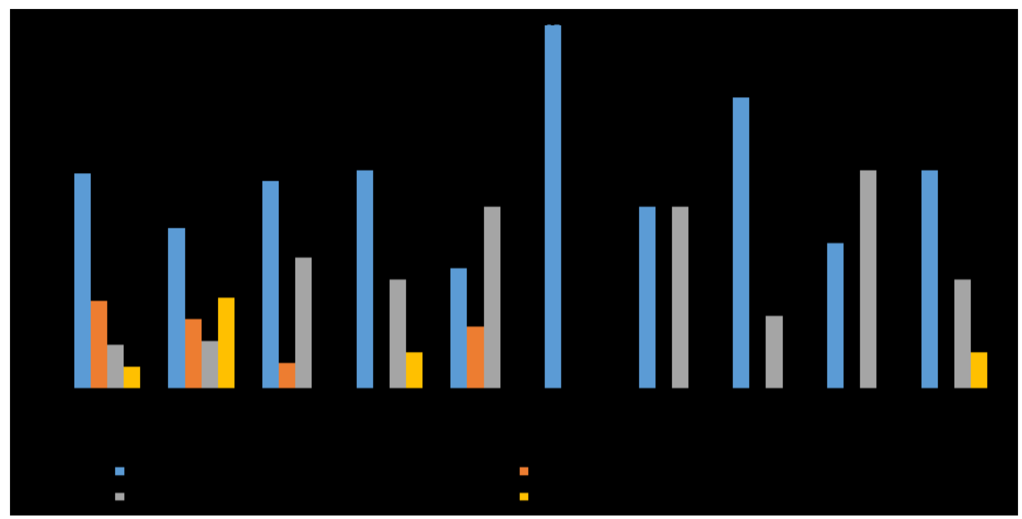


Availability of nephrology training program by ISN region

Figure 2.6: Structure of nephrology training programs in 121 countries

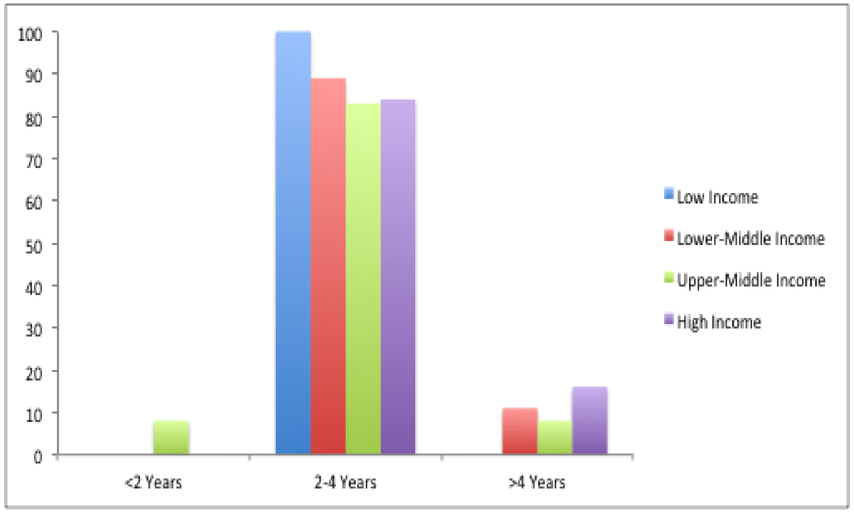


Structure of nephrology training by World Bank income group

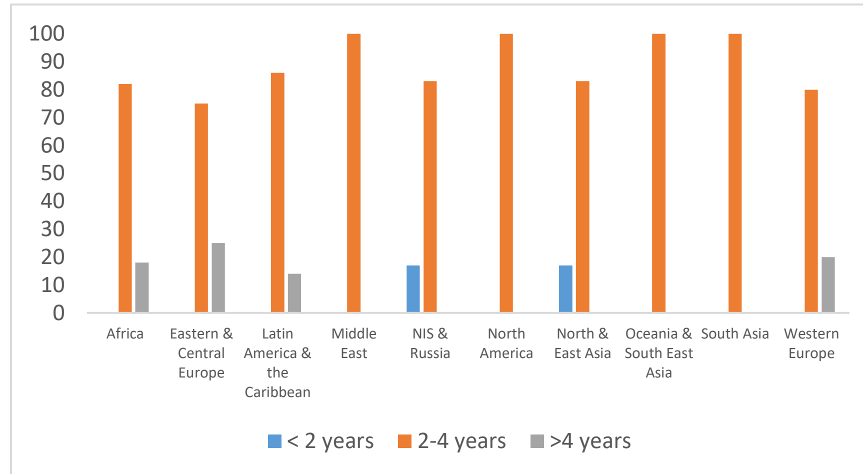


Structure of nephrology training by ISN region

Figure 2.7: Duration of nephrology training programs in 121 countries



Duration of nephrology training by World Bank income group



Duration of nephrology training by ISN region

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Chapter 3 : Potential applications of telenephrology to enhance global kidney care

(Published) **Osman MA**, Okel J, Okpechi IG, Jindal K, Bello AK. Potential applications of telenephrology to enhance global kidney care. BMJ Glob Health. 2017;2(2):e000292.

3.1 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 utilization 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 programs 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.

3.2 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 utilization/process measures.[6]

There have been no studies yet on impact (efficacy and effectiveness) and costs. Taking into consideration not only the role of clinical information systems among the six core elements vital for provision of adequate care in chronic disease including CKD,[3] but also 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.

3.3 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 health care, 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 health care providers.[10] The different facets of telehealth could be leveraged to optimize kidney care as summarized based on associated advantages and disadvantages (**Table 3.1**). 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 summarized in **Table 3.2**.[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 centers (**Table 3.1**).[22] Due to its diversity and growing innovative processes, telehealth is recognized 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]

3.3.1 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, diarrheal diseases) and chronic non-communicable diseases, as well as a myriad of challenges in offering chronic disease care that includes a severe shortage of all cadre of health care providers.[24] In addition, they lack the resources to offer the usually resource intensive CKD care including adequate pre-dialysis 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 minimizes 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 considerable implications for the future of health care, especially where access 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 centers, typically led by PCPs or nurse practitioners, to be pooled into centrally led virtual nephrology centers. 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 centers 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 used, 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 health care 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 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 50km.[31] In this regard, telehealth may become useful in overcoming the geographic barrier and improve patient's access to specialized CKD care. Patients usually display a high degree of satisfaction when such services are available, and health care providers do not have to spend any extra time than usual care.[32] Telehealth has also been shown to be useful for managing remote hemodialysis units from tertiary referral centers with no difference in outcomes compared with patients followed up by an on-site nephrologist in an urban area, but with the advantage of cost effectiveness, enhanced collaboration and education with the tertiary center.

3.3.2 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 organizations such as the National Kidney Disease Education Program (NKDEP), where kidney disease education is promoted via digital media with links to educational topics.[33]

3.3.3 Using telenephrology to improve CKD awareness

Current awareness programs, 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 maximize 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.

3.3.4 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 synthesized 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 randomized 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 minimize risk of disease progression and related complications.

3.4 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 and remuneration for time spent by physicians and nephrologists for review of electronic results and referrals.[47] 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.

3.5 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.

Table 3.1: 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 connection and other equipment (TV monitor, computer screen, cables) - May not be effective for practical hands-on demonstrations (e.g., 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 programs - Training of nephrologists / nurses in 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 programs - Reminders to attend clinics - Promoting appropriate CKD management	- No need for hospitalization - Opportunity to provide individualized 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	- No need for hospitalization - Allows for long-term and continuous monitoring /tracking of health status - Opportunity to provide individualized 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.

Table 3.2: Utilization 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-Consult	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 (Bernstein *et al*)[20]	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*)[19]	Teleconference	Peritoneal dialysis	Single centre	57	Prospective non-randomised study	- ↓ patient cost of care - ↓ hospitalisation	- Single centre - Small sample (57 patients)

Country (author)	Telehealth platform*	CKD population covered†	Setting‡	Number of patients	Design	Impact§	Identified loopholes and limitations (if any)
Canada (Alison *et al*)	Teleconference	Peritoneal dialysis	Single centre	8	Randomised parallel design	- ↑ patient satisfaction	- Small sample size
Canada (Sicotte *et al*)[18]	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
USA (Thompson *et al*)[17]	Teleconference	Post - transplant follow up	Single centre	138	Prospective randomized 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

*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.

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Chapter 4 : Barriers and facilitators for implementation of electronic consultations (eConsult) to enhance specialist access to care: a scoping review

(In Press) **Osman MA**, Schick-makaroff K, Thompson S, et al. Barriers and facilitators for implementation of electronic consultations (eConsult) to enhance specialist access to care: a scoping review protocol. (In Press, BMJ Open, 2018)

4.1 Abstract

Introduction: Electronic consultations (eConsult), asynchronous exchanges of patient health information at a distance, are increasingly used as an option to facilitate patient care and collaboration between primary care providers and specialists. Although eConsult has demonstrated success in increasing efficiency in the referral process and enhancing access to specialist care, little is known about the factors influencing its wider adoption and implementation by end-users. I therefore aimed to conduct a scoping review on the barriers and facilitators to a wider adoption and implementation of eConsult service across the globe.

Methods and analysis: I leveraged the framework pioneered by Arksey & O'Malley and later developed by Levac et al. in the conduct of the review, and the Joanna Briggs Institute guide on reporting of findings. Five electronic databases were searched in addition to grey literature to identify relevant studies. Two reviewers independently screened titles and full texts for inclusion. Studies that reported any barriers and/or facilitators to eConsult were eligible. I extracted data on study characteristics and key barriers and facilitators. Data was analyzed thematically and classified using the Quadruple Aim taxonomy. No date or language restrictions were applied.

Results: From a total of 2579 citations, 133 studies were selected for the review. Key barriers and facilitators to eConsult adoption and implementations were identified and summarized across four domains (patient, provider, health care system and cost). The key barriers were patient preference for a face to face contact with specialist, increased workload on providers, concerns of privacy and absence of reimbursement model for providers. The main facilitators identified were patient avoidance of travel, PCPs receiving timely response from specialist, utilizing case managers, addressing medico-legal issues and incentives for providers to use eConsult.

Conclusion and implication: There are multiple barriers and facilitations to eConsult adoption across the Quadruple Aim framework. Our findings will inform future studies on the development of practice tools to support the wider adoption and success of eConsult implementation.

4.2 Introduction

In well-established health care systems such as Canada,[1] United Kingdom[2], and United States for example,[3] primary care providers (PCPs) are the first point of contact for patients, and specialists rely on them to appropriately refer patients for specialist input into care. The demand for specialist care is growing and wait times to consult a specialist remain long.[4,5] In the recent Commonwealth survey, Canada had the longest average wait time to see a specialist (>4 weeks) among 11 developed countries who participated in the survey.[6]

In Canada, despite the increased adoption and uptake of electronic medical records (EMR) by PCPs (Alberta 87%, national 75%),[6-8] referrals to specialists remains paper-based with its attendant negative consequences (delays and duplications, loss of information) and dissatisfaction with the current process by patients,[9] PCPs and specialists.[10]

Health information technologies in the form of telemedicine hold the potential to mitigate some of these problems, [11,12] and electronic consultations (eConsult) are being adopted in many countries to streamline the pathway of communication between different providers to reduce inefficiencies.[13,14] Information on barriers and facilitators affecting adoption of eConsult is limited. I therefore aimed to review barriers and facilitators to eConsult implementation across the globe.

4.3 Methods

4.3.1 Theoretical basis

When designing and implementing a new health system delivery tool like eConsult, it is important to identify the factors that favor and hinder its wider uptake by the end-users (e.g., PCPs).[15] However, there is little evidence about these factors and how they influence eConsult adoption.[16] Given that this is a complex intervention, it is challenging to study these factors using conventional systematic review methodology. However, a scoping review provides the means to map key concepts and gaps in evidence through a comprehensive review of the literature.[17] A scoping review is useful in "mapping" the evidence, especially in an emerging field like eConsult.[18] One advantage of scoping reviews over systematic reviews is that scoping reviews typically incorporate different study designs which can be grouped to evaluate a particular topic of interest (**Table 4.1**).[19,20] Furthermore, the breadth of content that is obtained through a scoping review allows for a high-level overview of all interventions/contexts in the literature and therefore, the potential to identify gaps in knowledge that are more suitable for in-depth and narrow focus study — such as in systematic reviews. This method was chosen in the anticipation that the search on eConsult implementation will yield a low number of heterogeneous study designs that may not be suitable for a systematic review.

4.3.2 Approach

To guide the scoping review, I leveraged the framework first described by Arksey & O'Malley[21] and later developed by Levac et al.[22], which includes five steps: 1) identifying the research question; 2) identifying the relevant studies; 3) study selection; 4) charting the data; and 5) reporting the results; 6) Consultation exercise - optional step. We applied the guidance on reporting scoping reviews recently published by the Joanna Briggs Institute in reporting study findings.[19]

4.3.3 Identifying the research question

The underlining question for this scoping review to answer was "What is known about the barriers to and facilitators for the wider implementation of electronic consultations to enhance access to specialist care?". Keeping with the broader objective of this review, any determinants in the eConsult literature that can influence implementation positively or negatively was synthesized as barriers and facilitators at patient, provider and health care system levels. I used pre-identified themes[23] and published literature[16] on barriers and facilitators to identify themes (deductive approach) as well as newly identified themes (inductive approach).

4.3.4 Search strategy and terms

Studies were identified by conducting comprehensive searches of the following bibliographic databases: Ovid Medline (1946-), Ovid Embase (1988-), Wiley Cochrane Library (inception-), CINAHL via EBSCOhost (1937-) and Ovid PsycINFO (1987-). Our search used both index (subject headings) and text words, and combined concepts for electronic consultation, primary care and specialist care. In addition to these electronic databases, we also searched ProQuest Dissertations & Theses Global,[24] and included relevant grey literature by searching Conference Proceedings Citation Index (Clarivate Analytics) and screening the first five pages (n=100 results in total) from a Google search. Finally, through citation chaining[25] (a manual search technique to find more articles through citations [forward] and references [backward] of included studies) we reviewed the reference lists of included studies for relevant studies not identified from our initial search until saturation was achieved (i.e. when there is no new studies being identified). The specific search strategies (for the selected databases and other data sources) was developed and executed by an experienced information specialist (Robin Featherstone) and peer-reviewed by a second medical librarian (Tara Landry). No language or date restrictions were applied to the search strategy.

4.3.5 Selection criteria

The following criteria were used by the reviewers:

- Inclusion criteria
  1. Human studies
  2. Studies reporting on barriers and facilitators in store and forward (asynchronous) telemedicine settings similar to eConsult reported by patients, PCPs and specialists.

- Exclusion criteria
  1. Studies reporting on barriers and facilitators in real-time (synchronous) telemedicine settings, such as videoconferencing and continuous remote monitoring.[26]
  2. Image-based electronic consultations (i.e., image transfer only for referral or consultation process, such as in Tele-dermatology settings). Store and forward teledermatology preceded eConsult in other specialties, and reliable evidence (RCTs) exist for its cost-effectiveness and success in reducing wait time and increasing satisfaction in providers and patients alike.[27] However, it is narrowly

focused on a single specialty that is uniquely different from other internal medicine specialties.

3. Electronic consultations through non-secure portals (email, curbside consultations). Since security is central in the exchange of patients information electronically, we excluded these ways of communication as they may jeopardize patients privacy and are often informal and providers cannot be compensated for their work.[28]

4.3.6 Data extraction

The project lead (Mohamed Osman) and another reviewer (Liza Bialy) independently screened all identified citations for potential inclusion. In the initial screening of title and abstracts, potentially relevant papers were identified separately based on the inclusion and exclusion criteria, the two lists were compiled, and then full-text papers were obtained. When agreement on a citation could not be reached between the two reviewers, the project supervisor (Aminu Bello) was consulted for reconciliation.

Data was extracted from eligible studies using a data extraction tool previously piloted on five papers. Data items included study characteristics, study design and key barriers and facilitators at patient, provider and health system levels. Also, the system design that was used to build eConsult was also extracted based on two main approaches identified from the literature: 1) web-based (standalone online forms that can be accessed using internet)[29]; and 2) EMR-based (integrated delivery systems to the existing EMRs)[30] platforms. Data extraction was conducted in three stages: 1) details of the paper: publication year, first author, journal, study design, analytical approach was listed; 2) each paper was assessed for content in relation to pre-defined themes based on a preliminary review of the literature and the consultation exercise (see below); and 3) the key findings were subjected to the predefined inclusion and exclusion criteria. All data were extracted into a Microsoft Excel 2016.

4.3.7 Summarizing and reporting the results

Extracted data was analyzed, and interpreted qualitatively using deductive (pre-identified themes) and inductive (new identified themes) approaches.[31] Textual data from included papers were coded individually using a broad-based coding scheme (by Mohamed Osman), looking for common themes across papers.

The results were summarized into tables and figures based on the evaluation framework of the study (Quadruple Aim)[32,33] in forms of text (themes) and numbers (frequency) on reported items. We applied the Quadruple Aim framework to guide the mapping of the literature on barriers and facilitators for eConsult. This Framework for optimizing health systems performance started as a Triple Aim for improving patient perspective and population health while decreasing health care costs simultaneously;[34] recently a fourth dimension was added advocating for provider perspective, making it a Quadruple Aim.[33] This model has been proposed previously to evaluate eConsult.[28,32] In this scoping review, the provider perspective was further subdivided into PCPs and specialist perspectives; this division was helpful in this evaluation as the two providers encounter different set of factors influencing their use of health information technology.[35]

4.3.8 Quality assessment of included studies

Quality appraisal and risk of bias assessment was not conducted since it is not part of the scoping review methodology.[19,22] However, I reported on basic study characteristics, study design (analytical approach), and the use of statistical and qualitative analysis. Currently, a checklist for reporting is under development by Tricco and her colleagues and will be added to PRISMA guidelines.[36] This checklist was not available at the time of this analysis.

4.3.9 Consultation exercise prior to review

Arksey & O'Malley described a consultation process as an optional exercise for researchers conducting a scoping review.[21] In the pre-implementation phase of this study, we conducted a focus group with patients, policymakers and PCPs[23] in which we identified key themes of potential barriers and facilitators to eConsult service implementation specific to kidney care. We used these pre-identified themes **(Table 4.2)** to assist in in the analysis of this scoping review of the literature on barriers and facilitators of eConsult implementation across specialties.

4.3.10 Ethics

Approval by research ethics board was not required since the review only involved published and publicly available data with no involvement of identifiable patient records.

4.4 Results

4.4.1 Study selection

A total of 2579 unique citations were identified and assessed for eligibility. A total of 133 (126 primary studies and seven reviews) citations met the inclusion criteria (**Figure 4.1**).

4.4.2 Study Characteristics

Majority of identified studies were published in the last ten years (**Figure 4.2**). eConsult programs included in the review were from seven countries (Finland, Ireland, Canada, Spain, Brazil, United Kingdom [UK], Netherlands and United States of America [USA]) (**Figure 4.2**). Observational designs were commonly used to evaluate and report on eConsult programs such as surveys,[37-50] focus groups/interviews,[23,48,51-57] and mixed methods.[58-60] In addition, three randomized control trials (RCTs) on eConsult were identified.[61-63] Also, three systematic reviews[64-66] and four narrative reviews[67-70] were included. The included studies characteristics are summarized in **Table 4.3**.

4.4.3 Programs description

Of the 126 included primary studies, we identified a total of 34 unique eConsult programs; 20 programs based in the USA, 4 in Canada, 3 in the UK, 2 in Brazil, 2 in Finland, 2 in Spain, and a single program in both Netherlands and Ireland (**Table 4.3**). The platform used in the identified eConsult programs was evenly distributed between

EMR-based (10) and web-based (13). Although we identified two studies reporting a process similar to eConsult in Finland in the early 90s, the contemporary eConsult design started in the early 2000s and was further developed in the 2010s in the large-scale programs in Ontario and United States (**Figure 4.3**). In addition, we identified 3 non-civilian eConsult programs in the USA providing access to specialist care for military personnel and their families.[47,71-74]

4.4.5 eConsult terminology

The most common description for this approach of using telemedicine in literature was eConsult/e-Consult (**Figure 4.4**). eConsult/e-Consult first appeared in the literature as "ENT consult" in 2003 by Baum et al.[75] and later in 2009 by Stoves et al.[76] as "electronic consultation" and by Angstman et al.[77] as "e-Consult". Other less frequent terminologies identified were teleconsultation, asynchronous care and electronic referral/eReferral (**Figure 4.4**).

4.4.6 Barriers to eConsult

Identified barriers to eConsult are presented in **Table 4.4**, The distribution of these factors based on the Quadruple Aim taxonomy are shown for patients (**Figure 4.5**), provider (**Figure 4.6**), health system (**Figure 4.7**) and costs (**Figure 4.8**).

4.4.7 Patient perspective on barriers

For patients, the three central themes were identified were patient preference for a face to face contact with a specialist, patient perceived eConsult to limits accessibility to specialist care in a more comprehensive manner, and concerns for safety and/or appropriateness of eConsult (**Figure 4.5**).

- ✗ *"It's important to see the specialist to feel more secure."*[60]
- ✗ *"And if I feel like my doctor is brushing off that information, is not communicating other symptoms … you know, these are the only four symptoms that matter and so I'm just going to give those to the specialist, at that point I might feel like wow, there's more information that's not getting through"*[48]
- ✗ *"I asked someone and he told me to give you this. If something happens to you, it's not my responsibility because the other doctor prescribed it"*[48]

4.4.8 Providers perspective on barriers

A number of barriers related to PCP adoption of eConsult were identified that included increased workload and disruptions of workflow, technical challenges, loss of "immediate contact" and/or access to a specific specialist, unfamiliarity with using eConsult service, lack of PCPs financial incentive to use eConsult, challenges with patients 'follow up, and delays in responses from specialist. (**Figure 4.6**).

- *"Resistance to change, particularly to changes in PCP work flow, emerged prominently during our interviews"*[55]
- *"It was a lot easier and quicker for me to write a consultation on…paper…Now I'm having to go through a longer process with a few more hurdles in it. Just mechanically if we have any problems with the computer…"*[54]
- *"When I added a follow up question it never seems to go through and the consult disappeared. I had to request a new consult with my follow up question."*[78]
- *"PCP concerns included …unable to select the specific consultant"*[66]
- *"The preparation…, what kinds of tests have to be done"*[53]
- *"Lack of reimbursement for PCP to submit the consultation request electronically"*[79]
- *"The shortcomings of referral systems with exchanges between PCPs and consultants include …… and loss of patients to follow up"*[80]
- *"PCPs were not satisfied with the depth of the answer that was provided. Some providers were looking for more detail, whereas others felt their questions were not adequately addressed"*[78]

From the specialist perspective, the key barriers also included increased workload, concerns with liability, loss of patient contact, challenges with the quality/content of eConsult, use of technology, and absence of financial incentives for specialists in some jurisdictions. (**Figure 4.6**).

- *"Specialists also experienced greater workload in the form of pre-consultative exchange and virtual management, which also served as a barrier to implementation"*[55]
- *"Another challenge unique to electronic consultation and integrated eCR [eConsult] systems but not referral systems was specialist concern about liability"*[81]
- *"A minority of them prefer not to use VCs [virtual consults] because of ... or discomfort with an impersonal process"*[82]
- *"Referrals that lack a clear consultative question and relevant clinical data often render a specialist unable to make a clear diagnosis or a fully developed management plan"*[83]

- *"However, until a more slim-line IT system is developed reducing the number of steps involved in completing an eC[electronic consultation], … it appears to be beneficial for all parties except secondary care"*[84]

4.4.9 Health care system related barriers

Identified health care system related challenges were variation in licensure requirements across jurisdictions, concerns of privacy, and in the provision of requisite infrastructure and resources for implementation. (**Figure 4.7**).

- *"To find an application able to integrate seamlessly with diverse systems is often challenging"*[85]
- *"Health systems or practices initiating telehealth programs need to provide a base investment in the technology and then provide an ongoing and available infrastructure"*[69]
- *"In fact, licensure requirements also differ from state to state, and this introduces a significant possible variation in practice"*[69]
- *"Concerns over privacy remain a barrier to the adoption of electronic platforms or innovations among health care providers"*[60]

4.4.10 Cost related barriers

Cost related barriers included absence of reimbursement for providers in some jurisdictions, and the absence of specific provider's payment structure (Salaried physicians Vs. Fee-for-service models). (**Figure 4.8**).

- *"A key barrier to widespread adoption of preconsultation exchange is the development of reimbursement models"*[80]
- *"and might only be cost-effective in a non fee-for-service model such as one found in the VHA [Veterans Health Administration]"*[86]

4.4.11 Facilitators to eConsult

The key facilitators identified are summarized in **Table 5**. The distribution of these factors based on the Quadruple Aim taxonomy are shown for patients (**Figure 4.5**), provider (**Figure 4.6**), health system (**Figure 4.7**) and costs (**Figure 4.8**)

4.4.12 Patient perspective on facilitators

The main facilitator from a patient's perspective is the avoidance of travel, and other factors included timely access to specialist advice, cost savings, and patient's acceptance of eConsult as convenient model of care. (**Figure 4.5**).

- ✓ *"I live in a more remote location [...] A lot of the specialists probably aren't going to be here, so [eConsult can] save me a trip to Ottawa."*[52]
- ✓ *"From a patient perspective, fewer office visits translates to less time taken off work and reduced transportation costs."*[87]
- ✓ *"The service allowed a significant proportion of patients to avoid traditional consultations leading to the potential of cost savings"*[88]
- ✓ *"acceptance is vital to the success of any healthcare innovation, and patients' perspectives on new and innovative services must be thoroughly established"*[60]

4.4.13 Providers perspective on facilitators

From PCPs perspective, facilitators included efficiency such as timely response from a specialist, and enhancing capacity in chronic disease care (a platform to new knowledge and resources) (**Figure 4.6**).

- ✓ *"a very helpful service, giving timely help and input to the front-line generalist"*[41]
- ✓ *"timely answer. Great feedback. Offered useful resources."*[89]
- ✓ *"Thank you to Dr. X for the excellent advice. This will also help me manage patients with similar profiles in the future."*[78]
- ✓ *"Identifying the most common questions and content being asked via the eConsult service will allow for more informed continuing medical education programs for PCPs"*[88]

From a specialist's perspective, the use of eConsult facilitated communication with PCPs, provided educational opportunities for PCPs and also improved referral efficiency. Other factors included eConsult not requiring significant time commitment from specialists and specialist's ability to expedite face to face consultation if needed (**Figure 4.6**).

- ✓ *"I think it helps in the interaction with the health care provider. They tell you what information they have, you evaluate it and then if you need further information, you tell them 'This is what you need."*[29]
- ✓ *"[E-consultation] also provides education. If you take the time to write out the thinking, then they don't have to ask you the question again because you just taught them. So it helps them be a better physician and it also will cut down on the questions."*[90]

- ✓ *"satisfaction with the e-consult was high among nephrologists; in the majority of cases thought that the e-consult was efficient"*[91]
- ✓ *"It's always quicker to read someone's findings rather than to go ahead and do the full exam yourself. I probably would spend anywhere from 30 to 45 minutes with a new patient. What I reported as having spent on e-consultation was much less than that. Nothing more than 20 minutes."*[29]
- ✓ *"If we have any reservations or the patient has any reservations, we see them [face-to face]."*[53]

4.4.14 Health care system related facilitators

Health care related emerging themes included efficiency (enhanced access and fast triage of patients) at both referring and receiving providers ends, opportunity to utilize other care providers (e.g. case managers), and medico-legal elements (**Figure 4.7**).

- ✓ *"The benefits include improved access to specialty care for those practicing in remote communities"*[69]
- ✓ *"use of referral case managers to improve efficiency"*[51]
- ✓ *"We reviewed our e-consult process with risk management lawyers and we were able to reassure providers that this system would not place them at undue legal risk."*[92]
- ✓ *"4% of cases PCPs were not planning on sending the patient for a traditional face-to-face referral … however, the eConsultant recommended one due to the potential high-acuity nature or complexity of the problem"*[37]
- ✓ *"Obtaining buy-in from health system leadership is essential to lay the necessary ground work"*[93]
- ✓ *"eConsults from a medical legal perspective are considered along the same lines as a ''curbside consult'' in that the specialist provider does assume a duty of care once the case is reviewed"*[37]
- ✓ *"Disseminate the benefits (using actual data) of E-Consults for patients and for workflow to participating providers"*[57]
- ✓ *"In contrast, a high-volume site participant noted that training was crucial"*[59]
- ✓ *"I think the reason why they've jumped onto the bandwagon is because they probably saw how efficient it was with GI."*[54]

4.4.15 Cost related facilitators

Cost-related recurring themes in the literature as facilitators for eConsult implementation were developing payment models and incentives for providers to use eConsult. Other facilitators included potential cost savings for society, insurance payers and health care system (**Figure 4.8**).

- ✓ *"Its success at San Francisco General Hospital depended on …… and on financial incentives that were not completely wedded to clinic productivity."*[68]
- ✓ *"Referral to specialty departments dramatically affects the annual cost of medical care for a group of insured patients"*[77]
- ✓ *"cost savings for eConsult from the societal perspective attributable to patient avoided costs, as patients whose PCPs had originally considered a referral but ultimately chose not to refer them avoided the travel costs and lost wages/productivity"*[94]
- ✓ *"Please continue with e-consult services as it will save on health [dollars] in the long run and will assist in improvement of patient care"*[78]

4.5 Discussion

This scoping review provides insights into the barriers and facilitators for eConsult adoption as reported in the current literature. The Quadruple Aim Framework taxonomy[33] was leveraged to summarize findings into the four domains of patient, provider, health care system and cost. Key barriers identified were: patient preference to see a specialist directly, patient perception of eConsult limiting their accessibility to specialist care, provider perception of eConsult creating additional workload, concerns around privacy, and lack of a reimbursement model for providers. The main facilitators identified were patient avoidance of travel to see a specialist, PCPs receiving timely responses from specialists, integration of case managers, overcoming medico-legal issues and providing incentives for providers to use eConsult.

To our knowledge, this is the first scoping review aimed at identifying barriers and facilitators to eConsult adoption and implementation. An existing qualitative study by Tout and colleagues identified a number of facilitators including engaged leadership, provider incentives, user-friendly technology and integration with EMRs, as well as barriers including provider resistance, lack of reimbursement, liability concerns and lack of integration into EMRs.[16] Their study examined a select number of organizations in the United States that had recently implemented eConsult.

From the patient perspective, more facilitators for eConsult were identified than barriers. However, few studies directly evaluated patient perspectives on eConsult. In one study,[92] it was reported that more than 9 out of 10 (91.3%) surveyed patients were highly satisfied with their eConsult experience and in another study the majority of patients (86.6%) stated that eConsult was "useful in their situation".[52] Other studies utilized PCPs perception as a proxy to evaluate patient satisfaction. In several studies the majority of providers rated eConsult as "very good" to "excellent" service for their patients.[38,40,41,43,44,78,95] PCPs perspective is also important, as one study on patient engagement in eConsult found that most patients expressed minimal desire to directly engage with eConsult and rather wanted their PCPs to take on that role.[48] In this review, top barriers identified from a patient perspective centred on access to specialty care as well as some patient's preference to see face to face. This seems to be related to patient's knowledge and attitudes towards eConsult, as most of patients who were exposed to the system had high satisfaction and acceptance rates. Thus these challenges can be addressed by strategies that increase patient awareness about the process of eConsult and its benefits through educational brochures and patient handouts. A systematic review on patient decision aids found that the most significant benefits of its use were improved patient knowledge of options and outcomes.[96] The aids may include user-friendly information such as metrics of response time, impact on wait times and the purpose of eConsult — that is to avoid face to face visits unless necessary.

The key barriers identified from the perspective of care providers were concerns with increased workload. The apparent benefits of using eConsult may not be realized if use of the service creates an additional burden on clinicians. However, several studies showed specialists' self-reported time responding to consultation was less than 10 minutes on average.[37,38,42,44,97-99] For PCPs, the time commitment was less clear, one study reported that a consultation takes on average 10 minutes to be completed by both PCPs and specialists.[100] PCPs involvement with eConsult includes many factors in addition to initiating and responding to consultation, such as conducting extra tests and communicating the outcome of consultations to patients. Findings from studies quantifying PCPs workload in relation to eConsult will be useful in engaging PCPs. Similar to patients, providers' barriers can be addressed by targeted interventions such as academic detailing, audit and feedback,[101] and soliciting provider's feedback[85] in the development of eConsult tools. Moreover, using clinician champions to advocate for eConsult among their peers was found to be effective.[85]

Recent studies published after the completion of our review, are consistent with our findings.[102,103] In a qualitative study evaluating 40 PCPs' perspectives on eConsult, authors reported themes common to our findings.[103] Identified facilitators from PCP interviews included timely access to specialist input, and ability to broaden their scope of practice, while reported barriers were increased workload, as more specialist care moved to PCPs.[103] Interestingly, authors also discussed the difference in these barriers between two systems of eConsult: discretionary systems (eConsult as an add-on service to traditional referral pathways) and mandatory systems (all referral goes through eConsult). Discretionary eConsult were found to be associated with more positive perceptions among PCPs in regards to workload, compared to mandatory eConsult. However, this method was associated with less utilization of the service.[103] More importantly, based on the above qualitative study, authors developed a tool for programs seeking to implement eConsult to guide their decision making at multiple levels.[103] This tool consisted of a list of questions at the levels of eConsult design (PCPs interface design, process design), eConsult process (pre/post eConsult decisions), and eConsult management decisions (implementation planning and maintenance).[91] Similar eConsult adoption facilitation tools can be developed using the findings of this scoping review and subsequently evaluated to assess their impact. From a specialist perspective, another recent work has demonstrated that specialists perceived eConsult positively and as a platform to facilitate communication with PCPs and provide educational opportunities for both providers for capacity building.[102]

Of note, none of the facilitators identified were unique to specific programs except for the platform choice and provider reimbursement model. The Veterans Affairs eConsult[104,105] reported shared EMR as a necessary pre-requisite platform for the success of eConsult implementation while the Ontario eConsult advocated for a stand-alone web-based system.[65,85] While both approaches are acceptable, other factors (e.g., patient and provider perceptions on eConsult and the provision of incentives to use eConsult) have more influence on implementation. It also appears that the presence of a compensation model rather than a specific payment structure, such as fee-for-service or salary, is a key facilitator for eConsult adoption.[86]

Overall, the key gaps identified in the literature from this review were; first, most studies focused on process evaluation, and these studies are often non-randomized.

Second, few studies evaluated the outcome of eConsult on population health, for example only three studies reported on these outcomes.[42,61,62] Third, we could not identify in the review any eConsult programs currently being implemented in low-income nations.

4.5.1 Limitations

This review followed a rigorous and transparent method, however, since the objective was to map the literature, study appraisal and risk of bias assessment was not performed. Further, scoping reviews are by nature broad with limited or no focus on a specific research question and/or hypothesis as this kind of reviews typically focus on addressing broad and complex questions.[106] Another common limitation reported in literature is lack of comprehensiveness of the search for relevant literature. We mitigated this by conducting the search in a stepwise fashion following the recommended guidelines and using several databases, grey literature and manually searching the reference lists of included studies.

4.5.2 Conclusion

Even though the benefits of the eConsult on improving access to care including reduced wait times are well documented, the adoption of eConsult remains poor even in high-income countries with well-established health systems (eHealth infrastructure), and these programs are entirely non-existent in LMIC. The design of successful eConsult systems requires careful consideration of all factors that hinder or favor implementation. In this study, I identified the common barriers and facilitators for eConsult implementation to improve access to specialist care. The key barriers identified were patient preference for a face to face visit with specialist, providers perceived increased workload, privacy concerns and absence of reimbursement model for providers in some jurisdictions. The key facilitators identified were avoidance of travel from a patient's perspective, timely response from specialists, opportunity to integrate non-physician practitioners (e.g., case managers, referral coordinators, nurse practitioners), circumventing medico-legal obstacles, and provision of incentives for providers to use eConsult (e.g., fee for service model or other funding models).

Future studies are needed to identify effective strategies that can be used to address identified barriers to eConsult implementation. Moreover, rigorous and pragmatic studies are needed to evaluate the impact of eConsult on process of care and outcomes to provide solid evidence for its use and for any unintended consequences to be mitigated. Studies are also needed on the optimal ways to facilitate implementation of eConsult in LMIC. The findings of this review can support future studies on eConsult implementation by providing evidence from the experience of established programs to inform implementation and scale up in any setting across the world.

Figure 4.1: Flow chart for study search and decision process

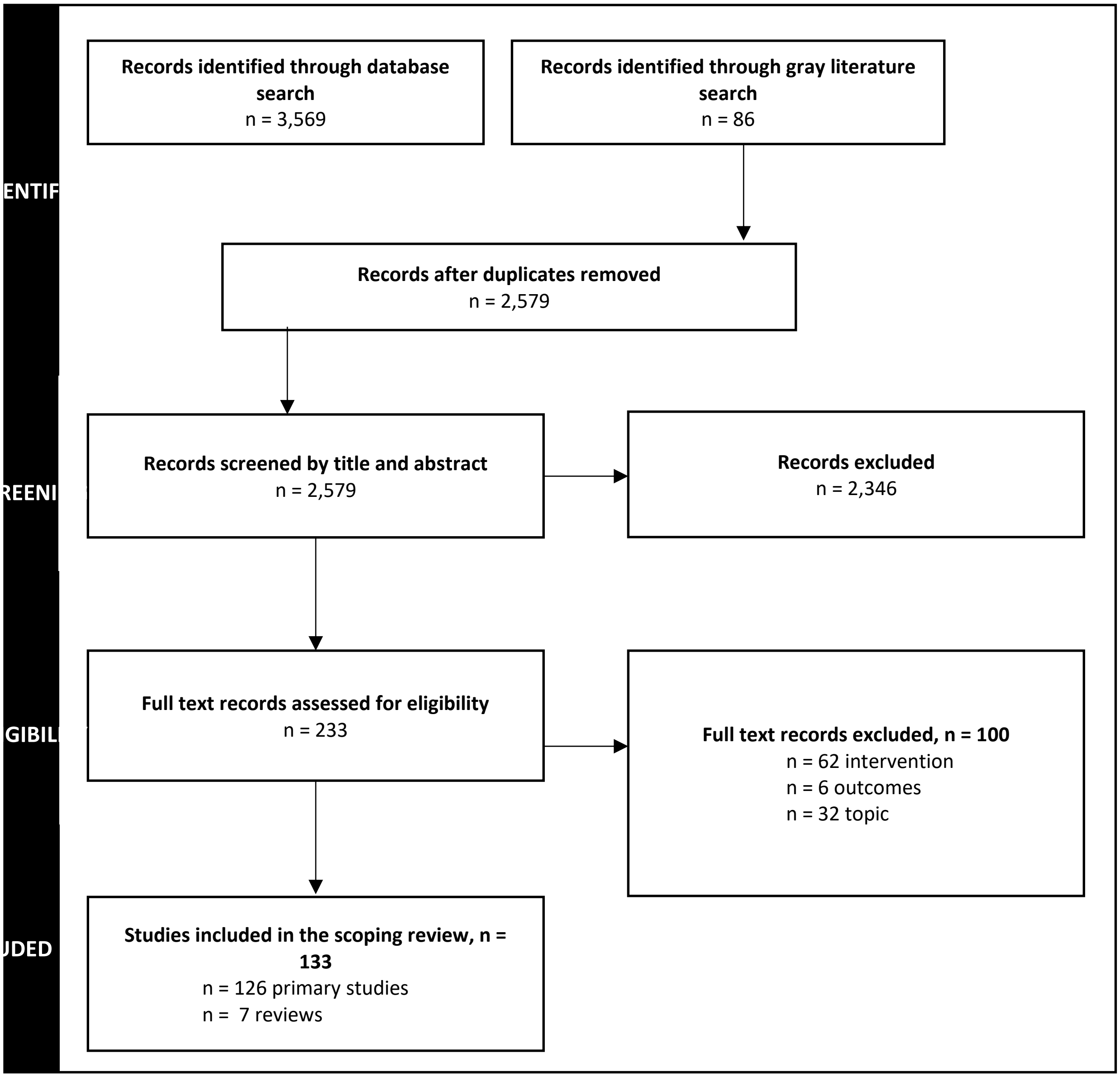


Figure 4.2: Bubble plot on the evolution of eConsult literature

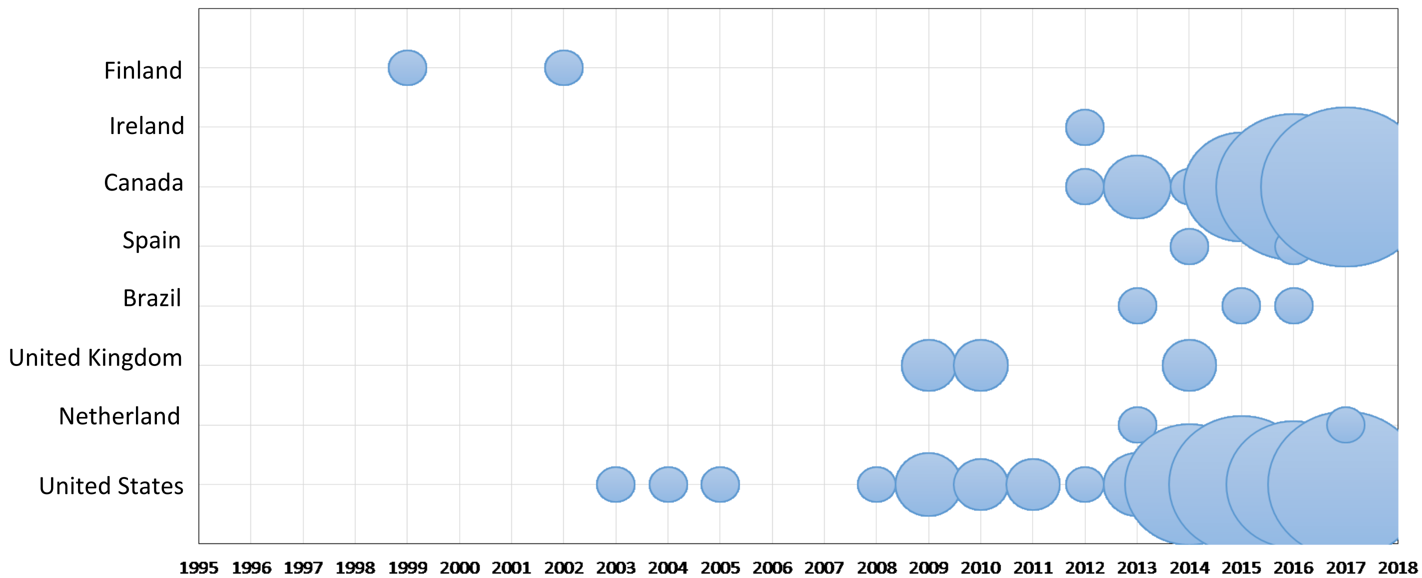
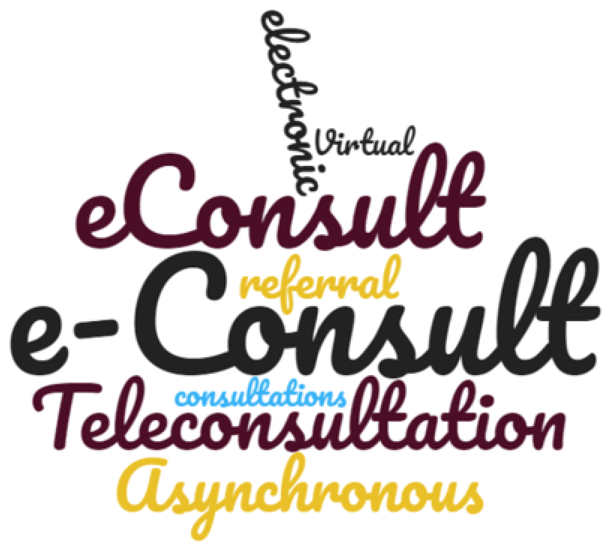


Figure 4.3: The big 4 programs in eConsult implementation

Program	Percentage of eConsult literature*
Champlain BASE eConsult	34%
VA U.S. Department of Veterans Affairs	15%
UCSF Department of Medicine	14%
MAYO CLINIC	4%

* As of search date for this scoping review

Figure 4.4: Word cloud on electronic consultations programs terminology



terms used to describe electronic consultations	Count (%)
e-Consult*	9 (30%)
eConsult*	7 (23%)
Teleconsultation	5 (17%)
Asynchronous	4 (13%)
electronic referral	3 (10%)

* include both full (e-Consultations) and truncated (e-Consult) words

Figure 4.5: Patient perspective

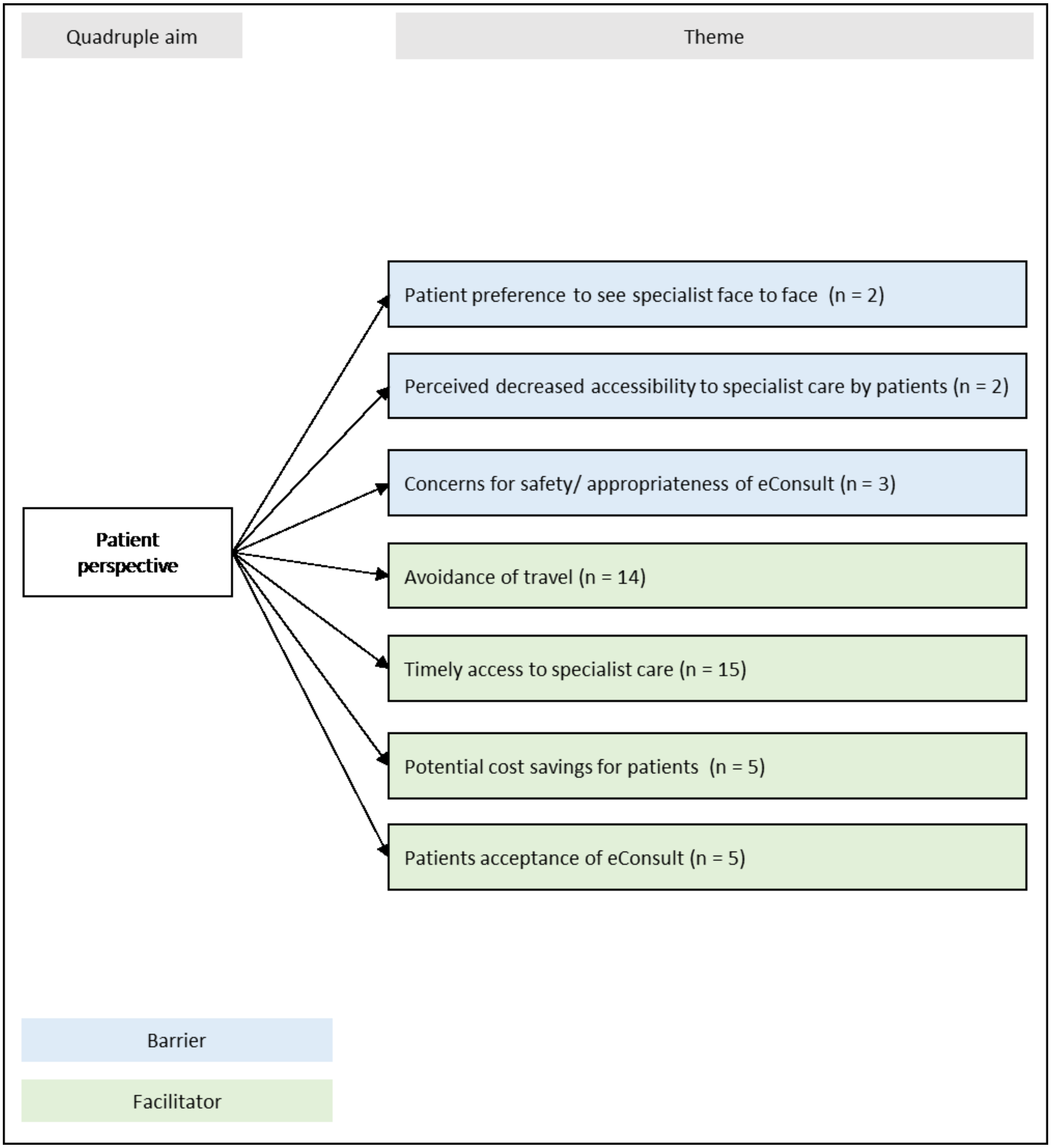


Figure 4.6: Providers perspective

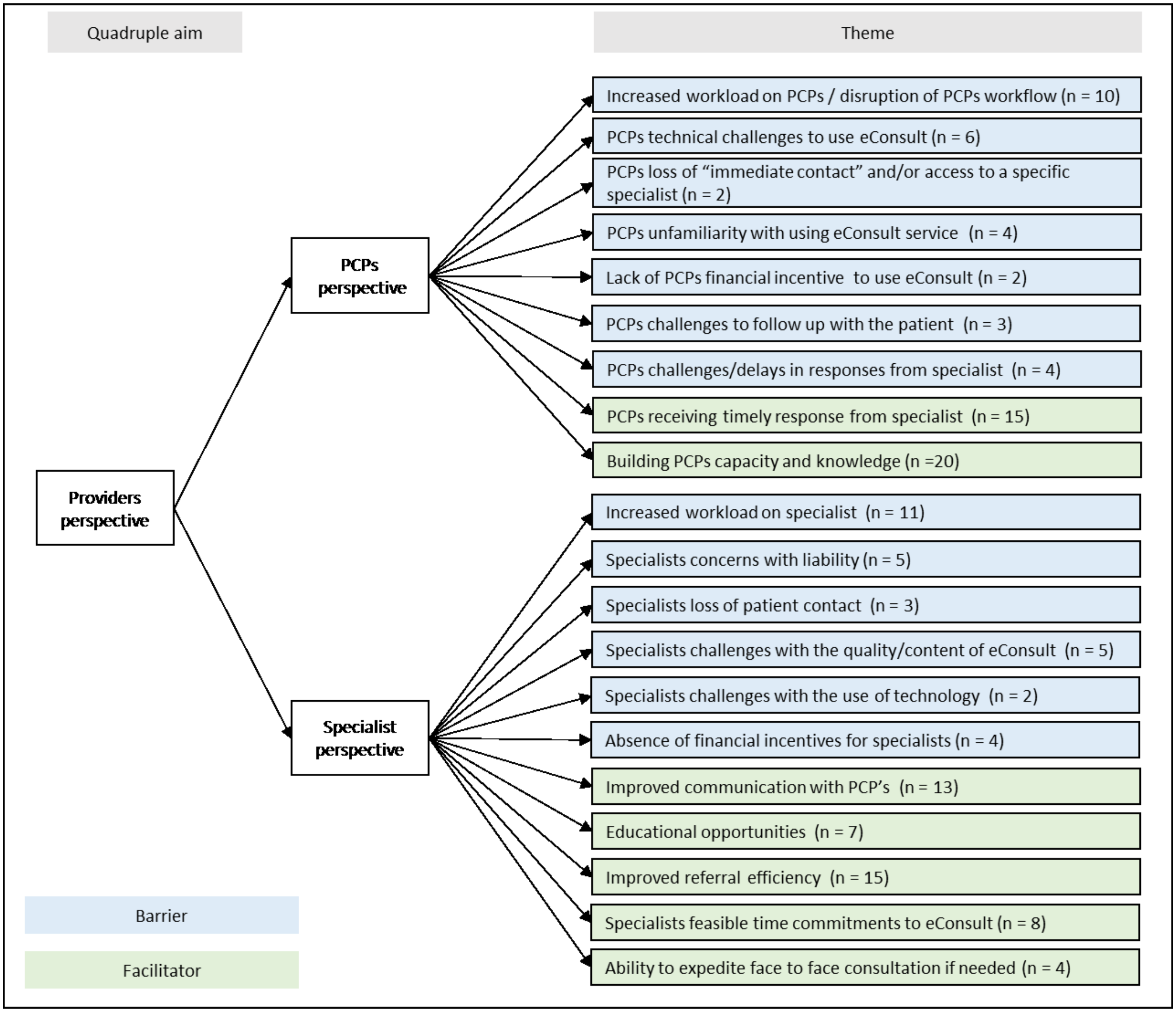


Figure 4.7: Health care system level

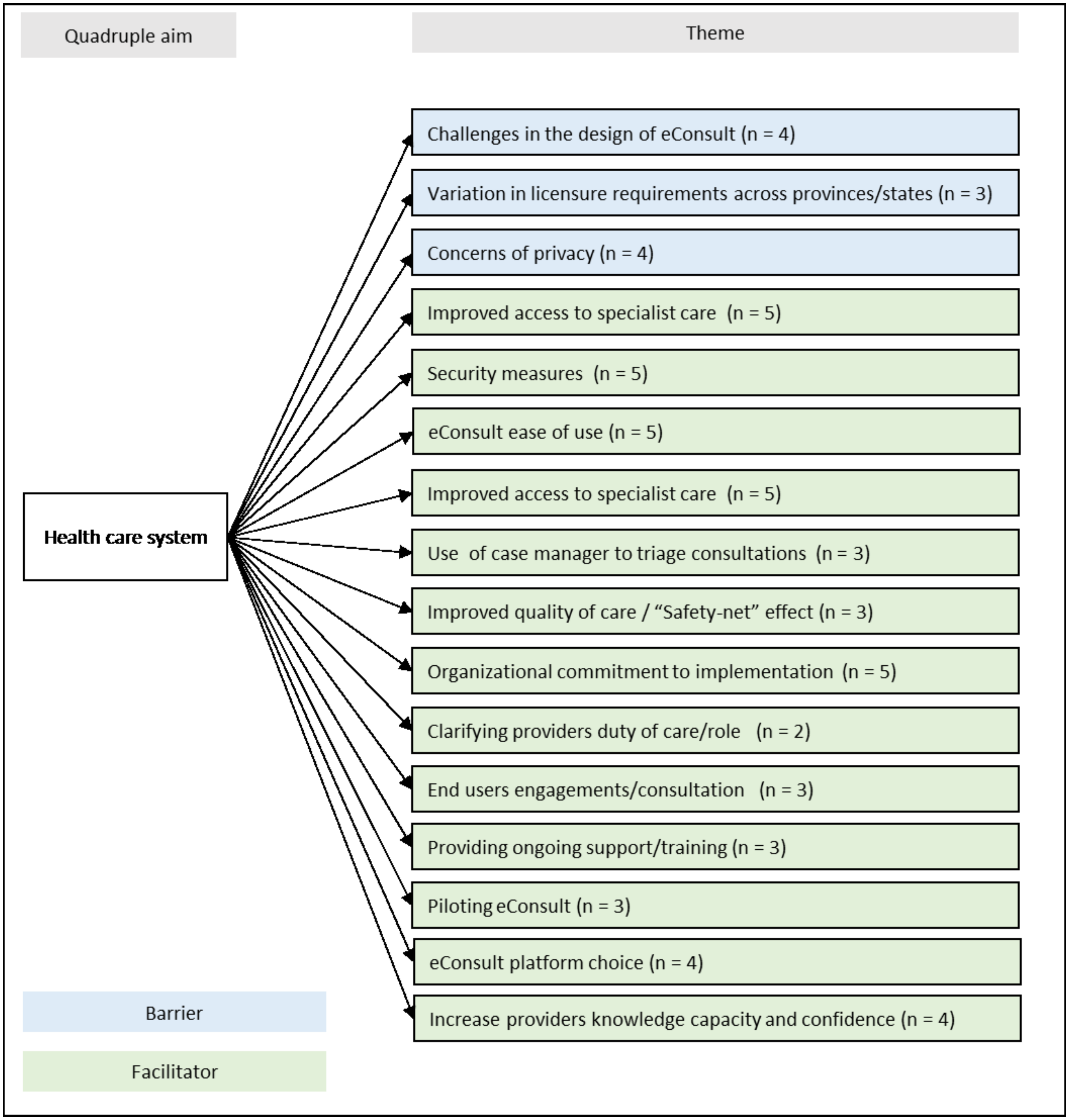


Figure 4.8: Cost related factors

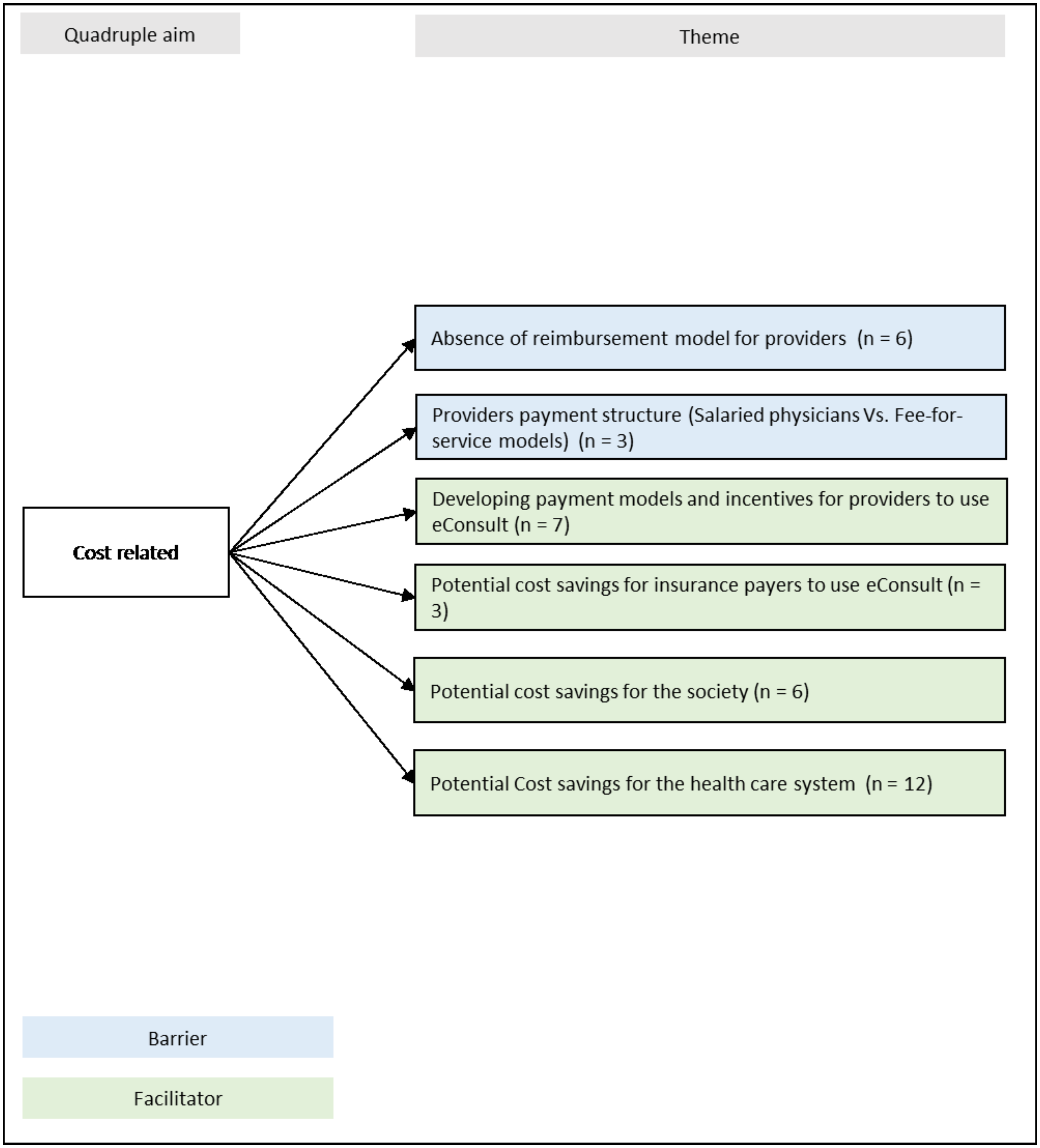


Table 4.1: A comparison of scoping and systematic reviews

Scoping Review	Systematic review
Broad research question	Focused research question
No critical appraisal of included studies	Quality and risk of bias assessment included
Research protocol developed but it involves iterative approach with changes based on initial search results	Research protocol developed a priori
More qualitative than quantitative synthesis	Often quantitative analysis
Used in "mapping the literature" to identify gaps in a body of literature, identify key terms and concepts	Used to formulate a conclusion about a focused research question; assesses the quality of existing evidence

* Adopted from Ref. (20) with permission.

Table 4.2: Pre-identified themes of potential eConsult barriers and facilitators

Facilitators	Barriers
Improvement in care coordination	Issues with privacy and security
Better clinical care	Limited awareness and ease of use
Disseminate best practice and educational platform	Aversion to adopt new technology
Facilitate better continuity of care	Required pace of change
Comprehensive data to make decisions easily without the need for a face-to-face consultation	Cost
Quick feedback to primary care providers	Limited workforce
Clarity of information and improved details	Lack of interest
Timeliness/reduced delays for patient	Aversion to change
Convenience (e.g., less travels for patient)	Lack of time
Rapid triage and identification of cases needing urgent care	Convincing patients to agree difficult
	Compensation issues

Table 4.3: Characteristics of included studies

First Author, Year	Journal	Data Extracted	Study Design	Analytical approach
The Champlain BASE (Building Access to Specialists through eConsultation), Canada, Ontario				
Bradi, 2017 [107]	Neurology	Healthcare system	Categorization of eConsult questions by topic and type	Quantitative analysis
Canning, 2016 [108]	Canadian Journal of Gastroenterology and Hepatology (Abstract)	Primary provider; Healthcare system	Categorization of eConsults using ICPC-2 taxonomy	Not specified
Chan, 2016 [109]	Canadian Journal of Cardiology (Abstract)	Primary provider; Specialist; Healthcare system	Retrospective review	Thematic analysis
Fogel, 2017 [37]	Journal of Telemedicine and Telecare	Primary provider; Healthcare system	Cross-sectional survey	Narrative description
Johnston, 2017 [38]	Journal of Pediatric Hematology / Oncology	Primary provider; Specialist; Healthcare system	Cross-sectional survey	Narrative description
Johnston, 2017 [39]	Pediatric Blood and Cancer (Abstract)	Patient	Cross-sectional survey	Not specified
Joschkoa, 2018 [52]	Family Practice	Patient	Patient interviews	Thematic analysis
Keely, 2017 [67]	Academic Medicine	Patient, Primary provider, Specialist	Narrative summary	Narrative description
Keely, 2015 [81]	Global Telehealth 2015	Specialist	Web-based questionnaire	Narrative description, content analysis
Keely, 2015 [70]	Electronic Healthcare Law Review	Patient; Healthcare system	Review	Not specified
Keely, 2015 [60]	Canadian Journal of Diabetes	Patient	Mixed methods	Not specified
Keely, 2013 [40]	Telemedicine and e-Health	Healthcare system	Prospectively collected survey	Narrative description, frequencies and percentages
Keely, 2012 [110]	Canadian Journal of Diabetes (Abstract)	Patient, Healthcare system	Observational (review of eConsults)	Descriptive statistics
Khamisha, 2015 [88]	Blood	Patient, Primary provider, Healthcare system	Not specified	Categorization based on validated taxonomy
Kohlert, 2017 [41]	The Laryngoscope	Patient; Primary provider; Specialist; Healthcare system; Costs	Prospectively collected survey	Independently reviewed by two authors using pre-defined list of question types and clinical topics
Liddy, 2017 [42]	Canadian Family Physician	Patient, Primary provider	Cross-sectional survey	Descriptive statistics; when appropriate quantitative analysis to examine associations between characteristics of referral and all other eConsults
Liddy, 2017 ([111])	Healthcare Policy	Patient, Primary Provider, Healthcare System	Cross-sectional study	Quadruple aim model
Liddy, 2017 [98]	Journal of the American Board of Family Medicine	Primary provider; Specialist; Healthcare system	Retrospective eConsult review	Thematic analysis
Liddy, 2017 [49]	Scandinavian Journal of Pain	Patient	Cross-sectional survey	Descriptive statistics
Liddy, 2016 [95]	Pain Medicine	Patient, Primary provider, Specialist	Cross-sectional review of eConsults	Median, IQR, tabulated counts
Liddy, 2016 [43]	Gerontology & Geriatric Medicine	Healthcare system; Costs	Cross-sectional survey	Median, IQR, tabulated counts

First Author, Year	Journal	Data Extracted	Study Design	Analytical approach
Liddy, 2016 [44]	International Journal of Circumpolar Health	Primary provider; Healthcare system; Costs	Cross-sectional survey and cost analysis	Total societal costs and savings
Liddy, 2016 [112]	BMJ Open	Patient; Healthcare system; Costs	Costing evaluation from societal perspective	Total societal cost of eConsult included estimated direct (costs to the payer) and indirect costs (costs to the patient)
Liddy, 2016 [64]	Family Practice	Primary provider; Healthcare system; Costs	Systematic review	Thematic analysis
Liddy, 2016 [113]	Journal of the American Association of Nurse Practitioners	Primary provider	Cross-sectional and content analysis	Content analysis
Liddy, 2016 [94]	BMJ Open	Costs	Costing evaluation from societal perspective	Estimation of costs
Liddy, 2016 [114]	Informatics	Specialist; Healthcare system; Costs	Economic evaluation	Cost analysis / calculations
Liddy, 2015 [115]	Health Reform Observer	Patient; Primary provider; Specialist; Healthcare system; Costs	Commentary	Not specified
Liddy, 2015 [113]	Journal of the American Board of Family Medicine	Primary provider; Costs	Mixed methods	Thematic analysis
Liddy, 2015 [65]	Global Telehealth 2015	Healthcare system	Systematic literature review and interviews	Not specified
Liddy, 2013 [85]	Telemedicine and e-Health	Healthcare system; Costs	Case report	Not specified
Liddy, 2013 [29]	Open Medicine	Patient; Primary provider; Specialist; Healthcare system; Costs	Mixed methods	Not specified
McKellips, 2017 [116]	British Journal of General Practice	Primary provider	Cross-sectional study	Descriptive overview of cases
Murthy, 2016 [99]	Open Forum Infectious Diseases	Patient; Primary provider	Retrospective record review	Coding and descriptive statistics
O'Toole, 2017 [117]	The International Society of Dermatology	Primary provider; Specialist; Healthcare system; Costs	Survey	Descriptive statistics
Poulin, 2017 [79]	Journal for Healthcare Quality	Patient; Primary provider; Specialist	Cross-sectional study	Descriptive statistics
Rostom, 2015 [118]	The Journal of Rheumatology (Abstract)	Primary provider	Characterization of eConsults	Not specified
Shehata, 2016 [89]	Obstetrics & Gynecology	Primary provider; Specialist	Retrospective review of eConsult	Descriptive analyses were used to quantify the most common clinical topics or question types
Shoki, 2015 [119]	Canadian Cardiovascular Society (Abstract)	Primary provider	Not specified	Categorization based on validated taxonomy
Skeith, 2017 [120]	Thrombosis Research	Primary provider; Specialist; Healthcare system	Cross-sectional study	qualitative thematic analysis of responses from survey to identify emerging themes
Stanistreet, 2017 [121]	Healthcare Quarterly	Primary provider; Specialist; Healthcare system; Costs	Not specified	Not specified
Tran, 2016 [122]	Telemedicine and e-health	Primary provider; Specialist	Not specified	Categorization of questions and narrative description of eConsults

First Author, Year	Journal	Data Extracted	Study Design	Analytical approach
Tran, 2016 [87]	Endocrine Practice	Primary provider; Specialist; Healthcare system	Retrospective review of eConsult	Categorization of eConsults; associations using chi squared
Tran, 2014 [123]	Canadian Journal of Diabetes (Abstract)	Primary Provider	Retrospective review of eConsult	Analyzed independently by 2 reviewers and data discussed until consensus was reached
Witherspoon, 2017 [124]	Canadian Urological Association Journal	Primary provider; Specialist; Healthcare system	Retrospective review of eConsult	Review and categorization of eConsults
Witherspoon, 2016 [125]	Canadian Urological Association Journal (Abstract)	Patient	Retrospective review of eConsult	Categorization of clinical questions
Alberta Netcare eReferral, Canada				
Bello, 2017 [126]	BMJ Open	Patient; Primary provider; Specialist; Healthcare system; Cost	Qualitative focus group study	Thematic analysis
Consult Conduit, Canada				
Abouali, 2017 [127]	Canadian Family Physician	Primary provider; Specialist; Cost	Commentary	Descriptive summary
Veterans Health Administration, USA				
Chang, 2017 [128]	Journal of the American College of Rheumatology (Abstract)	Patient	Retrospective review of eConsults	Changes in frequency
Cordasco, 2015 [129]	Journal of General Internal Medicine (Abstract)	Patient; Primary provider	Observational mixed methods (survey, semi-structured interviews)	Descriptive summaries
Gleason, 2013 [130]	Journal of Complementary and Integrative Medicine (Abstract)	Patient; Primary provider; Specialist; Healthcare system; Cost	Not specified	Not specified
Gupte, 2016 [97]	JMIR Medical Informatics	Primary provider; Specialist; Healthcare system	Quality improvement study using mixed methods	Descriptive summary and frequencies
Haverhals, 2016 [59]	American Journal of Management Care	Healthcare system	Structured survey, open-ended interviews, structured site level ratings	Qualitative evaluations
Haverhals, 2013 [57]	Journal of General Internal Medicine (Abstract)	Healthcare system	Semi-structured interviews	Coding of interview data
Ho, 2013 [131]	Journal of General Internal Medicine (Abstract)	Primary provider	Description of Specialty Care Transformation as part of eConsult process	Not specified
Kahn, 2014 [132]	Sleep (Abstract)	Patient	Retrospective eConsult review	Descriptive summaries
Kim 2017 [133]	Journal of General Internal Medicine (Abstract)	Cost	Retrospective eConsult review	Not specified
Kirsh, 2015 [104]	American Journal of Management Care	Patient; Primary provider; Healthcare system; Cost	Follow-up qualitative study	Thematic analysis
Pawar, 2016 [134]	European Heart Journal (Abstract)	Healthcare system	Review of administrative data to quantify eConsult usage	Descriptive summaries of chart review
Rodriquez, 2015 [53]	JMIR Medical Informatics	Patient; Primary provider; Specialist; Healthcare system	Quality improvement	Descriptive summaries
Shanawani 2017 [135]	American Journal of Respiratory Critical	Patient; Primary provider; Healthcare system; Cost	Retrospective eConsult review	Not specified

First Author, Year	Journal	Data Extracted	Study Design	Analytical approach
	Care Medicine (Abstract)			
Uhlman, 2016 [86]	Journal of Urology (Abstract)	Healthcare system; Cost	Not specified	Not specified
Vimalananda, 2015 [66]	Journal of Telemedicine and Telecare	Patient; Primary provider; Specialist	Systematic review	Narrative synthesis
Vimalananda, 2014 [136]	Journal of General Internal Medicine (Abstract)	Primary provider	Examination of trends qualitative and quantitative	Median times and descriptive statistic
Weber, 2016 [137]	The American Journal of Gastroenterology (Abstract)	Patient	Not specified	Categorized using a three-tier taxonomy
Wild, 2012 [138]	Alzheimer's and Dementia (Abstract)	Primary provider; Specialist	Not specified	Not specified
Zoll, 2015 [139]	Medical Decision Making	Patient; Primary provider; Specialist; Healthcare system	Discrete event simulation model	Not specified
San Francisco's safety-net health system eReferral System, USA				
Chen, 2010 [68]	Health Affairs	Patient; Primary provider; Specialist; Healthcare system; Cost	Narrative summary of eConsult	Not specified
Chodos, 2015 [140]	Journal of General Internal Medicine (Abstract)	Healthcare system	Not specified	Not specified
Chodos, 2014 [141]	Journal of General Internal Medicine (Abstract)	Patient; Primary provider	Not specified	Not specified
Kim, 2009 [45]	Journal of General Internal Medicine	Patient; Primary provider; Specialist; Healthcare system	Online survey	Descriptive summary and frequencies
Kim-Hwang, 2010 [46]	Journal of General Internal Medicine	Healthcare system	Survey before and after implementation	Descriptive summary
McGeady, 2014 [80]	Urology Practice	Patient; Primary provider; Healthcare system; Cost	Retrospective eConsult review	Not specified
Mendu, 2016 [91]	American Journal of Kidney Disease	Patient; Primary provider; Specialist; Healthcare system	Review of questions submitted for eConsult	Not specified
Straus, 2011 [54]	Agency for Healthcare Research and Quality	Patient; Primary provider; Specialist; Healthcare system	Interviews	Qualitative and thematic analysis
Tuot, 2015 [55]	BMC Health Services Research	Patient; Primary provider	Interviews	Qualitative: direct content analysis
Tout, 2015 [142]	Healthcare	Primary Provider; Specialist; Healthcare system; Cost	Not specified	Logistic regression
Ulloa, 2017 [143]	BMC Health Services Research	Primary provider; Healthcare system	Retrospective review of eConsults	Distributions and bivariate associations
Los Angeles Safety-Net Program eConsult System, USA				
Chou, 2016 [144]	Arthritis and Rheumatology (Abstract)	Healthcare system; Cost	Retrospective review of eConsults	Not specified
Barnett, 2017 [145]	Health Affairs	Cost	Retrospective review of eConsults	Quantitative (plotting trends, proportions)
Barnett, 2017 [146]	Journal of General Internal Medicine (Abstract)	Healthcare system	Observational analysis of eConsult requests	To test for statistical significance, we used t-tests or for time trends, bivariate linear

First Author, Year	Journal	Data Extracted	Study Design	Analytical approach
				regression with a linear term for quarter
Denver Safety Net, USA				
Fort, 2017 [51]	The Permanente Journal	Patient; Primary Provider; Specialist; Healthcare system	Retrospective review and interviews (purposive sample)	Thematic analysis
University of California, San Francisco, USA				
Ackerman, 2017 [50]	Journal of Medical Internet Research (Abstract)	Patient	Observational online survey	Not specified
Ackerman, 2014 [56]	Journal of Medical Internet Research (Abstract)	Primary provider; Healthcare system	Interviews	Content comparative methods
Cruz, 2015 [83]	Endocrine Practice	Primary Provider; Specialist; Healthcare system	administrative data analysis	Univariate statistics
Gleason, 2014 [147]	Journal of Medical Internet Research (Abstract)	Costs	Obtained data on referral rates, utilization and cost	Calculation of referral rates, modeled the effect of time using a linear spline analysis, used proportions to measure impact, utilization measured by using monthly means
Lowenstein, 2017 [148]	Journal of Medical Internet Research	Patient; Primary provider	Content analysis and chart review	coded consults as pertaining to diagnosis and/or management; categorization of medication choice, drug side effects or interactions, and queries about referrals and navigating the health care system
Prasad, 2015 [149]	Journal of Medical Internet Research (Abstract)	Healthcare system	Not specified	Not specified
Wrenn, 2017 [150]	Journal of Telemedicine and Telecare	Patient; Primary provider	Content analysis	Descriptive summary and frequencies
Wrenn, 2016 [151]	Journal of Medical Internet Research (Abstract)	Patient; Primary provider	narratives review	Descriptive summary and frequencies
Mayo Clinic, Center for Innovation, USA				
Angstman, 2009 [77]	Health Care Manager	Patient; Primary provider; Cost	Retrospective chart review	Quantitative to measure return visits
Angstman, 2009 [82]	Health Care Manager	Patient; Primary provider; Specialist; Cost	Cross sectional	Narrative description
Kirsh, 2014 [105]	Mayo Clinic Proceedings	Patient; Healthcare system; Cost	Review	Not specified
North, 2015 [152]	Journal of Telemedicine and Telecare	Specialist; Healthcare system; Cost	Retrospective review of eConsult	Kaplan Meier product limit curves and the log rank test for analysis of the e-consultation to face-to-face consult conversion
North, 2014 [153]	Journal of Telemedicine and Telecare	Healthcare system	Not specified	Not specified
Pecina, 2016 [154]	SAGE Open Medicine	Primary provider; Healthcare system; Cost	Retrospective review of eConsult	Not specified
Coordinating Optimal Referral Experiences (CORE), USA				
Davis, 2015 [93]	Family Medicine Updates (Abstract)	Patient; Primary provider; Specialist; Healthcare system; Cost	Description of eConsult process	Narrative description

First Author, Year	Journal	Data Extracted	Study Design	Analytical approach
Shipman, 2017 [155]	Journal of General Internal Medicine (Abstract)	Patient; Specialist; Cost	Cost estimate analysis	Cost analysis
Health Experts onLine at Portsmouth, USA				
Lin, 2017 [72]	Military Medicine	Healthcare system; Cost	Observational	Description of cost data
Lin, 2016 [74]	SAGE Open Medicine	Primary provider; Cost	Observational	Frequency and cost analysis
Electronic Children's Hospital of the Pacific (ECHO-Pac), USA				
Callahan, 2005 [71]	Archives of Pediatrics and Adolescent Medicine	Specialist; Healthcare system; Cost	Prospective trial	Not specified
Malone, 2004 [47]	Telemedicine Journal and eHealth	Patient; Primary provider; Healthcare system; Cost	Survey	paired t test for continuous variables and the Wilcoxon signed-rank or chi-square test for Non-continuous variables
ENTConsult.org, USA				
Baum, 2003 [66]	American Journal of Rhinology	Cost	Commentary	Not specified
Army Knowledge Online, USA				
McManus, 2008 [73]	Prehospital and Disaster Medicine	Patient; Primary provider	Commentary	Narrative description
Clinic located in Southeast rural Minnesota, USA				
Reber, 2014 [156]	Thesis, ProQuest	Primary provider; Healthcare system	Not specified	Not specified
Rancho Los Amigos Medical Center, USA				
Dhamija, 2014 [157]	American Journal of Kidney Diseases (Abstract)	Patient	Annual review of prospective trial	Not specified
Telehealth in Pediatric Populations, USA				
Brophy, 2017 [69]	Advances in Chronic Kidney Diseases	Primary provider; Healthcare system; Cost	Narrative review	Narrative description
Massachusetts General Hospital, Accountable Care Organization, USA				
Venkatesh, 2016 [158]	American Journal of Gastroenterology (Abstract)	Healthcare system	Review of medical records; survey of referring providers and consultants	Not specified
Community Health Center, Inc. Connecticut, USA				
Olayiwona, 2016 [61]	Annals of Family Medicine	Patient; Primary provider; Specialist; Healthcare system	Cluster RCT	Primary analysis analyzing the event time end point with a Cox proportional hazards model
Zuckerberg San Francisco General Hospital, USA				
Olayiwona, 2017 [48]	Health Services Research	Patient; Specialist; Healthcare system	Focus groups and survey	Thematic analysis
Allina Health, USA				
Golberstein, 2017 [63]	Healthcare	Primary provider; Specialist; Cost	Cluster RCT	Cross-sectional linear regression models
Massachusetts General Hospital, USA				
Chittle, 2015 [92]	Vascular Medicine	Patient; Primary provider; Specialist; Healthcare system; Cost	Commentary	Weekly review of eConsults
Hospital Universitario de Canarias, Rheumatology Service, Santa Cruz de Tenerife, Spain				
Segura, 2014 [159]	Annals of the Rheumatic Diseases (Abstract)	Patient; Specialist; Healthcare system	Retrospective review of virtual consults	Not specified

First Author, Year	Journal	Data Extracted	Study Design	Analytical approach
University Hospital Nuestra Senora de Candelaria, Cardiology Department, Santa Cruz de Tenerife, Spain				
Facenda-Lorenzo, 2016 (160)	European Journal of Preventive Cardiology (Abstract)	Specialist	Commentary	Categorized questions into three-tier taxonomy
Neurolink (St. Vincent's University Hospital and the National Healthlink project), Ireland				
Williams, 2012 (161)	The Irish Medical Journal	Patient; Primary provider	Audit of eReferral system	Not specified
Radboud University Nijmegen Medical Centre Department of Primary and Community Care and Department of Nephrology, Netherlands				
Scherpbeir, 2013 (100)	Annals of Family Medicine	Primary provider; Healthcare system; Cost	Prospective study	Comparison of rates and paired proportions
vanGelder, 2017 (62)	Family Practice	Primary provider	Cluster RCT	Descriptive statistics; multi-level logistic regression models
Satakunta Central Hospital, Finland				
Jaatinen, 2002 (162)	Journal of Telemedicine and Telecare	Patients; Primary provider	Randomized case-control study	statistical macro for one-dimensional distributions and cross tabling
District General Hospital Peijas, Finland				
Harno, 1999 (58)	Journal of Telemedicine and Telecare	Healthcare system; Cost	Survey, open-ended interviews, site level ratings	Qualitative evaluations
Telehealth Center of the Municipal Department of Health, Belo Horizonte, Brazil				
Marcolinoa, 2015 (163)	Studies in Health Technology & Informatics	Healthcare system	Retrospective satisfaction survey	Not specified
Ruas, 2013 (164)	Telemedicine and e-health	Healthcare system	Retrospective review	Diffusions of innovations theory
The Telehealth Center (NUTES), Brazil				
Diniz, 2016 (165)	Telemedicine Journal & e-Health	Healthcare system	Descriptive study	Not specified
Bradford Teaching Hospitals NHS Foundation Trust, UK				
Moreea, 2014 (84)	Gut (Abstract)	Specialist; Healthcare system; Cost	Not specified	Not specified
Moreea, 2014 (166)	Gut (Abstract)	Cost	Retrospective	Cost analysis
Stoves, 2010 (167)	Quality and Safety in Health Care	Patient; Primary provider; Specialist; Healthcare system	Before and after evaluation	Not specified
Stoves, 2009 (76)	Quality and Safety in Health Care (Abstract)	Primary provider; Healthcare system	Quality improvement	Not specified
Dewsbury District Hospital NHS Trust, UK				
Mohammad, 2014 (168)	Diabetic Medicine (Abstract)	Primary provider	E-consults performed by bespoke template reviewed using a pre-defined audit tool	Not specified
Royal Shrewsbury Hospital NHS Trust, UK				
Koo, 2010 (169)	BJU International (Abstract)	Healthcare system	Prospectively collected data	Not specified

ICIP: International Classification for Primary Care; **IQR**: Interquartile Range; **RCT**: Randomized Controlled Trial

Table 4.4: Barriers to eConsult implementation using the Quadruple Aim framework

Patient perspective	Provider perspective		Health care system/population health	Cost
	PCPs	Specialist		
Patient preference to see specialist face to face ✗ "It's important to see the specialist to feel more secure."[60]	Increased workload on PCPs / disruption of PCPs workflow* ✗ "It was a lot easier and quicker for me to write a consultation on…paper…Now I'm having to go through a longer process with a few more hurdles in it…"[54]	Increased workload on specialist* ✗ Specialists also experienced greater workload in the form of pre-consultative exchange and virtual management, which also served as a barrier to implementation[55]	Challenges in the design of eConsult* ✗ To find an application able to integrate seamlessly with diverse systems is often challenging[85]	Absence of reimbursement model for providers* ✗ A key barrier to widespread adoption of preconsultation exchange is the development of reimbursement models[80]
Perceived decreased accessibility to specialist care by patients* ✗ "And if I feel like my doctor is brushing off that information, is not communicating other symptoms …"[48]	PCPs technical challenges to use eConsult* ✗ "When I added a follow up question it never seems to go through and the consult disappeared. I had to request a new consult with my follow up question."[78]	Specialists concerns with liability ✗ Another challenge unique to electronic consultation and integrated eCR [eConsult] systems but not referral systems was specialist concern about liability[81]	Lack of resources* ✗ Health systems or practices initiating telehealth programs need to provide a base investment in the technology and then provide an ongoing and available infrastructure[69]	Providers payment structure (Salaried physicians Vs. Fee-for-service models) ✗ and might only be cost-effective in a non fee-for-service model such as one found in the VHA [Veterans Health Administration][86]
Concerns for safety/ appropriateness of eConsult ✗ "I asked someone and he told me to give you this. If something happens to you, it's not my responsibility because the other doctor prescribed it"[48]	PCPs unable to choose specialist / PCPs loss of contact with specialist ✗ PCP concerns included ……unable to select the specific consultant[66]	Specialist loss of patient contact ✗ A minority of them prefer not to use VCs [virtual consults] because of ... or discomfort with an impersonal process[82]	Variation in licensure requirements across provinces/states ✗ In fact, licensure requirements also differ from state to state, and this introduces a significant possible variation in practice[69]	
	PCPs unfamiliarity with eConsult service ✗ "The preparation…, what kinds of tests have to be done."[53]	Specialist challenges with the quality/content of eConsult ✗ Referrals that lack a clear consultative question and relevant clinical	Concerns of privacy* ✗ Concerns over privacy remain a barrier to the adoption of electronic platforms or innovations among health care providers[60]	

Patient perspective	Provider perspective		Health care system/population health	Cost
	PCPs	Specialist		
		data often render a specialist unable to make a clear diagnosis or a fully developed management plan[83]		
	Lack of PCPs financial incentive to use eConsult ✗ lack of reimbursement for PCP to submit the consultation request electronically[79]	Specialists challenges with the use of technology ✗ However, until a more slim-line IT system is developed reducing the number of steps involved in completing an eC[electronic consultation], … it appears to be beneficial for all parties except secondary care[84]		
	PCPs challenges to follow up with the patient ✗ concern about how and when to communicate with patients regarding a consultant's recommendations.[56]	Absence of financial incentives for specialists ✗ Concerns included … and the need for adequate protected time and credit[66]		
	PCPs challenges with responses from specialist/delay in response ✗ PCPs were not satisfied with the depth of the answer that was provided[78]			

* Pre-identified theme (deductive).

✗ Selected quotes supporting the theme from literature

Table 4.5: Facilitators to eConsult implementation using the Quadruple Aim framework

Patient perspective	Provider perspective: PCPs	Provider perspective: Specialist	Health care system/population health	Cost
Avoidance of travel* ✓"I live in a more remote location […] A lot of the specialists probably aren't going to be here, so [eConsult can] save me a trip to Ottawa."[52]	PCPs receiving timely response from specialist* ✓ "a very helpful service, giving timely help and input to the front-line generalist"[41]	Improved communication with PCP's ✓"I think it helps in the interaction with the health care provider. They tell you what information they have, you evaluate it and then if you need further information, you tell them 'This is what you need."[29]	Increase providers knowledge capacity and confidence ✓This information could be used to inform the planning of continuing medical education (CME) and professional development events for PCPs[37]	Developing payment models and incentives for providers to use eConsult ✓Its success at San Francisco General Hospital depended on …… and on financial incentives that were not completely wedded to clinic productivity.[68]
Timely access to specialist care ✓"if I wanted to see them [the specialist] face-to-face it would have taken possibly months."[52]	Building PCPs capacity and knowledge* ✓"Thank you to Dr. X for the excellent advice. This will also help me manage patients with similar profiles in the future."[78]	Educational opportunities* ✓"[E-consultation] also provides education. If you take the time to write out the thinking, then they don't have to ask you the question again because you just taught them. So it helps them be a better physician and it also will cut down on the questions."[90]	eConsult platform choice ✓Innovators may be tempted to develop a service as an extension of a specific EMR pro-gram or vendor, since harnessing an existing platform can reduce the upfront time and costs associated with development. However, greater flexibility will support wider adoption, allowing the service to reach a broader segment of the population[70]	Potential cost savings for insurance payers to use eConsult ✓Referral to specialty departments dramatically affects the annual cost of medical care for a group of insured patients[77]
Potential cost savings for patients ✓From a patient perspective, fewer office visits translates to less time taken off work and reduced transportation costs.[87]		Improved referral efficiency* ✓satisfaction with the e-consult was high among nephrologists; in the majority of cases thought that the e-consult was efficient[91]	eConsult ease of use ✓The workflow of the e-consultation system must fit as seamlessly as possible into the physician's usual workflow to ensure participation. It is important to minimize system usage time[85]	Potential cost savings for the society ✓cost savings for eConsult from the societal perspective attributable to patient avoided costs, as patients whose PCPs had originally considered a referral but ultimately chose not to refer them avoided the travel costs and lost wages/productivity[94]

Patient perspective	Provider perspective		Health care system/population health	Cost
	PCPs	Specialist		
Patients acceptance of eCounsult ✓ acceptance is vital to the success of any healthcare innovation, and patients' perspectives on new and innovative services must be thoroughly established[70]		Specialists feasible time commitments to eConsult ✓ Reassuringly, the average self-reported time it took specialists to complete an eConsult was 11.2 min, which is shorter than it would take to complete an in-person consult[120]	Improved access to specialist care* ✓ The benefits include improved access to specialty care for those practicing in remote communities[69]	Potential Cost savings for the health care system ✓ "Please continue with e-consult services as it will save on health [dollars] in the long run and will assist in improvement of patient care"[78]
		Ability to expedite face to face consultation if needed ✓ "If we have any reservations or the patient has any reservations, we see them [face-to face]."[53]	Use of case manager to triage consultations ✓ use of referral case managers to improve efficiency[51]	
			Security measures ✓ We reviewed our e-consult process with risk management lawyers and we were able to reassure providers that this system would not place them at undue legal risk.[92]	
			Improved quality of care / "Safety-net" effect* ✓ 4% of cases PCPs were not planning on sending the patient for a traditional face-to-face referral … however, the eConsultant recommended one due to the potential high-acuity nature or complexity of the problem[37]	

Patient perspective	Provider perspective		Health care system/population health	Cost
	PCPs	Specialist		
			Organizational commitment to implementation ✓Obtaining buy-in from health system leadership is essential to lay the necessary ground work[93]	
			Clarifying provider's duty of care/role ✓eConsults from a medical legal perspective are considered along the same lines as a ''curbside consult'' in that the specialist provider does assume a duty of care once the case is reviewed[37]	
			End users engagements/consultation ✓Disseminate the benefits (using actual data) of E-Consults for patients and for workflow to participating providers[57]	
			Providing ongoing support/training ✓In contrast, a high-volume site participant noted that training was crucial[59]	
			Piloting eConsult ✓"I think the reason why they've jumped onto the bandwagon is because they probably saw how efficient it was with GI."[54]	

* Pre-identified theme (deductive).

✓Selected quotes supporting the theme from literature

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Chapter 5 : Discussion and conclusion

5.1 Overview

The burden of CKD is significant public health issue worldwide particularly in LMIC where it is estimated that the disease prevalence is growing the fastest.[1,2] Going forward, early detection and treatment is crucial to stem the tide against the epidemic of CKD, and its risk factors to prevent ESRD which can lead to adverse health consequences and catastrophic health care expenditure from payments of dialysis and transplantation.[3]

The continuum of care delivery in kidney care ideally involves managing patients in a primary care setting where possible and consultation with a nephrologist when necessary.[4] However, this could be limited by the shortage of providers in LMIC and by long wait times to see a specialist in HIC countries. With the spread and proliferation of telecommunication technologies worldwide, telemedicine presents an opportunity to facilitate access to kidney care, especially those who live in the remote and rural parts of the world.

A patient's journey in the health care system from first point contact in primary care to secondary care can be viewed as an obstacle course due to factors such as excessive wait time to see a specialist[5] and poor communication among providers[6] leading to fragmentation in care that risk patient's outcomes,[7] impact health care cost[7] and often dissatisfaction with care.[8] Different models are emerging in many countries to address these problems in ambulatory care delivery. The use of telemedicine, in the form of eConsult, as an alternative to usual care showed promise by decreasing wait time to see specialists and improved care coordination. However, this benefit is limited only to the jurisdictions that implemented eConsult and adoption of eConsult remains relatively limited. Decision makers and administrations seeking evidence-based practice implementation need information on the factors that hinder or favor eConsult adoption.

5.2 Key findings

The overarching aims for this thesis were to 1) determine the existing global nephrology workforce capacity. 2) review the role of health information technology in enhancing access to specialist kidney care. 3) undertake a broad examination of barriers and facilitators to eConsult implementation.

To meet these objectives, I was able to establish the current global nephrology workforce capacity (average global nephrologists density of 8.83 PMP) and identify significant inter- and intra-regional gaps in the density and distribution of nephrologists and nephrologists trainees (**chapter 2**). The findings were closely related to the economical standing of various countries as shown by analysis of countries by World Bank country classification. The significant shortages of nephrologists identified would indicate that an astonishing number of people mainly in South Asia and sub-Saharan Africa have a limited access to kidney care.

Next, I a reviewed the literature on health information technology and identified that it will be an important mechanism to close the identified gaps in kidney workforce particularly in LMIC (**chapter 3**). The review highlighted the barriers to establishing telenephrology systems and identified the various applications of telenephrology in kidney care across the world (distribution, types). Moreover, a summary of the advantage and disadvantage of different types of telenephrology was given.

Finally, I focused on a local initiative that was evaluated to enhance access to kidney care in Alberta. I studied the barriers and facilitators to the implementation and adoption of eConsult (**chapter 4**). The key barriers were patient preference to see a specialist directly, providers perceived increased workload, privacy concerns and absence of reimbursement model for providers whilst the main facilitators identified were patient's avoidance of travel, PCPs receiving timely response from specialist, utilizing case managers, addressing medico-legal issues and incentives for providers to use eConsult.

5.3 Significance and implications for policy/practice and research

The workforce survey results (**Chapter 2**) represent the most comprehensive study of the global nephrology workforce and training capacity to date. In addition, to rigorous methodology, the survey had a high response rate and adequate representation of the world population (>93%). For instance, our findings on workforce can be used by local and international organizations to advocate and engage countries on capacity building to address the identified gaps in access to kidney care. Additionally, study findings provide a baseline to monitor countries progress in human resource for optimal kidney care delivery. Future studies are needed to ascertain the other factors that influence workforce development and how to maximize the roles of PCPs and allied health professionals in shared care for kidney disease.

The review on telenephrology (**chapter 3**) established that the use of telemedicine can be used to improve kidney care particularly in LMIC by closing gaps (where exist) on nephrology workforce. For instance, telenephrology modalities such as videoconferencing, instant messaging, emails and telephone consults could be used by primary care to link up with specialists (for example nephrologists) to communicate clinical information, send laboratory results and discuss appropriate treatment strategies and ongoing monitoring of patients with kidney disease irrespective of patient location. Telenephrology is therefore an important tool that could be leveraged to provide equitable access to kidney care in all parts of the globe. For its widespread adoption, it is important to understand common implementation barriers and facilitators. However, it is still unclear if eConsult is feasible across all settings in the LMIC due to the well-recognized health system structural deficits (e.g., limitations in health care resources, infrastructural deficits and poor technology platforms).

Design of eConsult program (as an example of telenephrology) requires careful consideration of all factors that hinder or support implementation. The scoping review I conducted was the first comprehensive examination of the literature to identify factors influencing the implementation of eConsult (**chapter 4**). The study findings can inform all relevant stakeholders (patients, providers and decision makers) in the development, implementation and scale up eConsult services in Canada and beyond.

5.4 Conclusion

My thesis examined the current global nephrology workforce capacity, an essential component of all country's health care system and integral part of the UHC elements, and have established the evidence of significant gaps in all cadres of workforce essential for optimal kidney care. I then reviewed literature on available eHealth platforms that could be used to reduce or close the identified gaps in workforce (e.g., nephrologists in developed world could leverage these tools to support care providers in LMIC). One of the most common tool identified in this review was eConsult, and I moved on to study the major barriers and facilitators for its implementation leveraging information from already well established systems across North America and Europe.

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For chapter 5:

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APPENDICES

Thesis outputs

A. Publications

- **Osman MA**, Okel J, Okpechi IG, Jindal K, Bello AK. Potential applications of telenephrology to enhance global kidney care. **BMJ Glob Health** 2017;2:e000292.
- **Osman MA**, Alrukhaimi M, Ashuntantang GE, et al. Global nephrology workforce: gaps and opportunities toward a sustainable kidney care system. **Kidney Int Suppl** 2018;8:52-63.
- **Osman MA**, Schick-makaroff K, Thompson S, et al. Barriers and facilitators for implementation of electronic consultations (eConsult) to enhance specialist access to care: a scoping review protocol. (**In Press, BMJ Open, 2018**)
- Bello AK, Levin A, Tonelli M, Okpechi I, Feehally J, Harris D, Jindal K, Salako B, Rateb A, **Osman MA**, Bilal Q, Syed S, Meaghan L, Natasha W, Feng Y, David W. Johnson. Assessment of global kidney health care status. **JAMA** 2017;317(18):1864-1881.

B. Abstracts and Presentations

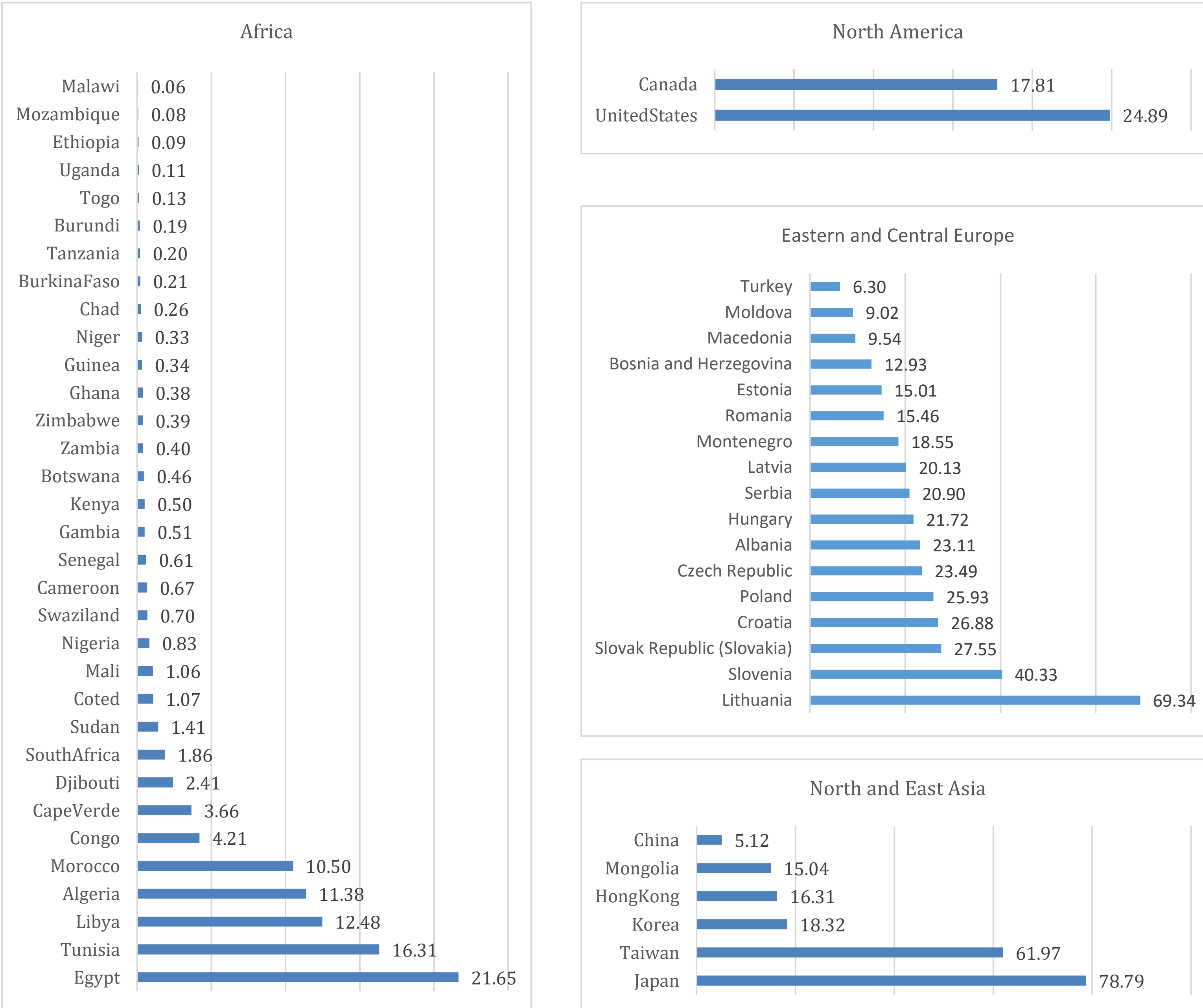
I. Provincial

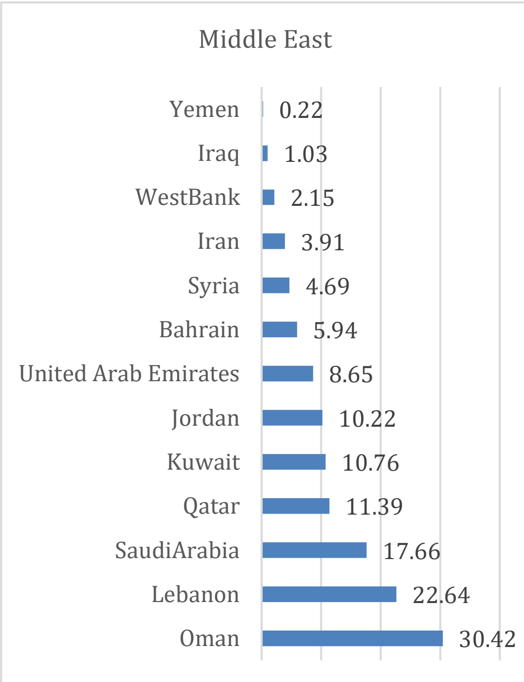
- Kidney Health Strategic Clinical Networks core committee meeting, Calgary, June 2017 “A process analysis on the engagement of patients and providers in defining barriers and facilitators to adoption of e-Consult in Alberta”
- Alberta SPOR Support Unit, Summer Institute 2018: Keys to collaboration meeting, Calgary, May 2018 “Perceived barriers and facilitators for implementation of electronic consultations (eConsult) by patients, policymakers and physicians: a scoping review”

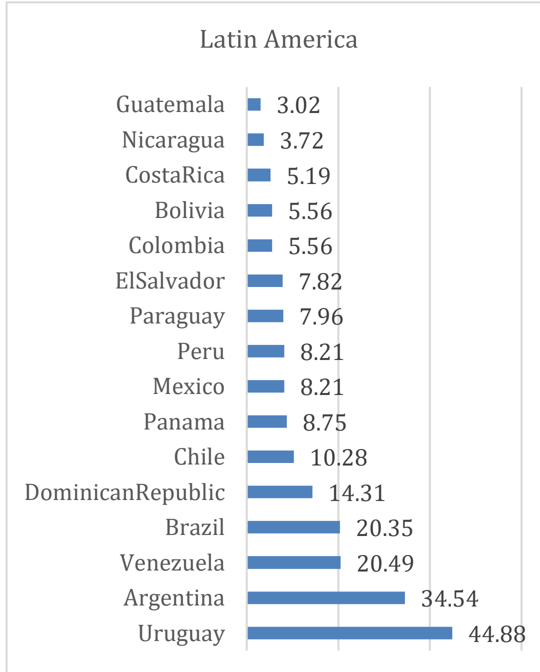
II. University

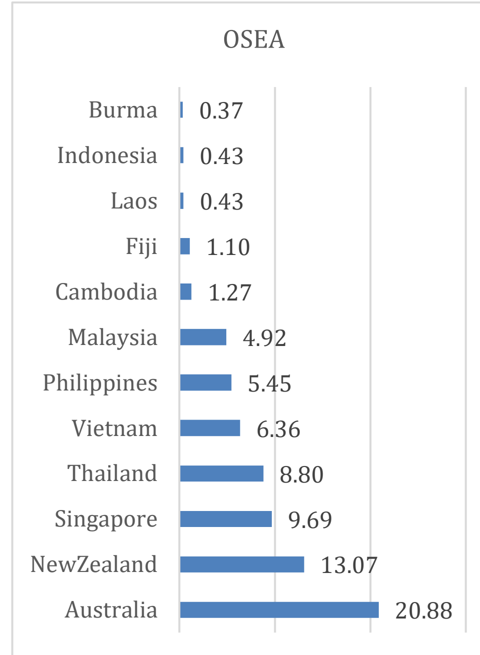
- Department of Medicine, Research Day, May 2017 “Current capacity for kidney care around the world: how does Canada compare to other OECD countries?”
- Department of Medicine, Research Day, May 2018 “ Perceived barriers and facilitators for implementation of electronic consultations (eConsult) by patients, policymakers and physicians: a scoping review”

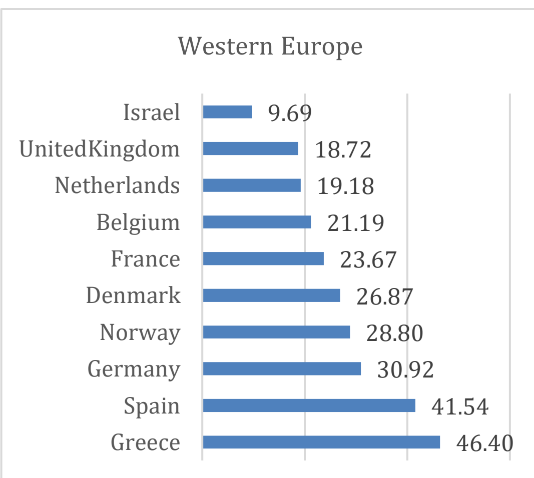
Appendix 2.1: Nephrologist density PMP from 121 countries grouped by ISN region

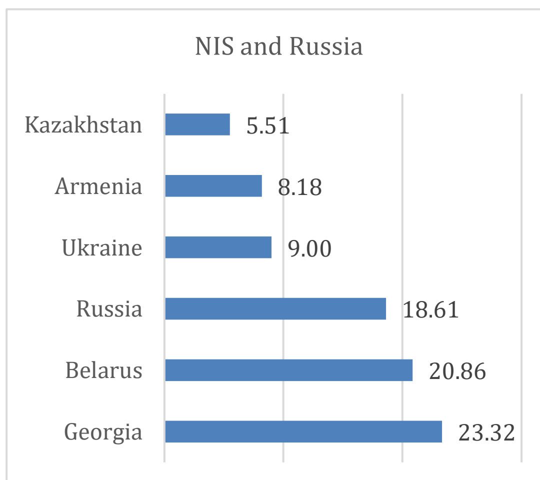


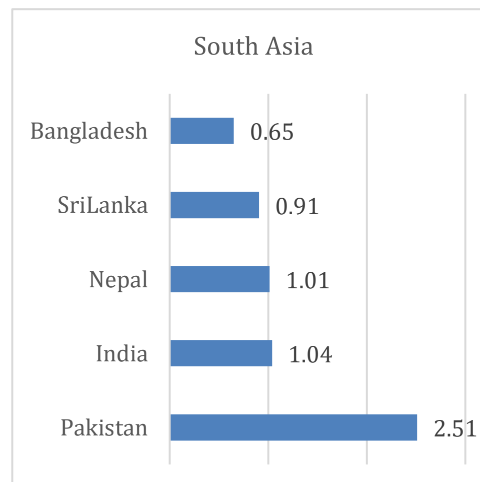

Middle East
Yemen 0.22
Iraq 1.03
WestBank 2.15
Iran 3.91
Syria 4.69
Bahrain 5.94
United Arab Emirates 8.65
Jordan 10.22
Kuwait 10.76
Qatar 11.39
SaudiArabia 17.66
Lebanon 22.64
Oman 30.42


Latin America
Guatemala 3.02
Nicaragua 3.72
CostaRica 5.19
Bolivia 5.56
Colombia 5.56
ElSalvador 7.82
Paraguay 7.96
Peru 8.21
Mexico 8.21
Panama 8.75
Chile 10.28
DominicanRepublic 14.31
Brazil 20.35
Venezuela 20.49
Argentina 34.54
Uruguay 44.88

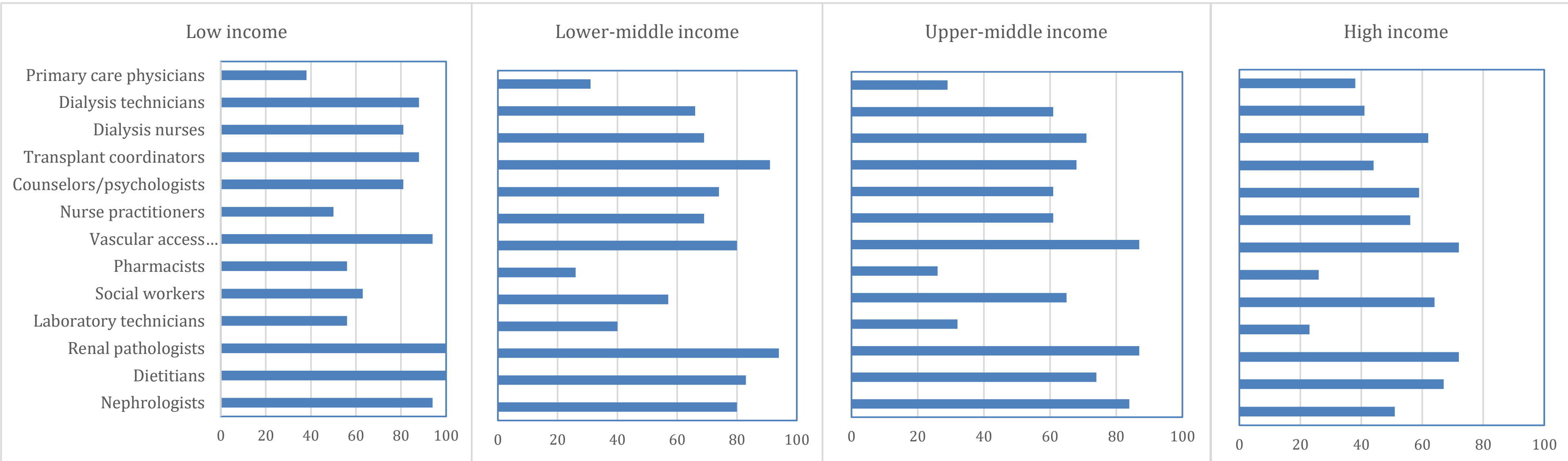

OSEA
Burma 0.37
Indonesia 0.43
Laos 0.43
Fiji 1.10
Cambodia 1.27
Malaysia 4.92
Philippines 5.45
Vietnam 6.36
Thailand 8.80
Singapore 9.69
NewZealand 13.07
Australia 20.88


Western Europe
Israel 9.69
UnitedKingdom 18.72
Netherlands 19.18
Belgium 21.19
France 23.67
Denmark 26.87
Norway 28.80
Germany 30.92
Spain 41.54
Greece 46.40


NIS and Russia
Kazakhstan 5.51
Armenia 8.18
Ukraine 9.00
Russia 18.61
Belarus 20.86
Georgia 23.32


South Asia
Bangladesh 0.65
SriLanka 0.91
Nepal 1.01
India 1.04
Pakistan 2.51

Appendix 2.2: Shortages in nephrology care providers from 121 countries grouped by World Bank income group



Appendix 2.3: Shortages in nephrology care providers from 121 countries grouped by ISN region