Postoperative Coronary Artery Bypass Graft Readmissions in Rural, Remote, and Northern Communities: A Case-Control Study Focused on the Social Determinants of Health

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Abstract

Background: *People living in rural, remote, and northern communities (RRNCs) are at higher risk for hospital readmissions following coronary artery bypass graft (CABG). The aim of this study was to identify factors associated with hospital readmission post-CABG in Canadian RRNCs, including social determinants of health (SDOH).*

Methods: *In this case-control study, we reviewed 44 patient charts readmitted within 30 days post-CABG to one RRNC hospital and the charts of 44 patients not readmitted to this hospital.*

Results: *Logistic regression analysis revealed that readmission was associated with history of myocardial infarction (OR 2.52; 95% CI 1.49–4.24), fewer days waiting for surgery (OR 1.02; 95% CI 1.00–1.03), living in a larger population centre (OR 0.18; 95% CI 0.07–0.51), shorter distance (km) to the hospital where the surgery took place (OR 1.01; 95% CI 1.01–1.02), and need for community care post-CABG (OR 14.97; 95% CI 4.03–55.65).*

Conclusion: *Readmission post-CABG was correlated with access to acute and community healthcare.*

Nursing Implications: *There is a need to integrate the SDOH in pre- and post-surgical education, discharge planning, and specialized community services in RRNCs.*

Keywords: case-control study, rural remote and northern communities, social determinants of health, coronary artery bypass graft, post-operative readmissions

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Key Highlights

1. Factors for readmission post-CABG were less associated with health-related factors and rather related to access to health services, physical environment, and community factors.
2. Seven of the 12 SDOH are neither routinely collected nor documented in patient charts.
3. There is a need to strengthen CABG clinical pathways by integrating the SDOH in pre- and post-surgical education, discharge planning, and specialized community services in RRNCs.

People living in rural, remote, and northern communities (RRNCs) in Canada have poorer health status and outcomes and experience different healthcare access, as compared to people living in urban areas (Hale et al., 2021; Health Quality Ontario, 2017; Smale & Holliday, 2020). In RRNCs, cardiovascular disease (CVD) affects more people than any other condition, with approximately **29.8%** of the population affected and many requiring coronary artery bypass graft (CABG) to treat advanced coronary artery disease (CAD; Statistics Canada, 2024; Smale & Holliday, 2020). Recovery from CABG can be challenging, often requiring numerous physical and social supports, with an inherent risk of readmission to hospital for various post-surgical complications, such as respiratory issues and infection (Shawon et al., 2021). Recent data from a pan-Canadian study of cardiac centres reported an average post-CABG readmission rate in one Northern Ontario hospital of 10.6%, while the readmission rate averaged 7.9% across all Southern Ontario hospitals (Canadian Institute of Health Information [CIHI], 2022). These differences

in readmission rates suggest that reasons for readmission go beyond sociodemographic and procedural outcomes and indicate that the social determinants of health (SDOH) may have a role. The SDOH are non-medical factors, whether social, economic, or environmental, that affect a person's health, quality of life, or progression of a disease in a complex and interconnected manner (Government of Canada, 2020). People residing in RRNCs often have different and more pronounced SDOH challenges compared to those living in urban settings (Canadian Association for Rural and Remote Nursing [CARRN], 2020). Factors, such as geography, transportation availability, and systemic resource allocation, including a lack of cardiac rehabilitation services, and reduced availability of home or telehealth support, can account for differences in readmission rates in urban as compared to rural settings (Teshale et al., 2023).

Rural, Remote, and Northern Communities

Statistics Canada (2021) defines northern communities as the northern sub-regions of each province. Rural communities are defined as any community outside a population centre (Statistics Canada, 2021). Population centres are classified into three groups: small (1,000 to 29,999 residents), medium (30,000 to 99,999 residents), and large (100,000 residents or more), with the last also referred to as urban areas. Remote communities are geographic areas accessible by air or roads built in the winter over land, frozen rivers and lakes (Statistics Canada, 2021).

There are disparities in CVD occurrence and outcomes as a result of the geographic variations between Canadian RRNCs and urban communities (Hale et al., 2021). People living in Canada's RRNCs have 50% higher rates of CVD associated with higher smoking rates, more precarious and stressful work environments, and limited access to specialized care, all risk factors for heart disease (CIHI, 2022). In terms of healthcare access, in Northern Ontario, only three hospitals perform coronary angiograms, servicing more than 700,000 residents (CIHI, 2022), creating a lengthy wait list for patients with confirmed or suspected CAD. During this wait, the disease has the opportunity to progress critically to the point of requiring invasive intervention, such as CABG (Vervoort et al., 2024). Notably, people living in RRNCs who require CABG are at higher risk for hospital readmission as compared to people living in urban areas (CIHI, 2022).

In Canada, the national average for length of stay post-CABG is 4 to 7 days (CIHI, 2022). However, for patients residing in urban communities it is noted to be shorter with high-volume cardiac surgery programs and longer for those residing in rural areas, due to delayed discharge planning or transportation issues (Vervoort et al., 2024). Rural, remote, and northern communities also often lack availability and accessibility of homecare services and telemonitoring, thus further complicating discharge planning (Vervoort et al., 2024).

Current research related to readmissions post-CABG has centred on demographic, clinical, and procedural factors. Researchers have identified comorbidities that increase risk for readmission, including heart failure (Benuzillo et al., 2018; Shah et al., 2019), atrial fibrillation (Shah et al., 2019), myocardial infarction (Benuzillo et al., 2018; Tam et al., 2018), and complications, such as incisional infections (Shah et al., 2019; Tam et al., 2018). Procedural factors, such as length of post-operative stay (Feng et al., 2018; Shah et al., 2019; Tam et al., 2018) and size of the hospital where surgery took place, also affected risk for readmission (Tam et al., 2018). Some attention has been drawn to insurance status, primarily in the United States (Feng et al., 2018; Khoury et al., 2019; Shawon et al., 2021). To our knowledge, no authors have comprehensively studied the SDOH as factors associated with readmission post-CABG in a Canadian context. This represents an important opportunity to address this gap in knowledge and to strengthen the development and delivery of more responsive healthcare services for people living in RRNCs in Canada.

Research Aim

The overarching aim of this research was to identify the social, demographic, and clinical factors associated with 30-day hospital readmission post-CABG in RRNCs, with principal attention to the SDOH.

Methods

Design

We conducted a retrospective case-control study. We received ethical approval from the Health Sciences North Research Ethics Board (File: 23-002), with administrative approval from the University of Ottawa Research Ethics Board, as this project was conducted in the context of a Masters' thesis project (File: H-03-23-9038). This study used secondary, de-identified administrative health data without direct engagement with Indigenous communities; therefore, an Indigenous-specific ethics review board was not consulted. We collected Indigenous status respecting Ownership, Control, Access, and Possession (OCAP®) principles, which affirm First Nations', Métis', and Inuit's rights to govern their data. While formal community approval was not required, our team acknowledges the importance of Indigenous data sovereignty and encourages future research to engage meaningfully with Indigenous governance and consultation (First Nations Information Governance Centre, 2014). This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2007).

Theoretical Framework

Winters and Lee's (2018) Rural Nursing Theory and the Government of Canada's (2020) SDOH framework provided the theoretical underpinning for this study. They were used to understand our findings in the context of providing

nursing care to patients undergoing CABG in a RRNC and guiding the interpretation of our results. The Rural Nursing Theory defines health as a way of life and a holistic state of mind for those living in rural environments (Winters & Lee, 2018). The theory offers an in-depth explanation of the characteristics of rural patients' health outlooks and how nurses can tailor their practice to incorporate them. The theory rests on two main assumptions. First, rural residents have a sense of self-reliance; they rely on one's own efforts to maintain health with minimal help from the formal healthcare system (Winters & Lee, 2018). Second, rural residents demonstrate great resilience as they remain strong during tough circumstances (Winters & Lee, 2018).

The Government of Canada (2020) recognizes 12 SDOH: 1) income and social status, 2) employment and working conditions, 3) education and literacy, 4) childhood experiences, 5) physical environments, 6) social supports and coping skills, 7) healthy behaviours, 8) access to health services, 9) biology and genetic endowment, 10) gender, 11) culture, and 12) race / racism. The SDOH play a critical role in achieving and maintaining cardiovascular health, particularly for people living in RRNCs where barriers, such as limited services, transportation challenges, and lower socioeconomic status, are more common. Research has shown that SDOH significantly affect cardiovascular outcomes (Teshale et al., 2023; Vervoort et al., 2024), yet few studies have explored their role in 30-day readmissions post-CABG in rural Canadian populations. This study addresses that gap by examining how social, demographic, and clinical factors, including SDOH, contribute to readmission risk.

Setting and Population

This study was conducted in Sudbury, Ontario, Canada, at Health Sciences North (HSN), which is the regional tertiary care centre for Northeastern Ontario and an academic teaching facility. Health Sciences North has 25 other sites, including hospitals, outpatient centres, dialysis centres, and more, providing critical, inpatient and outpatient care for more than 500,000 people living in Northern Ontario. Over 500 cardiac surgeries are performed each year at HSN, with a reported 10.6% readmission rate for isolated, open sternotomy CABG surgeries (CIHI, 2022).

Eligible participants included patients: 1) aged 18 years or older who underwent an isolated open sternotomy CABG at HSN between January 1, 2021 and December 31, 2023; and 2) living in a RRNC in Northeastern or Northwestern Ontario, based on a postal code starting with P, including centres with populations greater than 100,000 residents. Patients who met the eligibility criteria were classified as readmitted to HSN within 30 days of CABG (case) or not readmitted (control). Patients in the readmitted group had to be readmitted to HSN for the research team to access their data through the Meditech electronic medical record. We used the *International Classification of Disease*, Eleventh Edition (ICD-11) codes to identify a coronary artery bypass graft, defined by code PK80.14: other cardiac procedure associated with harm in diagnostic or therapeutic use, open.

Sample Size and Sampling Methods

The case group included all patients readmitted within 30 days post-CABG between 2021 and 2023. For the control group, a random selection of the same number of non-readmitted patients (1:1), matched by age, sex, and year of CABG (2021, 2022, or 2023) were obtained. The sample size was confirmed once the number of readmitted patients was identified. In retrospective case-control studies, sample size is often determined by the number of available cases, particularly when the outcome is relatively infrequent, as is the case with 30-day readmissions (Sedgwick, 2014). Matching helps study efficiency, even when sample sizes are small to moderate.

Data collection

Data were extracted from Meditech, the electronic medical record system used at HSN, including information from admission histories, discharge summaries, and consultation notes. Clinical and demographic variables, such as age, sex, comorbidities, medical history, and Indigenous status (as indicated by Non-Insured Health Benefits [NIHB] coverage), were obtained from their admission(s) for their coronary angiogram and/or CABG surgery. Non-Insured Health Benefits coverage, offered under the Indian Act, is used to identify people who self-identify as Indigenous, including First Nations, Inuit, and Métis (Government of Canada, 2019). Procedure-related data included length of stay pre- and post-operatively, time from angiogram to surgery, emergency level of surgery, postoperative complications, and discharge destination. For readmitted patients, additional data were collected on readmission date, reason, length of stay, and any complications. It should be noted that nursing and interdisciplinary care notes, documented on paper and not integrated into Meditech, were not accessible for this study.

Five SDOH were routinely collected and available in inpatient charts, including employment and working conditions; physical environments (i.e., distance from HSN in km, and size of population centre in which the patient resides); social supports; access to health services (need for community care post-discharge); and culture, including but not limited to Indigenous status. Not routinely collected (hence not available) were income, education, childhood experiences, healthy behaviours, biology and genetics, self-identified gender, nor race.

Analysis

Descriptive and inferential statistical analyses were conducted using the IBM SPSS statistical software (Version 29.0.1.0). Categorical variables were analyzed using

frequencies, an approach used in most retrospective database reviews (Sedgwick, 2014). Continuous variables were analyzed using measures of central tendency including mean, standard deviation, and range. A binary logistic regression analysis was conducted to estimate odds ratios (ORs) with 95% confidence intervals (CIs), assessing the association between 30-day readmission (yes/no) and selected independent variables. Variables included in the regression model were chosen based on clinical relevance, existing literature, and results of preliminary bivariate analyses. The final model included the independent variables as indicated in Table 4. The *p*-values were two-sided, with statistical significance evaluated at an alpha level of .05. Missing data was managed with a pairwise deletion method, ultimately removing missing values from the analysis (Kang, 2013). Given the small number of cases per group, we opted to avoid removing whole cases.

Findings

Of 1,021 patients who had an isolated CABG at HSN from January 2021 to December 2023, 44 patients (4%) were readmitted to HSN within 30 days of their surgery (cases). Eighteen patients were readmitted in 2021, 10 patients in 2022, and 16 patients in 2023. We reviewed an additional 44 charts of patients who were not readmitted post-CABG (controls), matched (1:1) by age, sex and year, for a total of 88 patient charts.

Patient and Procedure-Related Characteristics

Hypertension was the most common cardiac comorbidity, followed by hyperlipidemia, and myocardial infarction in the readmitted group (Table 1). Myocardial infarction was associated with a statistically significantly higher odds (OR 2.517; 95% CI 1.493–4.242) of readmission. Ten (25%) patients in the readmitted group had pleural effusion as a postoperative complication (OR 0.750; 95% CI 0.632–0.890) with none in the non-readmitted group.

The non-readmitted group experienced longer wait times for surgery after coronary angiogram, averaging 49.8 days versus 35.1 days (OR 1.016; 95% CI 1.003–1.030). Two patients in the readmitted group, and seven patients in the non-readmitted group did not have angiogram dates noted in their charts, thus their wait time could not be calculated.

The most common readmission diagnosis was heart failure (n = 9; 20.5%) and wound infection (n = 7; 15.9%; Table 2). Most patients (n = 20; 45.5%) did not experience additional complications during their readmission stay; however, seven (15.9%) patients did have a wound infection, which complicated their readmission stay.

Social Determinants of Health

Most patients (n = 30, 68.2%) in the readmitted group resided in a large population centre (urban) and lived an average 57.8 km away from the hospital. Patients in the non-readmitted group lived an average 182.0 km away. Of the patients who were readmitted, 72.7% (n = 32) were discharged home, while the others were discharged to another health care facility (n = 6; 13.6%) or a family member's home (n = 6; 13.6%). All patients in the non-readmitted group were discharged to their own home. Nearly 60% (n = 26; 59.1%) of patients who were readmitted were married and 18.2% (n = 8) were single. Yet, 77.3% (n = 34) of patients who were not readmitted were married. None were single. In the readmitted group, 6.8% (n = 3) identified as Indigenous based on their NIHB insurance status, whereas, there were none in the non-readmitted group.

Comparisons Between Readmitted and Non-Readmitted Groups

Logistic regression analysis identified several factors significantly associated with 30-day readmission, including a history of myocardial infarction (OR 2.52; 95% CI 1.49–4.24), shorter wait time between coronary angiogram and surgery (OR 1.02; 95% CI 1.00–1.03), living in a larger population centre (OR 0.18; 95% CI 0.07–0.51), residing closer to the surgical hospital (OR 1.01; 95% CI 1.01–1.02), and requiring community care after discharge (OR 14.97; 95% CI 4.03–55.65; Tables 1 and 3). No significant associations were found for the other factors noted.

Discussion

In this case-control study, we identified patient, procedure, and social-related factors associated with readmission post-CABG in one RRNC hospital in Ontario. To our knowledge, this is the first study to explore the associations between the SDOH and post-CABG readmissions in a Canadian RRNC context. We identified factors through logistic regression that are associated with readmission 30 days post-CABG: 1) previous myocardial infarction, 2) less wait time for surgery post-coronary angiogram, 3) residing in a larger population centre, 4) residing closer to the hospital where surgery took place, and 5) need for community care post-discharge. These findings suggest that readmission is influenced not only by clinical factors but also by access to care, geographic context, and social supports—elements that align with both the SDOH and the Rural Nursing Theory, and emphasize how environment, access, and resources shape health experiences and outcomes in rural populations.

We identified similar patient-related and procedure-related factors as described in the existing literature. These included myocardial infarction (Benuzillo et al., 2018; Tam et al., 2019), wait time for surgery (Feng et al., 2018; Shah et al., 2019; Tam et al., 2018), and a discharge destination other than the patient's home (Feng et al., 2018; Khoury et al., 2019). Tam et al., (2018), in one of the only studies conducted in Canada on this topic, revealed other reasons

Table 1

Participants' Clinical Characteristics, Readmitted vs Non-Readmitted

	Case Readmitted	Control Non-readmitted	Odds Ratio	95% Confidence Interval		*p* value
	***N* = 44**	***N* = 44**		**Lower**	**Upper**	
Cardiac history, *n* (%)						
Hypertension	41 (93.2%)	43 (97.7%)	0.318	0.032	3.180	0.141
Hyperlipidemia[§]	39 (88.6%)	44 (100.0%)	0.886	0.797	0.985	0.999
Myocardial infarction	22 (50.0%)	5 (11.4%)	2.517	**1.493**	**4.242**	**<0.001**
Atrial fibrillation	12 (27.3%)	5 (11.4%)	2.925	0.932	9.175	0.017
Heart failure	6 (13.6%)	10 (22.7%)	0.537	0.176	1.634	0.112
Peripheral artery disease	5 (11.4%)	9 (20.5%)	0.499	0.152	1.630	0.464
Non-cardiac history, *n* (%)						
Diabetes	21 (47.7%)	23 (52.3%)	0.834	0.361	1.924	0.872
Obesity	16 (36.4%)	14 (31.8%)	1.224	0.506	2.961	0.050
Arthritis	14 (31.8%)	6 (13.6%)	2.956	1.014	8.612	0.274
COPD	8 (18.2%)	3 (6.8%)	3.037	0.749	12.320	0.039
Chronic kidney disease	6 (13.6%)	6 (13.6%)	3.316	0.631	17.428	0.021
GERD	6 (13.6%)	5 (11.4%)	1.232	0.347	4.377	0.197
Obstructive sleep apnea	5 (11.4%)	7 (15.9%)	0.678	0.198	2.325	0.148
Recreational drug use*	3 (6.8%)	1 (2.3%)	3.146	0.314	31.484	0.094
CABG-related factor, mean (SD)						
LOS preoperative (days)[φ]	8.0 (8.9)	5.2 (7.2)	0.956	0.905	1.010	0.109
LOS postoperative (days)	7.4 (10.2)	4.9 (2.7)	0.918	0.796	1.059	0.242
Wait time post-coronary angiogram (days)	35.1 (28.2)	49.7 (9.2)	1.016	**1.003**	**1.030**	**0.016**
Surgery Urgency, *n* (%)	1.810	0.799	4.100	0.155		
Emergent	27 (61.4%)	21 (47.7%)				
Non emergent	17 (38.6%)	23 (52.3%)				
Postoperative complications, *n* (%)						
Pleural effusion[§]	11 (25.0%)	0 (0.0%)	0.750	0.632	0.890	0.997
Atrial fibrillation[¤]	10 (22.7%)	10 (22.7%)	1.000	0.396	2.710	0.668
Weakness	4 (9.1%)	1 (2.3%)	4.300	0.461	40.118	0.121
Infection (all types)	4 (9.1%)	5 (11.4%)	0.780	0.195	3.122	0.734

Note. CABG = coronary artery bypass graft; COPD = chronic obstructive pulmonary disease; GERD = gastroesophageal reflux disease; HSN = Health Sciences North; LOS = length of stay.

*Recreational drug use includes marijuana use.

φ LOS preoperative includes 1) patients admitted to hospital then underwent angiogram during their stay, 2) patients who have been readmitted directly post-angiogram, or 3) patients who are admitted up to 3 days preoperatively.

¤Post-operative atrial fibrillation was defined as new onset and heart rate >110 beats per minute.

§P-value not significant likely due to lack of variability in control group.

Table 2

Readmission Characteristics

Characteristic	Cases Readmitted (*n* = 44)
Days to readmission from discharge, mean (SD)	18.9 (17.1)
Readmission diagnosis, *n* (%)	
Congestive heart failure	9 (20.5%)
Other	9 (20.5%)
Wound infection	7 (15.9%)
Atrial fibrillation	5 (11.4%)
Gastrointestinal bleeding	3 (6.8%)
Acute coronary syndrome	3 (6.8%)
COPD	2 (4.5%)
Failure to cope	2 (4.5%)
Pneumonia	2 (4.5%)
Syncope	2 (4.5%)
Readmission complication, *n* (%)	
Wound infection	7 (15.9%)
Other*	5 (11.4%)
Atrial fibrillation	4 (9.1%)
Pleural effusion	4 (9.1%)
Pneumonia	2 (4.5%)
Acute kidney disease	2 (4.5%)
None	20 (45.5%)
LOS of readmission, (days) mean (SD)	6.8 (5.7)
Intensive care unit stay required, yes, *n* (%)	8 (18.2%)

Note. COPD = chronic obstructive pulmonary disease; LOS = Length of stay.
*Other included angina, acute coronary syndrome, cardiac arrest, cellulitis, hematuria, palpitations.

for readmission at 30 days post-CABG, which included heart failure (12.6%), arrhythmia (11.5%), pleural effusion (10.0%), surgical site infection (9.8%), angina (8.1%), and pneumonia (4.5%), all of which were revealed in our study.

In the literature, SDOH are rarely investigated and hence identified as factors associated with readmission following CABG. To date, authors have identified race and income/social status, where non-white race and insurance status (private insurance, Medicaid, Medicare and self-pay) were associated with readmission (Feng et al., 2018; Khoury et al., 2019; Shah et al., 2019; Shawon et al., 2021; Tam et al., 2018).

In our study, there was limited reference to race and culture, including Indigenous status, in the electronic health records. Canada lacks population data regarding race and ethnicity in health care settings (Ko et al., 2024), which impedes our understanding of the influence of race and ethnicity on health inequities. In three instances, Indigenous status was referenced in the charts, yet only determined through their insurance status of carrying valid federally-funded Non-Insured Health Benefits coverage, as outlined in the Indian Act (Government of Canada, 2019). By relying on Indigenous insurance status to determine a person's Indigenous identity, there is a greater possibility of not being able to systematically identify all Indigenous people through data included in their charts. The Rural Nursing Theory recognizes that systemic and institutional racism in health care can cause some Indigenous people to avoid public hospitals, choosing instead to seek care from Indigenous-led clinics where they feel safer and more culturally supported (Tsuji et al., 2023). Knowledge of a patient's Indigeneity can assist in the cultural tailoring of their care. For example, post-operative cardiac rehabilitation can be culturally adapted to benefit Indigenous communities (Ko et al., 2024). There is evidence suggesting that this lack of tailoring leads to some patients who identify as Indigenous, or those living in RRNCs, being less engaged in post-operative teachings and strategies to enhance recovery (Coombs et al., 2022). The SDOH framework also reinforces the need to address not only individual behaviours, but also cultural safety, access to care, and socioeconomic barriers to ensure equitable outcomes.

Although this study considered some key SDOH, income and social status—a core determinant—was not directly captured in the data. Income influences post-surgical outcomes through its impact on access to medications, transportation, housing stability, nutrition, and follow-up care. Patients in rural and remote northern communities often experience higher rates of unemployment, lower income, and reduced access to social resources, which can all impact their ability to recover post-CABG (Etowa & Hyman, 2022; CARRN, 2020).

The geographic particularities of RRNCs had important impact on our findings, in particular, distance of the patient's main residence from the hospital where the CABG took place, the population size of town of residence, and wait times. In our study, the non-readmitted group was mostly composed of patients living in small (45.5%) and medium (31.8%) population centres approximately 180 km away from HSN, while the readmitted group consisted of patients living in larger population centres (68.2%), located approximately 57 km from the hospital. While at first glance this may be surprising, it is possible that a proportion of patients in the non-readmitted group may have been readmitted to a hospital closer to their town of residence, in facilities outside HSN where we did not have access to patient charts. These patients are served by another main

Table 3

Social Determinants of Health, by Readmission Status

	Case Readmitted	Control Non-readmitted	Odds Ratio	95% Confidence Interval		*p* value
	N = 44	N = 44		Lower	Upper	
Employment and working conditions						
Employment group, *n* (%)						
Mining	6 (13.6%)	4 (9.1%)	0.889	0.125	6.319	0.906
Administration	3 (6.8%)	3 (6.8%)	1.524	0.305	7.604	0.608
Engineer	2 (4.5%)	1 (2.3%)	3.111	0.414	23.393	0.270
Food services*	1 (2.3%)	1 (2.3%)	0	0	0	0.999
Landscaping	1 (2.3%)	2 (4.5%)	1.333	0.057	31.121	0.858
Motor transport	3 (6.8%)	2 (4.5%)	2.667	0.158	45.141	0.497
Nursing	1 (2.3%)	1 (2.3%)	1.333	0.149	11.929	0.797
Postal services*	1 (2.3%)	1 (2.3%)	0	0	0	1.000
Teacher*	4 (9.1%)	5 (11.2%)	0	0	0	1.000
Not reported*	22 (47.7%)	24 (54.5%)	0	0	0	1.000
Private insurance, yes, *n* (%)	24 (54.5%)	33 (75.0%)	1.718	0.940	3.140	0.079
Physical environment						
Size of town of residence						
Large population	30 (68.2%)	10 (22.7%)	0.183	0.066	0.512	<0.001
Medium population	3 (6.8%)	14 (31.82%)		0.505	2.390	0.202
Small population	11 (25.0%)	20 (45.45%)				
Distance from HSN (km)	57.8 (80.3)	181.9 (137.3)	1.010	1.005	1.015	<0.001
Community care use	23 (52.3%)	3 (6.8%)	14.968	4.026	55.645	<0.001
Social supports						
Marital status (*n*, %)						
Married	26 (59.1%)	34 (77.3%)	0.255	0.048	1.367	0.111
Separated	7 (15.9%)	2 (4.5%)	1.308	0.573	1.160	0.303
Single	9 (21.5%)	0 (0%)				
Widowed	2 (4.5%)	8 (18.2%)	0.765	0.253	2.309	0.634
Discharge location*						
Home	32 (72.7%)	44 (100%)	1.375	0	0	0.170
Health care facility	6 (13.6%)	0 (0%)	18.203	0	0	1.000
Family's home	6 (13.6%)	0 (0%)				
Access to Health Services						
Patient has family health practitioner, yes, *n*(%)	38 (86.4%)	43 (97.7%)	0.147	0.017	1.279	0.082
Culture						
Indigenous insurance status	3 (6.8%)	0 (0%)				

Note. HSN = Health Sciences North

*Confidence intervals estimate of 0 likely due to lack of variability in control group

hospital, which does not offer specialized cardiac care, such as coronary angiograms and cardiac surgeries. Patients in RRNCs are challenged travelling long distances for cardiac services, enduring the implications of travel, including time, financial costs, life disruptions, and missed work (Health Quality Ontario, 2017; Law et al., 2022). With greater difficulties accessing care due to geographical distance from acute and specialized care, rural residents may be more likely to dismiss early signs of postoperative complications and symptoms.

Wait times for CABG following coronary angiography and CAD diagnosis are substantially different based on geography. Patients living in a smaller population centre and not readmitted (control) waited over 49 days, while those who were readmitted waited on average 35 days. In comparison, at one Southern Ontario hospital, the average wait times for CABG post-coronary angiogram was 19 days (Ontario Health, 2024). Waitlists for cardiac consultations and subsequent cardiac surgeries are an ongoing challenge for publicly-funded systems globally (Vervoort et al., 2024). Waitlists for cardiac surgery often result in unplanned re-hospitalization and an increased risk of death (Sun et al., 2021). Law et al. (2022) conducted a retrospective analysis using a comprehensive provincial surgical wait time database in Ontario to study various surgical wait times and socioeconomic status in provincially funded health care. The authors noted that patients in rural towns waited longest for surgeries (mean 74.1 days); in comparison to the overall mean waiting time for surgery of the population (mean 62.3 days). Similarly, De Jager's et al. (2023) cross-sectional study assessed patients' timely access to nonurgent inguinal hernia repairs, cholecystectomies, hip arthroplasties, knee arthroplasties, arthroscopies, benign uterine surgeries, and cataract surgeries in Ontario from April 2013 to December 2019. They revealed that 14% of surgeries performed in RRNCs exceeded the Health Quality Ontario wait time targets in comparison to surgeries performed in urban areas (10.6%). Both the Rural Nursing Theory and SDOH help us interpret how systemic delays and geographic barriers contribute to inequities in surgical outcomes, emphasizing the need for targeted interventions that account for rural realities.

Implications for Nursing Practice

We identified the importance of considering the SDOH in patients' journeys through CABG. These findings allow nurses caring for people living in RRNCs to be more aware of the interplay and influence of patient, procedure, and social-related factors on potential for readmission post-CABG. With this knowledge, nurses are well positioned to be able to identify patients at higher risk of readmission, so that they can receive tailored postoperative teaching, and be referred to appropriate community care and available support. Nurses can enhance pre- and post-operative teaching and care based on the needs, locations, and lifestyles of each patient, their families, and close social supports. Eliciting and documenting SDOH in patients' charts are vital to gaining a holistic view of recovery, as factors, such as housing, income, transportation, and caregiver availability, can significantly affect outcomes (Etowa & Hyman, 2022). Designing a comprehensive discharge plan of care that integrates SDOH should be standard practice to ensure comprehensive, patient-centred care. Central to reducing readmission risk in patients living in RRNCs is health equity, defined as creating a fair health environment for all groups of people and being able to access health services without barriers, such as distance or income (Public Health Agency of Canada, 2024). Integration of the SDOH through CABG clinical pathways has the potential to enhance health equity for people living in RRNC. The Canadian Nurses Association has recognized that all nurses have "a professional and ethical responsibility to promote health equity" and "must include the social determinants of health in their assessments and interventions with individuals, families, and communities" (CARRN, 2020, pp.10). Nurses can uphold health equity by understanding patients as a whole, and capturing that understanding in their documentation (CARRN, 2020). The Protocol for Responding to and Assessing Patient Assets, Risks, and Experiences (PRAPARE) tool is an example of a screening tool that aims to capture SDOH, developed by the National Association of Community Health Centers (2016). Freely accessible (https://prapare.org/the-prapare-screening-tool/) and available in several languages, this tool consists of 21 questions assessing SDOH including race/ethnicity, language, housing status, education, employment, transportation, and social integration, among others. Howell et al., (2023) conducted a cohort study testing the PRAPARE tool in an American tertiary health care environment on more than 6,000 patients. They stated this tool facilitated the collection of SDOH and can be adaptable to different clinical settings, such as the emergency department, primary care, or community clinics. There is opportunity to validate this tool in the cardiac surgery context.

Finally, nurses can turn to advocacy to ensure people living in RRNCs can easily access health services and are able to afford nutritious food and medications, regardless of where they reside, their race, or socioeconomic status (Health Quality Ontario, 2017). Advocacy for services, such as remote monitoring and post-operative telemonitoring, is crucial to support recovery for CABG patients in rural areas. These technologies facilitate virtual follow-up and enable the early detection of complications. However, limited internet connectivity, digital literacy, and infrastructure in remote regions can restrict their use. Addressing these challenges is essential to ensure equitable access to post-discharge care. Furthermore, nurses must advocate for more specialized cardiac services, such as increasing the number of sites offering coronary angiograms and CABG, closer to RRNCs. This

must be paired with comprehensive strategies to recruit and retain nurses, and other health practitioners to staff them. The Registered Nurses Association of Ontario (2015) outlined 23 recommendations to support the Government of Ontario in recruiting and retaining nurses in RRNCs, including increased access to nursing education, infrastructure renewal for community growth, and strategies to address compensation and benefit inequities for nurses in both primary and acute care sectors (Scaini & Alacon, 2023).

Limitations

Our study is not without limitations. First, our study is an observational study and we cannot identify the causes of the revealed differences. In terms of the SDOH, we observed that readmitted patients were part of different employment groups, lived in a larger population centre, were discharged to a location other than their own home, required more community care services, and had less access to family practitioners. We can only make assumptions as to why these differences exist. For instance, the readmission rate at HSN between 2021 and 2023 was 4% lower than rates reported by other authors (CIHI, 2021; Shawon et al., 2021) and readmitted patients lived closer to the hospital in which the CABG occurred. It is possible that patients documented as non-readmitted in this study were in fact readmitted to smaller community hospitals closer to their home. We were limited to HSN's database and unable to access the medical records of smaller community hospitals in the RRNCs. Next, patients were matched based on age, sex, and year of surgery; however, other clinical variables, such as left ventricular function, number of bypass grafts, and surgical approach (e.g., off-pump CABG, minimally invasive, or traditional sternotomy) were not accounted for in the matching process. Differences in these clinical and procedural factors may influence postoperative outcomes and readmission risk, potentially introducing residual confounding and limiting the generalizability of findings. We also obtained all available data points of interest, but it remains that some data were missing from the patients' charts, a common limitation of retrospective database studies (Talari & Goyal, 2020). We did consider all forms of documentation in the electronic charts that were available to us, but we were limited to what data was available in Meditech. Furthermore, few SDOH were routinely collected and documented in the electronic medical charts. Most of the SDOH data captured were through narrative notes suggesting that, at present, it is at the individual practitioner's discretion to capture and document them. Finally, there was a potential under-identification of Indigenous individuals, as this data relied on federal insurance records (e.g., NIHB). This may not capture patients using employer or provincial coverage, leading to incomplete representation of Indigenous identity and health care utilization.

Conclusion

Factors for readmission post-CABG included access to health services, physical environment, and availability of services in the community, all notable within the SDOH. The findings of this study are an important step toward improving health service delivery within RRNC. To enhance holistic care for patients living in RRNCs undergoing CABG, we ought to consider the SDOH alongside patient and clinical related factors when developing plans of care for optimal outcomes. This work serves as an important stepping stone for future research, underscoring the urgent need to build more robust systems for collecting and documenting the SDOH within patient records, for greater health equity.

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Conflicts of Interest

None

Disclosure

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