Article

Emergency Department Use among Patients with CKD: A Population-Based Analysis

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Abstract

Background and objectives Although prior studies have observed high resource use among patients with CKD, there is limited exploration of emergency department use in this population and the proportion of encounters related to CKD care specifically.

Design, setting, participants, & measurements We identified all adults (≥18 years old) with eGFR<60 ml/min per 1.73 m^2 (including dialysis-dependent patients) in Alberta, Canada between April 1, 2010 and March 31, 2011. Patients with CKD were linked to administrative data to capture clinical characteristics and frequency of emergency department encounters and followed until death or end of study (March 31, 2013). Within each CKD category, we calculated adjusted rates of overall emergency department use as well as rates of potentially preventable emergency department encounters (defined by four CKD-specific ambulatory care-sensitive conditions: heart failure, hyperkalemia, volume overload, and malignant hypertension).

Results During mean follow-up of 2.4 years, 111,087 patients had 294,113 emergency department encounters; 64.2% of patients had category G3A CKD, and 1.6% were dialysis dependent. Adjusted rates of overall emergency department use were highest among patients with more advanced CKD; 5.8% of all emergency department encounters were for CKD-specific ambulatory care-sensitive conditions, with approximately one third resulting in hospital admission. Heart failure accounted for over 80% of all potentially preventable emergency department events among patients with categories G3A, G3B, and G4 CKD, whereas hyperkalemia accounted for almost one half (48%) of all ambulatory care-sensitive conditions among patients on dialysis. Adjusted rates of emergency department events for heart failure showed a U-shaped relationship, with the highest rates among patients with category G4 CKD. In contrast, there was a graded association between rates of emergency department use for hyperkalemia and CKD category.

Conclusions Emergency department use is high among patients with CKD, although only a small proportion of these encounters is for potentially preventable CKD-related care. Strategies to reduce emergency department use among patients with CKD will, therefore, need to target conditions other than CKD-specific ambulatory care-sensitive conditions.

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Introduction

CKD affects approximately 10% of the adult population and is associated with increased morbidity and mortality (1–5). Prior studies have also observed high resource use among patients with CKD (6–9). The majority of these studies have focused on either inpatient use or emergency department (ED) use among patients with ESRD (8,10–13). There has been limited exploration of how patients with CKD use the ED and whether utilization is associated with disease severity.

Although the ED is essential for providing urgent or emergent care, identifying ways of improving ED efficiency and decreasing wait times has been recognized as a priority in multiple countries (14–16). Improving coordination and management of care for patients with multiple chronic conditions (the norm for CKD) in an outpatient setting may meet health care needs and ultimately, improve patient experience and outcomes while reducing the burden currently placed on the ED (17–19). However, this requires an understanding of ED use among patients with CKD and the proportion of use that is amenable to outpatient care.

Using a large population-based cohort, we explored how rates of ED use vary by kidney disease severity among nondialysis- and dialysis-dependent patients with CKD and the proportion of these events that is potentially preventable by high-quality ambulatory care. This foundational information will help determine if specific subgroups of patients with CKD could be targeted to reduce ED use and improve patient experience and outcomes.

Materials and Methods

Data Sources and Study Population

We conducted a retrospective cohort study using laboratory and administrative data from Alberta, Canada (20). The study population included Alberta residents ages 18 years old or older with CKD (nondialysis and dialysis dependent) between April 1, 2010 and March 31, 2011. CKD status was defined on the basis of the patient's first (index) outpatient serum creatinine measurement in 2010–2011 that equated to eGFR of <60 ml/min per 1.73 m^2 using the Chronic Kidney Disease Epidemiology Collaboration equation (21). CKD severity was categorized using Kidney Disease Improving Global Outcomes (KDIGO) guidelines as G3A (45–59 ml/min per 1.73 m^2), G3B (30–44 ml/min per 1.73 m^2), G4 (15–29 ml/min per 1.73 m^2), and G5 (<15 ml/min per 1.73 m^2) (22). Dialysis-dependent CKD (category G5D) was defined by receipt of chronic dialysis as captured by the provincial dialysis registry (23). We excluded patients who died on their index date and patients with kidney transplant before their index date due to inherent differences in health status and system usage within this patient subgroup (24,25).

Measurement of Covariates

Patients with CKD were linked to administrative data sources obtained from the provincial health ministry to capture additional clinical characteristics and measures of health care use. Patient-level characteristics included age, sex, registered First Nations status (all individuals registered under the Federal Indian Act), median neighborhood household income quintile, and urban/rural status. Presence of 28 comorbidities was ascertained on the basis of individual validated International Statistical Classification of Diseases and Health Related Problems, Ninth (ICD-9) and Tenth (ICD-10) Revisions coding algorithms (26). Presence of albuminuria was measured using a hierarchical combination of albumin-to-creatinine ratio (ACR), protein-to-creatinine ratio, or urine dipstick (UDIP; on the basis of availability) within the prior 2 years. Severe albuminuria (A3) was defined in accordance with KDIGO guidelines as ACR>300 mg/g (>30 mg/mmol), protein-to-creatinine ratio >500 mg/g (>50 mg/mmol), or UDIP of 2+ or more. Moderate albuminuria (A2) was defined as ACR between 30 and 300 mg/g (between 3 and 30 mg/mmol), protein-to-creatinine ratio from 150 to 500 mg/g (15–50 mg/mmol), or UDIP of trace or 1+. Normal/mild albuminuria (A1) was defined as ACR<30 mg/g (<3 mg/mmol), protein-to-creatinine ratio <150 mg/g (<15 mg/mmol), or normal UDIP (22). Outpatient primary care encounters in the 2-year period before index were categorized on the basis of the 25th and 75th percentiles as 0–7, 8–20, or >20 encounters. We also measured primary care continuity as defined by the proportion of outpatient primary care encounters made to a single provider in the prior 2 years (among those with at least three visits). This was categorized as 100%–75% (good attachment), 74%–50% (moderate attachment), or <50% (low attachment) (27,28). Finally, the proportion of patients with one or more visits to a nephrologist in the prior 2 years was captured.

Outcome—ED Utilization

We followed all patients from index date (first serum creatinine measurement that defined CKD status) until death, outmigration, or end of study (March 31, 2013). During this period, we recorded the count of ED encounters for each patient. We also identified specific encounter-level characteristics, including acuity (on the basis of the Canadian Emergency Department Triage and Acuity Scale [29] categorized as nonurgent, semiurgent, urgent, emergency, resuscitation, or unknown) and discharge disposition (admitted, died, or other). Multiple encounters on the same day were reported as one event. Of these multiple events, the one with the highest acuity or most serious discharge disposition was reported.

Identification of Potentially Preventable ED Use

Potentially preventable ED use was defined as acute care encounters for CKD-related ambulatory care-sensitive conditions (ACSCs). ACSCs are health conditions for which high-quality ambulatory care may prevent the need for acute care services (30,31), and they are recognized internationally as a quality indicator (32). Four CKD-specific ACSCs, including hyperkalemia, malignant hypertension, heart failure, and volume overload, were identified using previously defined ICD-9/ICD-10 coding algorithms (33,34). These were developed using a Delphi technique and have been used to identify ACSC encounters in patients with CKD in prior studies (34). The key difference between heart failure and volume overload as assessed using these algorithms is the latter comprising causes of extracellular fluid volume expansion not directly attributable to poor cardiac function.

Analyses

Patient characteristics and comorbidities were stratified by CKD category and described using proportions and means (SD) as appropriate. ED encounter-level characteristics were also reported across CKD category and reported as proportions. We also determined the top 10 most frequent diagnoses for all ED visits using the most responsible ICD-10 diagnostic code. Unadjusted rates of ED use (per 1000 person-years) were initially calculated. We then fit count models of the negative binomial family after testing for overdispersion, which was present in all patients, and estimated adjusted rates on the basis of these models. We adjusted for all of the demographic and clinical characteristics in Table 1, excluding nephrologist visits. Rates were adjusted to the sample proportions of the demographic and clinical characteristics of the cohort and reported by CKD category.

We repeated our analysis for CKD-specific ACSC ED use. The total number of ACSC encounters, characteristics of the encounters, and relative proportion of each CKD-specific ACSC were reported by CKD category. Similarly, unadjusted and fully adjusted rates for any ACSC encounter were calculated. Adjusted rates for ED encounters related to heart failure and hyperkalemia were also calculated by CKD category. Similar analyses could not be completed for malignant hypertension and volume overload given the small number of events and unreliable estimates obtained from the regression models. We used STATA 11.2 for all analyses (Stata Corp., College Station, TX). The Conjoint Health Research Ethics Board of the University of Calgary approved this study and granted waiver of patient consent.

Results

We identified 1,100,129 adults with at least one outpatient serum creatinine during the study period. After

Table 1. Cohort characteristics by CKD category (*n*=111,087)

Characteristics	CKD Category[a]					Overall, *n*=111,087
	G3A, *n*=71,347	G3B, *n*=28,020	G4, *n*=8653	G5 (Nondialysis), *n*=1305	G5 (Dialysis), *n*=1762	
Demographic characteristics						
Age, yr						
18–64	22.6	12.7	16.4	29.5	48.9	20.1
65–74	28.7	20.6	17.2	19.9	22.8	25.6
75–84	33.6	38.7	35.6	29.6	22.5	34.8
≥85	15.2	27.9	30.9	21.0	5.8	19.5
Mean (SD)	73.3 (11.8)	77.8 (11.5)	77.3 (13.1)	72.1 (15.3)	63.7 (15.8)	74.6 (12.2)
Women	58.0	59.6	57.7	51.2	41.8	58.1
First Nations	1.2	1.3	1.8	4.3	7.4	1.4
Urban/rural						
Urban	77.5	76.8	77.8	76.2	81.1	77.4
Rural	22.4	23.0	22.1	23.6	18.8	22.5
Unknown	0.1	0.2	0.1	0.2	0.1	0.1
Neighborhood income quintile (relative to Alberta)						
1 (Lowest)	27.3	29.6	31.5	29.6	29.2	28.3
2	23.2	24.5	24.3	22.6	25.4	23.7
3	17.4	17.0	16.0	17.8	16.0	17.2
4	15.0	13.3	12.7	12.3	11.6	14.3
5 (Highest)	14.6	12.7	12.2	13.2	12.9	13.9
Unknown	2.5	2.9	3.3	4.6	5.0	2.7
Albuminuria						
Normal/mild (A1)	62.2	51.5	34.8	14.0	1.8	55.9
Moderate (A2)	16.5	21.8	25.9	21.1	5.4	18.5
Severe (A3)	3.8	8.7	21.9	44.1	39.0	7.4
Unmeasured	17.5	18.0	17.3	20.8	53.8	18.2
Other comorbidities						
Alcohol misuse	2.7	3.2	4.2	6.1	7.6	3.1
Asthma	4.5	5.8	6.2	4.7	7.5	5.0
Atrial fibrillation	13.4	20.8	24.0	18.8	19.1	16.3
Cancer—lymphoma	0.8	1.0	1.4	1.6	2.0	1.0
Cancer—metastatic	1.6	2.2	2.2	2.9	2.9	1.8
Cancer—nonmetastatic	7.2	7.7	8.2	8.9	7.9	7.4
Congestive heart failure	14.4	27.0	38.2	34.6	43.9	20.2
Chronic pain	11.5	13.1	12.6	10.0	15.6	12.0
Chronic pulmonary disease	24.2	30.6	35.1	30.0	32.5	26.8
Chronic viral hepatitis B	0.1	0.1	0.1	0.2	0.8	0.1
Cirrhosis	0.4	0.7	1.0	0.8	1.9	0.6
Dementia	7.5	12.1	13.8	13.0	6.5	9.2
Depression	10.2	10.1	10.9	12.0	13.4	10.3
Diabetes	26.6	36.1	44.8	49.0	57.7	31.1

Table 1. (Continued)

Characteristics	CKD Category[a]					Overall, n=111,087
	G3A, n=71,347	G3B, n=28,020	G4, n=8653	G5 (Nondialysis), n=1305	G5 (Dialysis), n=1762	
Epilepsy	1.8	1.8	2.4	2.6	5.3	1.9
Hypertension	77.6	90.2	93.2	90.4	93.7	82.4
Hypothyroidism	20.6	23.2	23.3	18.5	15.4	21.3
Irritable bowel disease	1.5	1.5	1.8	1.8	2.4	1.6
Irritable bowel syndrome	3.4	3.3	3.4	3.5	2.7	3.4
Multiple sclerosis	0.6	0.6	0.5	0.7	0.8	0.6
Myocardial infarction	7.8	12.0	15.2	15.0	17.8	9.7
Parkinson disease	0.9	1.3	1.3	1.4	1.6	1.0
Peptic ulcer disease	0.4	0.5	0.9	1.0	1.5	0.5
Peripheral vascular disease	3.6	5.9	7.8	7.0	27.9	4.9
Psoriasis	1.2	1.4	1.4	1.2	1.1	1.3
Rheumatoid arthritis	5.1	6.5	7.2	4.1	7.8	5.6
Schizophrenia	1.4	1.4	1.5	1.9	1.6	1.4
Stroke	16.9	23.5	27.0	24.7	25.3	19.6
Total no. of chronic conditions, mean (SD)	2.8 (2.0)	3.8 (2.2)	4.6 (2.3)	4.5 (2.2)	5.2 (2.4)	3.3 (2.2)
Total no. of chronic conditions (excluding CKD), mean (SD)	2.7 (1.9)	3.4 (2.0)	3.9 (2.1)	3.7 (2.1)	4.2 (2.4)	3.0 (2.0)
Primary care use in 2 yr before index						
No. of GP visits in 2 yr before index						
0–7	26.0	20.1	20.3	28.7	47.7	24.5
8–20	51.2	49.6	45.4	43.7	35.9	50.0
>20	22.7	30.3	34.4	27.7	16.5	25.5
Median (25th, 75th percentile)	12 (7, 19)	14 (9, 23)	15 (9, 25)	13 (6, 22)	8 (3, 16)	13 (8, 21)
GP continuity						
Low (<50% with same GP)	8.8	8.2	8.4	11.6	11.1	8.7
Medium (50% to <75% with same GP)	24.4	23.5	23.3	23.4	21.0	24.0
High (≥75% with same GP)	62.1	63.8	62.8	55.2	45.4	62.2
Less than three GP visits (continuity not defined)	4.7	4.5	5.5	9.8	22.5	5.1
At least one visit with a nephrologist in prior 2 yr	3.2	11.6	36.8	63.9	99.7	10.2

GP, general practitioner.
[a]Percentage unless otherwise indicated.

excluding patients with eGFR≥60 ml/min per 1.73 m^2 and those who received a prior kidney transplant or died on their index date, our final cohort included 111,087 patients (Figure 1). Within this cohort, the majority had category G3A CKD (64.2%), whereas 1.2% and 1.6% had nondialysis- and dialysis-dependent category G5 CKD, respectively. The mean (SD) age of the cohort was 74.6 (12.2) years old. Patients on dialysis were younger than those with categories G3, G4, and G5 (nondialysis) CKD. Comorbidity burden also increased with CKD category. The mean (SD) number of chronic conditions was 3.3 (2.2), whereas patients on dialysis had an average of 5.2 (2.4) conditions. Primary care use was high in the 2-year period before index, with a median of 13 (interquartile range, 8–21) visits. However, primary care continuity was lower among patients with more advanced CKD, with 11.1% of patients on dialysis having low continuity (<50% with the same primary care physician). Conversely, the proportion of patients with at least one nephrologist visit increased with severity of disease (Table 1).

During an average follow-up of 2.4 years, 111,087 patients with CKD had 294,113 ED encounters (Table 2). Of these ED encounters, approximately one third resulted in an admission to the hospital, with similar proportions across disease severity. The acuity of the ED visits was often higher among patients with more advanced CKD, with patients on dialysis (category G5D) having a higher proportion of urgent or emergent visits to the ED. Figure 2 shows the graded association between adjusted rates of ED use and CKD category, with patients with G3A CKD having 849 (95% confidence interval [95% CI], 840 to 857) ED visits per 1000 person-years and patients on dialysis having 1798 (95% CI, 1686 to 1911) ED visits per 1000 person-years. The top 10 diagnoses for all ED visits among the CKD cohort are reported in Supplemental Appendix. The most frequent diagnoses were heterogeneous and

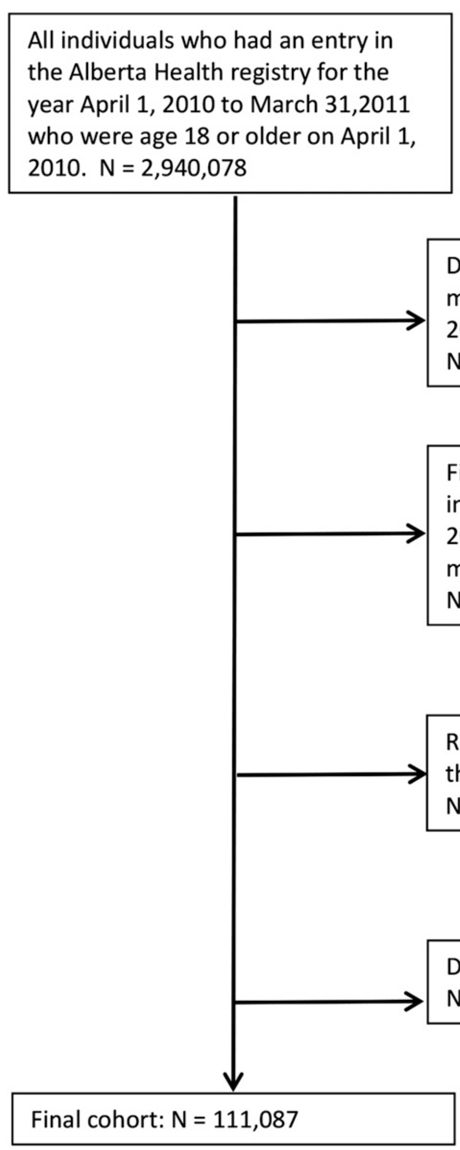

Figure 1. | **Flow diagram for cohort formation.**

Table 2. Encounter-level descriptive information for all emergency department visits in the CKD cohort (294,113 emergency department visits for 111,087 patients)

Encounter-level Variables	CKD Category				
	G3A, *n*=71,347	G3B, *n*=28,020	G4, *n*=8653	G5 (Nondialysis), *n*=1305	G5 (Dialysis), *n*=1762
No. of ED visits	162,806	83,384	31,461	6245	10,217
No. of person-yr	177,232	66,986	19,574	2808	4168
Unadjusted rate per 1000 person-yr (95% CI)	919 (914 to 923)	1245 (1236 to 1253)	1607 (1590 to 1625)	2224 (2169 to 2280)	2451 (2404 to 2499)
ED visits by discharge disposition,[a] %					
Admitted	23.9	29.8	35.1	33.0	33.0
Died	0.3	0.3	0.4	0.2	0.4
Other	75.8	69.8	64.4	66.8	66.5
ED visits by acuity level,[a] %					
Nonurgent	15.9	14.7	13.4	16.8	10.9
Semiurgent	28.4	27.4	25.6	24.0	22.1
Urgent	34.9	36.4	38.0	37.4	38.2
Emergency	13.7	14.7	16.4	15.8	22.4
Resuscitation	0.6	0.8	1.0	0.8	1.4
Unknown	6.4	6.0	5.6	5.2	5.0

ED, emergency department; 95% CI, 95% confidence interval.
[a]Where there was more one ED visit in a day, the one that was counted was the one rated with the highest acuity or the one with the most serious discharge disposition.

included (but were not limited to) ICD-10 codes for antibiotic therapy, urinary tract infections, and pain-related complaints.

Of the total number of ED encounters, 17,176 (5.8%) were for CKD-specific ACSCs (Table 3). The majority of these ACSC encounters resulted in a hospital admission (70.5% for category G5 disease), whereas a higher proportion of encounters resulting in death was observed among patients on dialysis (1.1%). The acuity of these ED encounters also showed a higher proportion of resuscitations and

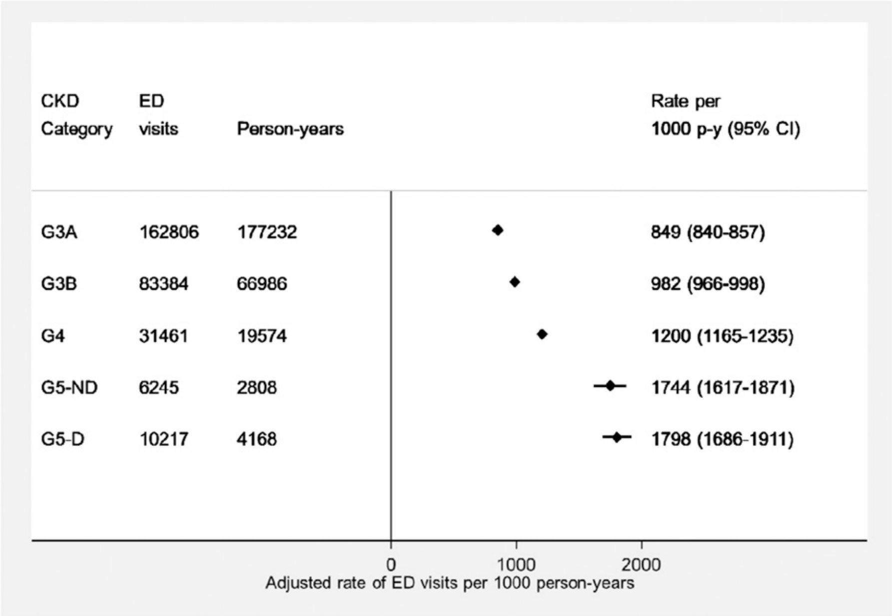

Figure 2. | Plot of increasing adjusted rates (95% confidence interval [95% CI]) of all emergency department (ED) visits per 1000 person years (p-y) by CKD category. Rates were adjusted to the sample proportions of the demographic and clinical characteristics in the cohort. G5-D, dialysis dependent; G5-ND, nondialysis.

Table 3. Encounter-level descriptive information for emergency department visits for a CKD-related ambulatory care-sensitive condition (17,176 emergency department visits for 111,087 patients)

Encounter-level Variables	CKD Category				
	G3A, n=71,347	G3B, n=28,020	G4, n=8653	G5 (nondialysis), n=1305	G5 (dialysis), n=1762
No. of ED visits for a CKD-related ACSC[a]	6687	6013	3363	465	648
Person-time, person-yr	177,232	66,986	19,574	2808	4168
Unadjusted rate per 1000 person-yr (95% CI)	38 (37 to 39)	90 (88 to 92)	172 (166 to 178)	166 (151 to 181)	155 (144 to 168)
ED visits for a CKD-related ACSC by discharge disposition,[b] %					
Admitted	59.9	62.4	65.4	70.5	57.4
Died	0.5	0.4	0.4	0.2	1.1
Other	39.7	37.1	34.2	29.2	41.5
ED visits for a CKD-related ACSC by acuity level,[b] %					
Nonurgent	4.8	4.8	4.2	1.5	1.4
Semiurgent	15.8	15.1	14.7	15.1	7.3
Urgent	43.7	43.0	44.0	44.9	43.5
Emergency	30.3	30.8	32.3	32.5	42.3
Resuscitation	1.6	1.8	2.0	3.2	3.5
Unknown	3.7	4.5	2.8	2.8	2.0
ED visits for a CKD-related ACSC by type of ACSC,[a] *n* (%)					
Heart failure	5896 (88.2)	5163 (85.9)	2715 (80.7)	309 (66.5)	264 (40.7)
Hyperkalemia	809 (12.1)	896 (14.9)	645 (19.2)	148 (31.8)	316 (48.8)
Volume overload	39 (0.6)	30 (0.5)	62 (1.8)	23 (4.9)	109 (16.8)
Malignant hypertension	24 (0.4)	8 (0.1)	8 (0.2)	1 (0.2)	2 (0.3)

ED, emergency department; ACSC, ambulatory care-sensitive condition; 95% CI, 95% confidence interval.
[a]The number represents the number of days with at least one CKD-related ACSC ED visit of that type, and therefore, the total number of CKD-related ACSC ED visits does not equal the total across type of ACSC.
[b]Where there was more than one ED visit in a day, the one that was counted was the one rated with the highest acuity or the one with the most serious discharge disposition.

emergency events for patients on dialysis. The most common ACSC was heart failure, accounting for over 80% of all potentially preventable events among patients in categories G3A, G3B, and G4 and 66% among patients in category G5 (nondialysis). Encounters for hyperkalemia were also common, particularly among patients on dialysis, in whom this condition accounted for almost one half (48.8%) of all ACSCs recorded. Volume overload was also substantially higher in patients on dialysis (16.8%) compared with those with lower categories of disease (ranging from 0.5% to 4.9%), whereas the proportion of ED encounters for malignant hypertension was similar across all categories of CKD.

Adjusted rates for any ACSC encounters were higher among patients with more advanced CKD and highest among patients with category G5 CKD (nondialysis; 85.4; 95% CI, 69.9 to 100.9 ED visits per 1000 person-years) (Figure 3). When examining specific ACSCs, a U-shaped relationship was observed for encounters related to heart failure, with the highest ED rates among patients with category G4 (61.0; 95% CI, 56.0 to 66.0 ED visits per 1000 person-years) and lower rates among patients with category G5 CKD (nondialysis and dialysis dependent). A linear trend was observed for hyperkalemia, with the highest rates among patients with nondialysis-dependent category G5 CKD (22.9; 95% CI, 16.7 to 29.1 ED visits per 1000 person-years) and dialysis-dependent patients (22.4; 95% CI, 17.2 to 27.5 ED visits per 1000 person-years).

Discussion

In this large population-based cohort, we examined the association between CKD severity and ED utilization and found that overall rates of ED use were higher among patients with more advanced CKD and particularly high among dialysis-dependent patients. Furthermore, a small proportion (approximately 6%) of total ED use was for potentially preventable CKD-specific ACSCs. These findings suggest that strategies to reduce ED use among patients with CKD will need to be broad, although strategies targeting CKD-specific ACSCs may reduce a small but potentially important proportion of these ED encounters.

Prior studies have shown that health care use is high among patients with CKD and related to the medical complexity of this patient population (6–9,35). However, to our knowledge, few studies have examined the association between CKD category and use of ED services or have quantified the relative proportion of ED use that is for

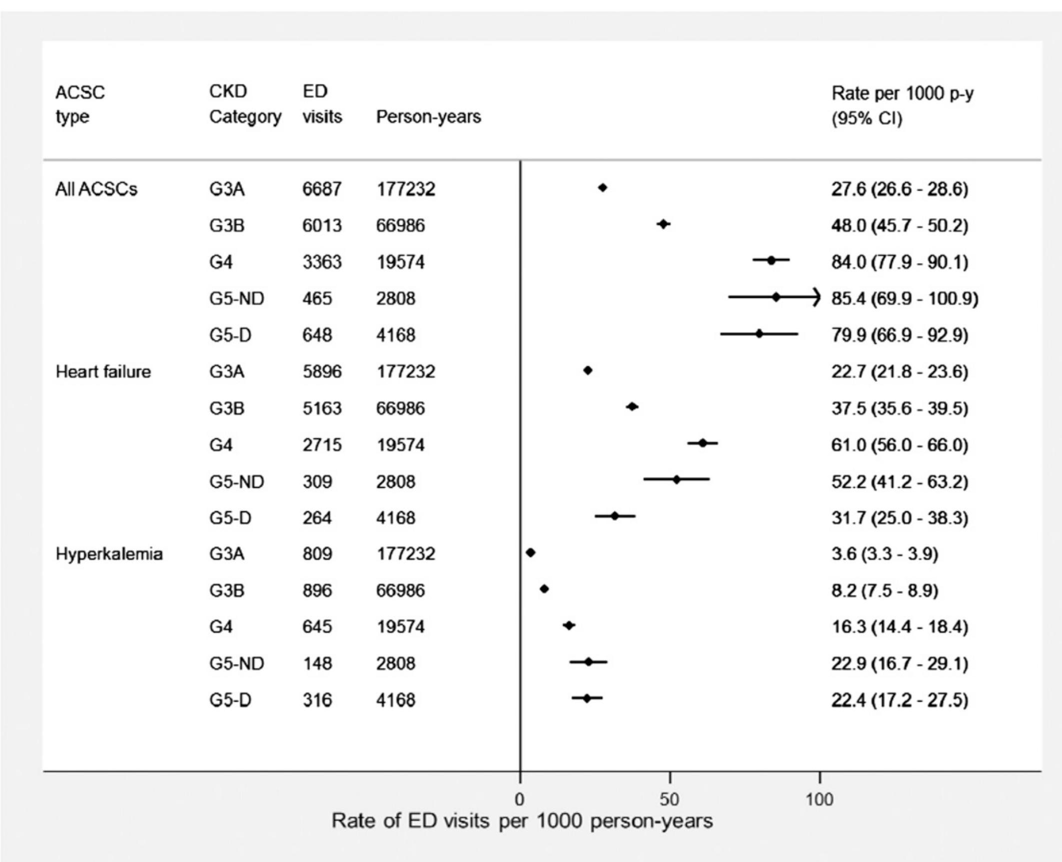

Figure 3. | Plot of adjusted rates (95% confidence intervals [95% CIs]) of emergency department (ED) visits for overall CKD-related ambulatory care sensitive conditions (ACSCs) per 1000 person years (p-y), heart failure, and hyperkalemia individually by CKD category. Rates were adjusted to the sample proportions of the demographic and clinical characteristics in the cohort. G5-D, dialysis dependent; G5-ND, nondialysis.

CKD-specific ACSCs. We found that the majority of CKD-specific ambulatory care-sensitive events were related to heart failure and hyperkalemia: conditions that are highly prevalent and key drivers of morbidity and mortality among patients with CKD (34,35). Despite the relatively low frequency of CKD-specific ACSCs, targeting patients with CKD at high risk of ED presentation for these two conditions could potentially improve the patient experience and clinical outcomes at modest cost if reductions in CKD-related ED use could be realized. However, any intervention would likely need to be modified for dialysis-dependent patients compared with those at milder stages of CKD.

With respect to prevention of hyperkalemia, educational strategies aimed at reducing sources of dietary potassium (36) and the use of standardized dialysate potassium protocols in the hemodialysis unit are examples of current strategies used for patients on dialysis (37,38). For heart failure, our results suggest that patients in earlier stages of disease progression could be targeted to potentially reduce the risk of ED encounters for this condition. Interventions to improve adherence to fluid restriction as well as methods of renin-angiotensin-aldosterone system inhibition have been shown to be effective therapies in heart failure, although the latter is not used in advanced CKD or among dialysis-dependent patients given the increased risk of hyperkalemia (39). Although this suggests that addressing hyperkalemia may improve the treatment of heart failure in this patient population, whether interventions aimed at one or both of these conditions could reduce ED utilization for hyperkalemia and/or heart failure is unknown and represents an area of future inquiry.

Regardless, our results must be put in context of overall ED use. The fact that 94% of ED encounters among patients with CKD were not related to CKD-specific care suggests that we should be focusing on not only interventions aimed at specific ACSCs *per se* but also, other medical conditions that seem to be driving overall ED use within this population. A better understanding of the comorbid profiles of patients with CKD, their health care needs, and the circumstances that result in presentation to the ED would be valuable when proposing strategies to improve care for patients with multimorbidity. This is particularly true for patients with early stages of CKD or underlying mental illness [a known driver of health care use in this population (34)], in whom early detection and integrated management strategies could mitigate downstream acute care use. Furthermore, improving coordination of care/attachment strategies for patients with CKD represents another avenue to potentially reduce overall ED use. We observed that primary care continuity decreased among patients with more advanced CKD; however, this may relate to the higher proportion of patients being cared for by a nephrologist with kidney disease progression. Greater continuity of care has been associated with decreases in ACSC encounters (40,41). Improving attachment to primary care among patients with CKD may, therefore, be an intervention that should be considered for future research in this patient population.

Our study should be interpreted in light of its limitations. First, we classified patients as having CKD on the basis of a single eGFR measurement, which may have resulted in misclassification. Second, the construct of ambulatory care-sensitive ED encounters likely represents a spectrum of preventability that requires consideration of other aspects of patient care, including use of outpatient and specialist services. Further to this point, CKD-specific ACSCs represent only a proportion of all ACSCs that have been proposed in the literature (42) and therefore, underestimate the total proportion of ED use that is potentially preventable. Third, two of four ACSCs considered were related to excess extracellular fluid volume. It is possible that there may be some overlap in the clinical application of the different administrative codes that constitute each condition, which may partially explain the U-shaped relationship observed between CKD category and rates of ED encounters for heart failure (*i.e.*, a greater proportion of physicians coding heart failure as volume overload among dialysis-dependent patients). Fourth, although we did show that patients with more severe disease have lower primary care continuity, there are likely other important patient- and system-level factors related to coordination of care that may place patients with CKD at increased risk for ED use for CKD-specific events. Fifth, although we were able to measure a number of clinical and demographic characteristics, we were unable to account for all of the social determinants of health that may influence the risk of ED presentation. Despite these limitations, our study has as a number of strengths, including the use of population-based data within a single province of Canada, which provides a unique opportunity to assess the association between CKD and ED use. Furthermore, the use of linked provincial laboratory and administrative data sources also allowed for accurate identification of eGFR, albuminuria, and clinical characteristics as well as an in-depth exploration of ED use among this cohort.

Although the ED remains critical for providing care to those with acute medical needs, identifying ways of improving ED efficiency remains a priority. We found that ED use is high among patients with CKD, and a small but important proportion of these ED encounters is potentially preventable CKD-specific events. Future work is needed to determine if improvements in community-based care or dialysis treatments could potentially mitigate the number of CKD-related ED events for heart failure and hyperkalemia, respectively. However, strategies to target other chronic conditions (other than from CKD-specific conditions) will need to be considered in attempts to reduce overall ED use in this high-risk population. This will require a better understanding of the interplay between concurrent morbidity and health care needs among patients with CKD.

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Disclosures

None.

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