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Original Investigation

The Prevalence of CKD in Rural Canadian Indigenous Peoples: Results From the First Nations Community Based Screening to Improve Kidney Health and Prevent Dialysis (FINISHED) Screen, Triage, and Treat Program

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Background: Indigenous Canadians have high rates of risk factors for chronic kidney disease (CKD), in particular diabetes. Furthermore, they have increased rates of complications associated with CKD, such as kidney failure and vascular disease. Our objective was to describe the prevalence of CKD in this population.

Study Design: Cross-sectional cohort.

Setting & Participants: Indigenous (First Nations) Canadians 18 years or older screened as part of the First Nations Community Based Screening to Improve Kidney Health and Prevent Dialysis (FINISHED) project, an initiative completed in 2015 that accomplished community-wide screening in 11 rural communities in Manitoba, Canada.

Predictors: Indigenous ethnicity and geographic location (communities accessible by road compared with those accessible only by air).

Outcome: Prevalence of CKD, presumed based on a single ascertainment of urine albumin-creatinine ratio (UACR) $\geq$ 30 mg/g and/or estimated glomerular filtration rate (eGFR) $<$ 60 mL/min/1.73 m^2.

Measurements: Kidney function measured by eGFR (CKD-EPI creatinine equation) and UACR.

Results: 1,346 adults were screened; 25.5% had CKD, defined as UACR $\geq$ 30 mg/g or eGFR $<$ 60 mL/min/1.73 m^2. Communities accessible by road had a lower prevalence of CKD (17.6%) than more remote communities accessible only by air (34.4%). Of those screened, 3.3% had reduced kidney function (defined as eGFR $<$ 60 mL/min/1.73 m^2). Severely increased albuminuria was present in 5.0% of those screened.

Limitations: Presumption of chronicity based on a single ascertainment. There is a possibility of sampling bias, the net direction of which is uncertain.

Conclusions: We found a 2-fold higher prevalence of CKD in indigenous Canadians in comparison to the general population and a prevalence of severely increased albuminuria that was 5-fold higher. This is comparable to patients with diabetes and/or hypertension. Public health strategies to screen, triage, and treat all Canadian indigenous peoples with CKD should be considered.

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INDEX WORDS: Screening; First Nations; indigenous community; Canada; chronic kidney disease (CKD); renal impairment; estimated glomerular filtration rate (eGFR); albuminuria; urine albumin-creatinine ratio (UACR); rural; remote; health care access; health disparities; early detection.

Chronic kidney disease (CKD) is a global health problem affecting 10% to 15% of the general population.[1] It is a potent risk factor for kidney failure, cardiovascular events, and early death.[2] These downstream outcomes are harmful for patients and costly for health systems.[3] Early detection and treatment of CKD using quantified spot proteinuria testing (urine albumin-creatinine ratio [UACR]), serum creatinine–based estimated glomerular filtration rate (eGFR), or both could decrease downstream harms and costs, but these benefits must be balanced against the harms and costs of the screening itself.[4] Most studies in primarily European and European American cohorts have concluded that population-based screening for CKD would not be cost-effective because of the low prevalence of CKD and the low probability of progression to kidney failure.[5] Current guidelines therefore recommend CKD screening only in high-risk subgroups, such as those with hypertension or diabetes.[6] It is unclear whether these recommendations can be generalized to other populations or racial and ethnic groups that have a higher prevalence of CKD or more rapid trajectory of progression.

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Canadian indigenous peoples are known to have a higher prevalence of major risk factors for CKD, such as diabetes and metabolic syndrome, and have increased rates of immune-mediated kidney diseases.[7] Furthermore, rates of complications associated with CKD, such as kidney failure and vascular disease, are higher among Canadian indigenous peoples.[8] The number of rural indigenous patients with kidney failure requiring dialysis has increased disproportionately in Canada over the last 25 years.[9] Although kidney failure rates are known to be much higher in this population, the true burden of non−dialysis-dependent CKD in indigenous communities remains undefined, with many affected individuals unaware of any underlying decreased kidney function.[10] This knowledge gap is attributable in part to reduced access to primary and specialty health care services, especially in rural communities.[11,12] These systemic barriers result in fewer opportunities for early detection of CKD in the primary health care setting and render prevalence estimates derived from administrative data sources unreliable.[13] An accurate description of the epidemiology of CKD in Canadian indigenous populations is a critical first step in the determination of the most cost-effective screening and treatment interventions in this population. These data would allow health systems to better realign CKD resources with clinical need and apply these strategies to other vulnerable populations at disproportionate risk.[14]

In order to address these important knowledge gaps, we analyzed cross-sectional data from the First Nations Community Based Screening to Improve Kidney Health and Prevent Dialysis (FINISHED) project, a 3-year, indigenous-led, 1-time screening, risk prediction and treatment initiative completed in April 2015. The primary objective of FINISHED was to provide mobile community-wide targeted screening for CKD, individualized kidney failure risk prediction, and risk-based counseling to all indigenous (First Nations) people 10 years and older residing in 11 representative Canadian rural communities across 2 Tribal Councils in Manitoba, Canada.[15] The current report summarizes the epidemiology of non−dialysis-requiring CKD among adult (aged ≥ 18 years) participants of FINISHED. Our analysis addressed 2 a priori hypotheses: first, rurally located indigenous adults would have higher rates of CKD than the general population, and second, remote communities accessible only by air would have higher rates of CKD than communities accessible by road, attributable to their reduced access to primary and specialty care.

METHODS

Approval and Consent

This project received approval from the Health Research Ethics Board at the University of Manitoba (HS16070) in addition to approvals from the Diabetes Integration Project Board of Directors, Tribal Council leaders, and the local governments of each community involved in the project. Ownership, Control, Access and Possession (OCAP) principles for indigenous research were strictly adhered to throughout this project. Patients provided informed consent to the use of screening data prior to point-of-care screening.

The FINISHED Screening Program

Methods of this screening program have been previously described, including a detailed overview of laboratory and clinical measurements.[15] In brief, the project was executed by an interdisciplinary team consisting of clinician scientists from the indigenous-led Diabetes Integration Project and the Manitoba Renal Program, the sole provider of kidney health care in Manitoba, Canada (population, ∼1.3 million). Extensive stakeholder consultation was obtained from various levels of government, community elders, federal and provincial health care payers, and regional health authority care providers.

Culturally safe protocols and standard operating procedures were developed to screen community members using point-of-care testing equipment deployed by mobile screening teams. The teams were indigenous led and trained in culturally safe practices. Risk for kidney failure was estimated in real time at the point of care, using a custom tablet–based app that incorporated the validated kidney failure risk equation, as well as other risk parameters for which the equation was not applicable (ie, eGFR > 60 mL/min/1.73 m^2; Fig S1, available as online supplementary material).[15,16]

Study Participation

Screening teams set up mobile clinics at nursing stations, community centers, and schools throughout chosen communities. All members of the community (aged ≥ 10 years) were invited to participate in the screening program regardless of comorbid predisposing risk factors for diabetes, hypertension, or CKD.

Data Collection and Study Definitions

As part of the screening process, the following data elements were obtained and entered into an electronic study database: demographic information, including age, sex, and community of residence; clinical data, including height, weight, body mass index, blood pressure, and laboratory values (serum creatinine, eGFR, UACR, and glycated hemoglobin [HbA_{1c}]). Serum creatinine was measured using the Piccolo Xpress (Abaxis) with daily quality assurance performed by Canadian External Quality Assurance Laboratories to ensure isotope-dilution mass spectrometry traceability.[17] UACR and HbA_{1c} were analyzed using the DCA Vantage Analyzer (Siemens). A mean of 6 blood pressure measurements were performed according to practices outlined by the Canadian Hypertension Education Program (CHEP) using the BPTru Medical Device (Coquitlam).[15]

eGFR was calculated using the CKD-EPI (CKD Epidemiology Collaboration) creatinine equation.[18] We defined CKD as a single measurement of UACR ≥ 30 mg/g and/or eGFR < 60 mL/min/1.73 m^2.[19] The cutoff for elevated blood pressure was taken as systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg. Diabetes was defined for the purposes of this study as HbA_{1c} level ≥ 6.5%. Moderately increased albuminuria was defined as UACR of 30 to <300 mg/g, and severely increased albuminuria, as UACR ≥ 300 mg/g.[19]

Data Analysis

Aggregate descriptive statistics on screening results were compiled on variables describing the prevalence and severity of CKD. Summary statistics were expressed as mean ± standard deviation for normally distributed continuous variables, median and interquartile range for non-normally distributed variables, and percentage for categorical variables. Comparative statistical testing

was performed between patients screened within communities accessible by road and those accessible only by air. Additionally, we compared those screened by diabetes status using a threshold of HbA_{1c} level ≥ 6.5%. Categorical variables were compared using χ^2 statistics, and continuous variables, using unpaired *t* test for normally distributed variables or Mann-Whitney *U* test (Wilcoxon rank sum test) for non-normally distributed variables when appropriate.

The spectrum of CKD risk in the screened communities was summarized using the KDIGO (Kidney Disease: Improving Global Outcomes) "heat map" staging system.[15] We further examined the overlap in diagnostic testing results for hypertension, diabetes, and CKD (eGFR and UACR) using a Venn diagram to ascertain the improvement in case-finding associated with targeting individuals without diabetes and hypertension.

RESULTS

Demographic Characteristics

In total, 1,700 individuals, including 1,346 adults, were screened. Screening teams spent a total of 260 days actively screening in communities over the course of the project and achieved a 22.4% overall screening rate, calculated using the entire registered on-reserve population 18 years or older as the denominator (Table 1). In communities accessible only by air, screenees had a mean age of 45 years, were predominantly female (62.2%), and had a high prevalence of diabetes, defined as HbA_{1c} level ≥ 6.5% (42.1%). In contrast, in communities accessible by road, screenees had a similar mean age (45 years) and female predominance (59.3%), but had a lower prevalence of diabetes (28.9%; Table 2).

Burden of CKD

In FINISHED, 343 (25.5%) adults screened had CKD as defined by a single measurement of elevated UACR or eGFR < 60 mL/min/1.73 m^2. Patients screened in communities accessible only by air (n = 630) had a higher burden of CKD compared with patients in communities accessible by road (n = 716). Significant differences between these 2 groups included a higher median UACR of 16.8 (interquartile range [IQR], 7.0-45.1] mg/g in communities accessible only by air versus 8.8 (IQR, 4.4-16.8) mg/g in road-access communities ($P < 0.001$) and higher risk for progression to kidney failure based on a risk assessment algorithm ($P < 0.001$; Fig S1). Individuals in communities accessible by road had a higher mean body weight (93.5 ± 28.1 [standard deviation] vs 89.7 ± 20.4 kg; $P = 0.04$) and diastolic blood pressure (76.2 ± 11.0 vs 74.7 ± 10.1 mm Hg; $P = 0.02$) in comparison to those in communities accessible only by air. No differences in mean eGFR, body mass index, or systolic blood pressure were observed between road-access and air-access-only communities (Table 2).

Communities accessible only by air had a higher prevalence of CKD than those with road access: 34.4% of adults in air-access communities had CKD defined by elevated UACR and/or eGFR < 60 mL/min/1.73 m^2 compared to 17.6% in road-access communities. Much of this prevalence is attributable to early-stage CKD (stages 1-2), with only 3.3% of those screened having eGFRs < 60 mL/min/1.73 m^2 (2.8% in road-access communities and 4.0% in air-access-only communities; $P = 0.7$). Overall, rates of severely increased and moderately increased albuminuria were 5.0% and 18.9%, respectively, in the entire screened cohort. In road-access communities, rates of severely and moderately increased albuminuria were 2.8% and 13.5%, respectively, in comparison to 7.5% and 25.1% in air-access-only communities. Distribution of patients according to the 2012 KDIGO CKD progression risk staging system is shown in Fig 1.

To assess the burden of diabetes, we further compared those screened by HbA_{1c} level (≥6.5%

Table 1. Screening Rates, Populations, and Number of Days Spent in Each Community

Community No.	Total Registered Reserve Community Population Aged ≥ 18 y	Total Number Screened Aged ≥ 18 y[a]	% of Registered Reserve Population Screened Aged ≥ 18 y	Days in Community Spent Screening	Accessibility
1	675	55	8.1	12	Air only
2	1,395	181	13.0	60	Air only
3	1,275	257	20.2	58	Air only
4	460	137	29.8	18	Air only
5	380	67	17.6	14	Road
6	695	125	18.0	21	Road
7	230	55	23.9	9	Road
8	205	103	50.2	22	Road
9	50	26	52.0	4	Road
10	220	122	55.5	14	Road
11	275	187	68.0	28	Road
Total	5,860	1,315	22.4	260	—

[a]The total number screened in this table does not include 31 individuals who were screened outside of community screening stations, but were still members of one of the tribal councils (road accessible).

Table 2. Demographic Characteristics of Screening Cohort

	All (N = 1,346)	Accessible by Road (n = 716)	Accessible Only by Air (n = 630)	*P*
Age, y	44.9 ± 14.5	45.2 ± 14.4	44.6 ± 14.6	0.5
Female sex	816 (60.7)	424 (59.3)	392 (62.2)	0.3
HbA_{1c} ≥ 6.5%	468 (35.1)	206 (28.9)	262 (42.1)	<0.001
eGFR, mL/min/1.73 m^2	106.3 ± 21.6	105.6 ± 20.4	107.2 ± 22.9	0.2
eGFR category				0.7
≥60 mL/min/1.73 m^2	1,301 (96.7)	696 (97.2)	605 (96.0)	
45-59 mL/min/1.73 m^2	24 (1.8)	9 (1.3)	15 (2.4)	
30-44 mL/min/1.73 m^2	15 (1.1)	8 (1.1)	7 (1.1)	
15-29 mL/min/1.73 m^2	4 (0.3)	2 (0.3)	2 (0.3)	
<15 mL/min/1.73 m^2	2 (0.2)	1 (0.1)	1 (0.2)	
UACR, mg/g	12.4 [5.3-28.3]	8.8 [4.4-16.8]	16.8 [7.0-45.1]	<0.001
Elevated blood pressure[a]	202 (15.0)	114 (16.0)	88 (14.0)	0.3
SBP, mm Hg	121.7 ± 16.7	121.9 ± 17.1	121.4 ± 16.3	0.8
DBP, mm Hg	75.5 ± 10.6	76.2 ± 11.0	74.7 ± 10.1	0.02
Weight, kg				
All	91.7 ± 24.9	93.5 ± 28.1	89.7 ± 20.4	0.04
Female	87.4 ± 22.8	88.4 ± 25.3	86.3 ± 19.8	0.3
Male	98.4 ± 26.4	100.9 ± 30.3	95.2 ± 20.3	0.07
Height, cm				
All	167.2 ± 9.0	168.2 ± 9.1	166.0 ± 8.7	<0.001
Female	161.9 ± 6.0	163.0 ± 6.2	160.9 ± 5.7	<0.001
Male	175.2 ± 6.6	175.8 ± 7.1	174.5 ± 5.8	0.01
BMI category				0.9
≥35 kg/m^2	419 (31.1)	222 (31.0)	197 (31.3)	
30-34.9 kg/m^2	404 (30.0)	215 (30.0)	189 (30.0)	
25-29.9 kg/m^2	342 (25.4)	180 (25.1)	162 (25.7)	
18.5-24.9 kg/m^2	142 (10.6)	80 (11.2)	62 (9.8)	
<18.5 kg/m^2	39 (2.9)	19 (2.7)	19 (3.2)	
Kidney failure risk[b]				<0.001
None	743 (55.2)	441 (61.6)	302 (47.9)	
Low	577 (42.9)	265 (37.0)	312 (49.5)	
Intermediate	13 (1.0)	5 (0.7)	8 (1.3)	
High	13 (1.0)	5 (0.7)	8 (1.3)	

Note: Summary statistics for categorical variables are given as number (percentage), values for normally distributed continuous variables are given as mean ± standard deviation, and those for non-normally distributed continuous variables, as median [interquartile range]. Some categories may not sum to 100% due to rounding.

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HbA_{1c}, glycated hemoglobin; SBP, systolic blood pressure; UACR, urine albumin-creatinine ratio.

[a]SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg.

[b]Criteria for determination of kidney failure risk are presented in Fig S1.

and <6.5%). Those with elevated HbA_{1c} levels (n = 468) were older (51.0 ± 12.1 vs 41.7 ± 14.6 years; $P < 0.001$), had a higher proportion of individuals with eGFRs < 60 mL/min/1.73 m^2 (5.6% vs 2.1%; $P = 0.005$), had higher levels of albuminuria (median, 22.1 [IQR, 10.6-89.4] vs 8.0 [IQR, 4.4-16.8] mg/g; $P < 0.001$), had a higher prevalence of hypertension (18.4% vs 12.9%; $P = 0.007$), were heavier ($P < 0.001$), and had a higher risk for kidney failure as determined by our screening algorithm (Fig S1): 88.9% at some risk for kidney failure and 4.5% requiring referral to nephrology (intermediate and high risk) versus 20.4% at some risk for kidney failure and 0.4% requiring referral to nephrology; $P < 0.001$; Table 3).

Of 343 cases with CKD as defined by KDIGO, 216 (60.2%) had elevated HbA_{1c} levels (≥6.5%) and 94 (27.4%) had elevated blood pressure (systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg). Offering CKD screening to only individuals with diabetes or hypertension would have missed 97 (28.3%) people who were found to have CKD in the absence of high blood pressure or elevated HbA_{1c} levels. Of individuals identified with CKD, 21 (6.1%) had reduced function measured by eGFR (<60 mL/min/1.73 m^2) without albuminuria (UACR < 30 mg/g), whereas 298 (86.9%) had kidney damage manifested by albuminuria; 24 (7.0%) had both reduced eGFR and albuminuria (Fig 2).

			Albuminuria (mg/g)			
			A1		A2	A3
			Optimal to high-normal		High	Very high to nephrotic
			<10	10-<30	30-<300	≥ 300
eGFR (mL/min/1.73 m^2)	G1a	≥105	26.4% (24.0%-28.7%)	18.6% (16.6%-20.7%)	10% (8.4%-11.6%)	1.9% (1.1%-2.6%)
	G1b	90-104	10.2% (8.6%-11.8%)	8.2% (6.8%-9.7%)	4.8% (3.6%-5.9%)	0.7% (0.2%-1.1%)
	G2a	75-89	5.3% (4.1%-6.6%)	3.2% (2.3%-4.1%)	2.6% (1.8%-3.5%)	1% (0.5%-1.6%)
	G2b	60-74	1.6% (0.9%-2.2%)	1.0% (0.4%-1.5%)	0.9% (0.4%-1.4%)	0.3% (0%-0.6%)
	G3a	45-59	0.4% (0.1%-0.8%)	0.8% (0.3%-1.3%)	0.3% (0%-0.6%)	0.2% (0%-0.5%)
	G3b	30-44	0.1% (0%-0.2%)	0.2% (0%-0.5%)	0.4% (0%-0.7%)	0.4% (0.1%-0.8%)
	G4	15-29	0% (0%-0%)	0% (0%-0%)	0% (0%-0%)	0.3% (0%-0.6%)
	G5	<15	0% (0%-0%)	0% (0%-0%)	0% (0%-0%)	0.1% (0%-0.4%)
Totals:			74.5% (72.2%-76.8%)	19.5% (17.4%-21.7%)	4.5% (3.4%-5.6%)	1.5% (0.8%-2.1%)

Figure 1. Chronic kidney disease (CKD) progression risk profile of the First Nations Community Based Screening to Improve Kidney Health and Prevent Dialysis (FINISHED) population. Risk classification based on the 2-axis staging system using estimated glomerular filtration rate (eGFR) and albuminuria from the 2012 KDIGO (Kidney Disease: Improving Global Outcomes) guideline for the management of CKD. Green represents, if no other markers of kidney damage, no CKD; yellow, moderately increased risk for CKD progression; orange, high risk for CKD progression; and red, very high risk for CKD progression.[19]

DISCUSSION

To our knowledge, FINISHED is the largest general-population CKD screening and treatment initiative in Canadian indigenous communities. Our report has 2 major findings. First, 25.5% of individuals screened had kidney disease as measured by a single ascertainment of eGFR < 60 mL/min/1.73 m^2 or elevated UACR. This prevalence is 2- to 3-fold higher than rates reported from other CKD prevalence studies in European and North American populations[20-22] and more than twice the estimated CKD prevalence in the general Canadian population measured from the Canadian Health Measures Survey.[23] Second, communities accessible only by air showed a higher prevalence of CKD than communities accessible by road, suggesting that access to health services may be an important modifiable barrier to maintaining kidney health.

The burden of CKD in FINISHED was similar to that found in other high-risk indigenous populations, such as Pima Indians and Navajo in the United States and Australian Aborigines. Moreover, the burden of CKD found in FINISHED was similar to that of high-risk nonindigenous groups, in particular those with diabetes and/or hypertension (Table S1).[24-33] This is particularly important because nearly a third (28.3%) of individuals in FINISHED who were found to have CKD did not have either elevated HbA_{1c} level or blood pressure in concurrently administered diagnostic tests, for whom decreased kidney function would not have been detected under existing guidelines.

A substantial proportion of identified kidney disease was attributable to albuminuria rather than reduced eGFR (87% of those screened with CKD had stages 1 and 2). This suggests that the increased burden of CKD observed in FINISHED is due primarily to early-stage and potentially treatable kidney disease, representing an opportunity to prevent or delay kidney failure. These patients might benefit from ongoing surveillance and treatment in order to minimize their chances of progression over time.[34-36]

The FINISHED population was entirely Canadian First Nations and as such, was substantially younger than the general Canadian population (9.7% [95% confidence interval, 8.1%-11.2%] older than 65 years in FINISHED in comparison to 12.7% [95% confidence interval, 11.6%-13.8%] in the Canadian general population). This youthful demographic likely explains the low prevalence of reduced eGFR observed in FINISHED compared with studies of nonindigenous Canadians, in whom CKD is mainly nonproteinuric and prevalent in older individuals.[23] The youth of individuals with CKD diagnosed may also explain the elevated lifetime risk for kidney failure among First Nations groups because younger individuals with proteinuria are more likely to progress

Table 3. Comparison by HbA_{1c} Level

	HbA_{1c} < 6.5% (n = 867)	HbA_{1c} ≥6.5% (n = 468)	*P*
Age, y	41.7 ± 14.6	51.0 ± 12.1	<0.001
Female sex	517 (59.7)	291 (62.2)	0.4
eGFR, mL/min/1.73 m^2	108.0 ± 20.5	103.2 ± 23.0	<0.001
eGFR category			0.005
≥60 mL/min/1.73 m^2	849 (97.9)	442 (94.4)	
45-59 mL/min/1.73 m^2	11 (1.3)	12 (2.6)	
30-44 mL/min/1.73 m^2	6 (0.7)	9 (1.9)	
15-29 mL/min/1.73 m^2	0 (0)	4 (0.9)	
<15 mL/min/1.73 m^2	1 (0.1)	1 (0.2)	
UACR, mg/g	8.0 [4.4-16.8]	22.1 [10.6-89.4]	<0.001
Elevated blood pressure[a]	112 (12.9)	86 (18.4)	0.007
SBP, mm Hg	120.0 ± 16.1	124.8 ± 17.5	<0.001
DBP, mm Hg	75.9 ± 10.7	74.7 ± 10.7	0.04
Weight, kg			
All	90.2 ± 23.7	94.7 ± 26.7	0.002
Female	86.6 ± 24.2	89.1 ± 20.4	0.1
Male	95.4 ± 21.9	103.9 ± 32.8	0.002
Height, cm			
All	90.2 ± 23.7	94.7 ± 26.7	0.2
Female	162.2 ± 6.1	161.7 ± 5.8	0.3
Male	175.4 ± 6.7	174.9 ± 6.2	0.4
BMI category			<0.001
≥35 kg/m^2	248 (28.6)	168 (35.9)	
30-34.9 kg/m^2	254 (29.3)	146 (31.2)	
25-29.9 kg/m^2	216 (24.9)	123 (26.3)	
18.5-24.9 kg/m^2	119 (13.7)	22 (4.7)	
<18.5 kg/m^2	30 (3.5)	9 (1.9)	
Kidney failure risk[b]			<0.001
None	688 (79.4)	52 (11.1)	
Low	175 (20.2)	395 (84.4)	
Intermediate	2 (0.2)	11 (2.4)	
High	2 (0.2)	10 (2.1)	

Note: Summary statistics for categorical variables are given as number (percentage), values for normally distributed continuous variables are given as mean ± standard deviation, and those for non-normally distributed continuous variables, as median [interquartile range]. Some categories may not sum to 100% due to rounding.

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HbA_{1c}, glycated hemoglobin; SBP, systolic blood pressure; UACR, urine albumin-creatinine ratio.

[a]SBP ≥ 140 mm Hg or DBP ≥ 90 mm Hg.

[b]Criteria for determination of kidney failure risk are presented in Fig S1.

to kidney failure than older nonproteinuric patients; it has been well documented that First Nations groups have a 2- to 3-fold higher prevalence of kidney failure than nonindigenous groups.[8]

Our findings have clinical, research, and policy implications. Clinicians working in indigenous communities should be aware of these disproportionate risks and consider at least one-off screening for CKD with both eGFR and albuminuria testing at routine health encounters. From a public health perspective, our results confirm the existence of a treatable public health problem of CKD in these communities, a problem that is worse in communities with the least immediate access to primary care physicians (ie, communities accessible only by air), which often have only itinerant irregular physician coverage and nursing stations with high turnover and frequent position vacancies. The prevalence of CKD in these communities is comparable to rates observed in high-risk nonindigenous patients (ie, those with hypertension and diabetes), a group for whom regular screening for CKD is recommended and cost-effective.[5] It seems reasonable, based on the current evidence, to endorse a policy of population-based screening and treating for CKD in Canadian indigenous communities, as is currently recommended for other high-risk groups.[6,19]

In this regard, the screen, triage, and treat model developed in the FINISHED project has many strengths and also some weaknesses as an intervention. Its primary strengths are that it has demonstrated the feasibility and efficacy of remote real-time CKD

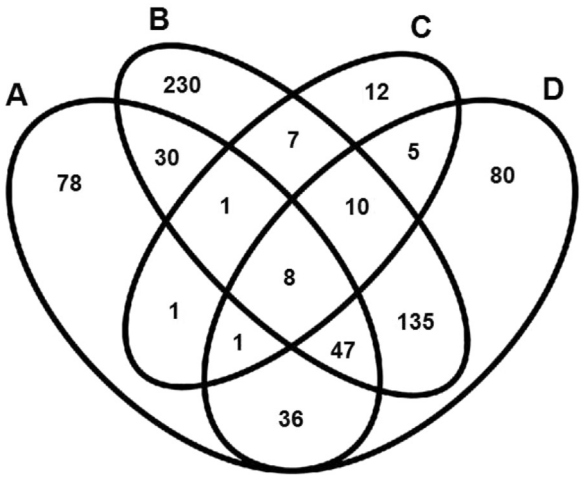

Figure 2. Intersection of diagnostic tests. (A) Systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg, (B) glycated hemoglobin ≥ 6.5%, (C) estimated glomerular filtration rate < 60 mL/min/1.73 m^2, and (D) urine albumin-creatinine ratio ≥ 30 mg/g.

screening using point-of-care testing equipment with instant direct feedback to patients. The strategy has been co-developed, embraced, and accepted by indigenous communities. Its main weaknesses are the uncertainties regarding its impact on downstream health outcomes and the optimal ongoing surveillance strategy, including rescreening frequency. Linkages to provincial administrative, laboratory, and prescription databases are planned to monitor the appropriateness of follow-up and treatment and assess downstream health outcomes. However, these results will not be available for several years. A formal cost-effectiveness model is being undertaken to evaluate the value for money achieved by this initiative as opposed to the current standard of passive screening at routine health encounters. Future research will be needed to establish whether less intensive approaches, such as augmenting in-community primary care infrastructure for the purposes of rescreening and surveillance, represent a viable alternative to the itinerant mobile team model used in FINISHED. Notwithstanding these uncertainties, we recommend consultation with stakeholders in order to determine feasible strategies for continued screening and intervention, particularly in the highest risk and least accessible communities.

This study also has important limitations. We presumed chronicity based on a single measurement, whereas a confirmed diagnosis of CKD would require reduced eGFR or albuminuria sustained over a 3-month period.[19] However, this is a limitation shared by most other one-time screening studies[20-22] and should not bias the comparison with these other findings. In addition, the definition used for diabetes in our study included only those with an elevated HbA_{1c} level and not individuals taking diabetes medication without an elevated HbA_{1c} level and as such, the prevalence of diabetes could have been underestimated and the number of patients with albuminuria and no diabetes may have been overestimated. A further limitation is the possibility of sampling bias. Communities accessible only by air had lower screening rates than those accessible by road, attributable to differences in access to transportation and health services in these more remote regions. There is also potential for bias introduced by patient self-selection for screening. In many clinical studies, self-selected participants tend to be healthier than the source population. This phenomenon in isolation would bias our results toward an underestimate of CKD prevalence. However, in a CKD screening study such as FINISHED, individuals with awareness of other risk features for CKD (diabetes, hypertension, and/or strong family history of CKD) might preferentially self-select to participate, biasing results toward an overestimate. The net effect of these biases on prevalence estimates remains uncertain.

Rural Canadian indigenous peoples exhibit a high prevalence of early-stage non−dialysis-dependent CKD. This prevalence is comparable to rates reported in cohorts of exclusively diabetic and hypertensive patients; however, a number of people in this population have no baseline hypertension or diabetes. Remote air-access-only communities carry an even higher burden of disease. Further study in this area to determine cost-effectiveness and other population-level interventions are needed to improve CKD and related health outcomes in this population. Our screening approach may be transferrable to other indigenous populations at high risk for CKD worldwide.

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Contributions: Research idea and study design: PK, BL, NT, CC, AD, CR; data acquisition: PK, BL, NT, CC, LM, AG, AD, CR; data analysis/interpretation: PK, BL, TWF, NT, CC, LM, AD, CR; statistical analysis: TWF. Each author contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overall work by ensuring that

questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved. PK and BL take responsibility that this study has been reported honestly, accurately, and transparently; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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SUPPLEMENTARY MATERIAL

Table S1: Summary of CKD prevalence studies.

Figure S1: Screening algorithm for risk of kidney failure.

Note: The supplementary material accompanying this article (http://dx.doi.org/10.1053/j.ajkd.2016.04.014) is available at www.ajkd.org

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