Kidney Disease and Care among First Nations People with Diabetes in Ontario, Canada: A Population-Based Cohort Study

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ABSTRACT

Background: End-stage kidney disease is a serious complication of diabetes. We described the prevalence of chronic kidney disease, prevalence and incidence of end-stage kidney disease, and the quality of early-stage kidney care for First Nations people with diabetes compared to other Ontarians.

Methods: We conducted a retrospective cohort study in Ontario, Canada using linked administrative data at ICES. We included adults with incident diabetes between 1994 and 2014, and used laboratory values to identify kidney disease and consensus-based quality indicators for early-stage care. We compared outcome measures in First Nations people to other people in Ontario, and used direct standardization for age and sex. We used Cox proportional hazards regression to compare the incidence of end-stage kidney disease between groups.

Results: Our study included 21,968 First Nations people with diabetes. The age and sex-standardized prevalence of chronic kidney disease was higher for First Nations people compared to others (22.5% vs. 18.9%), as was the prevalence of end-stage kidney disease (2.9% vs. 1.0%). The incidence of end-stage kidney disease was higher for First Nations people compared to others (9.3 vs. 4.7 events per 10,000 person-years; age and sex-adjusted hazard ratio 2.23, 95% confidence interval 1.72 - 2.89). Both groups were similarly likely to receive recommended medications to treat kidney disease, but were less likely to receive laboratory tests to confirm and monitor kidney disease.

Interpretation: Despite receiving similar quality of early-stage kidney care, First Nations people with diabetes had higher rates of end-stage kidney disease compared to other Ontarians.

INTRODUCTION

Diabetes is at least 3 times more common in First Nations people compared to other Canadians.(1) A serious complication of diabetes is end-stage kidney disease, which has a worse outcome than many advanced cancers and is fatal without life-sustaining treatments such as dialysis or kidney transplantation.(2) In 2017, around 39,000 Canadians were living with end-stage kidney disease.(3) People living with early-stage chronic kidney disease (over 2.9 million Canadians) are often asymptomatic, with laboratory tests needed for detection.(4) In Ontario primary care, it is a priority to detect kidney disease early and slow the progression to end-stage kidney disease.(5)

First Nations people generally have higher rates and an earlier onset of end-stage kidney disease compared to other Canadians.(6–9) However, the prevalence of kidney disease among First Nations people with diabetes in Ontario is not well known. Furthermore, there is little data on the quality of early-stage kidney care delivered by Ontario primary care providers to First Nations people with diabetes and chronic kidney disease.

The study objectives were to describe the prevalence of chronic kidney disease, the prevalence and incidence of end-stage kidney disease, and the quality of early-stage kidney care for First Nations people with diabetes compared to other people in Ontario.

METHODS

A detailed description of our general approach to diabetes cohort creation and linkage of administrative databases is available in *Slater et al. (2019)*.{{*SlaterCMAJ*}}

Study Design and Research Setting

Ontario, Canada has universal, publically funded healthcare that is managed both provincially (for the majority of Ontarians) and federally (for specific populations, including some First Nations people and communities). We conducted a retrospective population-based cohort study using provincial healthcare administrative data, which is held at ICES – a not-for-profit research institute in Ontario. We followed reporting guidelines for observational studies using routinely-collected healthcare data (Appendix 1).(10)

We used a community-based participatory research approach following principles of ownership, control, access, and possession (OCAP®, a registered trademark of the First Nations Information Governance Centre).(11) We also followed Chapter 9 of the Tri-Council Policy Statement on Ethical Conduct for Research Involving the First Nations, Inuit and Métis Peoples of Canada.(12) Additional details are available elsewhere.(13){{*SlaterCMAJ*}}

In addition to Ontario First Nations data governance processes, our project was reviewed and approved by the Research Ethics Boards at Queens University and Laurentian University.

Data Sources

We used 10 databases at ICES, which were linked using unique encoded identifiers, to ascertain information on First Nations status (Indian Register), hospitalizations and emergency department visits (Canadian Institute for Health Information's Discharge Abstract Database, Same Day Surgery Database, and National Ambulatory Care Reporting System), physician billings (Ontario Health Insurance Plan database), other physician information (ICES Physician database), treatment for end-stage kidney

disease (the Ontario portion of the Canadian Organ Replacement Register), outpatient test results (Ontario Laboratories Information System), outpatient prescriptions (Ontario Drug Benefit database), and vital status and demographic information (Registered Persons Database).

Cohort Assembly

We included all Ontario residents with a diabetes diagnosis prior to March 31, 2014, who were alive as of September 30, 2015. We used this cohort to assess prevalence of chronic kidney disease and end-stage kidney disease.

To assess quality of early-stage kidney care, we created four sub-cohorts for the denominators of interest using laboratory values from April 1, 2011 until September 30, 2014 (allowing one year follow-up to September 30, 2015) (Appendix 2). For each sub-cohort we excluded people with previous end-stage kidney disease (receipt of chronic dialysis or a kidney transplant), as we were interested in assessing early-stage care only.

To identify incidence of end-stage kidney disease, we created a fifth sub-cohort of people with a diabetes diagnosis between April 1, 2002 and December 31, 2014 – to allow at least one year of follow-up to December 31, 2015 – with no evidence of prior end-stage kidney disease.

Measures

To identify prevalence and severity of chronic kidney disease, we used the most recent outpatient serum creatinine and random urine ACR values in the 3 years prior to September 30, 2015. We used the Chronic Kidney Disease Epidemiology (CKD-EPI) equation to calculate eGFR, and since we had no information on race, we assumed all patients in the other Ontario population to be non-black in the equation (less than 5% of the Ontario population is of black race).(14,15) Based on these eGFR and urine ACR values, we used the chronic kidney disease classification from Kidney Disease: Improving Global Outcomes (KDIGO) Clinical Practice Guidelines.(16) We also identified kidney disease based on eGFR staging alone, since urine ACR testing is not done as routinely as serum creatinine testing. We defined chronic kidney disease as an eGFR <60 mL/min/1.73 m^2 or receipt of chronic dialysis.

To measure the prevalence of end-stage kidney disease, we identified people with evidence of chronic dialysis or a kidney transplant until the earliest date in our databases (up to 27 years prior to September 30, 2015). We identified incidence of end-stage kidney disease as initiation of chronic dialysis or kidney transplant, and censored for death or end of follow-up any time after diabetes diagnosis. For patients receiving dialysis, we identified the most recent modality as either in-centre hemodialysis or home dialysis (home hemodialysis / peritoneal dialysis). Among patients receiving in-centre hemodialysis, we measured great-circle distance (the shortest distance between two points on a sphere) in kilometres to their dialysis facility from their home residence.

To assess quality of care, we used consensus-based quality indicators for early-stage chronic kidney disease, including receipt of kidney function tests, prescription medication use (angiotensin converting enzyme (ACE) inhibitors, angiotensin II receptor blockers (ARBs) or avoidance of non-steroidal anti-inflammatory drugs (NSAIDs)), and nephrologist referral.(17,18) Indicator definitions are shown in Appendix 3. We restricted our assessment of prescription medication use to people 65 years and older, a segment of the Ontario population who has provincial drug coverage. Specialist referrals are not captured in our data sources, so we used patient visits with a nephrologist as a proxy.

Analysis

We conducted all analyses using SAS version 9.4 (SAS Institute, Cary, NC) at ICES Western in London, Ontario. All measures were described for First Nations people and other people in Ontario. We used direct standardization based on the other Ontario population to estimate age and sex-standardized prevalence estimates for First Nations people. We calculated proportions for binary and categorical measures, and medians (25th, 75th percentiles) to describe distance to dialysis facilities. We estimated probability of end-stage kidney disease during follow-up using Kaplan-Meier survival curves. We also compared incidence of end-stage kidney disease between First Nations people and other people in Ontario using a Cox proportional hazards regression model, adjusting for age and sex. Two-sided p-values <0.05 were considered statistically significant.

RESULTS

There were 21,968 First Nations people and 1,303,177 other people in Ontario living with diabetes as of September 30, 2015 (Table 1). See Appendix 2 for cohort assembly diagrams.

Prevalence of chronic kidney disease and end-stage kidney disease
Among patients with diabetes and at least one serum creatinine value or receipt of chronic dialysis, the age and sex-standardized prevalence of chronic kidney disease was higher for First Nations people (22.5%) compared to other people in Ontario (18.9%). According to the international scale for risk of adverse kidney disease-related outcomes based on serum creatinine and urine ACR values, the age and sex-standardized proportion for '*very high risk*' was 10.8% for First Nations people and 6.5% for other people in Ontario (Table 2).

Among people with diabetes, the age and sex-standardized prevalence of end-stage kidney disease was 2.9% for First Nations people and 1.0% for other people in Ontario. First Nations people were more likely to be receiving chronic dialysis (1.7%) compared to other people in Ontario (0.5%) (Figure 1).

Among patients with diabetes receiving chronic dialysis, the age and sex-standardized proportion receiving in-centre hemodialysis as opposed to home dialysis was higher in First Nations people (87.1%) compared to the other people in Ontario (80.0%) (Appendix 4). First Nations people receiving in-centre hemodialysis had a further travel distance to receive dialysis than other people in Ontario: median (25th, 75th percentiles) 11 (4, 41) km versus 7 (3, 16) km (Appendix 5).

Incidence of end-stage kidney disease
The incidence of end-stage kidney disease following diabetes onset was higher for First Nations people compared to others (9.3 vs. 4.7 events per 10,000 person-years; age and sex-adjusted hazard ratio 2.23, 95% confidence interval 1.72 - 2.89; Figure 2). The median (25th, 75th percentiles) age of end-stage kidney disease onset was 52 (43, 61) years for First Nations people and 60 (48, 70) years for other people in Ontario.

Quality of early-stage kidney care
See Table 3 for the proportion of people with diabetes meeting quality of early-stage kidney care indicators.

A similar proportion of First Nations people with diabetes and an initial eGFR <60 mL/min/1.73m^2 received a repeat serum creatinine test compared to other people in Ontario (44.4% vs. 46.5%, p=0.3), but a lower proportion received a follow-up ACR test within 6 months (18.1% vs. 23.8%, p=0.001). Among patients with diabetes and chronic kidney disease, a lower proportion in First Nations people

received regular kidney function monitoring than other people in Ontario (73.8% vs. 79.8% for serum creatinine monitoring, p=0.002; and 41.1% vs. 50.0% for ACR monitoring, p=0.0002).

Most patients with diabetes and chronic kidney disease were not prescribed an NSAID for longer than 2 weeks (89.9% for First Nations people vs. 88.0% for other people in Ontario, p=0.09). The majority for both groups (approximately 80%, p=0.09) was also being prescribed either an ACE inhibitor or an ARB, and most were not taking both concurrently. After ACE inhibitor or ARB therapy initiation, serum potassium monitoring within the following 7 to 30 days was completed for 17.4% of First Nations people and 13.2% of other people in Ontario (p=0.4).

Access to nephrology care was similar between First Nations people and other people in Ontario; among all patients meeting criteria for nephrology referral, approximately 20% (p=0.9) and 30% (p=0.3) had a visit with a nephrologist within the following 6 months and 1 year, respectively.

INTERPRETATION

This is the first population-based study in Ontario to identify the prevalence of chronic kidney disease, prevalence and incidence of end-stage kidney disease, as well as quality of early-stage kidney care for people living with diabetes among First Nations people compared to other people.

First Nations people are younger on average than the Canadian and Ontario population.(15,19) {{*SlaterCMAJ*}} Using age and sex-standardization, the prevalence of kidney disease was higher in First Nations people compared to other people in Ontario. First Nations people were also more likely to have end-stage kidney disease with an earlier age of onset. Our findings are consistent with research in Alberta, which showed rates of end-stage kidney disease progression were 2 to 3 times higher for First Nations people.(9) Consistent with findings from Alberta and Saskatchewan, we found that First Nations people were also more likely to receive in-centre hemodialysis (as opposed to home dialysis) compared to other people in Ontario with diabetes.(7,20) In our study, the proportion receiving a kidney transplant was similar between populations, but given the higher prevalence of end-stage kidney disease for First Nations people, this may signify lower kidney transplant access. In Alberta, researchers have noted that First Nations people have similar transplant referral rates to other people in the province, but may experience barriers to completing the transplant evaluation.(20) Another potential barrier for access to end-stage kidney disease therapy in our study was that First Nations patients had a further average distance to travel to receive dialysis, which has also been described in Saskatchewan.(7)

Since First Nations people in Ontario are more likely to live in rural or remote locations, {{*SlaterCMAJ*}} and may need to relocate to larger cities to receive treatment, alternative therapies to in-centre hemodialysis, including home dialysis modalities and kidney transplantation could be utilized more. However, a previous study identified barriers to receiving peritoneal dialysis among First Nations people including anxiety and financial reasons.(21) A large qualitative study among Indigenous people with end-stage kidney disease in Australia found that, although the majority of patients had favourable opinions about kidney transplant, many felt that they were not well-informed about the process.(22)

In regards to quality of early-stage kidney care, patients with diabetes in both populations were generally receiving recommended medications for their kidney disease. This is consistent with other Canadian research showing high use of ACE inhibitors or ARBs and statins for First Nations people with chronic kidney disease.(23,24) Furthermore, both groups were equally likely to visit a nephrologist when indicated; however, nephrologist visits were low for all Ontarians. First Nations people were less likely to

receive urine ACR tests to confirm kidney disease presence, and for regular monitoring among those with chronic kidney disease compared to other people in Ontario. However, as noted in the limitations section below, this may have been partly due to limitations with the data, rather than an actual care gap.

Despite receiving similar quality of early-stage kidney care, First Nations people with diabetes in Ontario were still more likely to have end-stage kidney disease and to initiate treatment at any earlier age compared to other people in Ontario. The higher risk of kidney disease may be due to other factors such as poor quality of diabetes care, food insecurity, physical inactivity, and barriers to diabetes self-management.(25){{*RosellaCMAJ &GreenCMAJ*}} Furthermore, the intergenerational impact of colonization among First Nations people is an important determinant of health.(26)

Limitations

To identify chronic kidney disease prevalence, we only captured people with outpatient laboratory tests between 2013 and 2015 in our data sources. Ontario hospitals started contributing laboratory results to an electronic repository at different times.(27) One concern is that most hospitals in the North West region (where at least 25% of First Nations people in our study resided) did not start contributing until 2015. Therefore, we did not capture outpatient laboratory tests done at most local hospitals in this region. This limitation does not apply to the quality of care indicators, since we used physician billing codes to identify laboratory test completion. However, this method has its own limitations, as outpatient laboratory tests done in some hospitals may be covered under the hospital's global budget and not reimbursed through fee-for-service billing codes. If First Nations people were more likely to receive outpatient laboratory tests at these hospitals compared to other people in Ontario, this could partly explain the lower proportion who received tests to confirm or monitor their kidney function.

Prescription medication information in our data sources was only available for people 65 years and older. Therefore the medication use quality indicators are not generalizable to people younger than 65 years. See *Slater et al. (2019)* for other limitations of the general study design and data sources. {{*SlaterCMAJ*}}

Conclusions

First Nations people with diabetes in Ontario have a higher prevalence of chronic kidney disease and end-stage kidney disease (with an earlier onset) despite receiving similar quality of early-stage kidney care. First Nations people are also less likely to receive home dialysis therapy and more likely to travel further to receive in-centre dialysis treatment. Policy initiatives should focus on community-based support and interventions to minimize the risk and burden of kidney disease in First Nations' communities.

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Publicly Available Data
The dataset from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the dataset publicly available, access can be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

Consent to Participate
ICES is a designated prescribed entity under Section 45 of the Personal Health Information Protection Act (PHIPA). Participant informed consent was not required for this study.

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Tables & Figures

Table 1: Demographic characteristics of First Nations people and other people in Ontario living with diabetes as of September 30, 2015.

Characteristic		First Nations People	Other People in Ontario
		N=21,968	N=1,303,177
Sex, n (%)	Male	10,172 (46.3%)	676,059 (51.9%)
	Female	11,796 (53.7%)	627,118 (48.1%)
Age, n (%), years	0-19	254 (1.2%)	10,141 (0.8%)
	20-34	1414 (6.4%)	38,549 (3.0%)
	35-49	5154 (23.5%)	170,143 (13.1%)
	50-64	8938 (40.7%)	448,351 (34.4%)
	65-74	4133 (18.8%)	333,836 (25.6%)
	75+	2075 (9.5%)	302,157 (23.2%)
Age at diabetes diagnosis, years	Mean (SD)	44.2 (13.8)	52.6 (14.7)
	Median (IQR)	45 (35-53)	53 (44-63)

Abbreviations: IQR, interquartile range; SD, Standard Deviation.

Table 2: Prevalence of chronic kidney disease and KDIGO risk groups among people living with diabetes in Ontario as of September 30, 2015.

	First Nations People		Other People in Ontario
	Crude prevalence n (%)	*Age and sex-standardized prevalence, %*	*Prevalence n (%)*
Chronic kidney disease (based on eGFR <60 mL/min/1.73 m^2 or receipt of chronic dialysis)	**N=15,699** [a]		**N=1,110,900** [a]
	2476 (15.8%)	22.5%	209,933 (18.9%)
Risk of kidney disease-related adverse events (based on KDIGO)(16)	**N=10,746** [b]		**N=768,569** [b]
Low risk [c]	6191 (57.6%)	51.7%	490,934 (63.9%)
Moderately increased risk [d]	2642 (24.6%)	25.3%	163,692 (21.3%)
High risk [e]	1099 (10.2%)	12.0%	64,250 (8.4%)
Very high risk [f]	814 (7.6%)	10.8%	49,693 (6.5%)

[a] Analysis restricted to people with a serum creatinine value or evidence of receiving chronic dialysis.

[b] Analysis restricted to people with both serum creatinine and urine albumin-to-creatinine ratio values.

[c] Low risk defined as: eGFR ≥90 with ACR <3 or eGFR 60 to <90 with ACR <3

[d] Moderately increased risk defined as: eGFR ≥90 with ACR 3 to 30, eGFR 60 to <90 with ACR 3 to 30, or eGFR 45 to <60 with ACR <3

[e] High risk defined as: eGFR ≥90 with ACR >30, eGFR 60 to <90 with ACR >30, eGFR 45 to <60 with ACR 3 to 30, or eGFR 30 to <45 with ACR <3

[f] Very high risk defined as: eGFR 45 to <60 with ACR >30, eGFR 30 to <45 with ACR 3 to 30, eGFR 30 to <45 with ACR >30, eGFR 15 to <30 with ACR <3, eGFR 15 to <30 with ACR 3-30, eGFR 15 to <30 with ACR >30, eGFR <15 with ACR <3, eGFR <15 with ACR 3-30, or eGFR <15 with ACR >30

Note: ACR units are mg/mmol; eGFR units are mL/min/1.73 m^2.

Abbreviations: ACR, albumin-to-creatinine ratio; eGFR, estimated glomerular filtration rate; KDIGO, Kidney Disease: Improving Global Outcomes.

Table 3: Number and proportion of patients meeting quality indicators for early-stage chronic kidney disease among people living with diabetes as of September 30, 2015.

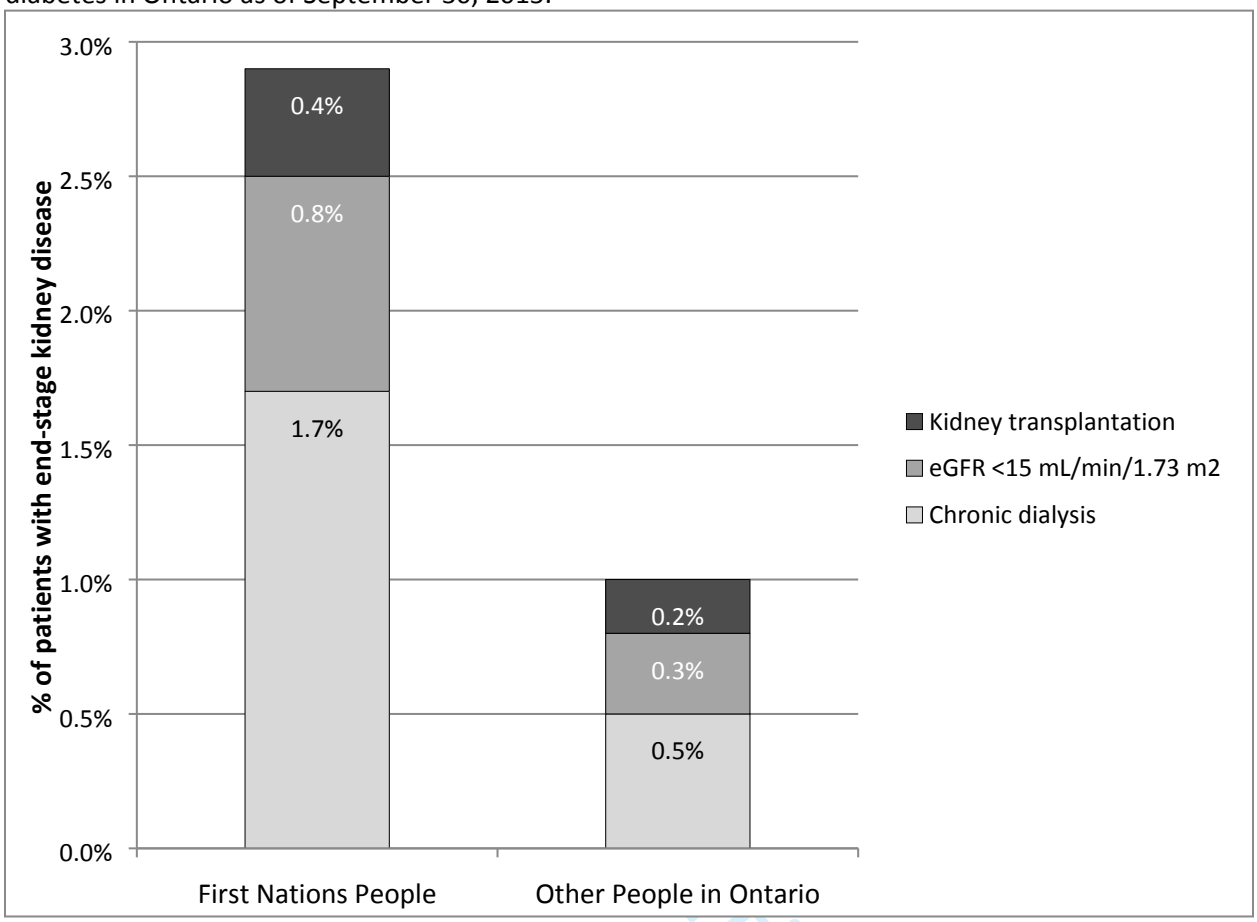
	First Nations People n/N (%)	Other People in Ontario n/N (%)	p-value
Among patients with diabetes and an initial eGFR <60 mL/min/1.73 m²:			
Repeat outpatient serum creatinine test within 6 months	246/554 (44.4%)	23,371/50,249 (46.5%)	0.3
Outpatient ACR test within 6 months	100/554 (18.1%)	11,956/50,249 (23.8%)	0.001
Among patients with diabetes and an initial ACR >3 mg/mmol:			
Repeat outpatient ACR test within 6 months	312/2018 (15.5%)	22,875/95,765 (23.9%)	<0.0001
Among patients with diabetes and chronic kidney disease:			
Outpatient serum creatinine test in following 18 months	327/443 (73.8%)	42,740/53,559 (79.8%)	0.002
Outpatient ACR test in following 18 months	182/443 (41.1%)	26,797/53,559 (50.0%)	0.0002
Not prescribed an NSAID for longer than two weeks in the following 12 months[a]	772/859 (89.9%)	111,720/127,008 (88.0%)	0.09
Not prescribed an ACE inhibitor and ARB simultaneously in the following 12 months[a]	840/859 (97.8%)	125,536/127,008 (98.8%)	0.009
ACE inhibitor or ARB prescription in the following 12 months[a]	686/859 (79.9%)	101,032/127,008 (79.5%)	0.9
Statin prescription in the following 12 months[b]	502/652 (77.0%)	61,667/77,741 (79.3%)	0.2
Serum potassium test 7-30 days after initial ACE inhibitor / ARB prescription[a]	8/46 (17.4%)	1,134/8584 (13.2%)	0.4
Serum creatinine test 7-30 days after initial ACE inhibitor / ARB prescription[a]	8/46 (17.4%)	1,298/8584 (15.1%)	0.7
Among patients with diabetes initially meeting criteria for referral to a nephrologist:			
Visit to a nephrologist within 180 days following referral eligibility date	136/672 (20.2%)	5687/27,611 (20.6%)	0.9
Visit to a nephrologist within 365 days following referral eligibility date	170/545 (31.2%)	6725/23,210 (29.0%)	0.3

Note: Number of people in the denominators / sub-cohorts for each indicator varied based on the amount of look-forward period needed to assess the indicator. For example, indicators requiring 18 months of follow-up time

included eligible patients with laboratory values to define the sub-cohorts on or prior to March 30, 2014 with follow-up to September 30, 2015; where indicators that required only one year follow-up included eligible patients with laboratory values to define the sub-cohorts on or prior to September 30, 2014 with follow-up to September 30, 2015.

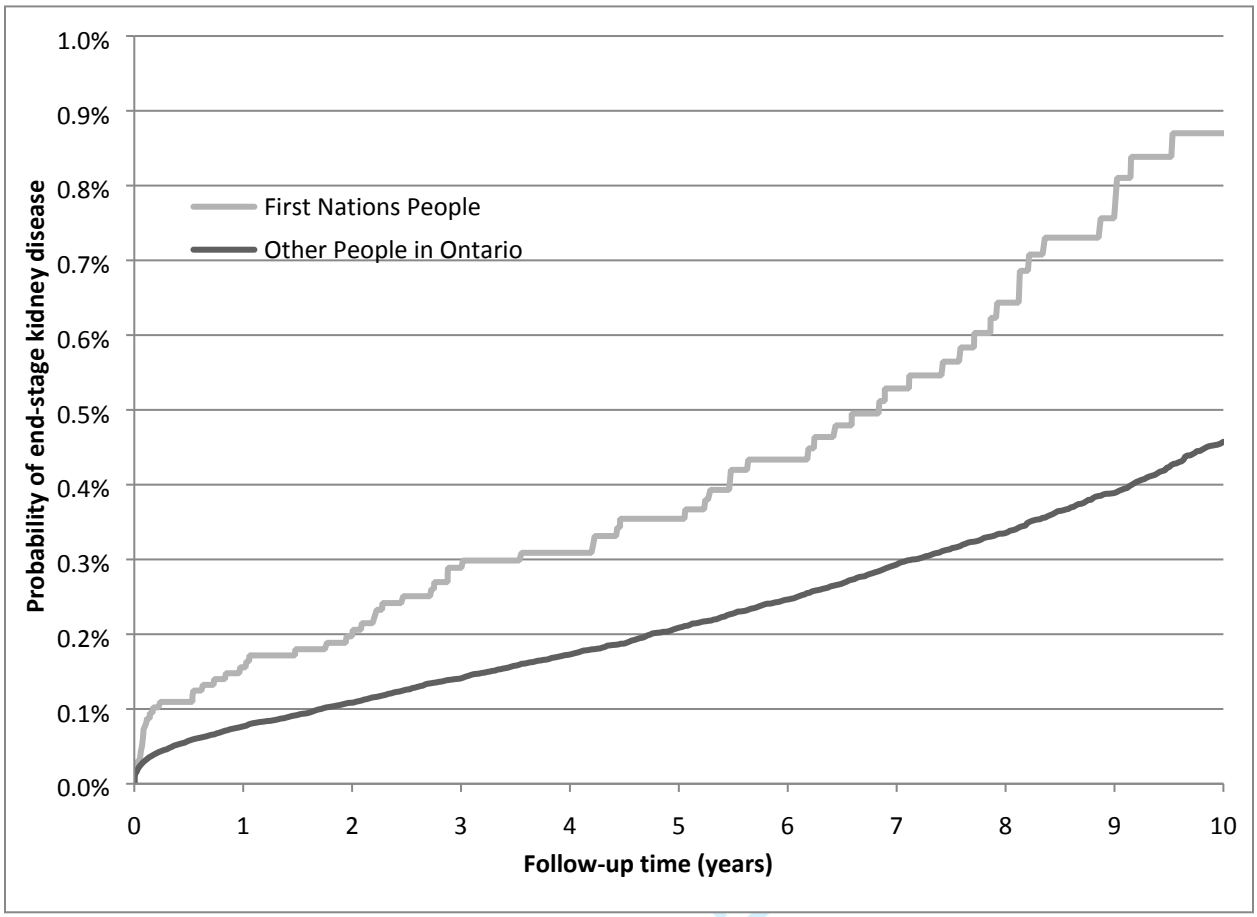
[a] Only among people 65 years of age or older
[b] Only among people between 65 and 80 years of age
Abbreviations: ACR, albumin-to-creatinine ratio; ACE, angiotensin converting enzyme; ARB, angiotensin II receptor blocker; eGFR, estimated glomerular filtration rate; NSAID, nonsteroidal anti-inflammatory drugs.

Figure 1: Age- and sex-standardized prevalence of end-stage kidney disease among people living with diabetes in Ontario as of September 30, 2015.



Abbreviations: eGFR, estimated glomerular filtration rate.

Figure 2: Probability of end-stage kidney disease following the diagnosis of diabetes among people diagnosed between April 1, 2002 and March 31, 2014.



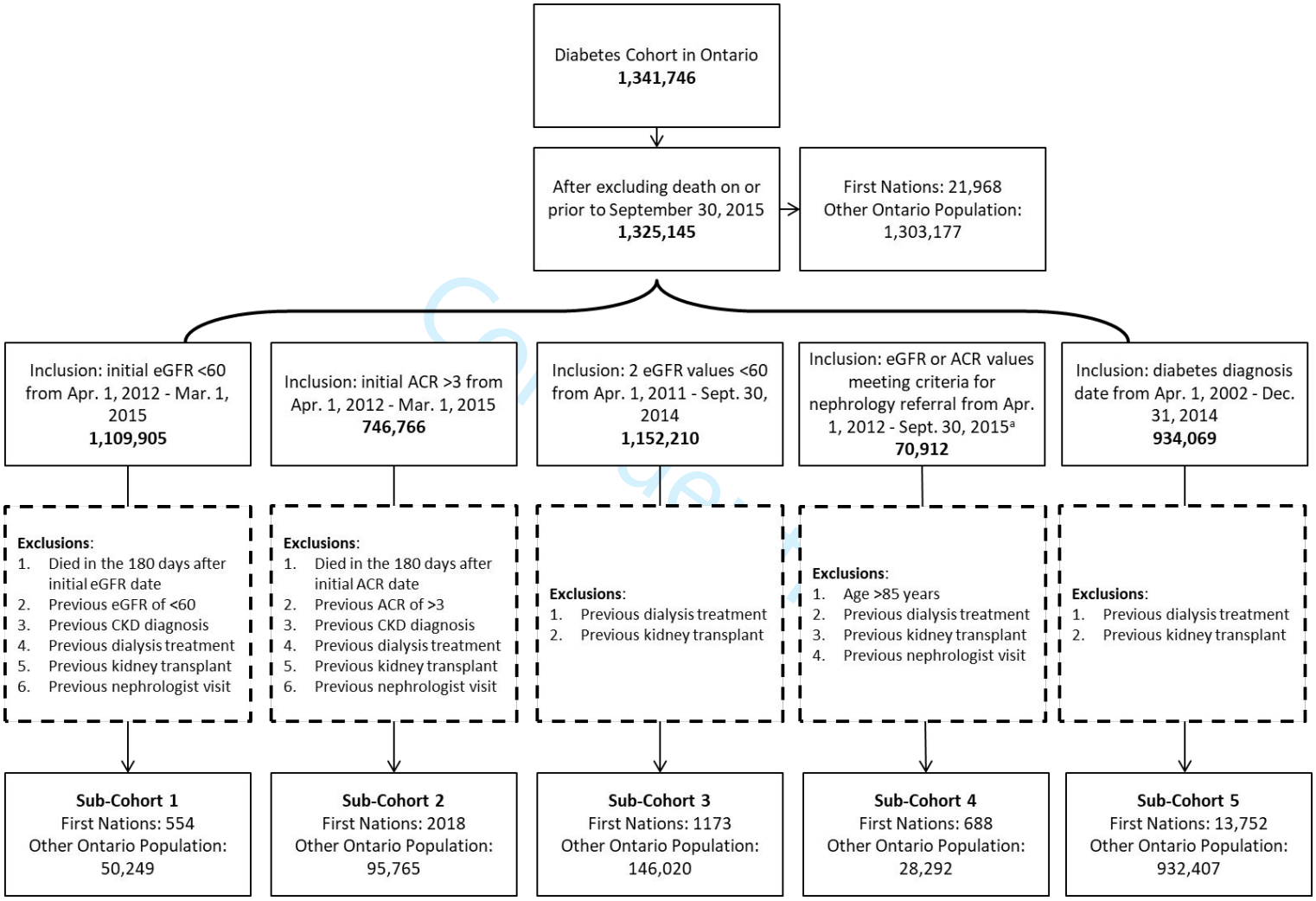
Appendix 1: Checklist of recommendations for reporting of observational studies using the REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement.(10)

	Item No	STROBE items	RECORD items	Page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract. (b) Provide in the abstract an informative and balanced summary of what was done and what was found.	(1.1) The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. (1.2) If applicable, the geographic region and time frame within which the study took place should be reported in the title or abstract. (1.3) If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	1 & 3
Introduction				
Background/ rationale	2	Explain the scientific background and rationale for the investigation being reported.		4
Objectives	3	State specific objectives, including any pre-specified hypotheses.		4
Methods				
Study design	4	Present key elements of study design early in the paper.		4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection.		4-5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. (b) For matched studies, give matching criteria and number of exposed and unexposed.	(6.1) The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. (6.2) Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. (6.3) If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	(7.1) A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be	5

			reported, an explanation should be provided.	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group.		4-5
Bias	9	Describe any efforts to address potential sources of bias.		5-6
Study size	10	Explain how the study size was arrived at.		Appendix 2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.		5-6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding. (b) Describe any methods used to examine subgroups and interactions. (c) Explain how missing data were addressed. (d) If applicable, explain how loss to follow-up was addressed. (e) Describe any sensitivity analyses.		5-6
Data access and cleaning methods		N/A	(12.1) Authors should describe the extent to which the investigators had access to the database population used to create the study population. (12.2) Authors should provide information on the data cleaning methods used in the study.	5
Linkage		N/A	(12.3) State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	4
Results				
Participants	13	(a) Report numbers of individuals at each stage of study--e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed. (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram.	(13.1) Describe in detail the selection of the persons included in the study (i.e., study population selection), including filtering based on data quality, data availability, and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	6 & Appendix 2
Descriptive data	14	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders. (b) Indicate number of participants with missing data for each variable of interest.		Table 1

		(c) Summarize follow-up time (e.g. average and total amount).		
Outcome data	15	Report numbers of outcome events or summary measures over time.		6-7, Tables 2-3, Figures 1-2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g. 95% confidence interval). Make clear which confounders were adjusted for and why they were included. (b) Report category boundaries when continuous variables were categorized. (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period.		6-7
Other analyses	17	Report other analyses done (e.g. analyses of subgroups and interactions, and sensitivity analyses).		N/A
Key results	18	Summarize key results with reference to study objectives.		7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	(19.1) Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported.	8 and reported in another manuscript
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.		8
Generalizability	21	Discuss the generalizability (external validity) of the study results.		8
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based.		1-2
Accessibility of protocol, raw data, and programming code		N/A	(22.1) Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	9

Appendix 2: Cohort assembly diagrams for patients living with diabetes as of September 30, 2015.



Abbreviations: ACR, albumin-to-creatinine ratio; eGFR, estimated glomerular filtration rate; CKD, chronic kidney disease.

[a] Criteria for nephrology referral included: eGFR <30, ACR >60, eGFR <45 and ACR >30-60, or eGFR <60 and ≥5 mL decline in the following 6 months.(16,18)
Note: ACR units are mg/mmol; eGFR units are mL/min/1.73 m^2.

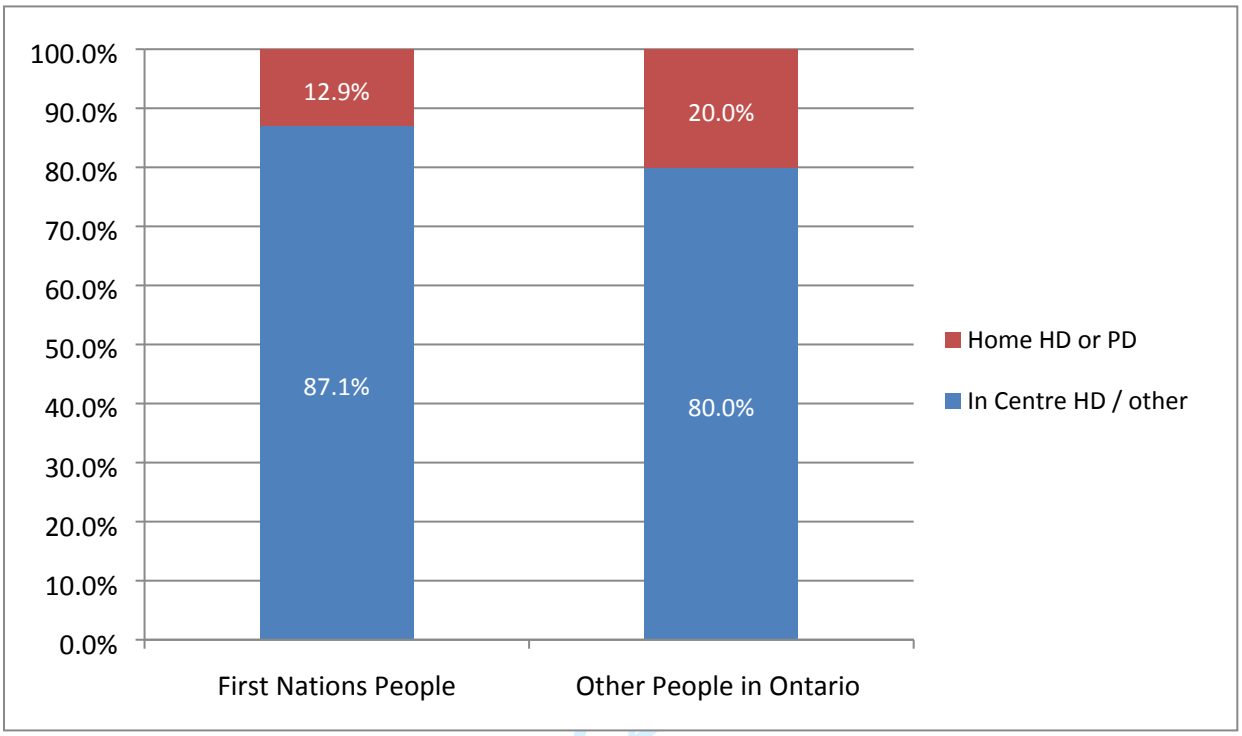
Appendix 3: Definitions of quality of care indicators for early-stage chronic kidney disease.(17,28)

Indicator Category	Numerator	Denominator
Screening for chronic kidney disease	Patients who receive a repeat outpatient serum creatinine test in the following 6 months, based on physician billing codes	Patients in the prevalent diabetes cohort with an initial outpatient eGFR <60 mL/min/1.73 m^2 (sub-cohort 1)
	Patients who receive an outpatient urine albumin in the following 6 months, based on physician billing codes	
	Patients who receive a repeat outpatient urine albumin test in the following 6 months, based on physician billing codes	Patients in the prevalent diabetes cohort with an initial outpatient ACR >3 mg/mmol (sub-cohort 2)
Monitoring of kidney function	Patients with an outpatient serum creatinine test in the following 18 months following the date of the second eGFR value, based on physician billing codes	Patients in the prevalent diabetes cohort with 2 eGFR values <60 mL/min/1.73 m^2 separated by at least 3 months but less than 18 months (sub-cohort 3)
	Patients with an outpatient urine albumin in the 18 months following the date of the second eGFR value, based on physician billing codes	
Use of appropriate medication	Patients who are not prescribed an NSAID for longer than 2 weeks at any time in the 1 year following the date of the second eGFR value	Patients in the prevalent diabetes cohort aged 66 and older with 2 eGFR values <60 mL/min/1.73 m^2 separated by at least 3 months but less than 18 months (sub-cohort 4)
	Patients who are not simultaneously receiving both an ACE inhibitor and an ARB at any time in the 1 year following the date of the second eGFR value. This was defined as a prescription for an ARB filled during the continuous use of an ACE inhibitor or an ACE inhibitor filled during the continuous use of an ARB	
	Patients who are prescribed an ACE inhibitor or ARB at any time in the 1 year following the date of the second eGFR value	
	Patients who are prescribed a statin at any time in the 1 year following the date of the second eGFR value	Patients in the prevalent diabetes cohort aged 66 to 80 with 2 eGFR values <60 mL/min/1.73 m^2 separated by at least 3 months but less than 18 months (sub-cohort 4)
Monitoring of ACE inhibitors and ARBs	Patients who receive an outpatient serum creatinine test 7 to 30 days after initial prescription date, based on physician billing codes	Patients in the prevalent diabetes cohort aged 66 and older with 2 eGFR values <60 mL/min/1.73 m^2 separated by at least 3 months but less than 18
	Patients who receive an outpatient serum potassium test 7 to 30 days after initial	

	prescription date, based on physician billing codes	months who receive an initial prescription for an ACE inhibitor or ARB (sub-cohort 4)
Appropriate referral to a nephrologist	Patients who have an outpatient visit to a nephrologist (based on physician billing codes) in the 6 months from first evidence of meeting one of the referral criteria	Patients in the prevalent diabetes cohort who meet at least 1 criteria for referral to a nephrologist (sub-cohort 5): • eGFR <30 mL/min/1.73 m^2 • ACR >60 mg/mmol • eGFR <45 mL/min/1.73 m^2 and ACR >30 – 60 mg/mmol • eGFR <60 mL/min/1.73 m^2 and at least 5 mL/ min/1.73 m^2 decline within 6 months
	Patients who have an outpatient visit to a nephrologist (based on physician billing codes) in the 1 year from first evidence of meeting one of the referral criteria	

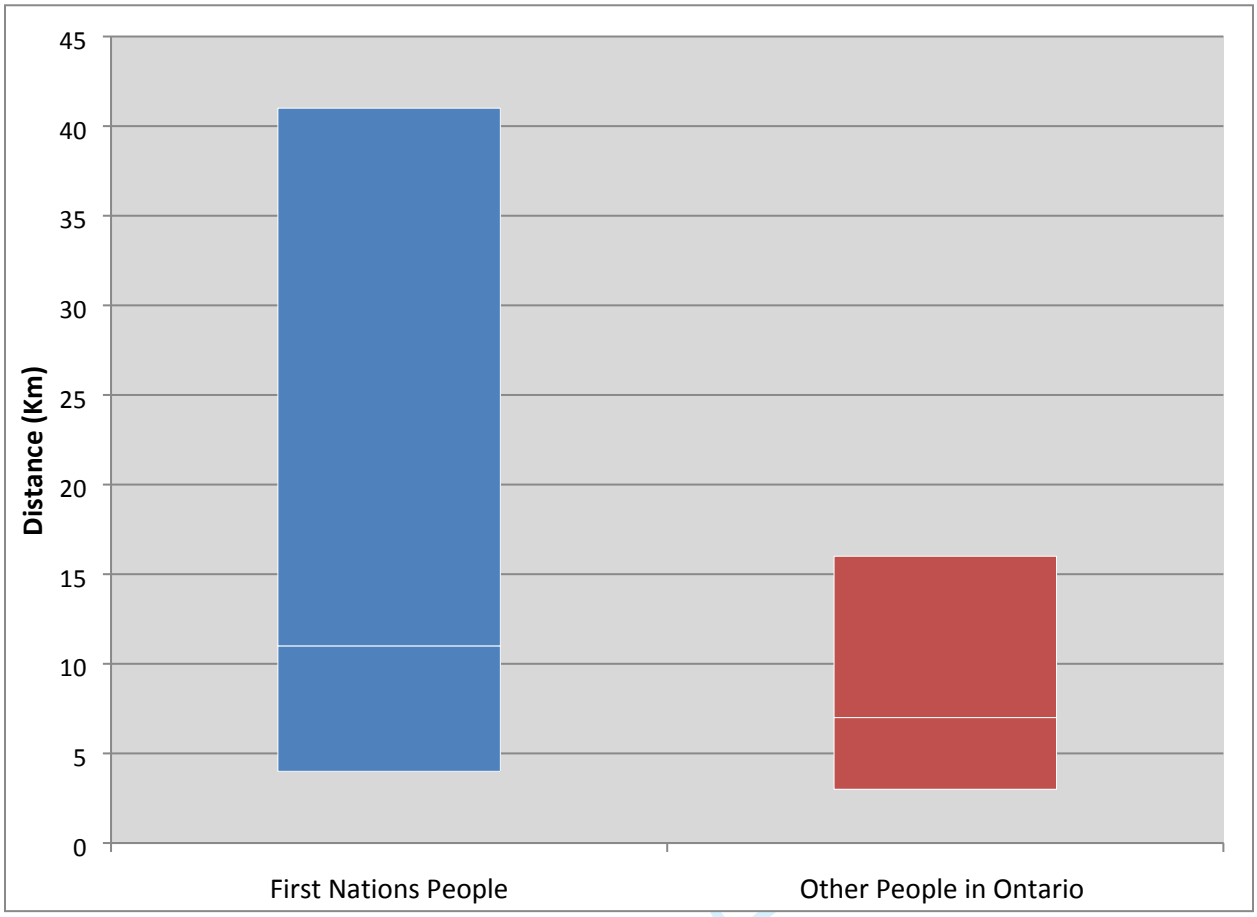
Abbreviations: ACR, albumin-to-creatinine ratio; ACE, angiotensin converting enzyme; ARB, angiotensin II receptor blockers; eGFR, estimated glomerular filtration rate; NSAID, nonsteroidal anti-inflammatory drugs.

Appendix 4: Age- and sex-standardized dialysis modality use among people with diabetes and receiving chronic dialysis treatment in Ontario as of September 30, 2015.



Abbreviations: HD, Hemodialysis; PD, Peritoneal Dialysis.

Appendix 5: Distance travelled to receive treatment among people receiving in-centre hemodialysis and living with diabetes in Ontario as of September 30, 2015.



Note: The white line within each bar is the median, and the top and bottom of the bar is the 75th and 25th percentiles, respectively.

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			reported, an explanation should be provided.	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group.		4-5
Bias	9	Describe any efforts to address potential sources of bias.		5-6
Study size	10	Explain how the study size was arrived at.		Appendix 2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.		5-6
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding. (b) Describe any methods used to examine subgroups and interactions. (c) Explain how missing data were addressed. (d) If applicable, explain how loss to follow-up was addressed. (e) Describe any sensitivity analyses.		5-6
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Linkage		N/A	(12.3) State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	4
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Accessibility of protocol, raw data, and programming code		N/A	(22.1) Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	9