Original Article

Prevalence of Cardiovascular Disease in a Population-Based Cohort of High-Cost Healthcare Services Users

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ABSTRACT

Background: Data are limited data on the prevalence of cardiovascular disease (CVD) and multimorbidity in contemporary cohorts of high-cost users (HCUs) in Canada.

We examined the following: (i) the prevalence of CVD, with a comparison of total healthcare costs among HCUs with vs without CVD; (ii) the contribution of other comorbidities to costs among HCUs with CVD; and (iii) the trajectory of healthcare costs in the years before and after becoming an HCU.

Methods: The study included adult Alberta patients in the Canadian Institutes of Health Research/Canadian Institute for Health Information Dynamic Cohort of Complex, High System Users from 2011-2012 through 2014-2015. We examined total healthcare costs, including hospital, ambulatory care, physician services, and drugs.

RÉSUMÉ

Introduction : Les données sur la prévalence des maladies cardiovasculaires (MCV) et de la multimorbidité au sein des cohortes contemporaines de grands utilisateurs (GU) du Canada sont limitées. Nous avons examiné ce qui suit : (i) la prévalence des MCV en comparant les coûts totaux des soins de santé entre les GU atteints de MCV et les GU non atteints de MCV; (ii) la contribution des autres comorbidités aux coûts liés aux GU atteints de MCV; (iii) la trajectoire des coûts des soins de santé dans les années avant et après avoir été considérés comme un GU.

Méthodes : L'étude portait sur des patients adultes de l'Alberta de la Cohorte dynamique de grands utilisateurs du système de santé aux besoins complexes de 2011-2012 à 2014-2015 des Instituts de recherche en santé du Canada et de l'Institut canadien d'information sur la santé. Nous avons examiné les coûts totaux des soins de santé,

Healthcare expenditures have significantly increased over time in developed countries, including Canada and the US.^{1,2} A widely recognized fact is that only a small portion of the population accounts for a large portion of health expenditures in these countries. In the US, 5% of the population has been

shown consistently to be responsible for > 50% of healthcare costs.^{3,4} In Canada, estimates indicate that the top 1% and 5% of Ontario's population account for 34% and 64% of healthcare expenditure, respectively; in British Columbia, the top 5% of healthcare users consumed 30% of physician services spending.^{5,6} Historically, heart disease has been identified as one of the most costly conditions in the US.⁷ However, data are limited on the contribution of cardiovascular disease (CVD) in more contemporary cohorts of high-cost users (HCUs) in Canada. The need to fill this important evidence gap is clear, as CVD therapeutics have advanced greatly in the past few decades.

Accordingly, we examined the prevalence of CVD in a cohort of complex HCUs between fiscal years (FYs) 2011-2012 and 2014-2015 in Alberta, Canada and compared health expenditures among HCUs with vs without CVD. In order to provide a more comprehensive estimate of total healthcare costs, we examined not just the hospitalization costs that were used to define the cohort, but also costs of

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Results: Among 88,536 HCUs, 23.4% had no CVD, 28.9% were hospitalized with a primary diagnosis of CVD, and 47.7% were hospitalized with a secondary diagnosis of CVD. Total healthcare costs were \$2.0 billion (20.4% non-hospital costs), \$2.8 billion (24.1% non-hospital costs), and \$4.9 billion (19.8% non-hospital costs), respectively, in the 3 groups. Many HCUs with CVD were frail (74.2%) and many had diabetes (33.8%) or chronic obstructive pulmonary disease (27.9%), which contributed to higher costs and mortality. Healthcare expenditures in HCUs with CVD were several times higher than per capita health expenditures in the years prior to, and following, their inclusion in the dynamic HCU cohort.

Conclusions: CVD is very common in HCUs of healthcare. HCUs with CVD have high rates of frailty and multimorbidity. Further research is needed to identify and intervene earlier, in order to flatten the cost curve in these complex patients.

emergency department visits, ambulatory care visits, physician services, and drugs in these patients. We examined the incremental cost of frailty and multimorbidity among HCUs with CVD. In addition to a cross-sectional view, we examined healthcare utilization trajectories by assessing healthcare costs in the 2 years leading up to, and the 2 years after, identification as an HCU with CVD.

Methods

Patient population

Alberta patients, aged 18-years and older, in the Canadian Institutes of Health Research (CIHR)/Canadian Institute for Health Information (CIHI) Dynamic Cohort of Complex, High System Users were included in the study.⁸ The CIHR/CIHI Dynamic Cohort includes patients whose cumulative acute care (inpatient) costs during a specific fiscal year were in the top 10%. Hospitalization records for FY2011-2012 - FY 2014-2015 (ie, April 1, 2011 through March 31, 2015), were stratified by age group (children, adults), province, and FY.

Data

The following data for FY 2009-2010 - FY 2017-2018 were obtained for all Alberta HCUs in the dynamic cohort: (i) discharge abstract database (DAD) of all acute care hospitalizations (which includes the primary or most responsible diagnosis and up to 24 secondary diagnoses); (ii) National Ambulatory Care Reporting System (NACRS) of all ambulatory (including emergency department) clinic visits; (iii) practitioner claims for physician cost data; (iv) the Alberta Blue Cross and Pharmaceutical Information Network (PIN) pharmaceutical claims data; and (v) the Alberta Health Care Insurance Plan (AHCIP) registry for demographic data and mortality status.

Costs

The cumulative cost per patient, including inpatient, ambulatory, physician, and drug costs, was estimated for the

notamment les coûts hospitaliers, les coûts des soins ambulatoires, des services médicaux et des médicaments.

Résultats : Parmi les 88 536 GU, 23,4 % n'avaient pas de MCV, 28,9 % étaient hospitalisés et avaient un diagnostic principal de MCV, et 47,7 % étaient hospitalisés et avaient un diagnostic secondaire de MCV. Les coûts totaux des soins de santé des 3 groupes étaient respectivement de 2,0 G\$ (20,4 % de coûts non hospitaliers), 2,8 G\$ (24,1 % de coûts non hospitaliers) et 4,9 G\$ (19,8 % de coûts non hospitaliers). Plusieurs GU atteints de MCV étaient fragiles (74,2 %) et beaucoup avaient le diabète (33,8 %) ou une maladie pulmonaire obstructive chronique (27,9 %), qui contribuaient à des coûts et à une mortalité plus élevés. Les dépenses de santé par personne liées aux GU atteints de MCV étaient beaucoup plus élevées que les dépenses de santé par personne dans les années qui précédaient ou suivaient leur inclusion dans la cohorte dynamique de GU atteints de MCV.

Conclusions : Les GU de soins de santé sont très fréquemment atteints de MCV. Les GU atteints de MCV présentent des taux de fragilité et de multimorbidité élevés. D'autres recherches sont nécessaires pour cerner et intervenir plus tôt afin d'aplatir la courbe des coûts chez ces patients aux besoins complexes.

entire FY in which they were an HCU. The cost of each hospitalization and ambulatory visit was estimated by multiplying the cost of standard hospital stay (CSHS) by its resource intensity weight.^{9,10} The CSHS data for the years of the study are available from the CIHI. Our calculations relied on Alberta's provincial CSHS using the most recently available case mix grouper (CMG+) for that FY. The PIN data include specifics on all community pharmaceutical dispensing, without restriction by age. Given that the PIN data do not include drug costs, we used the drug cost data included in the Alberta Blue Cross drug database (available primarily for Albertans who are 65 years or older) to obtain the costs. Physician costs were obtained from the practitioner claims data. Most Alberta physicians are remunerated on a fee-for-service basis.¹¹ Estimates of the value of non-fee-for-service physicians' clinical services were determined using the assessed value of their "shadow billing" claims. Shadow billing refers to claims that are submitted merely for reporting purposes and compensated through alternate physician payment methods.

Total health expenditures were estimated as the sum of the expenditures identified in inpatient, ambulatory, practitioner claims, and drug prescription fulfillment. The total health expenditure was divided by the total number of patients in each year of the HCU cohort to arrive at the average health expenditure per patient-year.

All costs were adjusted using the consumer price index, to 2018 Canadian dollars, to facilitate comparisons.

Analysis

Patients identified as HCUs in each FY of the dynamic cohort were categorized into 3 groups, as follows: (i) patients with no CVD hospitalizations (no CVD); (ii) patients with hospitalizations with CVD as the primary diagnosis (primary CVD); and (iii) patients with hospitalizations with CVD as a secondary diagnosis (secondary CVD). We developed a comprehensive list of *International Classification of Diseases*, version 10 codes to define CVD ([Supplemental Table S1](#)).

Figure 1. Patient flow diagram. FY, fiscal year; HCU, high-cost users.

Cardiovascular codes relating to pregnancy were excluded from our analysis.

The unit of analysis was person-year, and patients who were HCUs in multiple years were included in the cohorts for each of those years. The demographics, clinical characteristics, and outcomes of patients in the 3 groups, overall and by FY, were examined. Continuous variables are presented as means ($\pm$ standard deviation) and medians (interquartile range), and categorical variables are presented as frequencies. Comorbidity burden was assessed based on the presence of specific *International Classification of Diseases*, version 10 codes in any of the patient's hospitalization records during the year.¹² In addition to individual comorbidities, we calculated the Charlson Comorbidity Index (CCI) and the Hospital Frailty Risk Score (HFRS).¹³⁻¹⁵ The CCI provides a weighted score of a patient's comorbidity burden based on the number and severity of 19 predefined comorbid conditions; the HFRS weights 109 comorbidities to categorize patients as not-frail (HFRS ≤ 5) or frail (HFRS > 5). The CCI was computed based on comorbidities recorded in any hospitalization during the FY in which the patient was an HCU. The HFRS was

calculated based on hospitalizations during the FY in which the patient was an HCU, as well as in the previous year. The ministry of health (Alberta Health) postal code translation file was used to categorize the patient as being either urban/metropolitan or rural.

The incremental impact of the presence of other comorbidities in conjunction with CVD in HCUs was examined by comparing the average total health expenditures in patients with vs without a specific comorbidity (diabetes, renal disease, mental health issues, chronic obstructive pulmonary disease, or cancer). To examine whether mortality modulated healthcare costs, we further stratified total health expenditures by the patient's vital status (alive/dead) in the year they were an HCU. Cancer services provided on an outpatient basis are provided at specific specialized centres in Alberta and are not fully accounted for in the databases included in our study. For example, our data do not include information on chemotherapy received in ambulatory cancer clinics. Accordingly, we conducted a sensitivity analysis comparing hospitalization costs alone for HCUs with CVD with vs without cancer. In addition to individual comorbidities, we

Table 1. Baseline characteristics of Alberta adult high-cost users (HCUs) of healthcare

Characteristic	Primary diagnosis of CVD	Secondary diagnosis of CVD	No CVD diagnosis	All
Number of HCUs	25,615	42,213	20,708	88,536
Female sex	10,967 (42.8)	20,970 (49.7)	10,360 (50.0)	42,297 (47.8)
Age, y, median	74.0	74.0	57.0	71.0
Urban/metropolitan residence	17,488 (68.3)	29,829 (70.7)	14,346 (69.3)	61,663 (69.6)
Charlson Comorbidity Index	3 (2, 5)	3 (1, 5)	1 (0, 2)	2 (1, 4)
Frailty	17,318 (67.6)	32,997 (78.2)	10,381 (50.1)	60,696 (68.6)
Myocardial infarction	7375 (28.8)	3868 (9.2)	—	11,243 (12.7)
Heart failure	11,556 (45.1)	7496 (17.8)	—	19,052 (21.5)
Peripheral vascular disease	3929 (15.3)	2748 (6.5)	—	6677 (7.5)
Cerebrovascular disease	5827 (22.7)	3566 (8.4)	—	9393 (10.6)
Hypertension	18,252 (71.3)	28,851 (68.3)	—	47,103 (53.2)
Dementia	2876 (11.2)	7691 (18.2)	2425 (11.7)	12,992 (14.7)
Chronic pulmonary disease	7248 (28.3)	11,683 (27.7)	2634 (12.7)	21,565 (24.4)
Diabetes mellitus	9231 (36.0)	13,662 (32.4)	2600 (12.6)	25,493 (28.8)
Renal disease	4307 (16.8)	5015 (11.9)	574 (2.8)	9896 (11.2)
Liver disease	1175 (4.6)	3254 (7.7)	1016 (4.9)	5445 (6.2)
Cancer	3184 (12.4)	10,336 (24.5)	4999 (24.1)	18,519 (20.9)

Data are presented as n (%), unless otherwise noted. Charlson Comorbidity Index is presented as median (25th percentile, 75th percentile).

CVD, cardiovascular disease.

Table 2. Total resource utilization and costs among Alberta adult high-cost users (HCUs)

Resource and cost	Primary diagnosis of CVD	Secondary diagnosis of CVD	No CVD diagnosis	All
High-cost users, n	25,615	42,213	20,708	88,536
Hospitalizations	78,625	112,668	49,253	240,546
Days in hospital	1,368,946	2,920,733	1,319,698	5,609,377
Days in intensive care units	100,163	112,711	28,529	241,403
Physician claims	3,047,203	5,202,316	2,402,581	10,652,100
Ambulatory visits	537,779	735,535	334,848	1,608,162
ED visits (subset of ambulatory)	111,983	162,338	79,839	354,160
Non-hospital drug dispenses	2,058,630	3,705,341	1,356,385	7,120,356
Procedures				
PCI	1694	108	0	1802
CABG	3420	34	0	3454
Heart transplant	58	2	0	60
Implantable cardiac device	2134	146	0	2280
Total cost, B	2.8	4.9	2.0	9.7
Hospitalization cost, B	2.1 (75.9)	3.9 (80.2)	1.6 (79.6)	7.7 (78.8)
Ambulatory (including ED) cost, M	248.1 (8.7)	314.7 (6.4)	120.8 (6.0)	683.7 (7.0)
Claims cost	363.4 M (12.8)	529.8 M (10.8)	235.1 M (11.7)	1.1 B (11.6)
Non-hospital drug cost, M	75.8 (2.6)	128.9 (2.6)	53.8 (2.7)	258.6 (2.6)

Values other than costs are n. Costs with (%) are given in 2018 Canadian \$.

B, billion; CABG, coronary artery bypass graft; CVD, cardiovascular disease; ED, emergency department; M, million; PCI, percutaneous coronary intervention.

examined healthcare costs by frailty and overall comorbidity burden. For the latter, HCUs with CVD (primary or secondary) were categorized into quartiles, according to their CCI, and average healthcare costs were examined in each group. In addition to unadjusted comparisons, we used a multivariable gamma generalized linear model with log-link to examine the association between the following: demographic factors: FY, individual comorbidities of interest, frailty, overall comorbidity burden, and total healthcare costs.

Finally, for patients who were identified as HCUs with CVD in any of the 4 years of the dynamic cohort (FYs 2011-2014), health expenditures in the 2 years preceding (FY 2009-2010 and FY 2010-2011) and the 2 years after (FY 2015-2016 and FY 2016-2017) meeting the HCU case definition were calculated.

This study was approved by the University of Alberta's Health Research Ethics Board (Pro00077645). The board determined that due to the retrospective design of the study, subject consent for access to personally identifiable health information would not be reasonable, feasible, or practical, and it therefore waived the need for informed consent. All analyses were done using SAS 9.4 (SAS Software, Cary, CA).

Results

There were 21,560 adult HCUs in FY 2011; 21,988 in FY 2012; 22,613 in FY 2013; and 23,114 in 2014 in Alberta (Fig. 1). After exclusion of patients with incomplete or incorrect data (0.8%), a total of 88,536 adult HCUs were identified in Alberta between April 1, 2011 and March 31, 2015. Among these, 68,357 were HCUs in 1 year of the cohort; 8124 were HCUs in 2 years; 1133 were HCUs in 3 years; and 133 were HCUs in all 4 years of the cohort. Overall, 20,708 (23.4%) had no CVD diagnosis; 25,615 (28.9%) were hospitalized with a primary diagnosis of CVD; and 42,213 (47.7%) were hospitalized with a secondary diagnosis of CVD during the year in which they were identified as an HCU (Table 1). HCUs with CVD were significantly older than HCUs without CVD (median age: 74 years vs 57 years). HCUs with primary CVD included a lower proportion of female patients (42.8%), whereas females accounted for half the number of HCUs either without CVD or with CVD as a secondary diagnosis. The proportions of patients who were frail were 50.1%, 67.6%, and 78.2% among HCUs with no CVD, primary CVD, and secondary CVD, respectively. Among HCUs with primary CVD, 45.1% had heart failure, 9.2% had myocardial infarction, 8.4% had

Figure 2. Annual total healthcare costs among high-cost users with cardiovascular disease. CAD, 2018 Canadian dollars; CVD, cardiovascular disease; M, million.

Figure 3. Distribution of healthcare costs among high-cost users with cardiovascular disease. CAD, 2018 Canadian dollars; CVD, cardiovascular disease; ED, emergency department.

cerebrovascular disease, and 6.5% had peripheral artery disease. Among HCUs with CVD listed in a secondary-diagnosis field, 17.8% had heart failure, 28.8% had myocardial infarction, 22.7% had cerebrovascular disease, and 15.3% had peripheral artery disease. Rates of dementia and diabetes were highest in HCUs with secondary CVD, compared to those with primary CVD or no CVD. The demographic and clinical characteristics of the patients were similar across the 4 years of the study (Supplemental Table S2).

Healthcare costs

HCUs with CVD accounted for substantially higher healthcare resource use and expenditures compared to HCUs without CVD. Over the 4 years, the total cost of hospitalization, ambulatory care, physician services, and drug prescriptions was \$2.0 billion among HCUs without CVD, \$2.8 billion among those with a primary diagnosis of CVD, and \$4.9 billion among HCUs with CVD as a secondary diagnosis (Table 2). Total costs among HCUs with primary CVD increased from \$680.5 million in FY 2011–2012 to \$750.7 million in FY 2014–2015; total costs among HCUs with secondary CVD increased from \$1.2 billion to \$1.3 billion during the same time period (Fig. 2; Supplemental Table S3).

In both groups, hospital costs accounted for the largest proportion of total cost each year; however, costs associated with physicians, ambulatory care, and drugs accounted for an additional 24% of healthcare costs among HCUs with primary CVD, and an additional 20% of costs among HCUs with secondary CVD (Fig. 3).

The average (and median) cost per HCU patient per year with primary CVD was \$111,500 (\$86,100), and \$116,700 (\$88,500) for an HCU patient with secondary CVD, and \$97,000 (\$76,400) for an HCU patient with no CVD (Table 3).

Frailty and multimorbidity

The most prevalent comorbidity among HCUs with CVD (either primary or secondary diagnoses) was diabetes (33.8%), followed by chronic obstructive pulmonary disease (27.9%; Table 4). Approximately 20% of HCUs with CVD had cancer, 18.3% had mental health issues, and 13.7% had renal disease. In general, the average annual health expenditure among HCUs with CVD who had these comorbidities was higher than that among HCUs with CVD who did not have these comorbidities. The average hospitalization cost alone among HCUs with CVD and cancer was \$86,892, compared

Table 3. Annual costs per patient among Alberta adult high-cost users (HCUs)

Cost	Primary diagnosis of CVD (n = 25,615)	Secondary diagnosis of CVD (n = 42,213)	No CVD diagnosis (n = 20,708)	All (n = 88,536)
Total, mean (SD)	111.5 (84.7)	116.7 (113.9)	97.0 (81.6)	110.6 (99.4)
Total, median (IQR)	86.1 (64.6–128.1)	88.5 (63.9–134.9)	76.4 (57.9–109.4)	84.7 (62.5–126.7)
Hospitalization, mean (SD)	84.7 (75.0)	93.6 (107.8)	77.2 (78.0)	87.2 (92.9)
Hospitalization, median (IQR)	61.9 (44.3–97.2)	67.5 (46.9–107.3)	57.0 (42.2–87.0)	63.1 (44.8–99.4)
Ambulatory, mean (SD)	9.6 (15.8)	7.4 (13.6)	5.8 (8.5)	7.7 (13.4)
Ambulatory, median (IQR)	5.6 (3.1–9.6)	4.0 (2.0–7.4)	3.7 (1.8–6.9)	4.4 (2.2–8.0)
Physician, mean (SD)	14.1 (10.4)	12.5 (9.8)	11.3 (8.6)	12.7 (9.8)
Physician, median (IQR)	11.8 (7.9–17.2)	10.1 (6.5–15.4)	9.1 (5.6–14.5)	10.4 (6.6–15.8)
Non-hospital drug, mean (SD)	2.9 (7.9)	3.0 (10.2)	2.6 (7.7)	2.9 (9.0)
Non-hospital drug, median (IQR)	1.9 (0.9–3.5)	1.6 (0.6–3.4)	1.0 (0.3–2.8)	1.6 (0.6–3.3)

Costs are given in thousands of 2018 Canadian \$. n indicates number of HCUs. Total cost = hospitalization, ambulatory (including emergency department), physician, non-hospital drug.

CVD, cardiovascular disease; IQR, interquartile range; SD, standard deviation.

Table 4. Impact of comorbidities on healthcare costs among high-cost users (HCUs) with cardiovascular disease (CVD)

Comorbidity	With comorbidity, %	Mean cost, with comorbidity, \$	Mean cost, without comorbidity, \$	Died, with comorbidity, %	Died, without comorbidity, %
Mental health	18.3	131,865	110,983	23.4	27.2
COPD	27.9	116,633	114,091	31.8	24.5
Diabetes	33.8	123,879	110,176	27.0	26.3
Renal	13.7	133,263	111,859	34.7	25.2
Cancer	19.9	110,615	115,843	46.1	21.6
Frailty*	74.2	124,974	85,572	29.6	17.7
Charlson score					
0	10.9	106,165	—	8.5	—
1–2	33.5	106,134	—	18.4	—
3–4	27.8	118,078	—	26.6	—
5+	27.7	125,372	—	43.3	—

Costs are given in 2018 Canadian \$.

COPD, chronic obstructive pulmonary disease.

*Based on the Hospital Frailty Risk Score (HFRS).

to \$91,164 among HCUs with CVD who did not have cancer. The mortality rate among HCUs with CVD with cancer was 46.1%, compared to 21.6% among HCUs with CVD without cancer. Overall, 74.2% of HCUs with CVD were frail, and the average healthcare cost among frail patients was higher (\$124,974) compared to that among HCUs with CVD who were not frail (\$85,572). The mortality rate among frail patients was 29.6%, compared to 17.7% among those who were not frail. When evaluating multimorbidity burden as a whole, we found that 10.9% of HCUs with CVD had a CCI of 0; 33.5% had a score of 1–2; 27.8% had a score of 3–4; and 27.7% had a score > 5 (Table 4). Both the healthcare cost burden as well as the mortality burden increased substantially across CCI categories among HCUs with CVD.

In multivariable analyses, frailty was one of the most important drivers of healthcare costs, followed by peripheral vascular disease and renal disease (Fig. 4). Older patients and females had lower healthcare costs, whereas urban residency and multimorbidity (CCI ≥ 2) were associated with higher total healthcare costs.

Cost trajectories among HCUs

We examined the trajectory of healthcare costs among HCUs with CVD in the years leading up to their inclusion in the dynamic cohort. We found that, compared to the annual per capita health expenditure in Alberta of \$4001.30 and \$4499 in FY 2009–2010 and FY 2010–2011, respectively, the average annual healthcare cost (unadjusted for inflation) among HCUs with primary CVD was \$11,013 and \$14,690.40, and \$11,775.20 and \$16,539.50 among HCUs with secondary CVD in these 2 FYs. In the years following their inclusion in the dynamic cohort, the average annual healthcare cost among HCUs with primary CVD was \$27,579.70 and \$23,750.10, and \$29,140.30 and \$26,163.70 among HCUs with secondary CVD, compared to the annual per capita health expenditure in Alberta of \$4836.10 and \$4977.10 in FY 2015–2016 and FY 2016–2017, respectively.¹

Discussion

Our study examined the prevalence and healthcare costs associated with CVD in a dynamic cohort of complex HCUs from FY 2011–2012 through FY 2014–2015 in Alberta. We

found that almost a third of the HCUs were hospitalized with a primary diagnosis of CVD, and an additional half were hospitalized with a secondary diagnosis of CVD, leading to a prevalence of CVD of over 75%. Healthcare costs among HCUs with CVD accounted for \$7.7 billion of the total \$9.7 billion for all HCUs in Alberta during the 4-year time period. Hospitalization costs accounted for 80% of healthcare expenditures among HCUs with CVD, and costs of physician services, ambulatory care, and drugs accounted for the remaining 20% of total healthcare costs. Frailty and multimorbidity were major drivers of both costs and mortality among HCUs with CVD. The trajectory of increasing healthcare costs in the years prior to becoming a HCU suggest that developing prognostic models to identify CVD patients at high risk of becoming HCUs may be worthwhile.

Estimates of the prevalence of CVD in the general population vary significantly—from an overall 3% in Canada, to 48% among adults age ≥ 20 years in the US.^{16,17} In our cohort of HCUs, the prevalence of CVD was 76.6%. Although the use of a broader definition may account for some of the observed higher prevalence, the findings of our study demonstrate the significant contribution of CVD to healthcare costs and highlight the need to identify strategies to flatten the cost curve among patients with heart disease.

Of course, this is easier said than done. Following anecdotal accounts of success in reducing healthcare utilization among “hot spotters” or “super-utilizers,” a randomized clinical trial of the Camden Core Model transition care model vs usual care showed no difference in readmission rates in patients in the intervention arm.¹⁸ In Canada, high-risk patients who were randomized to virtual wards, which extend elements of hospital care into community-based settings, had similar readmission and mortality rates at 30 days and 1 year, compared with those assigned to usual care.¹⁹ Similarly, heart failure patients randomized to receive evidence-based transitional care services demonstrated no improvements in readmission, emergency department presentation, or death at 3 months, compared to patients who received usual care.²⁰ However, it has been suggested that the controlled randomized clinical trial framework may not be the best vehicle for studying the impact of interventions targeting HCUs; and real-world, population-based surveillance for upstream identification and intervention may yield better results.²¹ In longitudinal analysis, we observed a trajectory of increasing

Figure 4. Association of demographic factors, frailty, and comorbidities with total healthcare costs. CI, confidence interval; CVD, cardiovascular disease; ref, referent.

healthcare costs in the years prior to patients being identified as HCUs. Both the development of “learning” healthcare systems that integrate primary and tertiary health data with exogenous factors, such as social determinants and environmental data, and the employment of novel methods, such as machine learning, may offer opportunities for early identification of potential HCUs.

We have previously shown that physician continuity and initiatives to increase access to specialized heart failure clinics are associated with a decrease in mortality and readmission rates.²²⁻²⁵ Further work is needed to examine their impact on healthcare costs, especially among HCUs. We also have documented the impact of alternative venues of care, such as

hospices and long-term care facilities on end-of-life costs in heart failure patients, and the cost implications of excessive or unnecessary diagnostic testing in patients with acute coronary syndromes.²⁶⁻²⁸ Better integration between research and health policy is needed to move the needle from documentation to developing effective interventions.

Approximately 20% of the HCUs with CVD had cancer. The lower average healthcare costs observed among HCUs with cancer, compared to HCUs without cancer, are likely due to at least 2 factors. The first is the incompleteness of capture of ambulatory services for cancer patients in our data. Hence, the difference in costs between those with vs without cancer was substantially attenuated when our

examination was restricted to hospitalization costs alone. The second factor is the high mortality rate (46.1%) among HCUs with CVD and cancer. Additional research, as part of the emerging field of cardio-oncology, may assist in providing better understanding of the reasons for this high prevalence, and its substantial impact on mortality and costs, of cancer among HCUs with CVD.

Limitations

Our study has several limitations. First, the CIHR/CIHI Dynamic Cohort HCUs were identified as those accounting for the top 10% of acute care (hospitalization) costs only, and not for total healthcare costs. We categorized HCUs who had a CVD diagnosis in an inpatient setting as an HCU with CVD for the entire year. Although it is highly unlikely that such cases occurred, HCUs with CVD who were treated entirely in the outpatient setting in a specific year would be categorized in the HCU no CVD group. Although our study provides an estimate of total healthcare costs for HCUs in Alberta by examining ambulatory, physician, and drug costs in HCUs, we could not estimate other costs, such as those related to laboratory tests, diagnostic imaging, long-term care, or home care. We only included the cost of physicians, and not of other community-based allied healthcare professionals, such as pharmacists, physiotherapists, dietitians, social workers, and others who were likely involved in the care of these patients. Our study does not take into account any indirect costs, such as days away from work, for either the patients or their caregivers. As discussed above, healthcare costs for cancer patients are underestimated, as they may not include all costs of non-acute hospitalizations or outpatient visits. Lastly, our inpatient and ambulatory cost estimates are based on averages, which may underestimate or overestimate true costs, depending on the facilities where care was provided.

Conclusions

CVD accounts for a large proportion of healthcare costs among HCUs. Although hospitalization accounts for the highest proportion of costs among HCUs, they also incur substantial ambulatory, physician, and drug costs. HCUs with CVD have high rates of other comorbidities that contribute substantially to healthcare costs and adverse outcomes. Further research, using longitudinal, population-level cohorts, is needed to identify these highly complex patients at more proximal time points and aid in the design of interventions to modify elements of their care before they become HCUs.

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Disclosures

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Supplementary Material

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