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Health Services Use and Outcomes for Hospital Admissions With a Major Cardiovascular Event Recorded in Health Care Administrative Data in Patients Receiving Maintenance Hemodialysis: A Retrospective Cohort Study

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Abstract

Background: Administrative data are used in studies of hemodialysis care to report cardiovascular-related hospitalizations. Showing recorded events are associated with significant health care resource use and poor outcomes would confirm that administrative data algorithms identify clinically meaningful events.

Objective: The objective of this study was to describe the 30-day health service use and outcomes when a hospital admission with myocardial infarction, congestive heart failure, or ischemic stroke is recorded in administrative databases.

Design: This is a retrospective review of linked administrative data.

Patients and Setting: Patients receiving maintenance in-center hemodialysis in Ontario, Canada, between April 1, 2013, and March 31, 2017, were included.

Measurements: Records from linked health care databases at ICES in Ontario, Canada were considered. We identified hospital admission with the most responsible diagnosis recorded as myocardial infarction, congestive heart failure, or ischemic stroke. We then assessed the frequency of common tests, procedures, consultations, post-discharge outpatient drug prescriptions, and outcomes within 30 days following the hospital admission.

Methods: We used descriptive statistics to summarize results using counts and percentages for categorical variables and means with standard deviations or medians with quartile ranges for continuous variables.

Results: There were 14368 patients who received maintenance hemodialysis between April 1, 2013, and March 31, 2017. The number of events per 1000 person-years was 33.5 for hospital admissions with myocardial infarction, 34.2 for congestive heart failure, and 12.9 for ischemic stroke. The median (25th, 75th percentile) duration of hospital stay was 5 (3-10) days for myocardial infarction, 4 (2-8) days for congestive heart failure, and 9 (4-18) days for ischemic stroke. The chance of death within 30 days was 21% for myocardial infarction, 11% for congestive heart failure, and 19% for ischemic stroke.

Limitations: Events, procedures, and tests recorded in administrative data can be misclassified compared with medical charts.

Conclusions: In patients receiving maintenance hemodialysis, hospital admissions of major cardiovascular events routinely recorded in health administrative databases are associated with significant use of health service resources and poor health outcomes.

Abrégé

Contexte : Les données administratives sont utilisées pour signaler les hospitalisations liées aux maladies cardiovasculaires dans les études portant sur les soins en hémodialyse. Montrer que les événements signalés sont associés à une utilisation importante des ressources en santé et à une évolution défavorable confirmerait que les algorithmes de données administratives identifient les événements cliniquement significatifs.

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Objectif: Décrire les interventions et l'évolution de l'état de santé sur une période de 30 jours lorsqu'une hospitalisation pour infarctus du myocarde, insuffisance cardiaque congestive ou accident vasculaire cérébral (AVC) ischémique est enregistrée dans les bases de données administratives.
Type d'étude: Revue rétrospective de bases de données administratives couplées.
Sujets et cadre de l'étude: Patients sous hémodialyse chronique en milieu hospitalier en Ontario (Canada) entre le 1er avril 2013 et le 31 mars 2017.
Mesures: Les dossiers provenant des bases de données couplées de l'ICES en Ontario (Canada). Nous avons répertorié les hospitalisations dont le diagnostic principal enregistré était un infarctus du myocarde, une insuffisance cardiaque congestive ou un AVC ischémique. Nous avons ensuite évalué la fréquence des examens, des procédures, des consultations, des ordonnances de médicaments en consultation externe après la sortie de l'hôpital et des résultats dans les 30 jours suivant l'hospitalisation.
Méthodologie: Nous avons utilisé des statistiques descriptives pour résumer les résultats. Des décomptes et pourcentages ont été utilisés pour les variables catégoriques; des moyennes avec écarts-types ou des médianes avec des intervalles de quartiles ont été utilisées pour les variables continues.
Résultats: En tout, il y avait 14 368 patients sous hémodialyse chronique entre le 1er avril 2013 et le 31 mars 2017. Le nombre d'événements par 1 000 années-personnes était de 33,5 pour les hospitalisations avec infarctus du myocarde, de 34,2 avec insuffisance cardiaque congestive et de 12,9 pour AVC ischémique. La durée médiane (25^e, 75^e percentile) de l'hospitalisation était de 5 (3 à 10) jours pour l'infarctus du myocarde, de 4 (2 à 8) jours pour l'insuffisance cardiaque congestive et de 9 (4 à 18) jours pour l'AVC ischémique. Le risque de décès dans les 30 jours était de 21 % pour l'infarctus du myocarde, de 11 % pour l'insuffisance cardiaque congestive et de 19 % pour l'AVC ischémique.
Limites: Les événements, les procédures et les examens enregistrés dans les bases de données administratives peuvent être sujets à des erreurs de classification par rapport aux dossiers médicaux.
Conclusion: Chez les patients sous hémodialyse chronique, les hospitalisations enregistrées dans les bases de données administratives à la suite d'événements cardiovasculaires majeurs sont associées à une utilisation importante des ressources en santé et à une évolution défavorable de l'état de santé.

Keywords
cardiovascular diseases, myocardial infarction, congestive heart failure, ischemic stroke, epidemiology, hospitalization, death, administrative data, outcomes, health service use

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Introduction

Maintenance hemodialysis provides life-preserving treatment for persons whose kidneys have failed (approximately 3 million worldwide and 23 000 in Canada).[1,2] Cardiovascular disease is a leading cause of morbidity and mortality in this population. An estimated 400 000 individuals worldwide (2500 in Canada) are annually admitted to a hospital or die from a major cardiovascular-related event.[3-5] Codes in large administrative health care databases are increasingly used in quality improvement initiatives, observational studies, and randomized trials to identify major cardiovascular-related hospitalizations in patients receiving maintenance hemodialysis.[6-8] Knowing these recorded events are associated with significant health care resource use and poor outcomes would confirm that administrative data algorithms identify clinically meaningful events.

In the general population, codes for hospital admission with myocardial infarction, congestive heart failure, and ischemic stroke have moderate to high sensitivity, specificity, and positive predictive values compared with medical charts as the reference standard (Supplemental Appendix 1). These operating characteristics are one reason for the growing interest in using routinely collected health care data in

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the general population to record events in randomized trials. There are also ongoing efforts to ensure results will be similar regardless of the event recording method.[9-17]

Extending such studies to the hemodialysis population would help confirm the utility of these health care database codes.[7,8] Knowing these records are associated with significant health care utilization use (eg, cardiovascular-related procedures, cardiology consultations, outpatient drug prescriptions) and poor outcomes (eg, death) would give researchers more confidence in their clinical significance. For example, suppose a patient on hemodialysis had a hospital stay of fewer than 48 hours with congestive heart failure. It could suggest such events are simply from inadequate fluid removed on hemodialysis, which is easily correctable with an additional hemodialysis session rather than a more meaningful event.

This study is one step in informing the use of administrative databases to identify major cardiovascular events in patients receiving hemodialysis. Our main objective was to describe 30-day health service use and outcomes after a patient receiving maintenance hemodialysis have a hospital admission record for myocardial infarction, congestive heart failure, or ischemic stroke. Our 30-day outcomes following hospital admission, included death, in- and out-of-hospital resource use, health care utilization, and cost estimates.

Methods

This study followed the Reporting of Studies Conducted Using Observational Routinely-Collected Health Data (RECORD) guidelines for observational studies (Supplemental Appendix 2).[18]

Design and Setting

We conducted a retrospective review of administrative data in Ontario, Canada. We identified a cohort of patients receiving outpatient in-center maintenance hemodialysis between April 1, 2013, and March 1, 2017. Ontario had approximately 13.5 million residents with universal health care and physician services in 2013.[19] There were just over 100 hemodialysis units in the province during the study period that provided hemodialysis sessions to about 8000 patients at any time.[20]

Data Sources

We ascertained patient-level information using records from linked health care databases in Ontario, Canada. Supplemental Appendices 3 and 4 provide a list and brief description of data sources and algorithms used for this study. The data sets were linked using unique encoded identifiers and analyzed at ICES. ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement.[21] The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a Research Ethics Board (REB).

Patients

We created this cohort in the same way as a province-wide clinical trial called MyTEMP.[7,8] Briefly, we included patients receiving maintenance in-center hemodialysis on April 1, 2013, or who began treatment between April 1, 2013, and March 1, 2017, through the Ontario Renal Reporting System (ORRS). The ORRS database captures permanent and temporary changes in an individual's care trajectory. We applied a 90-day stability rule for inclusion to ensure individuals were stable on their in-center hemodialysis modality. This rule removes patients (1) who are acute or chronic (eg, patients who received temporary dialysis due to acute kidney injury) and (2) who are intended for a different modality (ie, pre-emptive kidney transplant with a brief need for dialysis or intended home dialysis). We excluded records with invalid Ontario Health Insurance Plan (OHIP) numbers ($<$0.05% of records), missing or invalid sex ($<$0.05% of records), and people younger than 18 or older than 105 years (0.06% of records). We followed patients after their cohort entry date until their first hospital admission for a cardiovascular event, death, receipt of a kidney transplant, switch to a modality other than in-center hemodialysis, emigration from the province, or end of the study period, whichever came first. Analysis was restricted to the first hospital admission for a cardiovascular event, as our prior analysis showed that after an initial event, less than 10% of patients have a subsequent cardiovascular event during the follow-up period.[8,22]

Hospital Admissions With Cardiovascular Events

We considered all hospital records for which the most responsible diagnosis was myocardial infarction, congestive heart failure, or ischemic stroke (Supplemental Appendix 1). These cardiovascular events are accurately recorded for the general population in provincial databases and demonstrate both high sensitivity and specificity.[7,8] In addition, we described the median follow-up time to each event and the corresponding event rate per 1000 person-years.

Among patients who experienced each major cardiovascular event, we searched for standard tests, procedures, consultations, and outpatient drug prescriptions within 30 days of the date of hospital admission. Examples of care processes include receiving coronary bypass revascularization, acute antithrombotic therapy, a coronary angiogram, a cardiac stent, carotid imaging, an electrocardiogram, an echocardiogram, a chest x-ray, Holter monitoring / telemetry / loop recording, a stress test, pacemaker implantation, non-invasive and invasive ventilation, head imaging, and receipt of serum troponin testing (where results were only available through

linked laboratory data between April 2013 and September 2015). We also identified new prescriptions dispensed from outpatient pharmacies for beta-blockers, clopidogrel, anticoagulants (direct oral anticoagulant or warfarin), and statins; these were limited to patients eligible for Ontario Drug Benefit (~90% of patients) and discharged and alive 30 days from the hospitalization of interest. We also searched for inpatient and outpatient billing consults with cardiologists, cardiac surgeons, and neurologists. In addition, we examined the length of stay in the hospital, intensive care unit (ICU), cardiac care unit, and stroke unit. We also counted the number of deaths during the hospital stay and within 30 days of hospital admission. Supplemental Appendix 4 has the administrative data algorithms used to capture the abovementioned outcomes. Finally, we estimated the individual-level costs within 30 days of the respective hospital admission. These estimates are based on a validated cost algorithm that calculates the cost of admission from the public payer's perspective by assigning average costs in Canadian dollars for each component of care provided in several health care databases (Supplemental Appendix 5).[23]

Analysis

We used descriptive statistics to summarize results using counts and percentages for categorical variables and means with standard deviations or medians with 25th and 75th percentiles for continuous variables. We reported our primary outcomes as rates per 1000 person-years. All analyses used SAS version 9.4 (SAS Institute, Cary, NC). Estimates of health care costs were reported in 2017 Canadian dollars.

Results

Cohort

Our cohort included 14 368 patients who received maintenance hemodialysis. Patient follow-up ranged between 1 and 1460 days; the median was 608 days (249-1144 days). Follow-up time was censored when patients died (34%, n = 4862), received a kidney transplant (9%, n = 1231), started home dialysis (6%, n = 880), emigrated from the province (4%, n = 609), or reached the end of the follow-up period (47%, n = 6786). Patients were followed for 27 426 person-years, averaging 1 year 11 months per patient.

Hospital Admission With Myocardial Infarction

There were 870 patients with a hospital admission record with myocardial infarction, a rate of 33.5 events per 1000 person-years. The mean age of patients with a hospital admission with myocardial infarction was 70 (11) years, 38% were women, and 8% lived in a rural setting (Table 1). Regarding baseline health, 78% had diabetes and 89% had hypertension. Among these 870 patients, 13.8% had a recurrent hospital admission with myocardial infarction during our follow-up period (n = 120). In the whole cohort of 14 368 patients, this corresponds to 0.8% (120/14 368), with a median follow-up of 584 (237-1102) days and a rate of 47.4 events per 1000 person-years (Supplemental Appendix 6). The median length of stay of the first hospitalization was 5 (3-10) days (Table 2). Admission to a coronary care unit (CCU) or ICU was found for 54% of patients (n = 474). Admission to the CCU alone was found for 37% of patients (n = 319). The median length of stay was 3 (2-5) days in either the ICU or CCU and 3 (2-5) days in the CCU alone. One hundred eighty-three patients (21%) died within 30 days of hospital admission. The median health care cost for the 30 days beginning the day of hospital admission was $18 079 CAD ($12 510-$25 111).

We identified patients with at least 2 Troponin I (n = 226; normal range: <0.045 μg/L) or high-sensitivity Troponin T (n = 65, normal range: <14 ng/L) tests during their hospital admission;[24,25] data only available in a subset of patients between April 2013 and September 2015. The median peak Troponin I value was 4.7 μg/L (1.4-18.4), and the median peak Troponin T value was 1108 ng/L (407-2412). The median difference between the peak and the lowest value was 2.3 μg/L (0.4-9.9) for Troponin I and 386 ng/L (68-1725) for Troponin T.

Most patients had a cardiologist consult (82%, n = 716), and some had a cardiac surgeon consult (15%, n = 127). Nearly every patient had a record of at least 1 electrocardiogram (98%, n = 855) and 1 chest x-ray (90%, n = 782), and most patients received an echocardiogram (69%, n = 600). About half of the patients received coronary artery revascularization (47%, n = 408); 42% (n = 362) received a percutaneous coronary intervention, and 6% (n = 54) received coronary artery bypass graft surgery. One-third of patients (32%, n = 279) received a cardiac stent.

There were 620 patients eligible for universal outpatient prescription drug coverage who were discharged from the hospital and alive 30 days after their hospital admission (Table 3), thus allowing us to assess outpatient drug utilization after discharge. Of these patients, in the 120 days prior to their hospitalization, 38% (n = 235) had no outpatient dispensed beta-blocker, 70% (n = 437) had no outpatient dispensed clopidogrel, 88% (n = 548) had no outpatient dispensed direct oral anticoagulant, and 32% (n = 201) had no outpatient dispensed statin. Among these patients, in the 30 days after hospital admission, 46% (n = 109 of 235) had a newly dispensed prescription for a beta-blocker, 51% (n = 224 of 437) had a newly dispensed prescription for a clopidogrel, 6% (n = 34 of 548) had a newly dispensed prescription for a direct oral anticoagulant, and 52% (n = 104 of 201) had a newly dispensed prescription for a statin.

Table 1. Baseline Characteristics of Major Cardiovascular Events.

Characteristic	Myocardial infarction n = 870	Heart failure n = 887	Ischemic stroke n = 343
Demographics			
Age in years, mean	70.3 (11.4)	71.6 (12.0)	71.6 (12.2)
<60	17.8%	15.7%	16.0%
60 to < 80	57.8%	54.8%	56.6%
≥80	24.4%	29.5%	27.4%
Sex, female	38.3%	45.5%	48.1%
Rural residence	8.2%	6.7%	9.0%
Comorbidities[a]			
Diabetes	77.8%	74.0%	71.4%
Hypertension	89.4%	90.2%	88.0%
Prior hospital admission with myocardial infarction	21.7%	21.9%	13.7%
Prior hospital admission with heart failure	26.4%	29.8%	21.0%
Prior hospital admission with ischemic stroke	4.3%	44.6%	5.2%
Coronary artery disease (including angina)	81.3%	77.3%	69.4%
Cerebrovascular disease	25.3%	24.1%	44.6%
Peripheral vascular disease	21.0%	20.1%	17.5%
Coronary revascularization (includes CABG, PCI, and angioplasty)	26.2%	21.6%	17.8%
Health care utilization[b]			
Hospitalizations, mean	1.4 (1.7)	1.7 (1.8)	1.5 (1.7)

Note. CABG = coronary artery bypass graft; PCI = percutaneous coronary intervention.
[a]Comorbidities in the 5 years prior to the cardiovascular event were considered.
[b]Health care utilization in the year prior to the cardiovascular event was considered.

Table 2. Descriptive Statistics for Major Cardiovascular Events.

Measure	Myocardial infarction	Heart failure	Ischemic stroke
Number of first events	870	887	343
Event rate in 1000 person-years	33.5	34.2	12.9
Time to event in days, mean	661 (482)	661 (482)	675 (485)
Length of hospital stay in days, mean	7.9 (9.3)	6.8 (10.2)	16.0 (26.7)
Length of hospital stay in days, median	5 (3 to 10)	4 (2 to 8)	9 (4 to 18)
Patients with hospital length of stay of more than 30 days, %	3.2%	3.3%	10.8%
Admission into an ICU[a]	54%	24%	17%
Admission into a CCU	37%	9%	NA
Admission into a stroke unit	NA	NA	49%
Death during the hospital stay	13%	7%	16%
Death within 30 days of hospital admission	21%	11%	19%
30-day health care costs (CAD), median	$18079 ($12510 to $25111)	$11705 ($9751 to $18185)	$18206 ($13423 to $26479)
30- day health care costs (CAD), mean	$21449 ($15057)	$15777 ($12957)	$22392 ($15219)
Cardiology consult, %	82%	38%	NA
Inpatient cardiology consult, %	56%	21%	NA
Cardiac surgery consult, %	15%	4%	NA
Inpatient cardiac surgery consult, %	9%	2%	NA
Neurology consult, %	NA	NA	61%
Inpatient neurology consult, %	NA	NA	40%
Electrocardiogram, %	98%	88%	88%
Chest x-ray, %	90%	92%	NA
Echocardiogram, %	69%	46%	70%
Coronary angiogram, %	64%	12%	2%
At least 1 coronary revascularization, %	47%	4%	NA
Percutaneous coronary intervention, %	42%	3%	< 2%[b]

(continued)

Table 2. (continued)

Measure	Myocardial infarction	Heart failure	Ischemic stroke
Cardiac stent, %	32%	2%	<2%[b]
All ventilation types, %	20%	13%	8%
Invasive ventilation, %	18%	7%	8%
Stress test, %	12%	8%	3%
Holter/telemetry/loop, %	3%	2%	29%
Carotid imaging, %	1%	1%	27%
Pacemaker, %	7%	3%	< 2%[b]
Coronary artery bypass graft surgery, %	6%	1%	0%
Brain imaging, %	17%	12%	97%
Peak troponin I, μg/L[c], median	4.7 (1.4 to 18.4)	NA	NA
Troponin I difference, μg/L[c], median	2.3 (0.4 to 9.9)	NA	NA
Peak Troponin T, ng/L[c], median	1108 (407 to 2412)	NA	NA
Troponin T difference, ng/L[c], median	386 (68 to 1725)	NA	NA

Note. NA = not applicable; CV = cardiovascular; CAD = Canadian dollar; ICU = intensive care unit; CCU = coronary care unit.
[a]Admission to the intensive care unit includes those admitted into the coronary care unit.
[b]These cells have been suppressed because we cannot display values with fewer than 6 individuals. Medians are presented with 25th to 75th percentile, and means are presented with standard deviation.
[c]Troponin values were only available from April 1, 2013, to September 30, 2015, in a subset of patients. At least 2 troponin tests had to be conducted during the 30 days of the first hospitalization for myocardial infarction. The difference in values was calculated as the lowest value subtracted from the highest troponin value during the first hospitalization. Two hundred twenty-six patients with at least 2 Troponin I values were hospitalized for myocardial infarction. Sixty-five patients with at least 2 high-sensitivity Troponin T values were hospitalized for myocardial infarction.

Table 3. New Outpatient Cardiovascular-Related Drug Dispensing 30 Days Following Hospital Admission.

Measure	Myocardial infarction(n = 620[a])	Heart failure(n = 723[a])	Ischemic stroke(n = 228[a])
Beta-blocker	109 of 235 (46%)	39 of 234 (17%)	7 of 95 (7%)
Clopidogrel	224 of 437 (51%)	28 of 550 (5%)	39 of 176 (22%)
Anticoagulant	34 of 548 (6%)	20 of 593 (3%)	19 of 204 (9%)
Statin	104 of 201 (52%)	33 of 241 (14%)	32 of 91 (35%)

Note. Denominators are patients who were eligible for ODB (ie, ≥ 66 years) or had at least 1 dispensed drug in the year before the hospitalization of interest, were alive and discharged from the hospital within 30 days, and did not have a dispensed record for the drug of interest in the 120 days before hospital admission. Anticoagulant = direct oral anticoagulant or warfarin; CV = cardiovascular.
[a]Patients eligible for Ontario Drug Benefit and discharged and alive 30 days from the hospitalization of interest.

Hospital Admission With Congestive Heart Failure

There were 887 patients with a hospital admission record with congestive heart failure, a rate of 34.2 events per 1000 person-years. The mean age of patients with a hospital admission with congestive failure was 72 (12) years and 46% were women (Table 1). Regarding comorbid baseline conditions, 74% had diabetes and 90% had hypertension. Among these 887 patients, a subsequent hospital admission with congestive heart failure occurred in 53 patients (6.0%) during our follow-up period. In the whole cohort of 14 368 patients, this number corresponds to 0.4% with a recurrent event (53/14 368), with a median follow-up of 580 (237-1102) days, and a rate of 45.4 events per 1000 person-years (Supplemental Appendix 6). The median length of stay was 4 days (2-8) (Table 2). Admission to either a coronary care unit (CCU) or ICU during their hospital stay was found for 24% (n = 217) of patients. Admission to the CCU alone was found for 9% (n = 76) of patients. The median length of stay was 3 (1-5) days in either the intensive or CCU and 3 (2-6) days in the CCU alone. Ninety-nine patients (11%) died within 30 days of hospital admission. The median health care cost for the 30 days beginning the day of hospital admission was $11 705 CAD ($9751-$18 185).

Some patients had a cardiologist consult (38%, n = 338), and 4% had a cardiac surgeon consult (n = 39). Almost all patients had at least 1 record for a chest x-ray (92%, n = 818) and electrocardiogram (88%, n = 784), and almost half had a record for an echocardiogram during their hospital stay (46%, n = 410).

There were 723 patients eligible for universal outpatient prescription drug coverage who were discharged from the hospital and alive 30 days after their hospital admission (Table 3). Of these patients, in the 120 days prior to their hospitalization, 32% (n = 234) had no outpatient dispensed

prescription for a beta-blocker, 76% (n = 550) had no outpatient dispensed prescription for clopidogrel, 82% (n = 593) had no outpatient dispensed prescription for a direct oral anticoagulant, and 33% (n = 241) had no outpatient dispensed prescription for a statin. In the 30 days after hospital admission, 17% (n = 39 of 234) had a newly dispensed prescription for a beta-blocker, 5% (n = 28 of 550) had a newly dispensed prescription for clopidogrel, 3% (n = 20 of 593) had a newly dispensed prescription for a direct oral anticoagulant, and 14% (n = 33 of 241) had a newly dispensed prescription for a statin.

Hospital Admission With Ischemic Stroke

There were 343 patients with a hospital admission record with ischemic stroke, a rate of 12.9 events per 1000 person-years. The mean age of patients with a hospital admission with ischemic stroke was 72 (12) years, 48% were women and 9% resided in a rural setting (Table 1). Regarding baseline health, 71% had diabetes, and 88% had hypertension. Among these 343 patients, 20 (5.8%) had at least 1 subsequent hospital admission for ischemic stroke during our follow-up period. Among the whole cohort of 14 368 patients, this represents 0.1% (20/14 368) with a recurrent event, with a median follow-up of 599 (237-1132) days and a rate of 14.9 events per 1000 person-years (Supplemental Appendix 6). The median length of stay was 9 (4-18) days (Table 2). Tissue plasminogen activator (tPA) was administered for 9% (n = 31) of hospitalizations. Sixty patients (17%) were admitted to the ICU, and 49% (n = 168) were admitted to the stroke unit. The median length of stay was 3 (1-8) days in the ICU and 9 (5-19) days in the stroke unit. Sixty-five patients (19%) died within 30 days of hospital admission. The median health care cost for the 30 days beginning the day of hospital admission was $18 206 CAD ($13 423-$26 479).

Two hundred ten (61%) patients had a neurology consult. Almost all patients had at least 1 record for brain or head imaging (97%, n = 332) and an electrocardiogram (88%, n = 300) during their hospital stay.

Antithrombotic prescriptions were dispensed for 67% of patients (n = 229) at hospital discharge. There were 228 patients eligible for universal outpatient prescription drug coverage who were discharged from the hospital and alive 30 days after their hospital admission (Table 3). Of these patients, in the 120 days prior to their hospitalization, 42% (n = 95) had no outpatient dispensed beta-blocker, 77% (n = 176) had no outpatient dispensed clopidogrel, 89% (n = 204) had no outpatient dispensed direct oral anticoagulant, and 40% (n = 91) had no outpatient dispensed statin. In the 30 days after hospital admission, 7% (n = 7 of 95) had a newly dispensed prescription for a beta-blocker, 22% (n = 39 of 176) had a newly dispensed prescription for clopidogrel, 9% (n = 19 of 204) had a newly dispensed prescription for a direct oral anticoagulant, and 35% (n = 32 of 91) had a newly dispensed prescription for a statin.

Discussion

This work describes the 30-day health service use and outcomes after a hospital admission record with myocardial infarction, congestive heart failure, or ischemic stroke in administrative databases for patients receiving outpatient maintenance hemodialysis. As expected, hospitalization for major cardiovascular events is common in the hemodialysis population. We observed that 13% experienced at least 1 event over a 4-year follow-up period (with a median individual follow-up of 1.7 years), corresponding to 76 events per 1000 person-years. Seventeen percent of hospitalized patients died within 30 days of hospital admission. In addition, we observed significant use of in-hospital resources (eg, length of stay, inpatient consults, electrocardiograms, x-rays) and outpatient resources (eg, follow-up tests and procedures, outpatient consults). The 30-day average health care costs were $21 449 for patients admitted with myocardial infarction, $15 777 for patients admitted with congestive heart failure, and $22 391 for patients admitted with ischemic stroke (2017 Canadian dollars).

Reports of major cardiovascular event rates in patients receiving hemodialysis showed that cardiovascular events are common across settings and geographical regions. For example, data from the Dialysis Outcomes and Practice Patterns Study (DOPPS) in North America (n = 3893 patients) estimated 32 hospitalizations for a composite of myocardial infarctions or strokes per 1000 person-years.[26] Data from 300 European Fresenius Medical Care dialysis centers (n = 11 244 patients) estimated 100 myocardial infarctions, 71 congestive heart failures, and 54 cerebrovascular events per 1000 person-years.[27] We are unaware of published reports examining health care resource use after major cardiovascular-related hospitalizations for patients on maintenance hemodialysis.

This study's strengths include its large cohort size, encompassing a population in a jurisdiction with a publicly funded hospital system. We also used consistent coding algorithms to capture outcomes across all hospitals in Ontario. Although some of our databases are specific to Ontario (ie, the renal registry), the same cohort eligibility and principles can be used to obtain a similar cohort and replicate our findings in other provinces and internationally. However, our study also has some limitations. First, events, procedures, and tests recorded in administrative data can be misclassified compared with medical charts. Misclassification of hospitalizations might misestimate our abovementioned results. Second, we excluded patients on hemodialysis for less than 90 days. This exclusion results from the 90-day stability rule to ensure a specific cohort of patients receiving chronic maintenance in-center hemodialysis. While this removed individuals who received temporary hemodialysis for acute kidney injury or drug overdoses, this approach inadvertently removes patients who died shortly after starting their hemodialysis treatment resulting in a potential underestimate of cardiovascular

events. Third, we only captured resource use and cost for the first hospitalization event during our study; these may differ for repeat events. Fourth, the cost of hospital care is most accurate when applied to Ontario residents over 1 or more years. Our average cost estimates should be interpreted cautiously because we only looked at costs for 30 days after hospital admission. Fifth, we followed patients for outpatient procedures and tests up to 30 days after hospital admission. However, out-of-hospital resource use may extend beyond 30 days. Finally, we only captured cardiac imaging most often used in routine care as we examined outcomes throughout Ontario, including community and academic hospitals. Key functional imaging cardiac imaging modalities such as positron emission tomography, stress magnetic resonance imaging, and computerized coronary tomography were not examined as they were unavailable at some centers.

Conclusion

This study provides insights into the use of administrative databases to identify major cardiovascular events in patients receiving hemodialysis. Overall, hospitalizations for major cardiovascular events used significant health service resources, and patients experienced poor health outcomes. Further studies are needed in this population to compare cardiovascular events from administrative data to medical charts or adjudicated cardiovascular events from clinical trials.

Declaration of Conflicting Interests

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Availability of Data and Materials

Data Access/Access to Data Analysis Protocol: The analysis was conducted by members of the ICES Kidney Dialysis & Transplantation (KDT) team at the ICES Western facility (London, Ontario). Yuguang Kang was responsible for the data analysis. The data sets from this study are held securely in coded form at ICES. While data-sharing agreements prohibit ICES from making the data publicly available, access may be granted to those who meet prespecified criteria for confidential access, available at www.ices.on.ca/DAS.

Supplemental Material

Supplemental material for this article is available online.

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