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Quality of care and mortality are worse in chronic kidney disease patients living in remote areas

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Many patients with non-dialysis dependent chronic kidney disease (CKD) live far from the closest nephrologist; although reversible, this might constitute a barrier to optimal care. In order to evaluate outcomes, we selected 31,452 outpatients older than 18 years with an estimated glomerular filtration rate (eGFR) less than 45 ml/min per 1.73 m^2 who had serum creatinine measured at least once during 2005 in Alberta, Canada. We then used logistic regression to examine the association between outcomes of 6545 patients who lived more than 50 km from the nearest nephrologist. Over a median follow-up of 27 months, 7684 participants died and 15,075 were hospitalized at least once. Compared with those living within 50 km, those further away were significantly less likely to visit a nephrologist or a multidisciplinary CKD clinic within 18 months of the index measurement of the eGFR. Similarly, remote dwellers with diabetes were significantly less likely to have hemoglobin A1c evaluated within 1 year of the index eGFR measurement, to have urinary albumin assessed biannually, or to receive an angiotensin converting enzyme inhibitor or receptor blocker in the setting of diabetes or proteinuria. Remote-dwelling participants were also significantly more likely to die or be hospitalized during follow-up than those living closer. Thus, among people with CKD, remote dwellers were less likely to receive specialist care, recommended laboratory testing, and appropriate medications, and were more likely to die or be hospitalized compared with those living closer to a nephrologist.

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Chronic kidney disease (CKD) is an important public health problem associated with accelerated cardiovascular disease and increased mortality.[1] Two recent Canadian studies suggested that mortality was higher among remote-dwelling hemodialysis and peritoneal dialysis patients.[2,3] Previous studies have shown that remote/rural dwelling patients with other (non-renal) conditions are not as likely to receive effective preventive therapies.[4,5] This raises the possibility that the excess mortality in remote-dwelling dialysis patients may be because of documented gaps between recommended practice and real world care.[6–9] This issue is especially germane for Canadian provinces where rural/remote residence is common and specialists are often located only in larger centers.

It is unknown whether remote-dwelling patients with non-dialysis dependent CKD have worse clinical outcomes, and whether they are less likely to receive preventive therapies to manage kidney disease and its complications, such as atherosclerosis. As timely and appropriate treatment for CKD is known to reduce morbidity, mortality, and progression to kidney failure[10–15] correcting such gaps in care would be expected to result in better clinical outcomes and might reduce health care costs.

We studied a large cohort of people with CKD in a single Canadian province and examined the relation between residence location and markers of good quality care including access to specialty care and adherence to clinical practice guidelines, including the use of relevant laboratory testing and appropriate medications. We also considered whether the risk of clinically relevant outcomes was increased among remote dwellers.

RESULTS

Figure 1 shows participant flow. Figure 2 shows the density of people with estimated glomerular filtration rate (eGFR) <45 ml/min per 1.73 m^2 in Alberta in relation to available nephrologists or internists. Characteristics of the 31,452 participants by distance to the closest nephrologist are shown in Table 1; 79% lived within 50 km of a nephrologist and so were considered urban dwellers. The remaining 21%

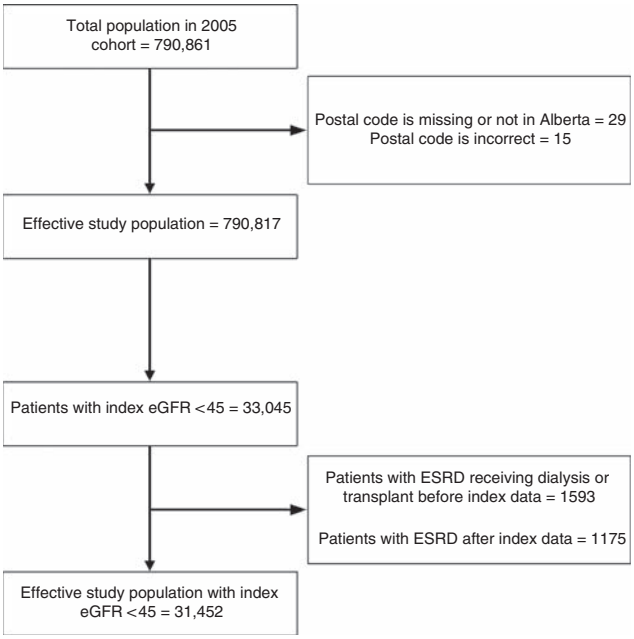

Figure 1 | Study flow. Abbreviations: eGFR, estimated glomerular filtration rate; ESRD, end-stage renal disease.

of participants were classified as remote dwellers. As shown in Table 1, remote dwellers were younger, more likely to be of aboriginal race, and more frequently received financial subsidy/assistance. Remote dwellers also carried a higher burden of comorbidities such as heart failure, chronic obstructive pulmonary disease, diabetes and peripheral vascular disease, and tended to have more severely impaired kidney function.

A similar proportion of participants in every distance category had at least one visit to a primary care practitioner within 18 months following the index eGFR (99.8, 99.8, 99.9, and 99.4% for 0–50, 50.1–100, 100.1–200, and >200 km respectively).

Table 2 shows the likelihood of a nephrologist visit within 18 months following the index eGFR by distance category. Remote dwellers were significantly less likely to visit a nephrologist or a multidisciplinary CKD clinic within 18 months of the index eGFR, as compared with those living closer to a nephrologist ($P<0.0001$). Compared with urban dwellers, patients living >200 km from the closest nephrologist had odds of 0.34 (95% confidence interval (95% CI) 0.2, 0.57) for a nephrologist visit. Results were similar when the more liberal definition of specialist visit (including general internists as well as nephrologists and multidisciplinary clinics) was considered. When we further relaxed the definition of specialist visit to include visits to a nephrologist or multidisciplinary CKD at any time during follow-up, results again showed that remote dwellers were significantly less likely to receive specialist care ($P<0.0001$).

Table 3 summarizes process-based outcome markers for good quality care in patients with CKD, by distance category. There was a significant trend for decreased likelihood of annual hemoglobin A1c (HbA1C) measurement for participants with diabetes across distance categories ($P<0.0001$). Compared with participants with diabetes who lived <50 km from the closest nephrologists, those that lived >200 km were less likely (odds ratio (OR) 0.43; 95% CI 0.27, 0.70) to have A1c measured annually. Remote dwellers were also less likely to have urinary albumin assessed within 6 months of index eGFR <45 ml/min per 1.73 m^2 ($P<0.0001$), and to receive an angiotensin-converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB) in the setting of diabetes or proteinuria). Although appropriate statin use was also significantly less likely in remote dwellers ($P<0.007$), a clinically relevant decrease in the likelihood of statin use was only observed in those living 100–200 km from the closest nephrologist (0.78, 95% CI 0.63, 0.97).

During median follow-up of 27 months, 7684 (24%) of participants died, and 15075 (48%) were hospitalized at least once. Remote-dwelling participants were significantly more likely to die ($P<0.0001$) or to be hospitalized ($P<0.0001$) than those living closer (Table 4). Median length of stay among those hospitalized was also significantly longer among remote dwellers, than in those living closer to a nephrologist (Table 4). The likelihood of the composite renal outcome (end-stage renal disease (ESRD) or doubling of serum creatinine) did not vary between urban and remote dwellers ($P=0.21$; Table 4).

Results were similar when eGFR <30 ml/min per 1.73 m^2 was used as the threshold for appropriate referral to a nephrologist. Compared with those living within 50 km of the closest nephrologist, the OR among those living >200 km away were 0.24 (0.13, 0.44), 0.49 (0.27, 0.90), 0.78 (0.42, 1.45), and 1.23 (0.81, 1.88) for the likelihood of nephrologist visit, annual HbA1C measurement, assessment of urinary albumin, and statin prescription respectively. The relative rate of mortality (OR 1.20; 95% CI 1.01, 1.44), the OR of any hospitalization (OR 1.55; 95% CI 1.29, 1.87), and the median number of hospital days (seven versus five, $P<0.0001$) were also significantly higher in those living >200 km from the closest nephrologist, compared with the referent group—but not the likelihood of ACEI or ARB prescription (OR 1.23; 95% CI 0.69, 2.22).

Results were similar in the other sensitivity analyses described in the methods. Specifically, remote dwellers remained less likely to receive specialist care, to undergo assessment of HbA1C and proteinuria, and to receive an ACEI or ARB in the setting of proteinuria—but were more likely to die or be hospitalized.

DISCUSSION

In Alberta nearly one in five patients with non-dialysis dependent CKD lives further than 50 km from the closest nephrologist. Our findings demonstrate that the further such patients live from an urban center, the less likely they are to visit a specialist or specialty clinic for evaluation. Given the complexity of managing CKD, this decreased contact with specialists may have resulted in the lower likelihood of

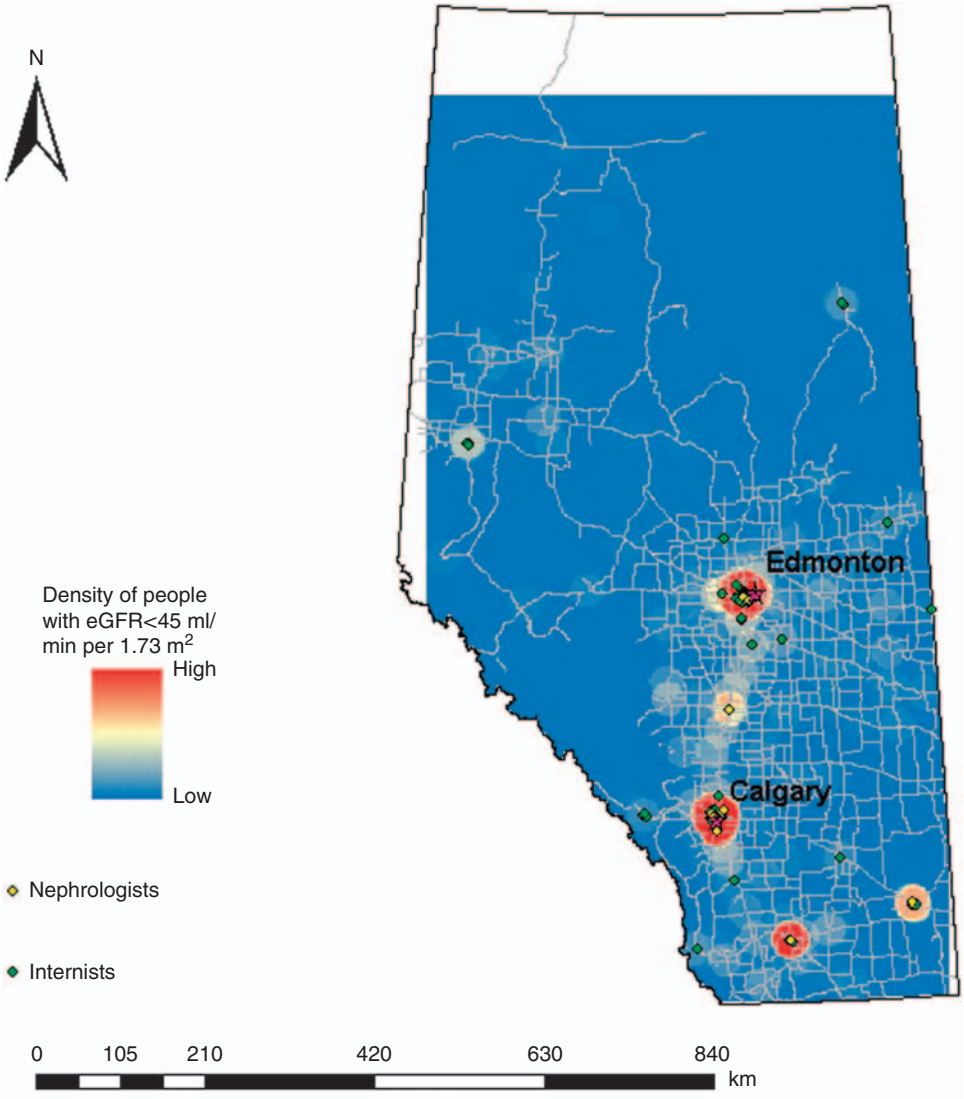

Figure 2 | Location of specialist physicians and people with chronic kidney disease in the province of Alberta. eGFR, estimated glomerular filtration rate.

markers of good quality care (measurement of HbA1c and urinary albumin in diabetics and initiating ACE or ARB treatment) also observed with increasing remoteness. Lack of specialist involvement and these different patterns of care may also have contributed to the increased risk of mortality and hospital admission that we observed among remote dwellers, compared with those living closer. Results were similar using two different eGFR thresholds to define criteria for referral, and in several sensitivity analyses—increasing confidence that the findings are robust.

Why was residing further from the closest nephrologist associated with worse process-based and clinical outcomes among people with identified CKD? The simplest explanation is that nephrologists and internists are predominantly located in major centers (Figure 2). Thus, remote-dwelling patients might decline referrals to urban specialists as the associated travel may pose financial and logistical difficulties. Alternatively, primary care physicians may have a higher threshold for referral of remote dwellers to urban physicians for similar reasons. We speculate that these patient- and physician-related barriers to specialist referral led to the decreased use of measured characteristics of good quality care (and perhaps to decreased use of other beneficial treatments that we were unable to quantify), which in turn led to the excess mortality and risk of hospitalization observed in our study. Why remote residence location was not also associated with higher risk of dialysis treatment is unclear, but may relate to survivorship bias, a lower likelihood of agreeing to initiate dialysis among remote dwellers, or perhaps reduced statistical power for this less frequent outcome.

Previous studies have examined remote-urban health differences in various aspects of CKD care with mixed results. Studies from North America have shown that in terms of renal transplantation, remote dwellers have no disadvantage,[2] and waiting times may even be shorter for those living further away.[16] However, in CKD patients

Table 1 | Demographic and clinical characteristics by geographical distance from the closest nephrologist

Characteristic	Distance from nephrologists, number (%) of patients				P
	0–50 km n=24,907	50.1–100 km n=2214	100.1–200 km n=2169	>200 km n=2162	
Age, mean (s.d.), years	76.0 (12.5)	75.5 (12.3)	76.9 (11.9)	73.7 (13.5)	<0.0001
Female	15,987 (64)	1460 (64)	1368 (63)	1292 (60)	0.0006
Aboriginal status	175 (1)	118 (5)	39 (2)	126 (6)	<0.0001
Index eGFR	35.2 (8.5)	34.3 (9.1)	34.4 (8.8)	34.2 (9.3)	<0.0001
eGFR stages					
<15	868 (3)	104 (5)	83 (4)	117 (5)	<0.0001
15–29.9	4783 (19)	493 (22)	502 (23)	458 (21)	—
30–44.9	19,256 (77)	1617 (73)	1584 (73)	1587 (73)	—
					—
Comorbidities					
Cancer	3466 (14)	307 (14)	327 (15)	297 (14)	0.497
Cardiovascular disease	3368 (14)	285 (13)	316 (15)	290 (13)	0.417
Heart failure	6147 (25)	667 (30)	735 (34)	655 (30)	<0.0001
COPD	6505 (26)	598 (27)	703 (32)	725 (34)	<0.0001
Dementia	2820 (11)	256 (12)	252 (12)	199 (9)	0.021
Diabetes mellitus	5151 (21)	537 (24)	495 (23)	581 (27)	<0.0001
HIV	8 (0.03)	2 (0.09)	0 (0)	0 (0)	0.216[a]
Metastatic cancer	535 (2)	71 (3)	51 (2)	57 (3)	0.008
Myocardial infarction	3505 (14)	298 (13)	269 (12)	309 (14)	0.152
Mild liver disease	520 (2)	46 (2)	34 (2)	64 (3)	0.013
Moderate/severe liver disease	155 (1)	15 (1)	14 (1)	22 (1)	0.187
Paraplegia	428 (2)	27 (1)	37 (1)	36 (2)	0.380
Peptic ulcer disease	1219 (5)	134 (6)	101 (5)	101 (5)	0.084
Peripheral vascular disease	2820 (11)	204 (9)	201 (9)	241 (11)	0.001
Rheumatological disease	1062 (4)	118 (5)	90 (4)	96 (4)	0.121
Income[b]					
Below poverty line	2354 (9)	424 (19)	256 (12)	194 (10)	<0.0001
Between poverty line and Alberta median income	12,356 (50)	1529 (70)	1680 (78)	1063 (53)	—
Higher than median	10,143 (41)	233 (11)	219 (10)	762 (38)	—

Abbreviations: COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate; HIV, human immunodeficiency virus.
[a]Exact test.
[b]Median income was unavailable for 239 participants. The Alberta median individual employment income was $29,500/year in 2005. The poverty line is $14,914/year for rural areas, $18,659/year for urban areas (except Calgary and Edmonton), and $21,666/year for Calgary and Edmonton.
Values are *n* (%) or mean (s.d.) as appropriate.

Table 2 | Likelihood of timely specialist referral by distance from the closest nephrologist

	0–50 km	50.1–100 km	100.1–200 km	>200 km
Referral to nephrologist or CKD multidisciplinary clinic, within 18 months[a] of index eGFR[b]				
People (no.)	24,853	2186	2155	2019
Events (no.)	10,000	626	585	496
Adjusted OR (95% CI)	1	0.56 (0.47, 0.68)	0.53 (0.41, 0.68)	0.34 (0.20, 0.57)
P for trend				<0.0001
Referral to nephrologist, CKD multidisciplinary clinic, or general internist, within 18 months of index eGFR[a]				
People (no.)	24,853	2186	2155	2019
Events (no.)	15,630	1099	938	936
Adjusted OR (95% CI)	1	0.53 (0.50, 0.58)	0.38 (0.28, 0.52)	0.37 (0.27, 0.50)
P for trend				<0.0001
Any referral to a nephrologist or CKD multidisciplinary clinic without a time constraint[b]				
People (no.)	24,853	2186	2155	2019
Events (no.)	18,557	1423	1345	1078
Adjusted OR (95% CI)	1	0.63 (0.41, 0.96)	0.56 (0.42, 0.75)	0.28 (0.16,0.5)
P for trend				<0.0001

Abbreviations: CI, confidence interval; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; LDL, low-density lipoprotein; OR, odds ratio.
[a]Measurement in relation to index eGFR<45 ml/min per 1.73 m^2.
[b]Sensitivity analysis in which any referral to nephrologists or CKD clinic was considered acceptable.
Adjusted for age, index eGFR, gender, income, aboriginal race, diabetic status, and all comorbidities noted in Table 1.

Table 3 | Likelihood of process-based outcomes, by distance from the closest nephrologist

	0–50 km	50.1–100 km	100.1–200 km	>200 km
Glycosylated hemoglobin (A1C) tested annually for diabetic patients				
People (no.)	7715	747	703	708
Events (no.)	4068	337	267	256
Adjusted OR (95% CI)	1	0.73 (0.57, 0.93)	0.58 (0.35, 0.95)	0.43 (0.27, 0.7)
P for trend				<0.0001
Urinary albumin measured[a]				
People (no.)	24,853	2186	2155	2019
Events (no.)	16,243	1141	1070	1119
Adjusted OR (95% CI)	1	0.58 (0.41,0.81)	0.54 (0.37,0.79)	0.62 (0.36, 1.1)
P for trend				<0.0001
ACEI or ARB use among participants aged >66 with diabetes or significant proteinuria[a]				
People (no.)	6297	605	580	509
Events (no.)	4928	448	441	371
Adjusted OR (95% CI)	1	0.81 (0.64, 1.03)	0.93 (0.72, 1.20)	0.75 (0.63, 0.89)
P for trend				0.0003
Statin use among participants aged >66 with LDL >2.5 mmol/l[a]				
People (no.)	6195	447	464	395
Events (no.)	2671	204	172	169
Adjusted OR (95% CI)	1	1 (0.80, 1.30)	0.78 (0.63, 0.97)	0.98 (0.64, 1.50)
P for trend				0.007

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; CI, confidence interval; CKD chronic kidney disease; eGFR, estimated glomerular filtration rate; LDL, low-density lipoprotein; OR, odds ratio.
[a]Measurement within 6 months of index eGFR <45 ml/min per 1.73 m^2.
Adjusted for age, index eGFR, gender, income, aboriginal race, diabetic status, and all comorbidities noted in Table 1.

Table 4 | Clinically relevant outcomes in remote dwelling patients with CKD, by geographic distance from the closest nephrologist

	0–50 km	50.1–100 km	100.1–200 km	>200 km
Hospitalization				
People (no.)	24,853	2186	2155	2019
Events (no.)	11,346	1189	1263	1145
Adjusted OR (95% CI)	1	1.3 (1.2, 1.5)	1.5 (1.2, 2.0)	1.5 (1.3, 1.7)
Median length of stay (days)	0	4	4	3
P for trend				<0.0001
Mortality				
People (no.)	24,907	2214	2169	2162
Events (no.)	5943	557	591	593
Unadjusted rate: per 1000 per year (95% CI)	79.5 (77.8, 81.3)	83.8 (77.8, 89.9)	90.8 (84.5, 97.1)	91.4 (85.2,97.7)
Adjusted relative rate (95% CI)	1	1.03 (0.94,1.13)	1.05 (0.96, 1.14)	1.23 (1.12,1.34)
P for trend				<0.0001
P for relative rate trend				<0.0001
Composite renal outcome (ESRD or doubling of serum creatinine)				
People (no.)	24,701	2160	2117	2129
Events (no.)	2157	198	183	214
Adjusted OR (95% CI)	1	0.82 (0.73,0.93)	0.86 (0.69,1.07)	0.88 (0.7,1.11)
P for trend				0.219

Abbreviations: CI, confidence interval; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; ESRD, end-stage renal disease; LDL, low-density lipoprotein; OR, odds ratio.
Adjusted for age, index eGFR, gender, income, aboriginal race, diabetic status, and all comorbidities noted in Table 1.

receiving hemodialysis, remote dwellers had higher rates of mortality, particularly from infectious causes.[17] In a large cohort of people residing in South Carolina, higher ESRD incidence was observed with those living in rural areas, with higher physician density having a protective effect on the incidence of ESRD.[18] In Queensland (Australia), higher mortality from renal causes was observed in indigenous people, and this disparity increased with increasingly remote residence locations.[19]

Our study has several limitations. First, we excluded people without a valid postal code, although this accounted for <2% of the effective study population. Second, the

classification of residence was based on postal codes available at the time of the index eGFR measurement. As some participants may have moved geographic locations during the study, this may have resulted in misclassification. However, as patients with higher illness burden are more likely to move closer to specialist care, updated data on residence location during follow-up would have been expected to strengthen the observed observations. Third, calculating distances between residences and nephrologists necessitated some approximations. In an attempt to reduce this imprecision we used relatively broad categories to reduce the risk of bias. Fourth, we assessed eGFR and proteinuria at a single time point, which could have introduced misclassification given the variability in these measures. Finally, although our hypothesis that remote residence location functions as a geographical barrier to good quality care is plausible and appealing, the relationship between health and residential area is complex. Rural–urban differences are intimately linked to variations in age, ethnicity, social economic status, and lifestyle as well as to geographic location.[20] Therefore, it is probable that patient characteristics differed between those living close to and remote from nephrologists, which may have influenced our findings. Although we attempted to control for differences in measured characteristics across distance categories, we cannot exclude the possibility of residual confounding. In addition, it is likely that (assuming our hypothesis is correct), health outcomes and the quality of care are worse for remote dwellers with other chronic conditions besides CKD.

Potential solutions to overcoming geographic barriers to good quality CKD care include education of patients and primary care physicians; enhanced recruitment of specialists to rural areas; increased use of traveling specialists and/or mobile multidisciplinary clinics; and more investment in telehealth technologies. Future studies in this area should aim to further examine social and structural processes that influence the delivery of health care in remote geographic locations.[20] Interventions should be aimed at the primary care level and will need to address education, as prevention and early intervention is likely needed to improve outcomes in remote rural dwelling patients.[21]

In conclusion, our study demonstrates that the likelihood of timely specialist visits for management of CKD decreases with increasing remote residence location among patients treated within a universal healthcare system in Alberta, Canada. Remote residence location was also associated with decreased likelihood of good quality CKD care and increasing risk of mortality and hospitalization. These findings suggest an opportunity for targeted intervention to improve outcomes in this population.

METHODS

Setting and participants

Data from the Alberta Kidney Disease Network[22] and the provincial health ministry (Alberta Health and Wellness) were used for this study. From all outpatients aged >18 years who had serum creatinine measured in Alberta at least once between 1 January 2005, and 31 December 2005, we selected those with eGFR <45 ml/min per 1.73 m^2, representing advanced stage 3 CKD. We excluded people with ESRD receiving dialysis or transplant before their first creatinine measurement in 2005 (their index date) from analysis ($n=1593$). The six-digit postal code for each person's residence location at the time of index date was obtained from the health ministry. Geographic information systems techniques were used to determine the distance by road (km) and projected travel time between each person's home and the office locations of all nephrologists and internal medicine specialists (internists) practicing in the province of Alberta. For each participant, we then determined the distance by road to the closest nephrologist and to the closest internist as previously described.[17] Distance between each person's residence and these facilities was then classified into the following categories: 0–50, 50.1–100, 100.1–200, and >200 km. The median household income for each postal code was obtained using data from the 2005 Canadian census.

Other measurements

We assessed comorbidity using physician claims and hospitalization data together with validated algorithms[23] for the variables listed in Table 1. We linked to outpatient laboratory data for all participants between 1 January 2004 to 31 December 2007, including serum creatinine, low-density lipoprotein cholesterol, HbA1C, and proteinuria (urinary albumin:ratio or dipstick urinalysis). In Alberta, medications are provided free of charge to all residents >65 years of age; thus we obtained data on drug utilization for ACEI, ARB, statin and other hypolipidemic agents for such participants.

Outcomes

The primary outcome for this study was all-cause mortality. All-cause mortality, dates of hospitalization, and the date of first renal replacement therapy for people who developed ESRD were determined by linkage to the provincial health ministry and the provincial renal databases.[22] We evaluated the occurrence of a composite renal outcome: ESRD or doubling of serum creatinine (as compared with the baseline value). Markers of good quality care were based on recent studies and clinical practice guidelines: visit to see a specialist (within 18 months of an index eGFR measurement <45 ml/min per 1.73 m^2);[24] urinary albumin tested at least once within 6 months following index eGFR <45 ml/min per 1.73 m^2;[4] glycated hemoglobin tested at least annually during follow-up for patients with diabetes;[25] at least one prescription for a statin among patients aged >66 with at least one low-density lipoprotein value >2.5 mmol/l within 6 months of index eGFR <45 ml/min per 1.73 m^2,[13,14] and at least one prescription for an ACEI or ARB among patients aged >66 years with diabetes or significant proteinuria (defined by one or more of the following: albumin:creatinine ratio >30 mg/mmol; or protein:creatinine ratio >50 mg/mmol; or 24 h protein of >300 mg identified within 6 months

of index eGFR <45 ml/min per 1.73 m^2).[10–12,26–29] In effect, physicians had at least 6 months following the index eGFR measurement to take action in response to an abnormal laboratory value. However, we allowed 18 months following index eGFR for specialist consultation to occur.

In the primary analysis, we considered that a specialist visit had occurred if the participant had at least one visit to a nephrologist or multidisciplinary CKD clinic[30] (based on claims to the health ministry). In a secondary analysis, we considered visits to a nephrologist, a multidisciplinary clinic or an internist to constitute appropriate referral. Because criteria for referral to nephrologists are controversial, we performed a second sensitivity analysis that used an eGFR threshold of <30 ml/min per 1.73 m^2 to define appropriate referral. Outcomes relating to medication use were restricted to participants aged $\geqslant 66$ years because this group has universal medication coverage from the provincial drug plan.

Statistical analysis

The baseline demographics and clinic characteristics by distance were given as mean or proportion. Logistic regression models were used to identify the association between distance and markers of good quality care, and to determine the likelihood of death, hospitalization or kidney failure among participants in the different distance categories after adjustment for the following potential confounders: age, gender, index eGFR, previous diabetes, individual health insurance premium level (a marker of individual-level income), median neighborhood income, and comorbidity. Adjusted models were built by using the forward stepwise selection method using a *P*-value of 0.05 for removal. Hosmer–Lemeshow goodness of fit was used to examine the appropriateness of the fitted models. Mean score and Cochran–Armitage methods were used to test for trend by distance. To account for correlation between participants who underwent creatinine measurement in the same health service region of the province, we performed all logistic regression models using robust estimates of variance, defining the cluster (grouping) variable by each health region. End-of-study date for all analyses was 31 December 2007.

We also performed several sensitivity analyses. First, we explored the potential effect of misclassification of distance within a given postal code by testing two extremes: first assuming that participants resided as close as possible to the closest nephrologist within their postal code, and second taking the opposite perspective. Second, in case for which data were missing, a category of unknown was created and entered into the model. Third, we reclassified participants with index eGFR <45 ml/min per 1.73 m^2 but subsequent values $\geqslant 45$ ml/min per 1.73 m^2 as being free from CKD. Fourth, to reduce the likelihood that the competing risk of death influenced findings related to the process-based outcomes, we repeated analyses after excluding all those that died within the ascertainment period (6 months following the index eGFR for all process-based outcomes except specialist referral, which was 18 months following the index eGFR).

The institutional review boards for the Universities of Alberta and Calgary approved the study. Analyses were performed using SAS 9.12 and Stata SE 10.1.

DISCLOSURE

All the authors declared no competing interests.

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