BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-016267
Article Type:	Protocol
Date Submitted by the Author:	03-Feb-2017
Complete List of Authors:	Bello, A; University of Alberta, Edmonton, Alberta, Canada. , Medicine Ronksley, Paul; University of Calgary, Community Health Sciences Tangri, Navdeep; University of Manitoba, Medicine Singer , Alexander; University of Manitoba College of Medicine, Department of Family Medicine ; Manitoba Primary Care Research Network Grill, Allan; University of Toronto Nitsch, Dorothea; LSHTM Queenan, John; Queen's University in Kingston, ON, Canada Lindeman, Cliff; University of Alberta, Family Medicine Soos, Larka; University of Calgary, Calgary, AB, Canada, Family Medicine Freiheit, Elizabeth; University of Michigan, Ann Arbor, MI, United States, Institute for Social Research Mangin, Dee ; McMaster University, Family Medicine Drummond, Neil ; University of Alberta, Edmonton, AB, Canada, Family Medicine
Primary Subject Heading:	Renal medicine
Secondary Subject Heading:	Epidemiology, Evidence based practice, General practice / Family practice, Health informatics, Health services research
Keywords:	Protocols & guidelines < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Nephrology < INTERNAL MEDICINE, Chronic renal failure < NEPHROLOGY

Improving CKD management in primary care using the Canadian Primary Care Sentinel Surveillance Network: Study protocol of a retrospective observational study

Aminu K Bello[1], MD, PhD, FRCP, Paul E. Ronksley[2], PhD, Navdeep Tangri[3] MD, PhD, FRCPC, Alex Singer[4], MD, Allan Grill[5], MD, Dorothea Nitsch[6] MD,Dr Med, MSci, John A Queenan[7], PhD, Cliff Lindeman[8], MPH, Larka Soos[9] MSc, Elizabeth Freiheit[10] PhD, Dee Mangin[11] MBChB, DPH, FRNZCGP, Neil Drummond[12], PhD

[1]Department of Medicine, University of Alberta, Edmonton, AB, Canada
[2]Department of Community Health Sciences, University of Calgary, Calgary, AB, Canada.
[3]Department of Medicine, University of Manitoba, Winnipeg, MB, Canada
[4]Department of Family Medicine, University of Manitoba, Winnipeg, MB, Canada
[5]Department of Family and Community Medicine, University of Toronto, Toronto, ON, Canada
[6]Department of Non-Communicable Disease Epidemiology, London School of Hygiene &Tropical Medicine, London, UK
[7]Epidemiologist for the Canadian Primary Care Sentinel Surveillance Network, Department of Family Medicine, Queen's University in Kingston, ON, Canada
[8]Department of Family Medicine, University of Alberta, Edmonton, AB, Canada
[9]Department of Family Medicine, University of Calgary, Calgary, AB, Canada
[10]Institute for Social Research, University of Michigan, Ann Arbor, MI, United States
[11]Department of Family Medicine, McMaster University, Hamilton, ON, Canada
[12]Department of Family Medicine, University of Alberta, Edmonton, AB, Canada

Corresponding Author:
Aminu K Bello, MD PhD, FRCP
Division of Nephrology and Immunology
Department of Medicine
University of Alberta
11-107 Clinical Sciences Building, 8440 112 Street NW, Edmonton, Alberta, Canada T6B 2B7

Email: aminu1@ualberta.ca
Telephone: 780-492-1867
Fax: 780-407-7771

Word Count
Abstract: 300
Main Text: (excluding abstract, references, tables, and figure): 2446

Running title: CKD Management in Canadian Primary Care

ABSTRACT

Introduction: Effective chronic disease care is dependent on well-organized quality improvement (QI) strategies that monitor processes of care and outcomes for optimal care delivery. Although healthcare is provincially/territorially structured in Canada, there are national networks such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) as important facilitators for national QI-based studies to improve chronic disease care. The goal of our study is to improve the understanding of how patients with chronic kidney disease (CKD) are managed in primary care and the variation across practices and provinces to drive improvements in care delivery.

Methods and analysis: The CPCSSN database contains anonymized health information from the electronic medical records for patients of participating primary care practices (PCPs) across Canada (N=1200). The dataset includes information on patient socio-demographics, medications, laboratory results and comorbidities. Leveraging validated algorithms, case definitions and guidelines will help define CKD and the related processes of care, and enable us to: 1) ascertain the burden of CKD in primary care; 2) determine the current practice pattern on CKD risk identification in primary care; and 3) investigate the variation in care indicators (e.g. achievement of BP and proteinuria targets) across patients' demographics and provider and regional characteristics. The prevalence of CKD stages 3-5 will be presented as age-sex standardized prevalence estimates stratified by province and as weighted averages for population rates with 95% confidence intervals (CI) using census data. For each PCP, age-sex standardized prevalence will be calculated and compared with expected standardized prevalence estimates. The process-based outcomes will be defined using established methods.

Ethics and dissemination: The CPCSSN is committed to high ethical standards when dealing with individual data collected, and this work is reviewed and approved by the Network Scientific Committee. The results will be published in peer-reviewed journals and presented at relevant national and international scientific meetings.

Strengths and limitations of this study

- To our knowledge, this is the first nationwide and largest retrospective observational study on the epidemiology and management of CKD in primary care in Canada with potential to identify opportunities for improving quality of care for CKD at a national level.
- It will define the practice patterns on CKD risk identification in primary care by ascertaining whether high-risk groups are appropriately tested, monitored and managed for CKD based on existing guideline recommendations.
- It will investigate the variation in CKD care delivery across patient, provider and regional characteristics, relative to established quality indicators.
- This study leverages retrospective data collated at point of care, and therefore limitations include variable data quality and incomplete information in some data domains.
- The results of this study will enable the development of strategies and interventions to improve care and outcomes for patients with CKD.

INTRODUCTION

There is an absence of effective surveillance mechanisms for chronic kidney disease (CKD) in most countries despite the overwhelming opinion of key stakeholders supporting such developments[1,2]. As with all other non-communicable diseases (NCDs), planning, development and implementation of effective and efficient care programs require reliable national data systems to monitor the burden of disease, processes of care and clinical outcomes.[3-11] Once established, these systems can be used for routine surveillance (including secular trends), quality improvement and resource allocation (including workforce planning). In Canada, they would also allow for within-country comparisons across provinces and territories, and evaluation of how the country compares with similar nations in CKD care. If combined with existing data sources (e.g., administrative databases), data on CKD management in primary care might also facilitate efforts to integrate CKD management with care for other major NCDs (e.g., diabetes, cardiovascular diseases, hypertension, obesity).[4]

Effective and sustainable chronic disease care is dependent on well-organized quality improvement (QI) strategies to monitor processes of care and outcomes and inform optimal care delivery.[12] In the CKD domain, end-stage renal disease (ESRD) care has been the sole focus of national QI activities, often administered in conjunction with national/regional registries (e.g., Canadian Organ Replacement Register, United States Renal Data System, European Renal Registry).[4,12] While there is no surveillance system for non-dialysis-dependent CKD in most countries, including Canada,[4,13] a few have developed initiatives in this direction[14].[4,12,13,15] A national CKD surveillance system using routinely collected practice data is feasible in nations with well-developed healthcare systems as CKD lends itself particularly well to surveillance because of its laboratory-based diagnosis[16]. Although healthcare is provincially/territorially structured and administered in Canada, there are existing national networks and collaborations such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN)[17] that can be important facilitators for national QI-based studies.

We set out to improve the understanding of how patients with CKD are managed and the variation across practitioners, regions and provinces to drive improvements in care delivery. Our study is a multidisciplinary (nephrology, primary care) and cross-jurisdictional effort leveraging data from the CPCSSN to investigate the epidemiology and management of CKD in the Canadian primary care system. The overarching aim is to use data derived from primary care electronic medical records (EMRs) to identify gaps in care, and provide opportunities for interventions to improve care and patient outcomes.

Objectives:

1. Develop and validate a case definition for CKD in primary care and apply this to ascertain the burden of CKD in primary care, obtaining data on unidentified cases using standard criteria.[18,19]

2. Determine the current practice patterns on CKD risk identification in primary care by ascertaining whether high-risk groups (e.g., individuals with diabetes, hypertension and urologic disorders, and those with chronic use of nephrotoxic medications) are appropriately screened and managed for CKD.

3. Map the processes of care for CKD based on established quality indicators, and investigate the care variation across patients' demographics (age, sex, socio-economic status, rural/urban residence, comorbidity burden), provider characteristics (family physician/nurse practitioner, year of graduation, rural/urban, individual/group, fee for service) and regional characteristics (intra- and inter-provincial/territorial variation, rural versus urban).

METHODS AND ANALYSIS

Setting

The CPCSSN[17,20,21] is the first pan-Canadian multi-disease surveillance system. It is comprised of a network of twelve practice-based primary care research networks that collect primary care health information from the EMRs of primary care providers (PCPs) in eight out of the ten provinces and one out of the three territories in the country **(Figure 1)**. There are 1180 sentinels (i.e., participating PCPs) contributing data to the CPCSSN, which is updated quarterly. This actively expanding repository currently contains data on approximately 1.5 million Canadians. The initial focus of the CPCSSN was to conduct surveillance on five chronic conditions: diabetes, hypertension, osteoarthritis, chronic obstructive pulmonary disease and depression. Subsequently, it was expanded to included three neurological conditions: dementia, epilepsy and Parkinson's disease. Our project team has been instrumental in working with CPCSSN to further expand on these conditions by including CKD.

Population and data sources

Data for the CPCSSN database are extracted from the EMRs of participating sentinels, rendered anonymous, coded and processed using established frameworks described in detail elsewhere.[21,22] The data are placed in regional network databases and then merged into the national repository. It is made available for surveillance and research, and increasingly for quality improvement projects and for clinical decision support where available, through the implementation of a patient re-identification tool held only within the custodial clinics themselves. With appropriate data sharing agreements with its sentinel PCPs, CPCSSN data may be linked with administrative health data for future work to follow up on CKD-related outcomes (e.g., ascertainment of progression to dialysis requirement using registry data).

The CPCSSN database will be used to develop a cohort of CKD patients being managed in primary care between January 1, 2010 and December 31, 2015 (baseline cohort), and from January 1, 2016 onwards (open cohort). The database is updated quarterly, allowing for identification of new CKD patients who meet the inclusion criteria during the study period. The CPCSSN database contains patient information on socio-demographics (age, sex, socio-economic status (calculated deprivation category)), treatment (medications data), laboratory results and comorbidities **(Table 1, Figure 2)**.[21,23] Patients under 18 years of age will be excluded from the cohorts, as will those diagnosed with ESRD and on dialysis or having renal transplant. We will leverage validated algorithms, case definitions and guidelines to define CKD, at-risk population and processes of care measures based on established methods and criteria **(Table 2)**.[24,25,26]

Identification of CKD

The major focus is to validate a case definition for CKD in primary care using the CPCSSN repository to enable us to identify patients with CKD. We will leverage the existing frameworks

and conventions by national and international CKD guidelines, and definitions used elsewhere.[25,27] Individuals with at least one face-to-face PCP encounter and two calculated (using CKD-EPI equation) eGFR values <60 ml/min per 1.73 m^2 >90 days apart or having an International Classification of Diseases (ICD-9) diagnosis code for CKD used at least twice in an outpatient encounter as of December 31, 2015, will be defined to have CKD. We recognize the significant limitations of the ICD-9 codes when applied for CKD identification in the community, however, its use will allow us to capture those patients with CKD who may or may not have had an abnormal eGFR. In a secondary analysis, CKD will be defined by eGFR<45 ml/min/1.73m^2 using two values of eGFR >90 days apart. This definition was selected because although GFR<60 ml/min/1.73m^2 constitutes CKD, individuals with GFR between 45 and 60 ml/min/1.73m^2 usually have favorable prognosis in the absence of proteinuria, and are substantially fewer in number than those with GFR<45/min/1.73m^2. Patients with eGFR<45 ml/min/1.73m^2 are also a more attractive population for intervention due to higher risk of adverse clinical outcomes including risk of progression to ESRD[2,14]. Validation of the primary care CKD case definition algorithm will consist of an expert blinded chart review and identification of cases in a random sample of 1000 CPCSSN charts, containing both original and cleaned text data from the EMRs for patients aged 18 years or older, and comparison with the outcome of an independent search of the same sample using the CPCSSN case finding algorithm. Analysis will consist of calculations of sensitivity, specificity and positive and negative predicted values. The prevalence of CKD stages 3-5 will be presented as unadjusted prevalence estimates and weighted averages for population rates with 95% confidence intervals (CI) using the census data, and stratified by PCP, rural/urban location and province or territory.

Evaluation of processes of care

The process-based outcomes (quality of care metrics) will be defined and evaluated using established methods across key domains of risk identification and case finding for CKD, as well as delivery of appropriate management including monitoring of risk factors for progression and cardiovascular disease (CVD), and referral for specialist nephrology care where necessary. This entails monitoring for the classical risk parameters such as blood pressure, proteinuria, glycemia, dyslipidemia and progression risk based on eGFR and proteinuria trajectories over time **(Table 2)**.

Data analysis

Covariates definition and evaluation of CKD markers

Socio-demographic, clinical, laboratory and medication data will be classified using standard definitions established by the CPCSSN.[17,23,28-32] Other comorbid conditions relevant to the care of CKD patients but not defined by the CPCSSN (coronary artery disease, stroke, peripheral vascular disease, heart failure) will be identified using standard procedures to search for those diagnoses in patients' medical records (based on validated ICD-9-CM coding algorithms[33]). Baseline kidney function (using estimated glomerular filtration rate, eGFR) will be calculated using all serum creatinine measurements taken within a six-month period of the first creatinine measurement, with the index eGFR defined as the mean of the six-month measurements. Assessment of urine protein excretion will be estimated using the albumin: creatinine ratio (ACR) based on spot urine measurements using standard conventions.[24] All CKD cases will be risk-stratified, defined and classified according to current guideline recommendations.[24]

Demographic information (including age, sex and postal code) of those with and at risk of CKD will be extracted **(Tables 1 & 2)**. Normally distributed variables will be summarized as means with standard deviations (SD), and non-normally distributed data will be summarized as medians with interquartile ranges (IQR). Dichotomous data will be expressed in percentages. The representativeness of the study population will be tested by comparing their age and sex profiles to the population distribution as reported in the Canadian 2011 Census (adjusting for 2016 census data when available).

ETHICS AND DISSEMINATION

The CPCSSN is committed to high ethical standards when handling individual patient data collected from EMRs of participating PCPs from across Canada. These data are aggregated and stored in CPCSSN's central repository at the Centre for Advanced Computing, Queens University in Kingston, Ontario. There are well-developed organizational, physical and technological safeguards at all levels (clinic, provincial, national) to ensure that the privacy of patients is protected and that all collection, retention, use or disclosure of data complies with applicable privacy legislation and ethical requirements.[17,21] All personal identifiers are removed from the data in the national research repository to protect patient confidentiality.[21] The protocol has undergone a scientific review and approval by the CPCSSN Surveillance and Research Standing Committee (SRSC), and ethical approval for the study was granted by the University of Alberta Health Research Ethics Committee.

This project uses an integrated knowledge translation (KT) strategy, where relevant stakeholders (patients, practitioners, policymakers) have been involved from inception (proposal development) to ensure that the project addresses the needs of patients and practitioners. The high priority that the investigators and network leaders place on the project will ensure that we drive it forward to completion, to allow us to meaningfully change the way that care is delivered to CKD patients. For example, after identifying regions/clusters with especially suboptimal CKD care, we will partner with providers, policymakers and regional health authorities to improve care in those regions. We will apply the KT Canada Knowledge-to-Action Cycle Framework and other established methods (e.g., PDSA (Plan, Do, Study, Act) concept) to disseminate our findings to all relevant stakeholders and end-users for action.[34,35] We will leverage our collaborations with existing platforms and research networks such as the Canadian Society of Nephrology, CANN-NET (CAnadian KidNey KNowledge TraNslation and GEneration NeTwork), Can-SOLVE CKD (Canadians Seeking Solutions and Innovations to Overcome Chronic Kidney Disease) and the country-wide Primary and Integrated Healthcare Innovation Networks to ensure the translation of our findings across provinces and territories, as well as internationally through our associations with the International Society of Nephrology and the Kidney Disease Improving Global Outcomes (KDIGO) team.[4,36] The results will be published in leading general medicine, nephrology and primary care peer-reviewed journals and presented at relevant national and international scientific meetings. A performance report will be produced against the indicators relevant to each objective, aggregated by practice sentinel, to highlight practice performance and map out areas for improvement, critical for continuing professional development of PCPs and helping to enhance CKD management in primary care.

DISCUSSION & CONCLUSIONS

This work will close the information gap between observed and expected burdens and risks of CKD and map out standards of care achieved, providing opportunities for focused and effective population-level QI strategies and other service improvement initiatives. This project will demonstrate proof of concept for an early identification and management of CKD program in primary care, and provide the basis for developing relevant policies and KT strategies to enhance the uptake of findings – for people with CKD, and other chronic diseases as well. The work will facilitate identification and appropriate management of CKD patients at high risk of progression to ESRD.

We have anticipated potential threats and have devised strategies to mitigate them. The first related to feasibility within the defined timeframe **(Figure 3)**. This is unlikely to hinder the success of the project as we have completed significant preliminary work for data access, and the team has considerable experience with the use of this kind of data for policy-relevant research.[4,19,34,37,38] Second, limitations general to the use of EMR data in research are acknowledged. The collated information is based on clinical encounters and needs, and thus may be missing for some important key variables and data quality may vary by region and/or sentinel; specifically, data on patients' priorities and satisfaction of care are rarely collated in a clinical setting. However, most important demographic, clinical and laboratory information needed for this study are well captured in the existing platform chosen for this work.

Planning, development and implementation of nephrology services require reliable information systems and databases to capture information on trends in disease burden, processes of care and related outcomes. In the absence of national/regional health information systems, one way to achieve this is by the creation of surveillance systems using routine practice data, such as the CPCSSN. The established conventions and guidelines on CKD can be leveraged for systematic case definition and evaluation of quality of care across settings. This can be facilitated by validation as well as enactment of quality metrics to measure the processes, quality of care and related outcomes, and generate uniformity across databases which may permit analyses across countries and regions. It is important to detect CKD early enough to be able to implement effective interventions. On-going primary care management of key risk factors for CKD (e.g., hypertension, vascular disease, diabetes) is likely one effective strategy to reduce progression of CKD and reduce adverse complication rates. Early detection and treatment of CKD and reducing adverse events with appropriate medications also reduces the morbidity and cost of CKD and related complications. The work described in this protocol therefore has a huge potential to address the identified gaps for optimal care delivery of CKD at the primary care level that would impact positively on patients' outcomes and health system improvement.

Contributors: AKB and ND had the original idea for this study. AKB and PER wrote the first draft of the manuscript. PER, NT, AS, AG, DN, JAQ, CL, LS, EF, and DM contributed to the development of the idea, the study design and reviewed the manuscript for intellectual content. All authors approved the final submitted version of the manuscript.

Funding: This work is supported by the Canadian Institute of Health Research (CIHR) Operating Grant: SPOR PIHCI Network: Quick Strikes Grant (ref# RN281786), through the Universities of Alberta and Manitoba, and McMaster University.

Competing interests: None declared.

Ethics approval: This project has been approved by the University of Alberta Health Research Ethics Committee. Identifiable patient data will not be shared during the project, thus maintaining confidentiality.

Disclaimer: The views expressed are those of the authors and not necessarily those of the CIHR, CPCSSN or the various institutions represented.

Data sharing statement: The authors will make available the full statistical analysis of the study results following publication if and when required. The results of the study will be submitted for publication in a leading medical/nephrology peer-reviewed journa

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Table 1: Data variables

Domain	Variables
Patient Demographics and Clinical Data	• Patient ID (unique patient number generated by CPCSSN) • Sex • Month & Year of Birth • Occupation • Highest Education • Housing Status • Postal Code • EMR Status – Active, Deceased, Duplicate, Inactive, Unknown • Language • Race/Ethnicity • Deceased Year • Date Created (date this record was created) • Time Since Last Visit – 6, 12, 24 or 36 months • CPCSSN Conditions – yes / no for diabetes, depression, osteoarthritis, COPD, hypertension, dementia, Parkinson's, epilepsy • CPCSSN Conditions – count (i.e., numeric value) • Disease Case Indicator – disease (diabetes, depression, osteoarthritis, COPD, hypertension, dementia, Parkinson's, epilepsy) • Disease Case Indicator – Indicator Type (billing, encounter diagnosis, health conditions, lab result [HbA1C, fasting glucose], medication) • Disease Case Indicator – Indicator Value (numeric value of HbA1C and/or fasting glucose)
Patient-Provider Pairing	• Patient ID (unique patient number generated by CPCSSN) • Provider ID (unique provider number generated by CPCSSN; primary provider of patient) • Start Date • End Date
Provider	• Provider ID (unique provider number generated by CPCSSN) • Sex • Birth Year
Billing	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Service Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9, ICD10) • Diagnosis Code (i.e., 401)
Clinical Encounters	• Patient ID (unique patient number generated by CPCSSN) • Provider ID (unique provider number of the attending provider generated by CPCSSN) • Encounter Date • Encounter Type – academic clinic, community clinic • Reason for visit – cleaned • Reason for visit – original
Encounter Diagnoses	• Patient ID (unique patient number generated by CPCSSN) • Created Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9) • Diagnosis Code (i.e., 401)
Exam	• Patient ID (unique patient number generated by CPCSSN) • Exam Name – systolic BP, diastolic BP, height, weight, BMI, waist circumference, waist hip ratio (all values) • Result – cleaned numeric value • Result – original numeric value • Unit of Measure • Most Recent Value – yes, no

Health Condition	• Patient ID (unique patient number generated by CPCSSN) • Created Date • Onset Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9) • Diagnosis Code (i.e., 401)
Laboratory	• Patient ID (unique patient number generated by CPCSSN) • Date Performed • Lab Name – cleaned text (fasting glucose, glucose tolerance, HbA1C, HDL, LDL, total cholesterol, triglycerides, microalbumin, urine albumin creatinine ratio, hemoglobin, creatinine, eGFR / GFR) • Lab Name – original text • Lab Result – numeric value • Unit of Measure • Most Recent Value – yes, no
Medical/Surgical Procedure	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Date Performed • Procedure Name – cleaned text • Procedure Name – original text
Medication	• Patient ID (unique patient number generated by CPCSSN) • Start Date • Stop Date • Medication Name – cleaned text • Medication Name – original text • Medication Code – ATC code *(Anatomical Therapeutic Chemical classification system)* • Time Since (initial prescription) • DIN (Drug Identification Number) • Strength • Dose • Frequency • Unit of Measure
Referral	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Date Completed • Referral Name – cleaned text • Referral Name – original text
Risk Factor	• Patient ID (the unique patient number generated by CPCSSN) • Date Created • Start Date • Stop Date • Most Recent – yes, no • Risk Factor Name – cleaned text (smoking, alcohol, diet, exercise, obesity) • Risk Factor Name – original text • Status – cleaned (current, never, n/a, not current, past, unknown) • Status – original • Value – cleaned • Frequency • Duration • End

Abbreviations: BMI, body mass index; BP, blood pressure; COPD, chronic obstructive pulmonary disease; CPCSSN, Canadian Primary Care Sentinel Surveillance Network; eGFR, estimated glomerular filtration rate; EMR, electronic medical records; HbA1C, glycated hemoglobin concentration; HDL, high density lipoprotein; LDL, low density lipoprotein

Table 2: Elements of high quality CKD care as defined by standard national and international CKD Guidelines[24,39-43]

Domain	Objective	Measures
Identification of CKD risk factors	To establish an organized system for identification of people with risk factors, and evaluated for the presence of CKD markers	Percentage of patients with risk factors* (present for at least 1 year) tested for CKD within the last 12 months
Identification of CKD	To establish an organized system where people with CKD are appropriately identified	Proportion of patients with CKD correctly diagnosed and appropriately coded (validated based on KDIGO definition standard of using Scr measurements to derive eGFR<60mls/min based on 2 measures at least 90 days apart based on CKD-EPI equation.
Management of CKD: Monitoring of risk factors for progression and CVD	To establish an organized system to ensure CKD patients are receiving guideline-concordant care appropriate for the stage of CKD. This implies that those with early stages are being monitored appropriately in primary care.	Proportion of patients receiving appropriate testing and monitoring: - Percentage of patients with urinary albumin tested within 6 months of Index GFR<60 ml/min/1.73m^2 - Percentage of patients with Index GFR<60ml/min/1.73m^2 and diabetes mellitus who have glycated hemoglobin tested at least annually - Frequency of eGFR and albuminuria testing in patients with a baseline of eGFR<60mls/min and/or ACR of 70mmg/mmol (<1 year, 1-2 years, >2 years) Proportion of patients receiving appropriate cardiovascular risk management: - Percentage of patients >50 years of age and eGFR<45mls/min and/or CVD history on a statin medication - Percentage of patients with diabetes and proteinuria on an ACEi or ARB - Percentage of patients with history of CVD on appropriate secondary prevention (Aspirin, beta-locker, ACEi, statin) Proportion of patients achieving treatment targets (BP, proteinuria, HbA1c). - Percentage of patients with diabetes and/or proteinuria (ACR>70mg/mmol) achieving a target BP of ≤130/80mmHg - Percentage of patients with eGFR<60mls/min achieving a target BP of ≤140/90mmHg - Percentage of patients with proteinuria (ACR>70mg/mmol) achieving a target reduction to 50% of baseline - Percentage of patients with diabetes achieving a target HbA1c ~7%
Appropriate referral system	To develop a system where CKD patients that need specialist input to care are appropriately identified and referred.	Proportion of patients appropriately referred for specialist care (defined by any visit to nephrologist or multi-disciplinary CKD clinic within the last 12 months, for those patients that meet the KDIGO referral criteria**)

* Diabetes, hypertension, cardiovascular disease, nephrotoxic meds (NSAIDS, calcineurin inhibitors, lithium), certain urological disease (e.g., kidney stones, prostatic hypertrophy), multi-system diseases (e.g., lupus) and family history of kidney disease
** This would include advanced stages of CKD (eGFR<30-45 ml/min/1.73m^2), significant albuminuria (albumin: creatinine ratio ≥70 mg/mmol), rapid loss of eGFR, refractory hypertension and history of acute kidney injury.
Abbreviations: ACR, albumin: creatinine ratio; ACEi, angiotensin converting enzyme inhibitor; ARB, angiotensin-receptor blocker; BP, blood pressure; CKD, chronic kidney disease; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; HbA1c, glycated hemoglobin concentration; KDIGO, Kidney Disease Improving Global Outcomes. Scr=serum creatinine.

Figure 1: Map of Canada showing CPCSSN Networks Distribution

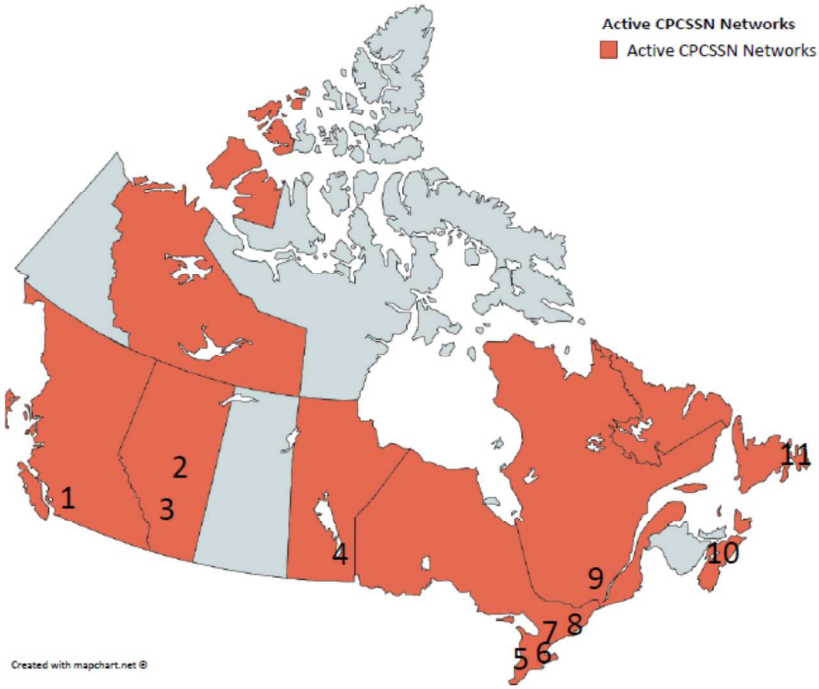
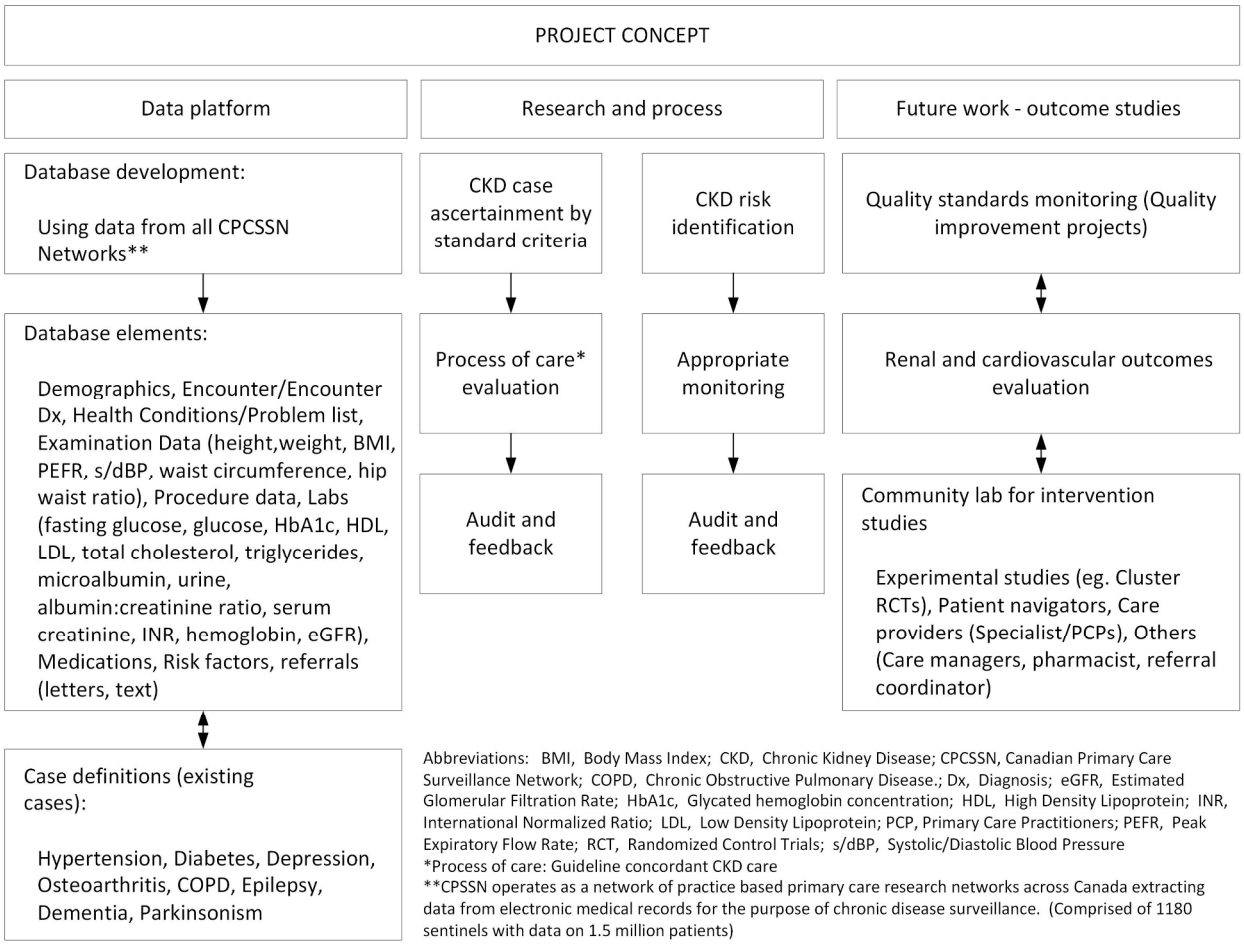


Figure legend: Map of Canada showing the distribution of primary care research networks contributing data to the CPCSSN:

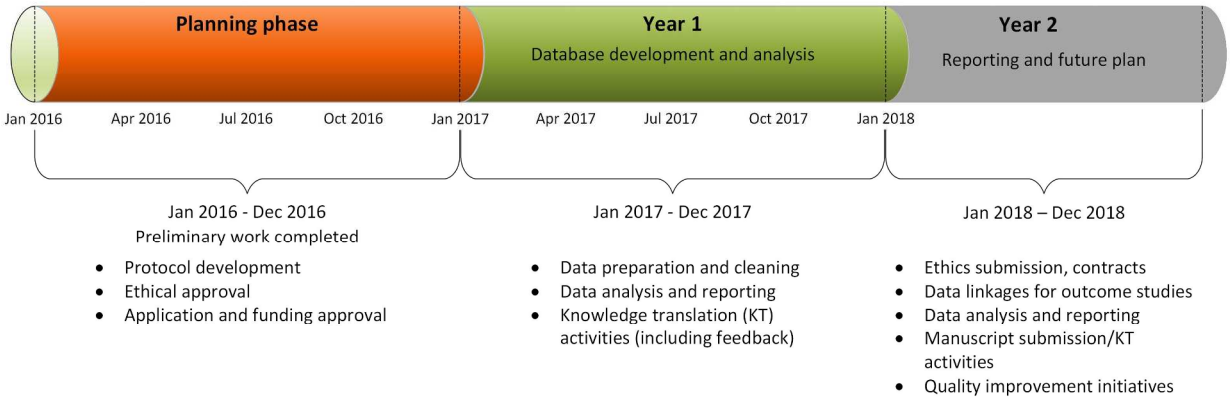
1. British Columbia Primary Care Research Network (BCPCReN)
2. Northern Alberta Primary Care Research Network (NAPCReN)
3. Southern Alberta Primary Care Research Network (SAPCReN)
4. Manitoba Primary Care Research Network (MaPCReN)
5. DELPHI (Deliver Primary Healthcare Information) Project
6. McMaster University Sentinel and Information Collaboration (MUSIC)
7. University of Toronto Practice Based Research Network (UTOPIAN)
8. The Eastern Ontario Network (EON)
9. Réseau de recherche en soins primaires de l'Université de Montréal (RRSPUM)
10. Maritime Family Practice Research Network (MaRNet-FP)
11. Atlantic Practice Based Research Network (APBRN)

Figure 2: The concept



Abbreviations: BMI, Body Mass Index; CKD, Chronic Kidney Disease; CPCSSN, Canadian Primary Care Surveillance Network; COPD, Chronic Obstructive Pulmonary Disease.; Dx, Diagnosis; eGFR, Estimated Glomerular Filtration Rate; HbA1c, Glycated hemoglobin concentration; HDL, High Density Lipoprotein; INR, International Normalized Ratio; LDL, Low Density Lipoprotein; PCP, Primary Care Practitioners; PEFR, Peak Expiratory Flow Rate; RCT, Randomized Control Trials; s/dBP, Systolic/Diastolic Blood Pressure
*Process of care: Guideline concordant CKD care
**CPSSN operates as a network of practice based primary care research networks across Canada extracting data from electronic medical records for the purpose of chronic disease surveillance. (Comprised of 1180 sentinels with data on 1.5 million patients)

Figure 3: Project timeline/milestones



BMJ Open

Improving CKD management in primary care using the Canadian Primary Care Sentinel Surveillance Network: Study protocol of a retrospective observational study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-016267.R1
Article Type:	Protocol
Date Submitted by the Author:	03-May-2017
Complete List of Authors:	Bello, A; University of Alberta, Edmonton, Alberta, Canada. , Medicine Ronksley, Paul; University of Calgary, Community Health Sciences Tangri, Navdeep; University of Manitoba, Medicine Singer , Alexander; University of Manitoba College of Medicine, Department of Family Medicine ; Manitoba Primary Care Research Network Grill, Allan; University of Toronto Nitsch, Dorothea; LSHTM Queenan, John; Queen's University in Kingston, ON, Canada Lindeman, Cliff; University of Alberta, Family Medicine Soos, Boglarka; University of Calgary, Calgary, AB, Canada, Family Medicine Freiheit, Elizabeth; University of Michigan, Ann Arbor, MI, United States, Institute for Social Research Tuot, Delphine; University of California, San Francisco Mangin, Dee ; McMaster University, Family Medicine Drummond, Neil ; University of Alberta, Edmonton, AB, Canada, Family Medicine
Primary Subject Heading:	Renal medicine
Secondary Subject Heading:	Epidemiology, Evidence based practice, General practice / Family practice, Health informatics, Health services research
Keywords:	Protocols & guidelines < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Nephrology < INTERNAL MEDICINE, Chronic renal failure < NEPHROLOGY

Improving CKD management in primary care using the Canadian Primary Care Sentinel Surveillance Network: Study protocol of a retrospective observational study

Aminu K Bello[1], MD, PhD, FRCP, Paul E. Ronksley[2], BSc, MSc, PhD, Navdeep Tangri[3] MD, PhD, FRCPC, Alex Singer[4], MB BAO BCh. CCFP, Allan Grill[5], MD, CCFP, MPH, Dorothea Nitsch[6] MD,Dr Med, MSci, John A Queenan[7], PhD, Cliff Lindeman[8], BSc, MPH, Larka Boglarka Soos[9] BSc, MMath, Elizabeth Freiheit[10] BSc, PhD, Delphine Tuot[11] MD, Dee Mangin[12] MBChB, DPH, FRNZCGP, Neil Drummond[13] PhD

[1]Department of Medicine, University of Alberta, Edmonton, AB, Canada
[2]Department of Community Health Sciences, University of Calgary, Calgary, AB, Canada.
[3]Department of Medicine, University of Manitoba, Winnipeg, MB, Canada
[4]Department of Family Medicine, University of Manitoba, Winnipeg, MB, Canada
[5]Department of Family and Community Medicine, University of Toronto, Toronto, ON, Canada
[6]Department of Non-Communicable Disease Epidemiology, London School of Hygiene &Tropical Medicine, London, UK
[7]Epidemiologist for the Canadian Primary Care Sentinel Surveillance Network, Department of Family Medicine, Queen's University in Kingston, ON, Canada
[8]Department of Family Medicine, University of Alberta, Edmonton, AB, Canada
[9]Department of Family Medicine, University of Calgary, Calgary, AB, Canada
[10]Institute for Social Research, University of Michigan, Ann Arbor, MI, United States
[11]Department of Medicine, UCSF School of Medicine, San Francisco, CA, United States
[12]Department of Family Medicine, McMaster University, Hamilton, ON, Canada
[13]Department of Family Medicine, University of Alberta, Edmonton, AB, Canada

Corresponding Author:
Aminu K Bello, MD PhD, FRCP
Division of Nephrology and Immunology
Department of Medicine
University of Alberta
11-107 Clinical Sciences Building, 8440 112 Street NW, Edmonton, Alberta, Canada T6B 2B7

Email: aminu1@ualberta.ca
Telephone: 780-492-1867
Fax: 780-407-7771

Word Count
Abstract: 302
Main Text: (excluding abstract, references, tables, and figure): 2958

Running title: CKD Management in Canadian Primary Care

ABSTRACT

Introduction: Effective chronic disease care is dependent on well-organized quality improvement (QI) strategies that monitor processes of care and outcomes for optimal care delivery. Although healthcare is provincially/territorially structured in Canada, there are national networks such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) as important facilitators for national QI-based studies to improve chronic disease care. The goal of our study is to improve the understanding of how patients with chronic kidney disease (CKD) are managed in primary care and the variation across practices and provinces to drive improvements in care delivery.

Methods and analysis: The CPCSSN database contains anonymized health information from the electronic medical records for patients of participating primary care practices (PCPs) across Canada (N=1200). The dataset includes information on patient socio-demographics, medications, laboratory results and comorbidities. Leveraging validated algorithms, case definitions and guidelines will help define CKD and the related processes of care, and enable us to: 1) ascertain the burden of CKD in primary care; 2) determine the current practice pattern on CKD risk identification in primary care; and 3) investigate the variation in care indicators (e.g. achievement of blood pressure [BP] and proteinuria targets) across patients' demographics and provider and regional characteristics. The prevalence of CKD stages 3-5 will be presented as age-sex standardized prevalence estimates stratified by province and as weighted averages for population rates with 95% confidence intervals (CI) using census data. For each PCP, age-sex standardized prevalence will be calculated and compared with expected standardized prevalence estimates. The process-based outcomes will be defined using established methods.

Ethics and dissemination: The CPCSSN is committed to high ethical standards when dealing with individual data collected, and this work is reviewed and approved by the Network Scientific Committee. The results will be published in peer-reviewed journals and presented at relevant national and international scientific meetings.

Strengths and limitations of this study

- To our knowledge, this is the first nationwide and largest retrospective observational study on the epidemiology and management of CKD in primary care in Canada with potential to identify opportunities for improving quality of care for CKD at a national level.
- It will define the practice patterns on CKD risk identification in primary care by ascertaining whether high-risk groups are appropriately tested, monitored, and managed for CKD based on existing guideline recommendations.
- It will investigate the variation in CKD care delivery across patient, provider, and regional characteristics, relative to established quality indicators.
- This study leverages retrospective data collated at point of care, and therefore limitations include variable data quality and incomplete information in some data domains.
- The results of this study will enable the development of strategies and interventions to improve care and outcomes for patients with CKD.

INTRODUCTION

There is an absence of effective surveillance mechanisms for chronic kidney disease (CKD) in most countries despite the overwhelming opinion of key stakeholders supporting such developments.[1,2] There are a few countries in the world with a well-established CKD surveillance systems (Australia, Japan, UK and USA).[1,3] As with all other non-communicable diseases (NCDs), planning, development and implementation of effective and efficient care programs require reliable national data systems to monitor the burden of disease, processes of care and clinical outcomes.[4-12] Once established, these systems can be used for routine surveillance (including secular trends), quality improvement and resource allocation (including workforce planning). In Canada, they would also allow for within-country comparisons across provinces and territories, and evaluation of how the country compares with similar nations in CKD care. If combined with existing data sources (e.g., administrative databases), data on CKD management in primary care might also facilitate efforts to integrate CKD management with care for other major NCDs (e.g., diabetes, cardiovascular diseases, hypertension, obesity).[5]

Effective and sustainable chronic disease care is dependent on well-organized quality improvement (QI) strategies to monitor processes of care and outcomes and inform optimal care delivery.[1] In the CKD domain, end-stage renal disease (ESRD) care has been the sole focus of national QI activities, often administered in conjunction with national/regional registries (e.g., Canadian Organ Replacement Register, United States Renal Data System, European Renal Registry).[1,5] While there is no surveillance system for non-dialysis-dependent CKD in most countries, including Canada,[5,13] a few have developed initiatives in this direction[14].[1,5,13,15] A national CKD surveillance system using routinely collected practice data is feasible in nations with well-developed healthcare systems as CKD lends itself particularly well to surveillance because of its laboratory-based diagnosis[16]. Although healthcare is provincially/territorially structured and administered in Canada, there are existing national networks and collaborations such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN)[17] that can be important facilitators for national QI-based studies.

We set out to improve the understanding of how patients with CKD are managed and the variation across practitioners, regions, and provinces to drive improvements in care delivery. Our study is a multidisciplinary (nephrology, primary care) and cross-jurisdictional effort leveraging data from the CPCSSN to investigate the epidemiology and management of CKD in the Canadian primary care system. The overarching aim is to use data derived from primary care electronic medical records (EMRs) to identify gaps in care, and provide opportunities for interventions to improve care and patient outcomes.

Objectives:

1. Develop and validate a case definition for CKD in primary care and apply this to ascertain the burden of CKD in primary care, obtaining data on unidentified cases using standard criteria.[18,19]

2. Determine the current practice patterns on CKD risk identification in primary care by ascertaining whether high-risk groups (e.g., individuals with diabetes, hypertension, and urologic disorders, and those with chronic use of nephrotoxic medications) are appropriately screened and managed for CKD.

3. Determine whether people with CKD are being managed based on established quality indicators, and investigate the care variation across patients' demographics (age, sex, socio-economic status, rural/urban residence, comorbidity burden), provider characteristics (family physician/nurse practitioner, year of graduation, rural/urban, individual/group, fee for service) and regional characteristics (intra- and inter-provincial/territorial variation, rural versus urban).

METHODS AND ANALYSIS

Setting

The CPCSSN[17,20,21] is the first pan-Canadian multi-disease surveillance system. The data resources profile and context within the Canadian health system are detailed elsewhere.[22] Canada is considered a high-income country by the World Bank Classification Index with a population of 35,362,905 (2016). It is the second largest country in the world with a land area of 9,984,670 sq km. It has a GDP of $1.634 trillion (2016), and about 10.1% of this is spent on healthcare. In Canada, health care is a provincial or territorial mandate under the oversight of the Canada Health Act and with financial assistance from the federal government ensuring universal, publicly funded health services to the population for medically-necessary care including physician visits, hospitalizations and, in some provinces universal drug coverage. Primary care is the first portal for accessing care particularly for routine chronic disease care.

The structure of CPCSSN comprised of a network of twelve practice-based primary care research networks that collect primary care health information from the EMRs of primary care providers (PCPs) in eight out of the ten provinces and one out of the three territories in the country **(Figure 1)**. There are 1180 sentinels (i.e., participating PCPs) contributing data to the CPCSSN, which is updated quarterly. This actively expanding repository currently contains data on approximately 1.5 million Canadians. The initial focus of the CPCSSN was to conduct surveillance on five chronic conditions: diabetes, hypertension, osteoarthritis, chronic obstructive pulmonary disease, and depression. Subsequently, it was expanded to included three neurological conditions: dementia, epilepsy, and Parkinson's disease. Our project team has been instrumental in working with CPCSSN to further expand on these conditions by including CKD, and this work on CKD will be conducted from January 2017 to December 2018. It will take place under the auspices of the Alberta's Strategy for Patient Oriented Research (SPOR)- Primary and Integrated Health Care Innovation Network (PIHCIN).

Population and data sources

Data for the CPCSSN database are extracted from the EMRs of participating sentinels, rendered anonymous, coded and processed using established frameworks described in detail elsewhere.[21,23] The data are placed in regional network databases and then merged into the national repository. It is made available for surveillance and research, and increasingly for quality improvement projects and for clinical decision support where available, through the implementation of a patient re-identification tool held only within the custodial clinics themselves. With appropriate data sharing agreements with its sentinel PCPs, CPCSSN data may

be linked with administrative health data for future work to follow up on CKD-related outcomes (e.g., ascertainment of progression to dialysis requirement using registry data).

The CPCSSN database will be used to develop a cohort of CKD patients being managed in primary care between January 1, 2010 and December 31, 2015 (baseline cohort), and from January 1, 2016 onwards (open cohort). The database is updated quarterly, allowing for identification of new CKD patients who meet the inclusion criteria during the study period. The CPCSSN database contains patient information on socio-demographics (age, sex, socio-economic status (calculated deprivation category)), treatment (medications data), laboratory results and comorbidities **(Table 1, Figure 2)**.[21,24] Patients under 18 years of age will be excluded from the cohorts, as will those diagnosed with ESRD and on dialysis or having renal transplant. We will leverage validated algorithms, case definitions and guidelines to define CKD, at-risk population and processes of care measures based on established methods and criteria **(Table 2)**.[25,26,27]

Identification of CKD

The major focus is to validate a case definition for CKD in primary care using the CPCSSN repository to enable us to identify patients with CKD. We will leverage the existing frameworks and conventions by national and international CKD guidelines, and definitions used elsewhere.[26,28] Serum creatinine (Scr) measurements will be used to calculate using CKD-EPI equation.[29] Individuals with at least one face-to-face PCP encounter and two calculated eGFR values <60 ml/min per 1.73 m^2 >90 days apart or having an International Classification of Diseases (ICD-9) diagnosis code for CKD used at least twice in an outpatient encounter as of December 31, 2015, will be defined to have CKD. We recognize the significant limitations of the ICD-9 codes when applied for CKD identification in the community, however, its use will allow us to capture those patients with CKD who may or may not have had an abnormal eGFR, for example cystic kidney diseases and other rare congenital disorders. In a secondary analysis, CKD will be defined by eGFR<45 ml/min/1.73m^2 using two values of eGFR >90 days apart. This definition was selected because although GFR<60 ml/min/1.73m^2 constitutes CKD, individuals with GFR between 45 and 60 ml/min/1.73m^2 usually have favorable prognosis in the absence of proteinuria, and are substantially fewer in number than those with GFR<45/min/1.73m^2. Patients with eGFR<45 ml/min/1.73m^2 are also a more attractive population for intervention due to higher risk of adverse clinical outcomes including risk of progression to ESRD[2,14]. Validation of the primary care CKD case definition algorithm will consist of an expert blinded chart review and identification of cases in a random sample of 1000 CPCSSN charts, containing both original and cleaned text data from the EMRs for patients aged 18 years or older, and comparison with the outcome of an independent search of the same sample using the CPCSSN case finding algorithm. Analysis will consist of calculations of sensitivity, specificity, and positive and negative predicted values. The prevalence of CKD stages 3-5 will be presented as unadjusted prevalence estimates and weighted averages for population rates with 95% confidence intervals (CI) using the census data, and stratified by PCP, rural/urban location and province or territory.

Evaluation of processes of care

The process-based outcomes (quality of care metrics) will be defined and evaluated using established methods across key domains of risk identification and case finding for CKD, as well as delivery of appropriate management including monitoring of risk factors for progression and cardiovascular disease (CVD), and referral for specialist nephrology care where necessary (Table 2). We are specifically focusing on the key domains of CKD management in primary care that include:

- CKD risk identification. This entails the evaluation of the proportion of patients with risk factors (diabetes and/or hypertension) present for at least 1 year that are tested for CKD within the previous 12 months of follow up.
- Identification of CKD. This is to determine the proportion of patients with CKD (defined based on laboratory measures), and correctly coded as having CKD in the EMR using defined clinical parameters.
- Management of CKD: This examines the current state of practice on the management of the common risk factors (BP, glycemia, proteinuria, dyslipidemia) associated with CKD progression and/or risk of CKD. For example, ascertaining the proportion of patients achieving guideline-concordant treatment targets (BP, proteinuria, HbA1c).
- Appropriate referral. This is to capture the proportion of patients appropriately referred for specialist kidney care (defined by any visit to nephrologist or multi-disciplinary CKD clinic within the last 12 months) based on guideline-concordant criteria for referral.

Data analysis

Covariates definition and evaluation of CKD markers

Socio-demographic, clinical, laboratory and medication data will be classified using standard definitions established by the CPCSSN.[17,24,30-34] Other comorbid conditions relevant to the care of CKD patients but not defined by the CPCSSN (coronary artery disease, stroke, peripheral vascular disease, heart failure) will be identified using standard procedures to search for those diagnoses in patients' medical records (based on validated ICD-9-CM coding algorithms[35]). Baseline kidney function (using estimated glomerular filtration rate, eGFR) will be calculated using all serum creatinine measurements taken within a six-month period of the first creatinine measurement, with the index eGFR defined as the mean of the six-month measurements. Assessment of urine protein excretion will be estimated using the albumin: creatinine ratio (ACR) based on spot urine measurements using standard conventions.[25] All CKD cases will be risk-stratified, defined and classified according to current guideline recommendations.[25] Demographic information (including age, sex and postal code) of those with and at risk of CKD will be extracted **(Tables 1 & 2)**. Normally distributed variables will be summarized as means with standard deviations (SD), and non-normally distributed data will be summarized as medians with interquartile ranges (IQR). Dichotomous data will be expressed in percentages. The representativeness of the study population will be tested by comparing their age and sex profiles to the population distribution as reported in the Canadian 2011 Census (adjusting for 2016 census data when available).

ETHICS AND DISSEMINATION

The CPCSSN is committed to high ethical standards when handling individual patient data collected from EMRs of participating PCPs from across Canada. These data are aggregated and stored in CPCSSN's central repository at the Centre for Advanced Computing, Queens University in Kingston, Ontario. There are well-developed organizational, physical and technological safeguards at all levels (clinic, provincial, national) to ensure that the privacy of patients is protected and that all collection, retention, use or disclosure of data complies with applicable privacy legislation and ethical requirements.[17,21] All personal identifiers are removed from the data in the national research repository to protect patient confidentiality.[21] The protocol has undergone a scientific review and approval by the CPCSSN Surveillance and Research Standing Committee (SRSC), and ethical approval for the study was granted by the University of Alberta Health Research Ethics Committee.

This project uses an integrated knowledge translation (KT) strategy, where relevant stakeholders (patients, practitioners, policymakers) have been involved from inception (proposal development) to ensure that the project addresses the needs of patients and practitioners. The activities underpinning the Alberta SPOR PIHCIN center around the patients and are patient-oriented, where the voices and perspectives of patients are solicited from research inception (e.g. defining research questions) to completion. The patients are collaborators rather than research subjects, and we have a patient representative on the project team to ensure patients voices and perspectives guide the work to completion, and that it remains patient-centered.

The involvement of the knowledge end-users (practitioners and policymakers) and the high priority that they place on the project will ensure that we drive it forward to completion and provide an opportunity to meaningfully change the way that care is delivered to CKD patients managed in primary care. For example, after identifying regions/clusters with especially suboptimal CKD care, we will collaborate with providers, policymakers and regional health authorities to improve care in those regions. We will apply the KT Canada Knowledge-to-Action Cycle Framework and other established methods (e.g., PDSA (Plan, Do, Study, Act) concept) to disseminate our findings to all relevant stakeholders and end-users for action.[36,37] We will leverage our collaborations with existing platforms and research networks such as the Canadian Society of Nephrology, CANN-NET (CAnadian KidNey KNowledge TraNslation and GEneration NeTwork), Can-SOLVE CKD (Canadians Seeking Solutions and Innovations to Overcome Chronic Kidney Disease) and the country-wide Primary and Integrated Healthcare Innovation Networks to ensure the translation of our findings across provinces and territories, as well as internationally through our associations with the International Society of Nephrology and the Kidney Disease Improving Global Outcomes (KDIGO) team.[5,38] The results will be published in leading general medicine, nephrology and primary care peer-reviewed journals and presented at relevant national and international scientific meetings. A performance report will be produced against the indicators relevant to each objective, aggregated by practice sentinel, to highlight practice performance and map out areas for improvement, critical for continuing professional development of PCPs and helping to enhance CKD management in primary care. In future, this database with be linked to the Canadian Organ Replacement Registry and relevant

provincial administrative databases to study clinically-relevant outcomes of risk and progression to[i] kidney failure (ESRD) and adverse cardiovascular outcomes[39,40] (**Figure 3**).

This work will close the information gap between observed and expected burdens and risks of CKD and map out standards of care achieved, providing opportunities for focused and effective population-level QI strategies and other service improvement initiatives. This project will demonstrate proof of concept for an early identification and management of CKD program in primary care, and provide the basis for developing relevant policies and KT strategies to enhance the uptake of findings – for people with CKD, and other chronic diseases as well. The work will facilitate identification and appropriate management of CKD patients at high risk of progression to ESRD. The findings will be reported based on existing reporting frameworks.[41]

We have anticipated potential threats and have devised strategies to mitigate them. The first related to feasibility within the defined timeframe **(Figure 3)**. This is unlikely to hinder the success of the project as we have completed significant preliminary work for data access, and the team has considerable experience with the use of this kind of data for policy-relevant research.[5,19,36,42,43] Second, limitations general to the use of EMR data in research are acknowledged. The collated information is based on clinical encounters and needs, and thus may be missing for some important key variables and data quality may vary by region and/or sentinel; specifically, data on patients' priorities and satisfaction of care are rarely collated in a clinical setting. However, most important demographic, clinical and laboratory information needed for this study are well captured in the existing platform chosen for this work. Third, lack of use of patient-reported outcomes measures such as satisfaction with care, self-management support, etc could not be included as these were not routinely collated in this database.

CONCLUSIONS

Planning, development, and implementation of nephrology services require reliable information systems and databases to capture information on trends in disease burden, processes of care and related outcomes. In the absence of national/regional health information systems, one way to achieve this is by the creation of surveillance systems using routine practice data, such as the CPCSSN and those established specifically for CKD in other jurisdictions across the world (Table 3). The established conventions and guidelines on CKD can be leveraged for systematic case definition and evaluation of quality of care across settings. This can be facilitated by validation as well as enactment of quality metrics to measure the processes, quality of care and related outcomes, and generate uniformity across databases which may permit analyses across countries and regions. It is important to detect CKD early enough to be able to implement effective interventions. On-going primary care management of key risk factors for CKD (e.g., hypertension, vascular disease, diabetes) is likely one effective strategy to reduce progression of CKD and reduce adverse complication rates. Early detection and treatment of CKD and reducing adverse events with appropriate medications also reduces the morbidity and cost of CKD and related complications. The work described in this protocol therefore has a huge potential to address the identified gaps for optimal care delivery of CKD at the primary care level that would impact positively on patients' outcomes and health system improvement.

Contributors: AKB and ND had the original idea for this study. AKB and PER wrote the first draft of the manuscript. PER, NT, AS, AG, DN, JAQ, CL, BS, EF, DT and DM contributed to the development of the idea, the study design and reviewed the manuscript for intellectual content. All authors approved the final submitted version of the manuscript.

Funding: This work is supported by the Canadian Institute of Health Research (CIHR) Operating Grant: SPOR PIHCI Network: Quick Strikes Grant (ref# RN281786), through the Universities of Alberta and Manitoba, and McMaster University.

Competing interests: None declared.

Ethics approval: This project has been approved by the University of Alberta Health Research Ethics Committee. Identifiable patient data will not be shared during the project, thus maintaining confidentiality.

Disclaimer: The views expressed are those of the authors and not necessarily those of the CIHR, CPCSSN or the various institutions represented.

Data sharing statement: The authors will make available the full statistical analysis of the study results following publication if and when required. The results of the study will be submitted for publication in a leading medical/nephrology peer-reviewed journa

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Table 1: Data variables

Domain	Variables
Patient Demographics and Clinical Data	• Patient ID (unique patient number generated by CPCSSN) • Sex • Month & Year of Birth • Occupation • Highest Education • Housing Status • Postal Code • EMR Status – Active, Deceased, Duplicate, Inactive, Unknown • Language • Race/Ethnicity • Deceased Year • Date Created (date this record was created) • Time Since Last Visit – 6, 12, 24 or 36 months • CPCSSN Conditions – yes / no for diabetes, depression, osteoarthritis, COPD, hypertension, dementia, Parkinson's, epilepsy • CPCSSN Conditions – count (i.e., numeric value) • Disease Case Indicator – disease (diabetes, depression, osteoarthritis, COPD, hypertension, dementia, Parkinson's, epilepsy) • Disease Case Indicator – Indicator Type (billing, encounter diagnosis, health conditions, lab result [HbA1C, fasting glucose], medication) • Disease Case Indicator – Indicator Value (numeric value of HbA1C and/or fasting glucose)
Patient-Provider Pairing	• Patient ID (unique patient number generated by CPCSSN) • Provider ID (unique provider number generated by CPCSSN; primary provider of patient) • Start Date • End Date
Provider	• Provider ID (unique provider number generated by CPCSSN) • Sex • Birth Year
Billing	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Service Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9, ICD10) • Diagnosis Code (i.e., 401)
Clinical Encounters	• Patient ID (unique patient number generated by CPCSSN) • Provider ID (unique provider number of the attending provider generated by CPCSSN) • Encounter Date • Encounter Type – academic clinic, community clinic • Reason for visit – cleaned • Reason for visit – original
Encounter Diagnoses	• Patient ID (unique patient number generated by CPCSSN) • Created Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9) • Diagnosis Code (i.e., 401)
Exam	• Patient ID (unique patient number generated by CPCSSN) • Exam Name – systolic BP, diastolic BP, height, weight, BMI, waist circumference, waist hip ratio (all values) • Result – cleaned numeric value • Result – original numeric value • Unit of Measure • Most Recent Value – yes, no

Health Condition	• Patient ID (unique patient number generated by CPCSSN) • Created Date • Onset Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9) • Diagnosis Code (i.e., 401)
Laboratory	• Patient ID (unique patient number generated by CPCSSN) • Date Performed • Lab Name – cleaned text (fasting glucose, glucose tolerance, HbA1C, HDL, LDL, total cholesterol, triglycerides, microalbumin, urine albumin creatinine ratio, hemoglobin, creatinine, eGFR / GFR) • Lab Name – original text • Lab Result – numeric value • Unit of Measure • Most Recent Value – yes, no
Medical/Surgical Procedure	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Date Performed • Procedure Name – cleaned text • Procedure Name – original text
Medication	• Patient ID (unique patient number generated by CPCSSN) • Start Date • Stop Date • Medication Name – cleaned text • Medication Name – original text • Medication Code – ATC code *(Anatomical Therapeutic Chemical classification system)* • Time Since (initial prescription) • DIN (Drug Identification Number) • Strength • Dose • Frequency • Unit of Measure
Referral	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Date Completed • Referral Name – cleaned text • Referral Name – original text
Risk Factor	• Patient ID (the unique patient number generated by CPCSSN) • Date Created • Start Date • Stop Date • Most Recent – yes, no • Risk Factor Name – cleaned text (smoking, alcohol, diet, exercise, obesity) • Risk Factor Name – original text • Status – cleaned (current, never, n/a, not current, past, unknown) • Status – original • Value – cleaned • Frequency • Duration • End

Abbreviations: BMI, body mass index; BP, blood pressure; COPD, chronic obstructive pulmonary disease; CPCSSN, Canadian Primary Care Sentinel Surveillance Network; eGFR, estimated glomerular filtration rate; EMR, electronic medical records; HbA1C, glycated hemoglobin concentration; HDL, high density lipoprotein; LDL, low density lipoprotein

Table 2: Elements of high quality CKD care as defined by standard national and international CKD Guidelines[25,44-48]

Domain	Objective	Measures
Identification of CKD risk factors	To establish an organized system for identification of people with risk factors, and evaluated for the presence of CKD markers	Percentage of patients with risk factors* (present for at least 1 year) tested for CKD within the last 12 months
Identification of CKD	To establish an organized system where people with CKD are appropriately identified	Proportion of patients with CKD correctly diagnosed and appropriately coded (validated based on KDIGO definition standard of using Scr measurements to derive eGFR<60mls/min based on 2 measures at least 90 days apart based on CKD-EPI equation.
Management of CKD: Monitoring of risk factors for progression and CVD	To establish an organized system to ensure CKD patients are receiving guideline-concordant care appropriate for the stage of CKD. This implies that those with early stages are being monitored appropriately in primary care.	Proportion of patients receiving appropriate testing and monitoring: - Percentage of patients with urinary albumin tested within 6 months of Index GFR<60 ml/min/1.73m^2 - Percentage of patients with Index GFR<60ml/min/1.73m^2 and diabetes mellitus who have glycated hemoglobin tested at least annually - Frequency of eGFR and albuminuria testing in patients with a baseline of eGFR<60mls/min and/or ACR of 70mmg/mmol (<1 year, 1-2 years, >2 years) Proportion of patients receiving appropriate cardiovascular risk management: - Percentage of patients >50 years of age and eGFR<45mls/min and/or CVD history on a statin medication - Percentage of patients with diabetes and proteinuria on an ACEi or ARB - Percentage of patients with history of CVD on appropriate secondary prevention (Aspirin, beta-locker, ACEi, statin) Proportion of patients achieving treatment targets (BP, proteinuria, HbA1c). - Percentage of patients with diabetes and/or proteinuria (ACR>70mg/mmol) achieving a target BP of ≤130/80mmHg - Percentage of patients with eGFR<60mls/min achieving a target BP of ≤140/90mmHg - Percentage of patients with proteinuria (ACR>70mg/mmol) achieving a target reduction to 50% of baseline - Percentage of patients with diabetes achieving a target HbA1c ~7%
Appropriate referral system	To develop a system where CKD patients that need specialist input to care are appropriately identified and referred.	Proportion of patients appropriately referred for specialist care (defined by any visit to nephrologist or multi-disciplinary CKD clinic within the last 12 months, for those patients that meet the KDIGO referral criteria**)

* Diabetes, hypertension, cardiovascular disease, nephrotoxic meds (NSAIDS, calcineurin inhibitors, lithium), certain urological disease (e.g., kidney stones, prostatic hypertrophy), multi-system diseases (e.g., lupus) and family history of kidney disease.

** This would include advanced stages of CKD (eGFR<30 ml/min/1.73m^2), significant albuminuria (albumin: creatinine ratio ≥70 mg/mmol), rapid loss of eGFR (>15 ml/min/1.73m^2)refractory hypertension and history of acute kidney injury.
Abbreviations: ACR, albumin: creatinine ratio; ACEi, angiotensin converting enzyme inhibitor; ARB, angiotensin-receptor blocker; BP, blood pressure; CKD, chronic kidney disease; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; HbA1c, glycated hemoglobin concentration; KDIGO, Kidney Disease Improving Global Outcomes. Scr=serum creatinine.

Table 3: Examples of Existing CKD Surveillance Programs

Program	Year of inception	Approach/methodology	Data sources	Spread	Funding
US CDC*	2006	Passive surveillance approach leveraging existing data sources	Administrative Surveys (NHANES)	National	Governmental support
England QoF	2006	An incentive-based (pay-for-performance system) that required all PCPs to establish a register for adults with CKD stages 3–5, and achieve guideline-concordant treatment targets.	Routine primary care records	National	Governmental support
CKD-JAC	2008	Routine care data across select CKD Clinics across Japan	Practice data	National	Japanese Society of Nephrology & Industry
CKD Queensland Registry	2009	Routine clinical care data	Practice data	Regional (state of Queensland)	Research organizations and industry
CPCSSN-CKD*	2017	Passive surveillance using routine practice database	Routine primary care databases	National (multiple regions and territories)	Research organizations and government (PHAC, CIHR)

Abbreviations: CKD-JAC=Chronic kidney disease Japan Cohort, CKD=chronic kidney disease, CPCSSN =Canadian Primary Care Sentinel Surveillance Network, QoF=Quality and Outcomes Framework, US CDC =The United States Centers for Disease Control and Prevention CKD Surveillance System. *Main database development started in 2005.

Figure legends

Figure 1: Map of Canada showing CPCSSN Networks Distribution

Figure 2: The project concept

Figure 3: Project timeline/milestones

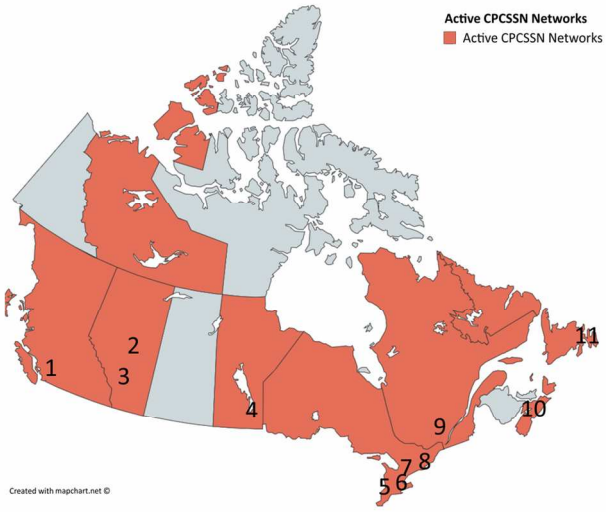

Figure legend: Map of Canada showing the distribution of primary care research networks contributing data to the CPCSSN:

1. British Columbia Primary Care Research Network (BCPCReN)
2. Northern Alberta Primary Care Research Network (NAPCReN)
3. Southern Alberta Primary Care Research Network (SAPCReN)
4. Manitoba Primary Care Research Network (MaPCReN)
5. DELPHI (Deliver Primary Healthcare Information) Project
6. McMaster University Sentinel and Information Collaboration (MUSIC)
7. University of Toronto Practice Based Research Network (UTOPIAN)
8. The Eastern Ontario Network (EON)
9. Réseau de recherche en soins primaires de l'Université de Montréal (RRSPUM)
10. Maritime Family Practice Research Network (MaRNet-FP)
11. Atlantic Practice Based Research Network (APBRN)

Map of Canada showing CPCSSN Networks Distribution

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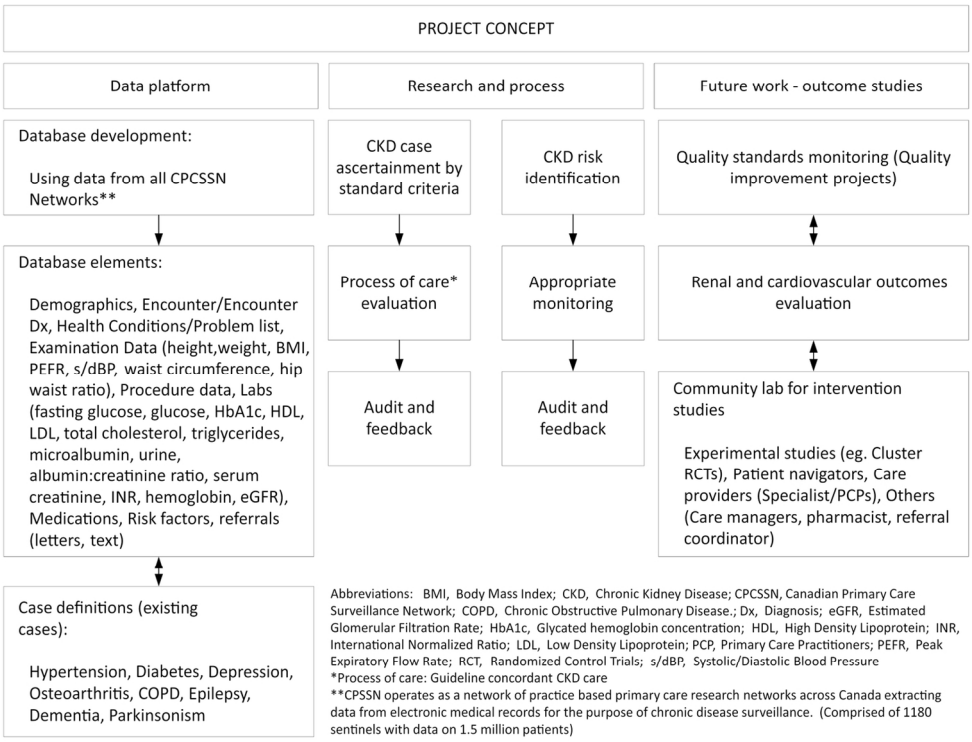

The project concept

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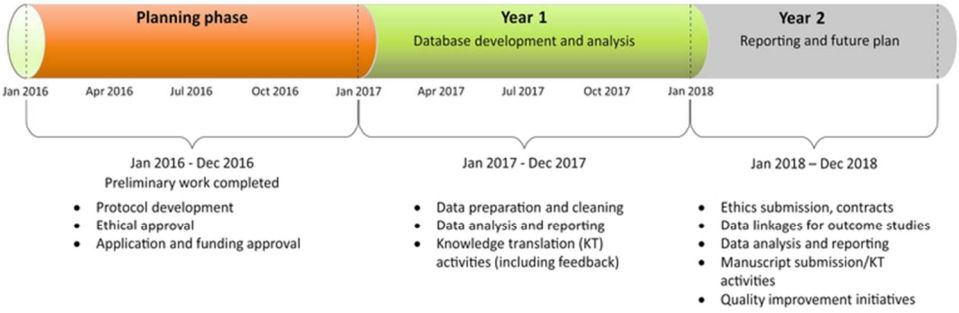

Project timeline/milestones

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BMJ Open

A National Surveillance Project on Chronic Kidney Disease Management in Canadian Primary Care: A Study Protocol

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2017-016267.R2
Article Type:	Protocol
Date Submitted by the Author:	30-May-2017
Complete List of Authors:	Bello, A; University of Alberta, Edmonton, Alberta, Canada. , Medicine Ronksley, Paul; University of Calgary, Community Health Sciences Tangri, Navdeep; University of Manitoba, Medicine Singer , Alexander; University of Manitoba College of Medicine, Department of Family Medicine ; Manitoba Primary Care Research Network Grill, Allan; University of Toronto Nitsch, Dorothea; LSHTM Queenan, John; Queen's University in Kingston, ON, Canada Lindeman, Cliff; University of Alberta, Family Medicine Soos, Boglarka; University of Calgary, Calgary, AB, Canada, Family Medicine Freiheit, Elizabeth; University of Michigan, Ann Arbor, MI, United States, Institute for Social Research Tuot, Delphine; University of California, San Francisco Mangin, Dee ; McMaster University, Family Medicine Drummond, Neil ; University of Alberta, Edmonton, AB, Canada, Family Medicine
Primary Subject Heading:	Renal medicine
Secondary Subject Heading:	Epidemiology, Evidence based practice, General practice / Family practice, Health informatics, Health services research
Keywords:	Protocols & guidelines < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Nephrology < INTERNAL MEDICINE, Chronic renal failure < NEPHROLOGY

A National Surveillance Project on Chronic Kidney Disease Management in Canadian Primary Care: A Study Protocol

Aminu K Bello[1], MD, PhD, FRCP, Paul E. Ronksley[2], BSc, MSc, PhD, Navdeep Tangri[3] MD, PhD, FRCPC, Alex Singer[4], MB BAO BCh CCFP, Allan Grill[5], MD, CCFP, MPH, Dorothea Nitsch[6] MD,Dr Med, MSci, John A Queenan[7], PhD, Cliff Lindeman[8], BSc, MPH, Larka Boglarka Soos[9] BSc, MMath, Elizabeth Freiheit[10] BSc, PhD, Delphine Tuot[11] MD, Dee Mangin[12] MBChB, DPH, FRNZCGP, Neil Drummond[13] PhD

[1]Department of Medicine, University of Alberta, Edmonton, AB, Canada
[2]Department of Community Health Sciences, University of Calgary, Calgary, AB, Canada.
[3]Department of Medicine, University of Manitoba, Winnipeg, MB, Canada
[4]Department of Family Medicine, University of Manitoba, Winnipeg, MB, Canada
[5]Department of Family and Community Medicine, University of Toronto, Toronto, ON, Canada
[6]Department of Non-Communicable Disease Epidemiology, London School of Hygiene &Tropical Medicine, London, UK
[7]Epidemiologist for the Canadian Primary Care Sentinel Surveillance Network, Department of Family Medicine, Queen's University in Kingston, ON, Canada
[8]Department of Family Medicine, University of Alberta, Edmonton, AB, Canada
[9]Department of Family Medicine, University of Calgary, Calgary, AB, Canada
[10]Institute for Social Research, University of Michigan, Ann Arbor, MI, United States
[11]Department of Medicine, UCSF School of Medicine, San Francisco, CA, United States
[12]Department of Family Medicine, McMaster University, Hamilton, ON, Canada
[13]Department of Family Medicine, University of Alberta, Edmonton, AB, Canada

Corresponding Author:
Aminu K Bello, MD PhD, FRCP
Division of Nephrology and Immunology
Department of Medicine
University of Alberta
11-107 Clinical Sciences Building, 8440 112 Street NW, Edmonton, Alberta, Canada T6B 2B7

Email: aminu1@ualberta.ca
Telephone: +1780-492-1867
Fax: +1780-407-7771

Word Count
Abstract: 315
Main Text: (excluding abstract, references, tables, and figure): 2964

Running title: CKD Management in Canadian Primary Care

ABSTRACT

Introduction: Effective chronic disease care is dependent on well-organized quality improvement (QI) strategies that monitor processes of care and outcomes for optimal care delivery. Although healthcare is provincially/territorially structured in Canada, there are national networks such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) as important facilitators for national QI-based studies to improve chronic disease care. The goal of our study is to improve the understanding of how patients with chronic kidney disease (CKD) are managed in primary care and the variation across practices and provinces and territories to drive improvements in care delivery.

Methods and analysis: The CPCSSN database contains anonymized health information from the electronic medical records for patients of participating primary care practices (PCPs) across Canada (N=1200). The dataset includes information on patient socio-demographics, medications, laboratory results and comorbidities. Leveraging validated algorithms, case definitions and guidelines will help define CKD and the related processes of care, and enable us to: 1) determine prevalent CKD burden; 2) ascertain the current practice pattern on risk identification and management of CKD; 3) study variation in care indicators (e.g. achievement of blood pressure [BP] and proteinuria targets) and referral pattern for specialists kidney care. The process of care outcomes will be stratified across patients' demographics as well as provider and regional (provincial/territorial) characteristics. The prevalence of CKD stages 3-5 will be presented as age-sex standardized prevalence estimates stratified by province and as weighted averages for population rates with 95% confidence intervals (CI) using census data. For each PCP, age-sex standardized prevalence will be calculated and compared with expected standardized prevalence estimates. The process-based outcomes will be defined using established methods.

Ethics and dissemination: The CPCSSN is committed to high ethical standards when dealing with individual data collected, and this work is reviewed and approved by the Network Scientific Committee. The results will be published in peer-reviewed journals and presented at relevant national and international scientific meetings.

Strengths and limitations of this study

- To our knowledge, this is the first nationwide and largest retrospective observational study on the epidemiology and management of CKD in primary care in Canada with potential to identify opportunities for improving quality of care for CKD at a national level.
- It will define the practice patterns on CKD risk identification in primary care by ascertaining whether high-risk groups are appropriately tested, monitored, and managed for CKD based on existing guideline recommendations.
- It will investigate the variation in CKD care delivery across patient, provider, and regional characteristics, relative to established quality indicators.
- This study leverages retrospective data collated at point of care, and therefore limitations include variable data quality and incomplete information in some data domains.
- The results of this study will enable the development of strategies and interventions to improve care and outcomes for patients with CKD.

INTRODUCTION

There is an absence of effective surveillance mechanisms for chronic kidney disease (CKD) in most countries despite the overwhelming opinion of key stakeholders supporting such developments.[1,2] There are a few countries in the world with well-established CKD surveillance systems (Australia, Japan, UK and USA).[1,3] As with all other non-communicable diseases (NCDs), planning, development and implementation of effective and efficient care programs require reliable national data systems to monitor the burden of disease, processes of care and clinical outcomes.[4-12] Once established, these systems can be used for routine surveillance (including secular trends), quality improvement and resource allocation (including workforce planning). In Canada, they would also allow for within-country comparisons across provinces and territories, and evaluation of how the country compares with similar nations in CKD care. If combined with existing data sources (e.g., administrative databases), data on CKD management in primary care might also facilitate efforts to integrate CKD management with care for other major NCDs (e.g., diabetes, cardiovascular diseases, hypertension, obesity).[5]

Effective and sustainable chronic disease care is dependent on well-organized quality improvement (QI) strategies to monitor processes of care and outcomes and inform optimal care delivery.[1] In the CKD domain, end-stage renal disease (ESRD) care has been the sole focus of national QI activities, often administered in conjunction with national/regional registries (e.g., Canadian Organ Replacement Register, United States Renal Data System, European Renal Registry).[1,5] While there is no surveillance system for non-dialysis-dependent CKD in most countries, including Canada,[5,13] a few have developed initiatives in this direction[14].[1,5,13,15] A national CKD surveillance system using routinely collected practice data is feasible in nations with well-developed healthcare systems as CKD lends itself particularly well to surveillance because of its laboratory-based diagnosis[16]. Although healthcare is provincially/territorially structured and administered in Canada, there are existing national networks and collaborations such as the Canadian Primary Care Sentinel Surveillance Network (CPCSSN)[17] that can be important facilitators for national QI-based studies.

We set out to improve the understanding of how patients with CKD are managed and the variation across practitioners, regions, and provinces to drive improvements in care delivery. Our study is a multidisciplinary (nephrology, primary care) and cross-jurisdictional effort leveraging data from the CPCSSN to investigate the epidemiology and management of CKD in the Canadian primary care system. The overarching aim is to use data derived from primary care electronic medical records (EMRs) to identify gaps in care, and provide opportunities for interventions to improve care and patient outcomes.

Objectives:

1. Develop and validate a case definition for CKD in primary care and apply this to ascertain the burden of CKD in primary care, obtaining data on unidentified cases using standard criteria.[18,19]

2. Determine the current practice patterns on CKD risk identification in primary care by ascertaining whether high-risk groups (e.g., individuals with diabetes, hypertension, and urologic disorders, and those with chronic use of nephrotoxic medications) are appropriately screened and managed for CKD.

3. Determine whether people with CKD are being managed based on established quality indicators, and investigate the care variation across patients' demographics (age, sex, socio-economic status, rural/urban residence, comorbidity burden), provider characteristics (family physician/nurse practitioner, year of graduation, rural/urban, individual/group, fee for service) and regional characteristics (intra- and inter-provincial/territorial variation, rural versus urban).

METHODS AND ANALYSIS

Setting

The CPCSSN[17,20,21] is the first pan-Canadian multi-disease surveillance system. The data resources profile and context within the Canadian health system are detailed elsewhere.[22] Canada is considered a high-income country by the World Bank Classification Index with a population of 35,362,905 (2016). It is the second largest country in the world with a land area of 9,984,670 sq km. It has a GDP of $1.634 trillion (2016), and about 10.1% of this is spent on healthcare. In Canada, health care is a provincial or territorial mandate under the oversight of the Canada Health Act and with a financial assistance from the federal government ensuring universal, publicly funded health services to the population for medically-necessary care including physician visits, hospitalizations and, in some provinces universal drug coverage. Primary care is the first portal for accessing care particularly for routine chronic disease care.

The structure of CPCSSN comprised of a network of twelve practice-based primary care research networks that collect primary care health information from the EMRs of primary care providers (PCPs) in eight out of the ten provinces and one out of the three territories in the country **(Figure 1)**. There are ~1200 sentinels (i.e., participating PCPs) contributing data to the CPCSSN, which is updated quarterly. This actively expanding repository currently contains data on approximately 1.5 million Canadians. The initial focus of the CPCSSN was to conduct surveillance on five chronic conditions: diabetes, hypertension, osteoarthritis, chronic obstructive pulmonary disease, and depression. Subsequently, it was expanded to included three neurological conditions: dementia, epilepsy, and Parkinson's disease. Our project team has been instrumental in working with CPCSSN to further expand on these conditions by including CKD, and this work on CKD will be conducted from January 2017 to December 2018. It will take place under the auspices of the Alberta's Strategy for Patient Oriented Research (SPOR)- Primary and Integrated Health Care Innovation Network (PIHCIN).

Population and data sources

Data for the CPCSSN database are extracted from the EMRs of participating sentinels, rendered anonymous, coded and processed using established frameworks described in detail elsewhere.[21,23] The data are placed in regional network databases and then merged into the national repository. It is made available for surveillance and research, and increasingly for quality improvement projects and for clinical decision support where available, through the implementation of a patient re-identification tool held only within the custodial clinics themselves. With appropriate data sharing agreements with its sentinel PCPs, CPCSSN data may

be linked with administrative health data for future work to follow up on CKD-related outcomes (e.g., ascertainment of progression to dialysis requirement using registry data).

The CPCSSN database will be used to develop a cohort of CKD patients being managed in primary care between January 1, 2010 and December 31, 2015 (baseline cohort), and from January 1, 2016 onwards (open cohort). The database is updated quarterly, allowing for identification of new CKD patients who meet the inclusion criteria during the study period. The CPCSSN database contains patient information on socio-demographics (age, sex, socio-economic status (calculated deprivation category)), treatment (medications data), laboratory results and comorbidities **(Table 1, Figure 2)**.[21,24] Patients under 18 years of age will be excluded from the cohorts, as will those diagnosed with ESRD and on dialysis or having renal transplant. We will leverage validated algorithms, case definitions and guidelines to define CKD, at-risk population and processes of care measures based on established methods and criteria **(Table 2)**.[25,26,27]

Identification of CKD

The major focus is to validate a case definition for CKD in primary care using the CPCSSN repository to enable us to identify patients with CKD. We will leverage the existing frameworks and conventions by national and international CKD guidelines, and definitions used elsewhere.[26,28] Serum creatinine (Scr) measurements will be used to calculate estimated glomerular filtration rate (eGFR) using CKD-EPI equation.[29] Individuals with at least one face-to-face PCP encounter and two calculated eGFR values <60 ml/min per 1.73 m^2 >90 days apart or having an International Classification of Diseases (ICD-9) diagnosis code for CKD used at least twice in an outpatient encounter as of December 31, 2015, will be defined to have CKD. We recognize the significant limitations of the ICD-9 codes when applied for CKD identification in the community, however, its use will allow us to capture those patients with CKD who may or may not have had an abnormal eGFR, for example cystic kidney diseases and other rare congenital disorders. In a secondary analysis, CKD will be defined by eGFR<45 ml/min/1.73m^2 using two values of eGFR >90 days apart. This definition was selected because although GFR<60 ml/min/1.73m^2 constitutes CKD, individuals with GFR between 45 and 60 ml/min/1.73m^2 usually have favorable prognosis in the absence of proteinuria, and are substantially fewer in number than those with GFR<45/min/1.73m^2. Patients with eGFR<45 ml/min/1.73m^2 are also a more attractive population for intervention due to higher risk of adverse clinical outcomes including risk of progression to ESRD[2,14]. Validation of the primary care CKD case definition algorithm will consist of an expert blinded chart review and identification of cases in a random sample of 1000 CPCSSN charts, containing both original and cleaned text data from the EMRs for patients aged 18 years or older, and comparison with the outcome of an independent search of the same sample using the CPCSSN case finding algorithm. Analysis will consist of calculations of sensitivity, specificity, and positive and negative predicted values. The prevalence of CKD stages 3-5 will be presented as unadjusted prevalence estimates and weighted averages for population rates with 95% confidence intervals (CI) using the census data, and stratified by PCP, rural/urban location and province or territory.

Evaluation of processes of care

The process-based outcomes (quality of care metrics) will be defined and evaluated using established methods across key domains of risk identification and case finding for CKD, as well as delivery of appropriate management including monitoring of risk factors for progression and cardiovascular disease (CVD), and referral for specialist nephrology care where necessary (Table 2). We are specifically focusing on the key domains of CKD management in primary care that include:

- CKD risk identification. This entails the evaluation of the proportion of patients with risk factors (diabetes and/or hypertension) present for at least one year that are tested for CKD within the previous 12 months of follow up.
- Identification of CKD. This is to determine the proportion of patients with CKD (defined based on laboratory measures), and/or correctly coded as having CKD in the EMR using defined clinical parameters.
- Management of CKD: This examines the current state of practice on the management of the common risk factors (BP, glycemia, proteinuria, dyslipidemia) associated with CKD progression and/or risk of CKD. For example, ascertaining the proportion of patients achieving guideline-concordant treatment targets (BP, proteinuria, HbA1c).
- Appropriate referral. This is to capture the proportion of patients appropriately referred for specialist kidney care (defined by any visit to nephrologist or multi-disciplinary CKD clinic within the last 12 months) based on guideline-concordant criteria for referral.

Data analysis

Covariates definition and evaluation of CKD markers

Socio-demographic, clinical, laboratory and medication data will be classified using standard definitions established by the CPCSSN.[17,24,30-34] Other comorbid conditions relevant to the care of CKD patients but not defined by the CPCSSN (coronary artery disease, stroke, peripheral vascular disease, heart failure) will be identified using standard procedures to search for those diagnoses in patients' medical records (based on validated ICD-9-CM coding algorithms[35]). Baseline kidney function (using estimated glomerular filtration rate, eGFR) will be calculated using all serum creatinine measurements taken within a six-month period of the first creatinine measurement, with the index eGFR defined as the mean of the six-month measurements. Assessment of urine protein excretion will be estimated using the albumin: creatinine ratio (ACR) based on spot urine measurements using standard conventions.[25] All CKD cases will be risk-stratified, defined and classified according to current guideline recommendations.[25] Demographic information (including age, sex and postal code) of those with and at risk of CKD will be extracted **(Tables 1 & 2)**. Normally distributed variables will be summarized as means with standard deviations (SD), and non-normally distributed data will be summarized as medians with interquartile ranges (IQR). Dichotomous data will be expressed in percentages. The representativeness of the study population will be tested by comparing their age and sex profiles to the population distribution as reported in the Canadian 2011 Census (adjusting for 2016 census data when available).

ETHICS AND DISSEMINATION

The CPCSSN is committed to high ethical standards when handling individual patient data collected from EMRs of participating PCPs from across Canada. These data are aggregated and stored in CPCSSN's central repository at the Centre for Advanced Computing, Queens University in Kingston, Ontario. There are well-developed organizational, physical and technological safeguards at all levels (clinic, provincial, national) to ensure that the privacy of patients is protected and that all collection, retention, use or disclosure of data complies with applicable privacy legislation and ethical requirements.[17,21] All personal identifiers are removed from the data in the national research repository to protect patient confidentiality.[21] The protocol has undergone a scientific review and approval by the CPCSSN Surveillance and Research Standing Committee (SRSC), and ethical approval for the study was granted by the University of Alberta Health Research Ethics Committee.

This project uses an integrated knowledge translation (KT) strategy, where relevant stakeholders (patients, practitioners, policymakers) have been involved from inception (proposal development) to ensure that the project addresses the needs of patients and practitioners. The activities underpinning the Alberta SPOR PIHCIN center on the patients and are patient-oriented, where the voices and perspectives of patients are solicited from research inception (e.g. defining research questions) to completion. The patients are collaborators rather than research subjects, and we have a patient representative on the project team to ensure patients voices and perspectives guide the work to completion, and that it remains patient-centered.

The involvement of the knowledge end-users (practitioners and policymakers) and the high priority that they place on the project will ensure that we drive it forward to completion and provide an opportunity to meaningfully change the way that care is delivered to CKD patients managed in primary care. For example, after identifying regions/clusters with especially suboptimal CKD care, we will collaborate with providers, policymakers and regional health authorities to improve care in those regions. We will apply the KT Canada Knowledge-to-Action Cycle Framework and other established methods (e.g., PDSA (Plan, Do, Study, Act) concept) to disseminate our findings to all relevant stakeholders and end-users for action.[36,37] We will leverage our collaborations with existing platforms and research networks such as the Canadian Society of Nephrology, CANN-NET (CAnadian KidNey KNowledge TraNslation and GEneration NeTwork), Can-SOLVE CKD (Canadians Seeking Solutions and Innovations to Overcome Chronic Kidney Disease) and the country-wide Primary and Integrated Healthcare Innovation Networks to ensure the translation of our findings across provinces and territories, as well as internationally through our associations with the International Society of Nephrology and the Kidney Disease Improving Global Outcomes (KDIGO) team.[5,38] The results will be published in general medicine, nephrology and primary care peer-reviewed journals and presented at relevant national and international scientific meetings. A performance report will be produced against the indicators relevant to each objective, aggregated by practice sentinel, to highlight practice performance and map out areas for improvement, critical for continuing professional development of PCPs and helping to enhance CKD management in primary care. In future, this database with be linked to the Canadian Organ Replacement Registry and relevant provincial administrative databases to study clinically-relevant outcomes of risk and progression to[i] kidney failure (ESRD) and adverse cardiovascular outcomes[39,40] (**Figure 3**).

This work will close the information gap between observed and expected burdens and risks of CKD and map out standards of care achieved, providing opportunities for focused and effective population-level QI strategies and other service improvement initiatives. This project will demonstrate proof of concept for an early identification and management of CKD program in primary care, and provide the basis for developing relevant policies and KT strategies to enhance the uptake of findings – for people with CKD, and other chronic diseases as well. The work will facilitate identification and appropriate management of CKD patients at high risk of progression to ESRD. The findings will be reported based on existing reporting frameworks.[41]

We have anticipated potential threats and have devised strategies to mitigate them. The first related to feasibility within the defined timeframe **(Figure 3)**. This is unlikely to hinder the success of the project as we have completed significant preliminary work for data access, and the team has considerable experience with the use of this kind of data for policy-relevant research.[5,19,36,42,43] Second, limitations general to the use of EMR data in research are acknowledged. The collated information is based on clinical encounters and needs, and thus may be missing for some important key variables and data quality may vary by region and/or sentinel; specifically, data on patients' priorities and satisfaction of care are rarely collated in a clinical setting. However, most important demographic, clinical and laboratory information needed for this study are well captured in the existing platform chosen for this work. Third, lack of use of patient-reported outcomes measures such as satisfaction with care, self-management support, etc could not be included as these were not routinely collated in this database.

In summary, planning, development, and implementation of nephrology services require reliable information systems and databases to capture information on trends in disease burden, processes of care and related outcomes. In the absence of national/regional health information systems, one way to achieve this is by the creation of surveillance systems using routine practice data, such as the CPCSSN and those established specifically for CKD in other jurisdictions across the world [44-48] **(Table 3)**. The established conventions and guidelines on CKD can be leveraged for systematic case definition and evaluation of quality of care across settings. This can be facilitated by validation as well as enactment of quality metrics to measure the processes, quality of care and related outcomes, and generate uniformity across databases which may permit analyses across countries and regions. It is important to detect CKD early enough to be able to implement effective interventions. On-going primary care management of key risk factors for CKD (e.g., hypertension, vascular disease, diabetes) is likely one effective strategy to reduce progression of CKD and reduce adverse complication rates. Early detection and treatment of CKD and reducing adverse events with appropriate medications also reduces the morbidity and cost of CKD and related complications. The work described in this protocol therefore has a huge potential to address the identified gaps for optimal care delivery of CKD at the primary care level that would impact positively on patients' outcomes and health system improvement.

Contributors: AKB and ND had the original idea for this study. AKB and PER wrote the first draft of the manuscript. PER, NT, AS, AG, DN, JAQ, CL, BS, EF, DT and DM contributed to the development of the idea, the study design and reviewed the manuscript for intellectual content. All authors approved the final submitted version of the manuscript.

Funding: This work is supported by the Canadian Institute of Health Research (CIHR) Operating Grant: SPOR PIHCI Network: Quick Strikes Grant (ref# RN281786), through the Universities of Alberta and Manitoba, and McMaster University.

Competing interests: None declared.

Ethics approval: This project has been approved by the University of Alberta Health Research Ethics Committee. Identifiable patient data will not be shared during the project, thus maintaining confidentiality.

Disclaimer: The views expressed are those of the authors and not necessarily those of the CIHR, CPCSSN or the various institutions represented.

Data sharing statement: The authors will make available the full statistical analysis of the study results following publication if and when required. The results of the study will be submitted for publication in a leading medical/nephrology peer-reviewed journal.

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Table 1: Data variables

Domain	Variables
Patient Demographics and Clinical Data	• Patient ID (unique patient number generated by CPCSSN) • Sex • Month & Year of Birth • Occupation • Highest Education • Housing Status • Postal Code • EMR Status – Active, Deceased, Duplicate, Inactive, Unknown • Language • Race/Ethnicity • Deceased Year • Date Created (date this record was created) • Time Since Last Visit – 6, 12, 24 or 36 months • CPCSSN Conditions – yes / no for diabetes, depression, osteoarthritis, COPD, hypertension, dementia, Parkinson's, epilepsy • CPCSSN Conditions – count (i.e., numeric value) • Disease Case Indicator – disease (diabetes, depression, osteoarthritis, COPD, hypertension, dementia, Parkinson's, epilepsy) • Disease Case Indicator – Indicator Type (billing, encounter diagnosis, health conditions, lab result [HbA1C, fasting glucose], medication) • Disease Case Indicator – Indicator Value (numeric value of HbA1C and/or fasting glucose)
Patient-Provider Pairing	• Patient ID (unique patient number generated by CPCSSN) • Provider ID (unique provider number generated by CPCSSN; primary provider of patient) • Start Date • End Date
Provider Information	• Provider ID (unique provider number generated by CPCSSN) • Sex • Birth Year
Billing Data	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Service Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9, ICD10) • Diagnosis Code (i.e., 401)
Clinical Encounters	• Patient ID (unique patient number generated by CPCSSN) • Provider ID (unique provider number of the attending provider generated by CPCSSN) • Encounter Date • Encounter Type – academic clinic, community clinic • Reason for visit – cleaned • Reason for visit – original
Encounter Diagnoses	• Patient ID (unique patient number generated by CPCSSN) • Created Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9) • Diagnosis Code (i.e., 401)
Physical Examination Data	• Patient ID (unique patient number generated by CPCSSN) • Exam Name – systolic BP, diastolic BP, height, weight, BMI, waist circumference, waist hip ratio (all values) • Result – cleaned numeric value • Result – original numeric value • Unit of Measure • Most Recent Value – yes, no

Health Condition	• Patient ID (unique patient number generated by CPCSSN) • Created Date • Onset Date • Diagnosis Text – cleaned • Diagnosis Text – original • Diagnosis Code Type (i.e., ICD9) • Diagnosis Code (i.e., 401)
Laboratory Data	• Patient ID (unique patient number generated by CPCSSN) • Date Performed • Lab Name – cleaned text (fasting glucose, glucose tolerance, HbA1C, HDL, LDL, total cholesterol, triglycerides, microalbumin, urine albumin creatinine ratio, hemoglobin, creatinine, eGFR / GFR) • Lab Name – original text • Lab Result – numeric value • Unit of Measure • Most Recent Value – yes, no
Medical/Surgical Procedure	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Date Performed • Procedure Name – cleaned text • Procedure Name – original text
Medication Records	• Patient ID (unique patient number generated by CPCSSN) • Start Date • Stop Date • Medication Name – cleaned text • Medication Name – original text • Medication Code – ATC code *(Anatomical Therapeutic Chemical classification system)* • Time Since (initial prescription) • DIN (Drug Identification Number) • Strength • Dose • Frequency • Unit of Measure
Referral Data	• Patient ID (unique patient number generated by CPCSSN) • Date Created • Date Completed • Referral Name – cleaned text • Referral Name – original text
Risk Factor data	• Patient ID (the unique patient number generated by CPCSSN) • Date Created • Start Date • Stop Date • Most Recent – yes, no • Risk Factor Name – cleaned text (smoking, alcohol, diet, exercise, obesity) • Risk Factor Name – original text • Status – cleaned (current, never, n/a, not current, past, unknown) • Status – original • Value – cleaned • Frequency • Duration • End

Abbreviations: BMI, body mass index; BP, blood pressure; COPD, chronic obstructive pulmonary disease; CPCSSN, Canadian Primary Care Sentinel Surveillance Network; eGFR, estimated glomerular filtration rate; EMR, electronic medical records; HbA1C, glycated hemoglobin concentration; HDL, high density lipoprotein; LDL, low density lipoprotein

Table 2: Elements of high quality CKD care as defined by standard national and international CKD Guidelines[25,44-48]

Domain	Objective	Measures
Identification of CKD risk factors	To establish an organized system for identification of people with risk factors, and evaluated for the presence of CKD markers	Percentage of patients with risk factors* (present for at least 1 year) tested for CKD within the last 12 months
Identification of CKD	To establish an organized system where people with CKD are appropriately identified	Proportion of patients with CKD correctly diagnosed and appropriately coded (validated based on KDIGO definition standard of using Scr measurements to derive eGFR<60mls/min based on 2 measures at least 90 days apart based on CKD-EPI equation.
Management of CKD: Monitoring of risk factors for progression and CVD	To establish an organized system to ensure CKD patients are receiving guideline-concordant care appropriate for the stage of CKD. This implies that those with early stages are being monitored appropriately in primary care.	Proportion of patients receiving appropriate testing and monitoring: - Percentage of patients with urinary albumin tested within 6 months of Index GFR<60 ml/min/1.73m^2 - Percentage of patients with Index GFR<60ml/min/1.73m^2 and diabetes mellitus who have glycated hemoglobin tested at least annually - Frequency of eGFR and albuminuria testing in patients with a baseline of eGFR<60mls/min and/or ACR of 70mmg/mmol (<1 year, 1-2 years, >2 years) Proportion of patients receiving appropriate cardiovascular risk management: - Percentage of patients >50 years of age and eGFR<45mls/min and/or CVD history on a statin medication - Percentage of patients with diabetes and proteinuria on an ACEi or ARB - Percentage of patients with history of CVD on appropriate secondary prevention (Aspirin, beta-locker, ACEi, statin) Proportion of patients achieving treatment targets (BP, proteinuria, HbA1c). - Percentage of patients with diabetes and/or proteinuria (ACR>70mg/mmol) achieving a target BP of ≤130/80mmHg - Percentage of patients with eGFR<60mls/min achieving a target BP of ≤140/90mmHg - Percentage of patients with proteinuria (ACR>70mg/mmol) achieving a target reduction to 50% of baseline - Percentage of patients with diabetes achieving a target HbA1c ~7%
Appropriate referral system	To develop a system where CKD patients that need specialist input to care are appropriately identified and referred.	Proportion of patients appropriately referred for specialist care (defined by any visit to nephrologist or multi-disciplinary CKD clinic within the last 12 months, for those patients that meet the KDIGO referral criteria**)

* Diabetes, hypertension, cardiovascular disease, nephrotoxic meds (NSAIDS, calcineurin inhibitors, lithium), certain urological disease (e.g., kidney stones, prostatic hypertrophy), multi-system diseases (e.g., lupus) and family history of kidney disease.

** This would include advanced stages of CKD (eGFR<30 ml/min/1.73m^2), significant albuminuria (albumin: creatinine ratio ≥70 mg/mmol), rapid loss of eGFR (>15 ml/min/1.73m^2)refractory hypertension and history of acute kidney injury.
Abbreviations: ACR, albumin: creatinine ratio; ACEi, angiotensin converting enzyme inhibitor; ARB, angiotensin-receptor blocker; BP, blood pressure; CKD, chronic kidney disease; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; HbA1c, glycated hemoglobin concentration; KDIGO, Kidney Disease Improving Global Outcomes. Scr=serum creatinine.

Table 3: Examples of Existing CKD Surveillance Programs

Program	Year of inception	Approach/methodology	Data sources	Spread	Funding
US CDC*	2006	Passive surveillance approach leveraging existing data sources	Administrative Surveys (NHANES)	National	Governmental support
England QoF	2006	An incentive-based (pay-for-performance system) that required all PCPs to establish a register for adults with CKD stages 3–5, and achieve guideline-concordant treatment targets.	Routine primary care records	National	Governmental support
CKD-JAC	2008	Routine care data across select CKD Clinics across Japan	Practice data	National	Japanese Society of Nephrology & Industry
CKD Queensland Registry	2009	Routine clinical care data	Practice data	Regional (state of Queensland)	Research organizations and industry
CPCSSN-CKD*	2017	Passive surveillance using routine practice database	Routine primary care databases	National (multiple regions and territories)	Research organizations and government (PHAC, CIHR)

Abbreviations: CKD-JAC=Chronic kidney disease Japan Cohort, CKD=chronic kidney disease, CPCSSN =Canadian Primary Care Sentinel Surveillance Network, QoF=Quality and Outcomes Framework, US CDC =The United States Centers for Disease Control and Prevention CKD Surveillance System. *Main database development started in 2005.

Figure legends

Figure 1: Map of Canada showing CPCSSN Networks Distribution

Figure 2: The project concept

Figure 3: Project timeline/milestones

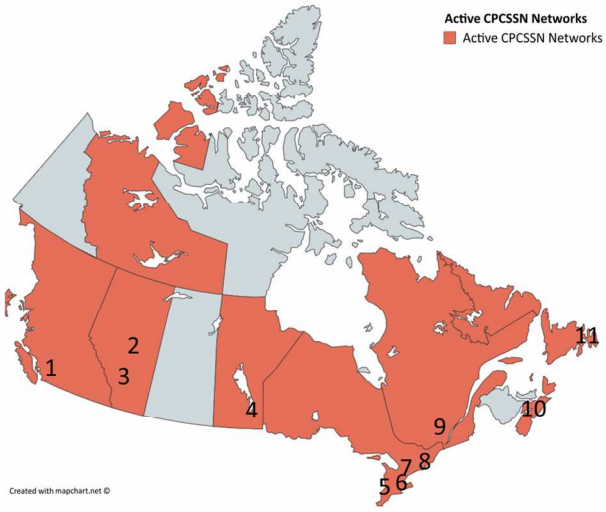

Figure legend: Map of Canada showing the distribution of primary care research networks contributing data to the CPCSSN:

1. British Columbia Primary Care Research Network (BCPCReN)
2. Northern Alberta Primary Care Research Network (NAPCReN)
3. Southern Alberta Primary Care Research Network (SAPCReN)
4. Manitoba Primary Care Research Network (MaPCReN)
5. DELPHI (Deliver Primary Healthcare Information) Project
6. McMaster University Sentinel and Information Collaboration (MUSIC)
7. University of Toronto Practice Based Research Network (UTOPIAN)
8. The Eastern Ontario Network (EON)
9. Réseau de recherche en soins primaires de l'Université de Montréal (RRSPUM)
10. Maritime Family Practice Research Network (MaRNet-FP)
11. Atlantic Practice Based Research Network (APBRN)

Figure 1: Map of Canada showing CPCSSN Networks Distribution

130x97mm (300 x 300 DPI)

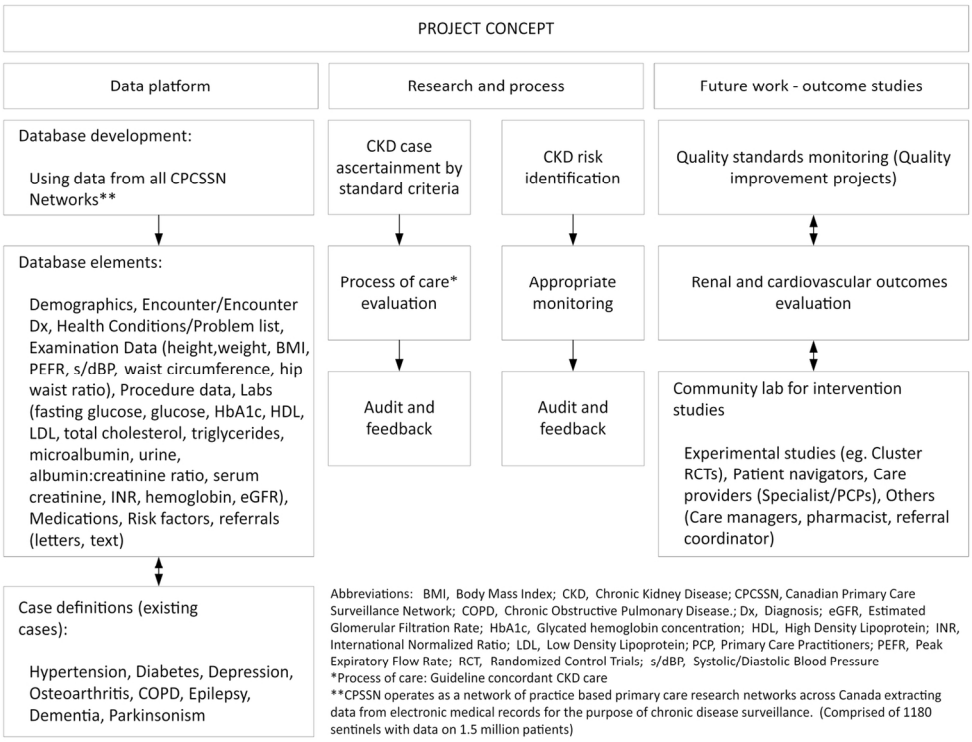

Figure 2: The project concept

132x101mm (300 x 300 DPI)

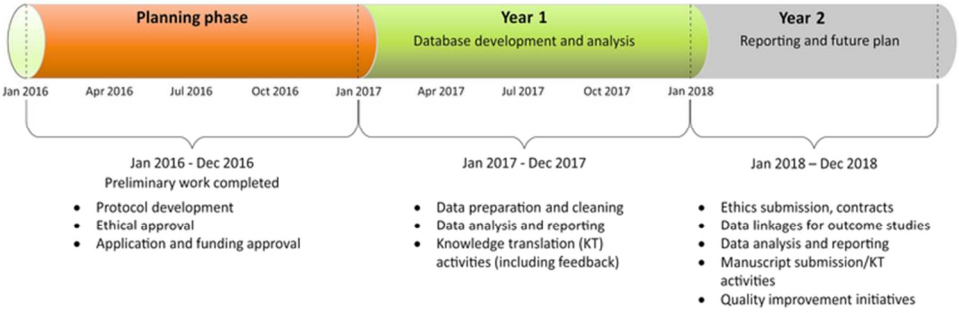

Figure 3: Project timeline/milestones

67x26mm (300 x 300 DPI)