Agreement Between Administrative Database and Medical Chart Review for the Prediction of Chronic Kidney Disease G category

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Abstract

Background: Chronic kidney disease (CKD) is a major health issue and cardiovascular risk factor. Validity assessment of administrative data for the detection of CKD in research for drug benefit and risk using real-world data is important. Existing algorithms have limitations and we need to develop new algorithms using administrative data, giving the importance of drug benefit/risk ratio in real world.

Objective: The aim of this study was to validate a predictive algorithm for CKD GFR category 4-5 (eGFR < 30 mL/min/1.73 m² but not receiving dialysis or CKD G4-5ND) using the administrative databases of the province of Quebec relative to estimated glomerular filtration rate (eGFR) as a reference standard.

Design: This is a retrospective cohort study using chart collection and administrative databases.

Setting: The study was conducted in a community outpatient medical clinic and pre-dialysis outpatient clinic in downtown Montreal and rural area.

Patients: Patient medical files with at least 2 serum creatinine measures (up to 1 year apart) between September 1, 2013, and June 30, 2015, were reviewed consecutively (going back in time from the day we started the study). We excluded patients with end-stage renal disease on dialysis. The study was started in September 2013.

Measurement: Glomerular filtration rate was estimated using the CKD Epidemiological Collaboration (CKD-EPI) from each patient’s file. Several algorithms were developed using 3 administrative databases with different combinations of physician claims (diagnostics and number of visits) and hospital discharge data in the 5 years prior to the cohort entry, as well as specific drug use and medical intervention in preparation for dialysis in the 2 years prior to the cohort entry.

Methods: Chart data were used to assess eGFR. The validity of various algorithms for detection of CKD groups was assessed with sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Results: A total of 434 medical files were reviewed; mean age of patients was 74.2 ± 10.6 years, and 83% were older than 65 years. Sensitivity of algorithm #3 (diagnosis within 2-5 years and/or specific drug use within 2 years and nephrologist visit ≥ 4 within 2-5 years) in identification of CKD G4-5ND ranged from 82.5% to 89.0%, specificity from 97.1% to 98.9% with PPV and NPV ranging from 94.5% to 97.7% and 91.1% to 94.2%, respectively. The subsequent subgroup analysis (diabetes, hypertension, and < 65 and ≥ 65 years) and also the comparisons of predicted prevalence in a cohort of older adults relative to published data emphasized the accuracy of our algorithm for patients with severe CKD (CKD G4-5ND).

Limitations: Our cohort comprised mostly older adults, and results may not be generalizable to all adults. Participants with CKD without 2 serum creatinine measurements up to 1 year apart were excluded.

Conclusions: The case definition of severe CKD G4-5ND derived from an algorithm using diagnosis code, drug use, and nephrologist visits from administrative databases is a valid algorithm compared with medical chart reviews in older adults.

Abrégé

Contexte: L’insuffisance rénale chronique (IRC) est un problème de santé majeur et un facteur de risque cardiovasculaire. La validité de la détection de l’IRC à partir des bases de données administratives est importante pour les études évaluant en situation réelle les bénéfices et les risques des médicaments. Les algorithmes existants comportent des limites et, compte tenu de l’importance revêtue par ce rapport bénéfices/risques, le développement de nouveaux algorithmes utilisant les bases de données administratives s’avère essentiel.
**Objectif:** Valider le pouvoir prédictif d’un algorithme pour détecter l’insuffisance rénale chronique sévère (DFGe < 30 mL/min/1.73 m², patient non-dialysé ou CKD G4-5ND) à partir des banques de données administratives de la province de Québec, avec le débit de filtration glomérulaire estimé (DFGe) comme point de référence.

**Type d’étude:** Étude de cohorte rétrospective réalisée à partir des dossiers médicaux et de données administratives.

**Cadre:** Des cliniques médicales communautaires et de protection rénale de Montréal et des régions rurales périphériques.

**Sujets:** Les dossiers médicaux de patients avec au moins deux mesures de la créatinine sérique (en moins d’un an) entre le 1er septembre 2013 et le 30 juin 2015 ont été revus consécutivement, en reculant dans le temps. Les patients avec insuffisance rénale terminale et dialysés ont été exclus. L’étude a débuté en septembre 2013.

**Mesures:** Le DFGe a été estimé à l’aide de la formule CKD Epidemiological Collaboration (CKD-EPI) à partir du dossier médical de chaque patient. Nous avons développé différents algorithmes en utilisant trois banques de données administratives avec différentes combinaisons de facturations médicales (diagnostics et nombre de visites en néphrologie) et de données colligées au congé de l’hôpital dans les cinq ans précédant l’entrée dans la cohorte, de même qu’avec la consommation de certains médicaments et les interventions médicales subies en préparation à la dialyse dans les deux ans précédant l’entrée dans la cohorte.

**Méthodologie:** Les données des dossiers médicaux ont été utilisées pour définir le DFGe. La validité des algorithmes développés a été évaluée en utilisant la sensibilité, la spécificité, la valeur prédictive positive (VPP) et la valeur prédictive négative (VPN).

**Résultats:** En tout, 434 dossiers médicaux ont été revus; l’âge moyen des patients était de 74.2 ± 10.6 ans et 83% avaient plus de 65 ans. La sensibilité de l’algorithme no.3 (diagnostic dans un délai de 2 à 5 ans et/ou l’usage de médicaments spécifiques dans un délai de 2 ans, et au moins quatre visites médicales en néphrologie dans les 2 à 5 ans précédant la date d’entrée dans la cohorte) dans l’identification d’une insuffisance rénale sévère (CKD G4-5ND) variait de 82.5% à 89.0%. La spécificité de ce même algorithme variait de 97.1% à 98.9% avec une PPV et une NPV allant respectivement de 94.5% à 97.7% et de 91.1% à 94.2%. L’analyse de sous-groupes (patients diabétiques, hypertendus, âgés de moins de 65 ans ou âgés de 65 ans et plus) ainsi que la comparaison de la prévalence prédite dans une cohorte de patients âgés par rapport aux données de la littérature font valoir la précision de notre algorithme pour les patients avec insuffisance rénale sévère (CKD G4-5ND).

**Limites:** Notre cohorte était composée essentiellement de sujets âgées, les résultats pourraient ne pas s’appliquer à tous les adultes. Les patients n’ayant pas eu deux mesures de la créatinine sérique à l’intérieur d’un an ont été exclus.

**Conclusion:** Chez les personnes âgées, la définition de cas pour une insuffisance chronique rénale sévère (CKD G4-5ND) estimée par un algorithme utilisant les codes diagnostiques, la consommation de médicaments spécifiques et les services médicaux de néphrologie tirés des données administratives s’avère un algorithme valide comparativement à l’examen du dossier médical.

**Keywords**
chronic kidney disease, eGFR, administration database, predictive positive value, population-based study

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(eGFR). Our algorithm (#3) has an excellent specificity and positive predictive value to detect severe kidney failure (CKD G4-5ND), which is the subgroup of CKD patients more at risk and hence more of interest.

Introduction

Chronic kidney disease (CKD) is an important public health burden associated with increased morbidity, mortality, and substantial health care costs worldwide. Approximately 11% of the adult population and 25% of individuals >70 years of age have CKD G3-5ND in North America; CKD is an important clinical endpoint in various medical conditions such as diabetes, hypertension, cardiovascular disease, and use of certain drugs; and it is also a risk factor for cardiovascular disease and death and larger use of health care resources. Detection and management of CKD have a significant impact by reducing the incidence of cardiovascular disease, the rate of progression of kidney function as well as the rate of adverse events by optimizing drug management and health care costs.

Measuring serum creatinine and estimating GFR are recommended in all patients with any risk factor for CKD (Canadian Society of Nephrology guidelines and predictive model of CKD). Following initial evaluation, if CKD is detected, routine evaluation of GFR is the standard of care. In pharmacoepidemiologic studies at the population level, databanks are a central tool but they often miss specific clinical data (eg, BP measurements) and lab results (eg, creatinine). Whether it is for cardiovascular assessment or mortality risk factors, as a clinical endpoint in specific diseases or conditions, or simply as justification for drug use and dose, identifying CKD is a very valuable addition to any pharmacoepidemiologic study regarding cardiovascular morbidity and mortality, hypertension, diabetes, or drug use.

Two systematic reviews have recently assessed the validity of existing data sources to identify CKD and showed major discrepancies in sensitivity values ranging from 3% to 88%. In addition, most of the studies included in those reviews had some transferability flags, such as a lack of a valid reference standard or the development of algorithms without consideration for the period of time, number of codes or medical services, and specific drug uses to define disease. Studies of CKD validation have reported that administrative databases are not recommended for CKD surveillance but may be a useful tool when an algorithm with high specificity is required, such as in pharmacoepidemiologic research. We aimed to determine the validity of a more accurate algorithm derived from administrative data (Quebec, Canada) for identifying severe CKD (G4-5) compared with the reference standard of estimated glomerular filtration rate (eGFR).

Materials and Methods

Design, Setting, and Patients

This is a retrospective diagnostic accuracy study of administrative data using a cohort of patients followed in 2 community outpatient medical clinics in Montreal (CMFU-Notre-Dame in downtown Montreal) and Valleyfield (Group of Familial Medicine Medival) and 2 pre-dialysis clinics in downtown Montreal and Valleyfield, Quebec, Canada. Medical files of patients 23 years and older receiving follow-up care in one of these clinics, with at least 2 serum creatinine measures (up to 1 year apart) between September 1, 2013, and June 31, 2015, were studied consecutively (going back in time from the day we started the study). The date of cohort entry was the date of the first eGFR during the period of 2013 to 2015. Patients had to be insured by the Régie de l’Assurance Maladie du Québec (RAMQ) drug plan for at least 2 years prior to the cohort entry. We collected the administrative data from RAMQ medical services and Med-Echo for data on hospitalizations for the last 5 years prior to the cohort entry.

Patients treated with peritoneal dialysis or hemodialysis in the 3 months prior to the date of cohort entry were excluded. In addition, to reduce the impact of possible episodes of acute kidney injury, laboratory measurements associated with hospital admission were also excluded. The selection of the study population is shown in Figure 1. We obtained approvals from institutional research ethics boards of the Centre Hospitalier de l’Université de Montréal (CHUM) and the Commission d’Accès à l’Information du Québec (CAI, provincial ethics body), as well as approval to waive requirement for patient consent.

Data Collection and Sources

Baseline patient characteristics and treatment were collected by retrospective chart review. These data were de-identified and merged with the administrative health databases (RAMQ and Med-Echo) from September 1, 2013, to June 30, 2015. The administrative records of hospitalization and medical services were provided in the 5-year period prior to the cohort entry, and the pharmaceutical files in the 2-year period prior to cohort entry.

The administrative health databases contain information about patient demographics, inpatient and outpatient International Classification of Disease (ICD-9 and ICD-10) diagnostic codes, and the physician claim database; however, no lab results are available, and were therefore retrieved from individual chart review. The acute care hospitalization data include admission and discharge dates, primary diagnosis, physician information, procedures, up to 18 secondary diagnosis (ICD-9/10) codes, and the length of stay. The physician database contains information on physician services such as dates and location of the visits, diagnostic code
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Total of patients in RAMQ database

Source population: Patients with e-GFR in three centers cohort study of patients followed in the outpatient medical clinic of Montreal and Valleyfield, Quebec, Canada (GMF of Montreal Center, GMF of peripheral region, Valleyfield, and Montreal Center and Valleyfield of pre-dialysis clinic). Eligible patients for inclusion must have had a second creatinine measurement within 1 year of their first, to confirm baseline eGFR. The date of cohort entry was the date of the first e-GFR during the period of 2013-2015.

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Inclusion criteria

Age > 23 at index date

Continuous coverage by RAMQ drug plan for the 2 years preceding the index date

No renal transplantation within the 10 years preceding the index date

No hemodialysis/peritoneal dialysis within the 3 months preceding the index date

Stable e-GFR between two measurements (50% or less for patients with <30 mL/min, and 30% or less for patients with >30 mL/min)

Number of patients selected in the cohort

434

586

(Excluded)

444

142

444

442

2

434

(8)

Figure 1. Flow chart of the study population.

Assessment of Kidney Function and Defining CKD

We estimated eGFR using the CKD Epidemiological Collaboration (CKD-EPI). Based on the eGFR, CKD was classified as CKD G3 (<60 mL/min/1.73 m²) and CKD G4-5 (<30 mL/min/1.73 m²). The date of cohort entry was the date of the first eGFR for classification of CKD. The CKD-EPI creatinine equation is the accurate method for estimating GFR for diverse populations.

Administrative Data to Define CKD

Using the unique provincial health insurance identifier, all patient files were linked to the administrative databases. To identify relevant ICD-9 and ICD-10 codes to define CKD, a detailed review of the literature was performed. Eight articles, all in adult populations, and one systematic review on the validity of administrative database coding for kidney disease were found. Based on these studies and expert opinion, we selected diagnostic codes and assessed the frequency at which these codes appeared within the physician claims database and Med-Echo database among patients with CKD (Table S3). We identified the codes with the highest frequencies to be ICD-9 585, 403, or 404 and ICD-10 N18, I12, or I13, which we then used to define the algorithms

(ICD-9), and provider specialty. The pharmaceutical database contains outpatient prescription information on patients with provincial medication insurance, representing more than 95% of the older adult population.

The RAMQ and Med-Echo databases have been used extensively to perform pharmacoepidemiologic studies. Data recorded in RAMQ prescription files (outpatient only) have been evaluated and found to be comprehensive and valid, as were medical diagnoses in the Med-Echo database.
for CKD (Table S4). The resulting algorithms thus defined
CKD for each patient using administrative data with differ-
ent combinations of physician visits and hospital discharge
data within the 5 years prior to the cohort entry. We first
defined CKD G 3-5ND with algorithm 1 and 2 (with spe-
cific medications); then CKD G 4-5ND with algorithm 1
and 2 with the inclusion of ≥ 4 outpatient medical visits to
a nephrologist for algorithm 3; then CKD G5ND with algo-
rithm 4. By elimination, patients who were not classified in
the G 3-5ND group using the algorithms above were auto-
matically classified in the CKD G 1-2.

Algorithm 1 (diagnostic codes only) (1) one physician
claim or one hospital discharge as primary or secondary
diagnosis within 2, 3, and 5 years; (2) two physician claims
or one hospital discharge within 2, 3, and 5 years; and (3)
three physician claims or one hospital discharge within 2, 3,
and 5 years.

Algorithm 2 (diagnostic codes and/or use of a specific
drug for CKD): algorithm 1 with the addition of specific
medications and doses used in CKD. The outpatient medica-
tions included in the definition were selected based on
previous research and expert opinion.33 As medications can
be used for indications other than CKD, we included strict
parameters in the algorithm to maximize specificity.
Specifically, we included users of medications including
carbonate calcium (≥1500 mg daily), and/or furosemide
(≥20 mg daily), and/or specific dosage of calcitriol, alfa-
calcidol, doxercalciferol, and/or any dosage of sevelamer,
lanthanum, cinacalcet, darbepoetin, or erythropoietin in
the 2 years prior to the index date (Table S5).

Algorithm 3 (diagnostic and/or use of a specific
drug for CKD and ≥4 nephrology visits): algorithm 2 with the inclu-
sion of ≥4 outpatient medical visits to a nephrologist within
2, 3, and 5 years prior to the cohort entry.

Algorithm 4 (diagnostic codes and/or use of a specific
drug for CKD and nephrology visit ≥4 or medical pro-
cedures): algorithm 3 for CKD G4-5ND with the addition of
either nephrology visits within 2, 3, and 5 years prior to the
cohort entry or the presence of medical procedures in prepa-
ration for peritoneal dialysis or hemodialysis, or duplex
ultrasound of forearms in the 2 years prior to the index date.

Subgroups Analysis

We assessed the case definitions across different subgroups
in our cohort, defined by administrative databases, as either
older or younger than 65 years, gender, presence or absence
of diabetes, and presence or absence of hypertension among
patients with G4-5ND. These 3 cohorts represent subgroups
of patients particularly at risk for CKD.

Comparison With a Cohort of Older Adults

Using algorithm 3 for a 5-year period case definition, we
proceeded to assess the predicted prevalence of CKD
G4-5ND among a cohort of older adults based on a 40% ran-
dom sample of individuals in the province of Quebec for the
period of January 2010 to December 2015, compared with
literature data. We evaluated the prevalence of CKD G4-5ND
among age groups including 66-69, 70-74, 75-79, and ≥80
years for men and women of the total cohort, with 2 further
subgroups of patients having a diagnosis of diabetes, and
those with a diagnosis of chronic heart failure, both groups of
patients at higher risk of CKD. We selected 2 subcohorts
among the total cohort to assess the ascertainment of CKD
G4-5ND among patient with diabetes using ICD-9 codes
(ICD-9: 250.xx, 357.2x, 362.0x, 366.41/ICD-10: E8, E9,
E10, E11, E13) and chronic heart failure (ICD-9 code “428.0,
428.1, 428.9” or ICD-10 code I50.0, I50.1, I50.9) in the
5-year period prior to the cohort entry (Table S4).48,49

Statistical Analyses

Descriptive statistics of the population were stratified by
eGFR using 2 algorithms. We reviewed the medical records of
patients selected in a community setting in 3 different Quebec
centers over 2013 to 2015, to estimate the sensitivity, specifi-
city, positive predictive values, and negative predictive values
of the diagnostic CKD codes, medications used, and medical
visits for nephrology using the Quebec administrative data-
bases. Validity indices were estimated for each case definition
combination using laboratory data as the reference standard.

Sensitivity was defined as the proportion of patients clas-
sified by the algorithm as having a given eGFR among all
patients within this eGFR category in clinical charts. Specific-
ity was defined as the proportion of patients classified
by the algorithm as not having a given eGFR among all
patients within this eGFR category as defined by medical
charts. We defined positive predictive value (PPV) as the propor-
tion of patients who were assigned a given eGFR in medical
charts among all patients classified by the algorithm
as being in the selected eGFR category. We defined negative
predictive value (NPV) as the proportion of patients who
were not assigned a given eGFR in medical charts among all
patients classified by the algorithm as not being in the eGFR
category. All analyses were planned a priori and conducted
using SAS statistical software, release 9.4 (SAS Institute
Inc., Cary, NC).

Sample Size Calculation

In this retrospective study, sample size was determined by
considering the number of elements included in the algo-
rithm, 10 patients per element, for each level of eGFR, and
with an alpha error of 0.05.50 The elements considered com-
prised medical visits, diagnosis of CKD, use of drugs, and
medical interventions in preparation for dialysis. Patients’
charts were reviewed consecutively up to the required num-
ber. A total of 434 medical files were studied, of which 154
participants had G4-5ND, including 41 from the pre-dialysis
Results

Patient Characteristics

A total of 434 patients met the inclusion criteria (Figure 1). Demographic and main clinical characteristics of these patients stratified by disease stage are shown in Table 1 (supplementary data are presented in Table S1). Mean age varied between 71.8 and 75.2 (74.2 ± 10.6) years, 83% of them being older than 65, and 48.1% to 63.4% of patients were female. When measured with administrative data in the 5 years prior to the index date, >90% of patients with G4-5ND had a diagnosis of CKD, while approximately 65% of patients with G3-5ND had such a diagnosis. Chronic kidney disease patients had a higher number of medical services compared with those without CKD (defined as G1-2). They also presented a higher prevalence of diabetes and hypertension compared with patients without CKD. In addition, the identification of diabetes and hypertension using administrative data closely resembled to the retrospective chart review.

Estimated Glomerular Filtration Rate Validation

The validity of administrative data in determining the presence of CKD compared with the reference standard (G4-5ND) varied across case definitions and length of administrative data observation (Table 2). Across the different algorithms tested, sensitivity ranged from 82.5% to 99.4%, specificity ranged from 76.1% to 98.9%, PPV ranged from 69.5% to 97.7%, and NPV ranged from 91.1% to 99.5%. Algorithm 2, using diagnosis and/or specific drug use, presented the least favorable validity results with respect to algorithms 1 and 3. On the contrary, algorithm 1, using diagnosis only, led to high estimates of sensitivity, specificity, and NPV (around >90%), where the PPV was a little lower (estimates ranging around >80%); and algorithm 3 led to similar estimates, but sensitivity estimates were lower. These results suggest that algorithm 1 favors the identification of true cases but increases chances of identifying false positives, while the addition of drug marker and nephrologist visits (algorithm 3) favors the identification of true positives by the algorithm, but also false negatives. To prioritize a higher specificity, algorithm 3 with its minimum 3-year observation period led to the most stable and optimal results.

Subgroup Analysis of Predicted CKD G4-5NDn

As shown in Table 4, we compared case definitions to the reference standard G4-5ND, in subgroups according to age, sex, diabetes, or hypertension, and found high sensitivity, specificity, PPV, and NPV estimates.

Comparison of Predicted Prevalence of CKD 4-5NDn Among an Older Adult Cohort

Demographic and clinical characteristics according to gender of the selected cohort of older adults can be found in Table S2. The results of our case definition for CKD G4-5ND were stratified by age group and gender among older adult patients with additional distinctions for those with diabetes, and those with chronic heart failure, as shown in Table 5. Among men aged 66-69, 70-74, 75-79, and ≥80 years old, the predicted prevalence of CKD G4-5ND was 1.7%, 2.3%, 3.1%, and 4.3%, respectively; the corresponding values were 1.0%, 1.3%, 2.0%, and 2.5% for women of the same age groups, respectively.

The predicted prevalence of CKD G4-5ND among older men with diabetes was 4.2%, 5.0%, 5.9%, and 7.2% for age groups 66-69, 70-74, 75-79, and ≥80 years, respectively; and those estimates were 2.7%, 3.4%, 4.4%, and 4.5% for women of the same age groups, respectively.

The predicted prevalence of G4-5ND among older men with chronic heart failure was 9.6%, 11.7%, 11.2%, and 11.3% for age groups 66-69, 70-74, 75-79, and ≥80 years, respectively; and those estimates for similarly grouped women were 8.5%, 8.7%, 10.0%, and 7.5%, respectively.

Discussion

We assessed the validity of an algorithm in the Quebec (Canada) administrative databank (RAMQ) to detect severe
Table 1. Demographic and Clinical Characteristics of CKD Patients and Non-CKD Patients as Reference According to Chart Review and Administrative Databases.

| CKD              | Clinical data (n = 41) | Databases* (n = 41) | Clinical data (n = 154) | Databases* (n = 154) | Clinical data (n = 276) | Databases* (n = 276) | Clinical data (n = 158) | Databases* (n = 158) |
|------------------|------------------------|---------------------|-------------------------|----------------------|-------------------------|----------------------|-------------------------|----------------------|
|                  | N (%)                  | N (%)              | N (%)                   | N (%)                | N (%)                   | N (%)                | N (%)                   | N (%)                |
| Age (mean ± SD)  | 71.8 (13.0)            | 72.8 (11.8)        | 75.2 (11.1)             | 72.5 (9.4)           | 74.7 ± 11.2             | 74.5 ± 12.4          | 6 (3.8)                 |
| Female (%)       | 26 (63.4)              | 74 (48.1)          | 143 (51.8)              | 93 (58.9)            | 93 (58.9)               | 93 (58.9)            | 0                       |
| eGFR (first value) (mean ± SD) | 11.6 ± 1.7            | 18.4 ± 5.4         | 30.9 ± 15.6             | 74.7 ± 11.2          | 74.7 ± 11.2             | 74.7 ± 11.2          | 0                       |
| eGFR (second value) (mean ± SD) | 13.6 ± 2.7            | 19.3 ± 5.7         | 32.2 ± 16.6             | 74.5 ± 12.4          | 74.5 ± 12.4             | 74.5 ± 12.4          | 0                       |
| Chronic kidney disease 5-year prior index date (%) | 38 (92.7)             | 149 (96.8)         | 181 (65.6)              | 6 (3.8)              | 63 (39.9)               | 63 (39.9)            | 0                       |
| Health care use 5 years prior index date | Nephrology community visit (mean ± SD) | —                  | 11.1 ± 8.5              | —                    | 6.6 ± 7.9               | —                    | 0.04 ± 0.3              |
|                  | Nephrology community visits (median) | —                  | 10                     | 3                    | 3                       | 3                    | 0                       |
|                  | Peritoneal dialysis or hemodialysis procedures in the last 2 years (%) | —                  | 9 (22.0)               | 15 (9.7)             | 16 (5.8)               | —                    | 0                       |
| Comorbidities 5 years prior index date (%)⁵ | Diabetes | 27 (65.9) | 99 (65.6) | 148 (54.2) | 72 (45.9) | — | — | — | — |
|                  | DX in the last 5 years | — | 29 (70.7) | 108 (70.1) | 151 (54.7) | — | 63 (39.9) | — | — |
|                  | Procedure in the last 5 years | — | 20 (48.8) | 75 (48.7) | 100 (36.2) | — | 27 (17.1) | — | — |
|                  | RX in the last 2 years | — | 26 (63.4) | 95 (61.7) | 137 (49.6) | — | 68 (43.0) | — | — |
|                  | DX or procedure or RX | — | 29 (70.7) | 108 (70.1) | 157 (56.9) | 72 (45.6) | — | — | — |
| Hypertension     | 40 (97.6)             | 144 (94.1)         | 248 (90.2)             | 122 (77.2)           | 122 (77.2)             | —                    | —                       |
|                  | DX in the last 5 years | — | 38 (92.7) | 127 (82.5) | 206 (74.6) | — | 86 (54.4) | — | — |
|                  | RX in the last 2 years | — | 38 (92.7) | 145 (94.2) | 249 (90.2) | — | 124 (78.5) | — | — |
|                  | DX or RX | 40 (97.6) | 150 (97.4) | 256 (92.8) | 128 (81.0) | — | — | — | — |
| Renal medication 2-year prior index date (%)⁶ | Calcium carbonate (≥ 1500 mg/day) | 5 (12.2) | 18 (11.7) | 18 (6.5) | — | 0.04 ± 0.3 | — | — |
|                  | Calcitriol (yes vs no) | 4 (9.8) | 5 (3.3) | 5 (1.8) | 0 | 0 | 0 | — | — |
|                  | Sevelamer (yes vs no) | 5 (12.2) | 8 (5.2) | 8 (2.9) | 0 | 0 | 0 | — | — |
|                  | Doxercalciferol (yes vs no) | 0 | 0 | 0 | 0 | 0 | 0 | — | — |
|                  | Alfacalcidol (yes vs no) | 8 (19.5) | 29 (18.8) | 29 (10.5) | 0 | 0 | 0 | — | — |
|                  | Cinacalcet (yes vs no) | 0 | 0 | 0 | 0 | 0 | 0 | — | — |
|                  | Lanthanum (yes vs no) | 1 (2.4) | 1 (0.7) | 1 (0.4) | 0 | 0 | 0 | — | — |
|                  | Erythropoietin (yes vs no) | 0 | 0 | 0 | 0 | 0 | 0 | — | — |
|                  | Darbepoietin (yes vs no) | 18 (43.9) | 48 (31.2) | 48 (17.4) | 0 | 0 | 0 | — | — |
|                  | Furosemide (mg/day) | ≥ 20 mg | 29 (70.7) | 101 (65.6) | 13 (48.2) | 17 (10.8) | 0 | 0 | — |
|                  |                  | ≥ 40 mg | 24 (58.5) | 78 (50.7) | 102 (37.0) | 5 (3.2) | 0 | 0 | — |
|                  |                  | ≥ 80 mg | 17 (41.5) | 47 (30.5) | 60 (21.7) | 0 | 0 | 0 | — |

Note. CKD = chronic kidney disease; eGFR = estimated glomerular filtration rate; DX = diagnostic; RX = medication; SD = standard deviation.

*Administrative databases are RAMQ/Med-Echo.

†Diagnosis definition with ICD-9/10 codes (ICD-9 585, 403, 404, ICD-10 N18, I12, I13) found in Table S4, drug markers found in Table S5.

‡Specific dosages found in Table S5.

§No multiple myeloma.
The results show that algorithm 3 has a sensitivity ranging from 82.5% to 89.0%, specificity from 97.1% to 98.9%, PPV from 94.5% to 97.7%, and NPV from 91.4% to 94.2% for detection of CKD G4-5ND. The increasing validity measurement was highly dependent on the number of variables of administrative

| Case definition | Sensitivity, % (95% CI) | Specificity, % (95% CI) | PPV, % (95% CI) | NPV, % (95% CI) |
|-----------------|--------------------------|--------------------------|----------------|----------------|
| **Algorithm 1:** diagnosis only within 2 to 5 years | | | | |
| 1 claim or 1 hospitalization in 2 years | 95.5 (91.4-97.9) | 90.7 (88.5-92.1) | 85.0 (81.4-87.1) | 97.3 (94.9-98.8) |
| 1 claim or 1 hospitalization in 3 years | 95.5 (91.3-97.9) | 88.9 (86.7-90.3) | 82.6 (79.0-84.7) | 97.3 (94.8-98.7) |
| 1 claim or 1 hospitalization in 5 years | 96.8 (92.8-98.8) | 86.4 (84.3-87.5) | 79.7 (76.4-81.3) | 98.0 (95.5-99.2) |
| 2 claims or 1 hospitalization in 2 years | 92.2 (87.8-95.3) | 91.8 (89.4-93.3) | 86.1 (82.0-89.0) | 95.5 (93.0-97.3) |
| 2 claim or 1 hospitalization in 3 years | 93.5 (89.2-96.4) | 90.4 (88.0-92.0) | 84.2 (80.3-88.6) | 96.2 (93.7-97.9) |
| 2 claim or 1 hospitalization in 5 years | 94.8 (90.6-97.4) | 88.9 (86.6-90.4) | 82.5 (78.8-84.8) | 96.9 (94.4-98.5) |
| 3 claims or 1 hospitalization in 2 years | 89.0 (84.3-92.5) | 91.8 (89.2-93.7) | 85.6 (81.1-89.1) | 98.0 (95.5-99.2) |
| 3 claim or 1 hospitalization in 3 years | 92.9 (88.5-95.9) | 90.4 (87.9-92.0) | 84.1 (80.1-86.9) | 95.8 (93.3-97.6) |
| 3 claim or 1 hospitalization in 5 years | 94.2 (89.9-97.0) | 89.3 (86.9-98.0) | 82.9 (79.1-85.3) | 96.5 (94.0-98.2) |
| **Algorithm 2:** diagnosis within 2 to 5 years and/or specific drug use within 2 years | | | | |
| 1 claim or 1 hospitalization in 2 years OR 2-year selected drugs | 98.7 (95.2-99.8) | 78.6 (76.7-79.2) | 71.7 (69.2-72.5) | 99.1 (96.7-99.8) |
| 1 claim or 1 hospitalization in 3 years OR 2-year selected drugs | 98.7 (95.2-99.8) | 78.2 (76.3-78.8) | 71.4 (68.8-72.1) | 99.1 (96.7-99.8) |
| 1 claim or 1 hospitalization in 5 years OR 2-year selected drugs | 99.4 (96.1-99.9) | 76.1 (74.3-76.4) | 69.5 (67.3-70.0) | 99.5 (97.2-99.9) |
| 2 claims or 1 hospitalization in 2 years OR 2-year selected drugs | 97.4 (93.5-99.2) | 79.3 (77.1-80.2) | 72.1 (69.2-73.4) | 98.2 (95.6-99.4) |
| 2 claim or 1 hospitalization in 3 years OR 2-year selected drugs | 98.1 (94.3-99.5) | 78.9 (76.9-79.7) | 71.9 (69.2-73.0) | 98.7 (96.1-99.7) |
| 2 claim or 1 hospitalization in 5 years OR 2-year selected drugs | 98.1 (94.3-99.5) | 77.9 (75.8-78.6) | 70.9 (68.2-71.9) | 98.6 (96.1-99.6) |
| 3 claims or 1 hospitalization in 2 years OR 2-year selected drugs | 96.8 (92.7-98.8) | 79.3 (77.1-80.4) | 72.0 (69.0-73.5) | 97.8 (95.0-99.2) |
| 3 claim or 1 hospitalization in 3 years OR 2-year selected drugs | 98.1 (94.3-99.5) | 78.9 (76.9-79.7) | 71.9 (69.2-73.0) | 98.7 (96.1-99.7) |
| 3 claim or 1 hospitalization in 5 years OR 2-year selected drugs | 98.1 (94.3-99.5) | 78.2 (76.2-79.0) | 71.2 (68.5-72.3) | 98.6 (96.1-99.6) |
| **Algorithm 3:** diagnosis within 2 to 5 years and/or specific drug use within 2 years and nephrologist visit ≥4 within 2 to 5 years | | | | |
| 1 claim or 1 hospitalization in 2 years OR 2-year selected drugs and visit in 2 years | 83.1 (79.6-84.6) | 98.9 (97.0-99.7) | 97.7 (93.6-99.4) | 91.4 (89.7-92.1) |
| 1 claim or 1 hospitalization in 3 years OR 2-year selected drugs and visit in 3 years | 88.3 (84.8-90.0) | 98.6 (96.6-99.5) | 97.1 (93.3-99.0) | 93.9 (92.0-94.8) |
| 1 claim or 1 hospitalization in 5 years OR 2-year selected drugs and visit in 5 years | 89.0 (85.1-91.5) | 97.1 (95.0-98.5) | 94.5 (90.3-97.2) | 94.1 (92.0-95.5) |
| 2 claims or 1 hospitalization in 2 years OR 2-year selected drugs and visit in 2 years | 82.5 (79.0-83.9) | 98.9 (97.0-99.7) | 97.7 (93.6-99.4) | 91.1 (89.4-91.8) |
| 2 claims or 1 hospitalization in 3 years OR 2-year selected drugs and visit in 3 years | 88.3 (84.8-90.0) | 98.6 (96.6-99.5) | 97.1 (93.3-99.0) | 93.9 (92.0-94.8) |
| 2 claims or 1 hospitalization in 5 years OR 2-year selected drugs and visit in 5 years | 89.0 (85.2-91.2) | 97.9 (95.8-99.1) | 95.8 (91.8-98.2) | 94.2 (92.2-95.3) |
| 3 claims or 1 hospitalization in 2 years OR 2-year selected drugs and visit in 2 years | 83.1 (79.6-84.6) | 98.9 (97.0-99.7) | 97.7 (93.6-99.4) | 91.4 (89.7-92.1) |
| 3 claims or 1 hospitalization in 3 years OR 2-year selected drugs and visit in 3 years | 88.3 (84.8-90.0) | 98.6 (96.6-99.5) | 97.1 (93.3-99.0) | 93.9 (92.0-94.8) |
| 3 claims or 1 hospitalization in 5 years OR 2-year selected drugs and visit in 3 years | 89.0 (85.1-91.5) | 97.1 (95.0-98.5) | 94.5 (90.3-97.2) | 94.1 (92.0-95.5) |

Note. CI = confidence interval; CKD = chronic kidney disease; NPV = negative predictive value; OR = odds ratio; PPV = positive predictive value.
data used. A final case definition employing 3 physician claims or 1 hospitalization within a 5-year period and/or specific use of drug in the last 2-year period and at least 4 nephrologist visits in the last 5-year period offered the best results with a sensitivity of 89.0%, specificity of 97.1%, PPV of 94.5%, and NPV of 94.1%. Regarding the validity of the administrative case definitions of CKD G3-5ND and CKD G5ND, there was low variation across case definitions and length of administrative data observation, but estimates were not as accurate as those of G4-5ND compared with the reference standard.

However, the accuracy of these case definitions would still make them useful for research purposes; for instance, NPV value for the patients with CKD G1-2 was at 90.9% and 98.3% for CKD G5 (eGFR $< 15 \text{ mL/min/1.73 m}^2$).

In the subgroup analysis (diabetes, hypertension, and different age groups) with our final case definition (algorithm 3) for CKD G4-5ND compared with the reference standard, we observed similar estimates specificity as reported in the study by Ronksley et al.,29 but much better sensitivity, PPV and NPV.

### Table 3. Validity of Case Definitions Compared to the Reference Standard of CKD G5ND.

| Case definition                                                                 | Sensitivity, % (95% CI) | Specificity, % (95% CI) | PPV, % (95% CI) | NPV, % (95% CI) |
|--------------------------------------------------------------------------------|-------------------------|-------------------------|----------------|----------------|
| Algorithm 4: diagnosis within 2 to 5 years and/or use of specific drug within 2 years and nephrologist visit ≥ 4 within 2 to 5 years or medical procedure within 2 years | 85.4 (71.0-93.8) 75.1 (73.6-75.9) 26.3 (21.9-28.9) 98.0 (96.0-99.2) | 87.8 (73.7-95.4) 73.3 (71.8-74.1) 25.5 (21.4-27.7) 98.3 (96.3-99.4) | 87.8 (73.7-95.4) 72.0 (70.5-72.8) 24.7 (20.7-26.8) 98.3 (96.3-99.3) | 82.9 (68.2-92.2) 75.1 (73.5-76.0) 25.8 (21.2-26.8) 97.7 (95.7-98.9) |

Note. CI = confidence interval; NPV = negative predictive value; OR = odds ratio; PPV = positive predictive value.

### Table 4. Validity of Selected Case Definition (Using Algorithm 3 Within 5 Years), Compared to Reference Standard G4-5ND, Stratified by Subgroups Defined in Administrative Database.

| Gender | Sensitivity, % (95% CI) | Specificity, % (95% CI) | PPV, % (95% CI) | NPV, % (95% CI) |
|--------|-------------------------|-------------------------|----------------|----------------|
| Female (n = 236) | 85.1 (78.1-89.5) | 96.3 (93.1-98.3) | 91.3 (83.8-96.0) | 93.4 (90.3-95.4) |
| Male (n = 198) | 92.5 (87.3-94.5) | 98.3 (94.8-99.7) | 97.4 (91.9-99.5) | 95.1 (91.7-96.4) |
| Age | | | | |
| <65 (n = 68) | 84.4 (74.1-84.4) | 100.0 (90.9-100.0) | 100.0 (87.9-100.0) | 87.8 (79.8-87.8) |
| ≥65 (n = 366) | 90.2 (85.5-93.2) | 96.7 (94.4-98.3) | 93.2 (88.4-96.4) | 95.2 (92.9-96.7) |
| Diabetes | | | | |
| Yes (n = 229) | 89.8 (85.2-92.2) | 96.7 (92.6-98.9) | 96.0 (91.1-98.6) | 91.4 (87.5-93.4) |
| No (n = 205) | 87.0 (77.3-92.4) | 97.5 (94.7-99.0) | 90.9 (80.9-96.6) | 96.3 (93.5-97.8) |
| Hypertension | | | | |
| Yes (n = 384) | 88.7 (84.7-91.3) | 96.6 (94.0-98.2) | 94.3 (90.1-97.1) | 93.0 (90.5-94.6) |
| No (n = 50) | 100.0 (47.5-100.0) | 100.0 (47.5-100.0) | 100.0 (47.5-100.0) | 100.0 (47.5-100.0) |

Note. CI = confidence interval; NPV = negative predictive value; PPV = positive predictive value.
Prevalence of eGFR in Quebec older adults with diabetes

| Age group | Men | Women |
|-----------|-----|-------|
| 66-69     | n = 22 209 | n = 26 545 |
| 70-74     | n = 20 906 | n = 24 540 |
| 75-79     | n = 12 829 | n = 16 243 |
| ≥80       | n = 12 265 | n = 21 292 |
| Total     | n = 68 209 | n = 88 620 |

Prevalence of eGFR in Quebec older adults with chronic heart failure

| Age group | Men | Women |
|-----------|-----|-------|
| 66-69     | n = 1246 | n = 4992 |
| 70-74     | n = 1558 | n = 5247 |
| 75-79     | n = 1342 | n = 4127 |
| ≥80       | n = 2019 | n = 5238 |
| Total     | n = 6165 | n = 6289 |

Prevalence of eGFR in the whole Quebec cohort of older adults

| Age group | Men | Women |
|-----------|-----|-------|
| 66-69     | n = 68 209 | n = 88 620 |
| 70-74     | n = 20 906 | n = 16 243 |
| 75-79     | n = 12 829 | n = 21 292 |
| ≥80       | n = 12 265 | n = 88 620 |
| Total     | n = 68 209 | n = 88 620 |

Note. eGFR = estimated glomerular filtration rate.
Conclusions

We suggest that our case definition of CKD G4-5ND derived from a composite of diagnosis code, drug use, and nephrologist visits using administrative databases is a valid algorithm when compared with medical chart reviews for older adults with CKD.

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Disclosure Statement

Drs Perreault, Roy, Zappitelli, White-Guay, Lafrance, and Mr Dorais report no disclosures.

Ethics Approval and Consent to Participate

We obtained approvals from institutional research ethics boards of the Centre Hospitalier de l’Université de Montréal (CHUM) and the Commission d’Accès à l’Information du Québec (CAI, provincial ethics body), as well as approval to waive requirement for patient consent.

Consent for Publication

All authors consent for publication.

Availability of Data and Materials

Deidentified patient data from medical information, RAMQ and Med-Echo administrative databases are not available according to the rules of Commission d’accès à l’Information du Québec (CAI, provincial ethics body).

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Trial Registration

Trial registration number is not applicable because this is a retrospective study.

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Supplemental Material

Supplemental material for this article is available online.

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