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Cardiac services accessibility: What we learned by studying angiogram trends among Status First Nations people and all other Manitobans

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Cardiac services accessibility: What we learned by studying angiogram trends among Status First Nations people and all other Manitobans

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Abstract

Objectives: To investigate differences in patient characteristics and rates of index coronary angiography between First Nations (FN) and non-FN populations in Manitoba, Canada.

Setting: Population-based, secondary analysis of provincial administrative health data.

Participants: All adults 18 years or older who received an index angiogram between 2000/01-2008/09.

Primary and Secondary outcome measures: (1) Descriptive statistics for age, sex, income quintile by rural and urban residency, and Charlson Comorbidity Index score for FN and non-FN patients between 2000/01 to 2008/09. (2) Annual index angiogram rates for FN and non-FN populations, and among those, the rates of ‘urgent’ angiograms based on AMI-related hospitalizations during the previous seven days. (3) Proportions of patients who received an angiogram in the 5 to 20 years preceding a diagnosis of IHD and among those with a reported cardiovascular death; stratified by age (<65 or ≥65 years old).

Results: FN patients were younger (56.2 vs 63.8 years; $p<.0001$), more likely residing in rural and lower income areas ($p<.0001$), and had higher Charlson scores (1.32 vs 0.78; $p<.001$). Overall index angiography rate was lower among FN people (2.67 vs 3.33 per 1000 population per year; $p<.001$). A higher proportion of index angiograms among the FN patients were urgent (28.8% vs 24.9%; $p<.01$). FN people who died from cardiovascular disease ($p<.01$), or were ≥65 years old at the time of IHD diagnosis ($p<.03$), were more likely to have received an angiogram in the preceding five or more years. FN people <65 years old at IHD diagnosis were less likely to have received an angiogram ($p<.01$).

Conclusions: These results suggest angiogram accessibility differences for FN compared to non-FN populations, which may contribute to reported IHD disparities. Strategies to challenge systemic forces that impede healthcare access and decision-making are imperative to reduce racial disparities in health status and healthcare access.

Strengths and Limitations of this study

1. Population-based study of all index coronary angiograms performed between 2000/01 and 2008/09 within a defined healthcare system.
2. Study of differences in coronary angiography between First Nation’s and non-First Nation’s populations in Canada are novel.
3. Investigation of angiography utilization trends among First Nation’s and non-First Nation’s populations is multi-faceted by addressing three objectives.
4. Retrospective analysis of administrative data is unable to identify clinical appropriateness of the angiograms performed, only identify differences in rates.
5. Crude rates of index angiography reported, which did not adjust for demographic or clinical factors differences between the two populations.

Introduction

Globally, ischemic heart disease (IHD) remains the single most frequent cause of mortality.¹

While still responsible for approximately 13% of deaths in Canada in 2013, rates of IHD deaths have been decreasing.² This trend is due to multiple factors, including those related to the reduction of risk factors and advances in evidence-based medical therapies, such as statins, and revascularization procedures, such as percutaneous coronary intervention (PCI) and coronary bypass graft (CABG) surgery.³⁻⁷ Despite these improvements, First Nations (FN) populations in Canada, who have a higher burden of IHD, have not experienced a reduction in mortality over the last few decades.⁸

Conventional risk factors such as obesity, hypertension, atherosclerosis, diabetes, smoking, and diet,⁸⁻¹³ are used to explain worse cardiovascular health outcomes among FN populations. These risk factors are too often attributed simplistically to individuals and their lifestyle choices and ignore the persistent effects of colonization and its ability to impact various areas of health, which includes risk factors and accessing services.¹⁴ Racial differences in the rates of important cardiovascular therapies, such as surgery and medications, have also been demonstrated.^{15,16}

Assessing the state of the coronary arteries through a diagnostic, (i.e., index) angiogram is an important component of cardiovascular care that is used to inform treatment decisions to manage IHD symptoms.¹⁷ This procedure reveals the presence and severity of vascular occlusion and is either performed on an elective basis, such as in patients with suspected IHD, or urgently, such as an acute myocardial infarction (AMI) to assess the feasibility of revascularization.

Lower rates of angiography have been demonstrated in FN patients who experience an AMI compared to non-FN patients. However, among patients who did receive an angiogram, there was no difference in the likelihood of undergoing PCI or CABG.¹⁸ Therefore, the decision regarding index angiography appears to play a significant role in cardiovascular health disparities between FN and non-FN people. In the United States, the complex pathways of causation and clinical decision-making in terms of cardiac care have been investigated, where findings consistently suggest access and treatment bias based on race.¹⁹⁻²⁴ Given the significantly higher rates of IHD in First Nations peoples in Canada, investigating rates of index angiograms may produce novel evidence concerning the burden of cardiovascular disease. Although differences in the prevalence of risk factors between FN and non-FN populations are well documented, there

has been minimal research about earlier disease stages and treatment processes, including angiography utilization. Furthermore, previous research has been limited to only patients who met certain diagnosis (i.e. AMI).

To address this evidence gap, we conducted a retrospective population-based investigation of index angiograms among FN and non-FN patients in Manitoba over a nine year period (2000/01 to 2008/09). While as part of a larger study we investigate various health and health service use outcomes among index angiogram patients in Manitoba, in this paper we focus on the following three objectives: 1) to describe demographic and comorbidity characteristics of those who received an index angiogram; 2) to investigate trends in index angiogram utilization rates over time, including angiograms associated with a recent AMI; and 3) to examine use of angiograms among those diagnosed with IHD, or who died from cardiovascular disease. The first two objectives aim to extend our understanding of angiography utilization and illustrate any disparities between the population groups. The third objective addresses a concern raised by Elders regarding racialized biases within healthcare that may result in some patients, despite being suitable candidates for angiography, not receiving the procedure. We designed the third objective based on this concern, as well as the knowledge that previous studies have demonstrated racialized referral and treatment preferences.¹⁹

Methods
Canadian and Manitoba Context

In Canada, health care services are publicly funded, providing universal coverage for all medically necessary hospital, physician and specialist services. Identification of medically necessary services is made at the provincial and territory level, through consultations between government and various health professional colleges. Health care services for status FN peoples living on-reserve (primarily public health services and limited primary health care) are funded, and in many cases delivered, through federal programs.²⁵ Meanwhile, hospital, physician and specialist services are funded by provincial governments regardless of FN status.²⁵ In Manitoba, all cardiac services are funded by the provincial government, and angiogram procedures are available at tertiary settings located in the provincial capital city of Winnipeg. Thus, all angiogram procedures provided to FN and non-FN patients in Manitoba are captured in the provincial administrative data system.

The term 'Indigenous' commonly represents people who self-report as either First Nation, Métis, or Inuit. There were 195,900 Indigenous people living in Manitoba in 2011, comprising 17% of the total provincial population, which is the largest proportion among Canadian provinces.²⁶ Approximately 58% (114,230) of the Manitoba Indigenous population is FN, of which 93% (105,820) are Registered Status Indians under the Indian Act.

Design

This study analyzed health administration data from the province of Manitoba (population 1.3 million). The Manitoba Population Research Data Repository, housed at the Manitoba Centre for Health Policy (MCHP), contains records of all health care services provided through the Manitoba health care system, as well as a variety of datasets from other domains (i.e. education, social). Repository data remains linkable at the individual level using a scrambled identifier to ensure privacy. The specific data files used in this study included:

- (1) The Manitoba Health Insurance Registry (referred to as the Health Registry), which captures virtually all Manitobans (FN and other), and includes person-level demographic information, and residential postal codes.
- (2) Hospital Discharge Abstracts, which contain information on all hospitalizations in Manitoba, including diagnoses and procedures provided (i.e., International Classification of Diseases [ICD]-10-CA codes).
- (3) Medical Services, which contains information on ambulatory physician visits in Manitoba and the associated ICD code for each visit.
- (4) The Vital Statistics Mortality Registry, which includes everyone who has died in Manitoba and the primary cause of death, as well as other underlying causes or external causes of death.
- (5) The Indian Registry System (IRS), which is a national database maintained by Indian and Northern Affairs Canada (INAC), and contains information on all registered Treaty FN people to determine eligibility for benefits under the Non-Insured Health Benefits Program. Since ethnic information is not available in Manitoba hospital abstracts, identification of FN patients within administrative data required linkage of the INAC

Indian Status Registry with the Personal Health Information Number held by Manitoba Health.

(6) The Drug Program Information Network (DPIN), which contains information on all prescription drugs dispensed from community-based pharmacies in Manitoba.

As part of a larger study, this research is supported by an interdisciplinary research team and collaborations with FN Elders. Study approval was obtained from the University of Manitoba’s Education and Nursing Research Ethics Board, the Manitoba Health Information Privacy Committee, and the Health Information Research Governance Committee at Nanaandawegimig, the First Nations Health and Social Secretariat of Manitoba. The linkage of the IRS data file and Health Registry approved through the research protocols of Assembly of Manitoba Chiefs prior to 2014, and Nanaandawewigamig First Nations Health and Social Secretariat of Manitoba thereafter (FNHSSM).

Study Population and Cohort Definitions

The study population used for the first two objectives included all adults (18+ years) who received an index angiogram between 2000/01 and 2008/09. Angiograms were identified using the Hospital Discharge Abstracts data file specific Canadian Classification of Health Interventions (CCI) procedure codes (Table 1), and were considered “index” if the patient had not previously received an angiogram or invasive cardiac procedure in the preceding 365 days. Two cohorts were formed for the third objective, and included all adults identified as having IHD between 2010/11 and 2014/15. IHD cases were identified with a validated algorithm based on patients who had one or more hospitalizations, or had two or more physician visits that resulted in specific ICD-9-CM or ICD-10-CA diagnostic codes (Table 1), or had one physician visit with these codes, and two or more prescriptions dispensed for medications to treat IHD symptoms;²⁷ (b) all Manitobans who were coded in Vital Statistics as having died between 1984 and 2015 with a primary cause of death in the cardiovascular chapter of the ICD-10-CA diagnostic system.

Variables of Interest

Patient characteristics: Descriptive characteristics of FN and non-FN patients who received an index angiogram between 2000/01 and 2008/09 were measured at the time of the angiogram and included: age, sex, area of residence, area-level income group (quintiles), and Charlson Comorbidity Index scores. Urban residency included those residing in Winnipeg, the only urban

Manitoba setting where angiogram services are available. Rural residency included all other Manitoba areas. Income quintiles were calculated separately for urban and rural residence areas, using postal codes and 2006 Canadian census average household incomes, which has been used in previous research and is a predictor of health and health service use.²⁸⁻³⁰ The Charlson Comorbidity Index provided a valid measure of each patient's comorbidity status and was calculated based on ICD codes from the hospital discharge abstract and physician claims databases.³¹

Index Angiography Trends: Annual population-based rates of index angiograms were calculated among FN and non-FN populations for each year from 2000/01 to 2008/09 along with an overall average of annual rates. Yearly FN and non-FN population counts of adults 18 years of age or older as of December 31 were obtained separately and used as the denominators for each rate calculation. We identified angiograms that were performed within seven days of the patient being hospitalized for an AMI, and categorized these angiograms as urgent. An AMI was defined using a validated definition: a hospitalization with a specific ICD-9-CM or ICD-10-CA code (Table 1) listed as the most responsible diagnosis, and a length of stay of three or more days (unless the patient died in hospital, in which case length of stay was not relevant).³² The proportion of angiograms in each year from 2000/01 to 2008/09 that were categorized as urgent were then calculated for the FN and non-FN groups.

Angiography among IHD and CVD-related death cohorts: The IHD cohort was stratified by FN status and age (<65, 65+ years as of December 31, 2012) and examined to determine if an angiogram occurred between 1984/85 and 2014/15. The cohort of individuals who died from CVD were also stratified by FN status and age (<65, 65+ years at the time of index angiogram), and examined for receipt of an angiogram in the 20 years prior to death. Proportions of FN and non-FN patients in both cohorts who received an angiogram were compared. Annual angiography trends were explored in a subset of cardiovascular deaths between 2002/03 and 2013/14, specifically in terms of whether or not they had an angiogram in the five years prior to death.

Statistical Analysis

All analysis was done on the secure server at the MCHP, using SAS® statistical analysis software, version 9.4 (SAS Institute Inc., 2011). Differences in demographic, socioeconomic,

and comorbidity were tested for significance using t-tests and chi-square tests. All differences in population-based angiography trends and the use of angiography among the IHD and CVD cohorts were tested for significance using chi-square tests. Statistical significance for all tests was set at $p<0.05$.

Results

Patient characteristics

In total, 25,816 adult Manitobans received an index angiogram between 2000/01 and 2008/09, of which 1,499 (5.8%) were FN (Table 2). Comparison of characteristics at the time of angiogram revealed significant differences. FN patients were younger (56.2 v. 63.8 years; $p<.0001$), less likely to be male (58.7% v. 65.8%; $p<.0001$), more likely to reside in rural areas (75.8% v. 36.4%; $p<.0001$), and had higher Charlson Comorbidity Index scores (1.3 v 0.8; $p<.0001$). In urban and rural areas, the proportion of index angiograms performed on FN patients was greatest among those living in the lowest income quintiles. Proportions decreased in each subsequently higher income quintile. Among the non-FN group, the proportion of index angiograms were more evenly distributed across the five income levels in urban and rural areas.

Trends in angiogram and urgent angiogram rates

The overall average angiogram rate between 2000/01 and 2008/09 was significantly lower in the FN population (2.67 v. 3.33 per 1000 population per year; $p<.001$; Figure 1). The annual rates of index angiograms ranged from 2.26 to 3.10/1000 per year for FN population versus 3.08 to 3.40/1000 per year for non-FN population. No temporal trends existed for either group; however, the angiogram rate was lower in the FN population each year, and statistically different in five of the nine years analyzed.

Of all index angiograms performed between 2000/01 and 2008/09, a higher proportion were related to a hospitalization for AMI among FN patients (defined as urgent; see Figure 2), compared to non-FN patients (28.8% v. 25.0%; $p<.01$). Although higher proportions among FN patients were observed for each year studied, the only statistically significant difference was observed in 2003/04 (33.9% v. 22.5%; $p<.01$). From 2000/01 to 2008/09, the proportion of AMI-related angiograms among FN and non-FN patients increased by 60.3% and 101.3%, respectively. Although the increase occurred steadily over time among non-FN patients, the pattern among FN patients was more variable.

Angiography among IHD and CVD-related death cohorts

The proportion of adult Manitobans with an IHD diagnosis between 2010/11 and 2014/15 who received an angiogram anytime since 1984/85 were similar between FN and non-FN groups (49.1% v. 49.2%; $p>.1$; Table 3). However, a significant difference was noted when those with IHD were stratified by age (<65 and ≥ 65 years). A significantly lower proportion of FN patients in the younger age group (47.8% v. 53.1%, $p<.01$) and a higher proportion in the older age group (50.9% v. 48.2%, $p<.025$) received an angiogram.

In patients who died from CVD-related causes, a significantly higher proportion of FN people than non-FN people received an angiogram within the 20 years before death (17.8% v. 12.5%, $p<.01$; Table 3). This difference persisted when the groups were stratified by age (<65 years, 19.7% v. 16.4%, $p<.01$; ≥ 65 years, 16.3% v. 12.0%, $p<.01$).

Overall, a higher proportion of FN people with CVD-related deaths had angiograms performed in the previous five years, compared to non-FN CVD deaths (17.2% v. 9.8%; $p<.05$; Figure 3). The proportions were higher among FN people in each year studied and significantly higher in all but three years. Although the proportion among the non-FN group increased gradually over time, no clear pattern existed among the FN group.

Discussion

Lower rates of index angiograms among FN population and raises questions for at least two reasons: 1) more of the FN index angiogram recipients lived in rural areas and 2) reported rates of IHD being higher among FN populations in Canada. A key strength and novelty of this study was analysis of population-based differences between FN and non-FN patient characteristics undergoing angiograms and utilization rates. Findings from the three objectives advances our evidence concerning angiography utilization among the two populations, rather than focusing on specified sub-populations, or focusing solely on individual choices and lifestyle factors. The aim underlying the three objectives was to expand insights into healthcare access for FN people and all other Manitobans.

At the time of index angiography, FN patients were younger by an average of 7.6 years, less likely to be male, to have higher comorbidity scores, and to reside in rural and lower income areas compared to non-FN patients. These differences reflect the compositions of the two

populations in Manitoba, and are comparable to differences reported among other Indigenous and non-Indigenous populations at the time of cardiovascular-related hospitalizations.^{18, 21, 33-36}

While the population-based rates of index angiograms varied for both groups over time, the overall rate and each annual rate was lower among the FN population compared to the non-FN population. While reported angiography rate differences found in this study are similar to that of the age and sex adjusted rates of cardiovascular surgeries performed among the Indigenous and non-Indigenous populations in Manitoba (0.76 and 1.15/1000 population, respectively),¹⁵ one might have anticipated rates being higher among the FN group, given the reported higher rates of cardiovascular disease.

The proportion of index angiograms that were performed on patients who had an AMI within seven days prior to their angiogram increased from 2000/01 to 2008/09 for both populations. While the trend over time for the non-FN population was linear, there was more variation in the trend for the FN population. The proportions of these “urgent” angiograms were consistently higher among FN patients than non-FN patients; however, differences between the two populations diminished over time. Given that there was not a clear trend regarding the rates of all index angiograms, the increasing rates of urgent angiograms among non-FN patients may indicate a change in practice for that population, especially related to elective angiograms. Therefore, it appears that there are no differences at this point in the proportions of angiograms that are performed on an elective or urgent basis between FN and non-FN patients, only that the FN population is undergoing lower rates of angiograms for either reason.

While our analysis did not attempt to determine which factors may explain the lower rates of angiography observed among the FN population, it is important to note that there are many clinical and non-clinical factors that influence the decision regarding whether an angiogram is performed. Older age (>65 years of age) has been associated with a lower likelihood of angiography,³⁷ which is attributed to the higher level of comorbidities among older adults, precluding them from angiography or revascularization. Guidelines indicate that some pre-existing conditions such as renal insufficiency and diabetes may increase the risk of subsequent complications.¹⁶ The FN population in Manitoba is younger than the general population, but they also experience a higher level of comorbidity, especially diabetes.^{38,39} Therefore, the pre-existing conditions among FN patients may result in a lower proportion of patients for which angiography

is appropriate. A higher proportion of the FN population live in rural areas of Manitoba than the non-FN population, which may also affect rates of angiography given that the only catheterization facilities in Manitoba were located in Winnipeg. However, the sex- and age-adjusted rates of cardiac surgeries have been shown to be higher for Indigenous patients residing in northern rural areas, and lower for urban patients compared to non-Indigenous patients living in the same areas.¹⁵ Furthermore, the proportions of cardiac surgeries performed on rural and urban Indigenous patients in Manitoba reported by Sood et al.¹⁵ were almost identical to the proportions of patients who received angiograms in our study. Therefore, it seems that the lower rates of angiography are not explained by living further from the catheterization facilities.

The lower rates of angiography among the FN population may be a function of a lower rate of FN individuals visiting a physician. For various reasons, many FN people view the healthcare system as racist and untrustworthy, with poor communication and care continuity, which influences how they access and utilize health services.⁴⁰⁻⁴² Such system-level barriers to access may result in FN people postponing cardiac care until an acute event. This may have been indirectly observed while addressing the third objective exploring the concern of biases in the healthcare system regarding race-based assumptions that may influence decision making. There were a higher proportion of FN individuals who died from a CV-related cause who also received an angiogram, regardless if they were younger or older than 65 years of age; while only in IHD patients over 65 years of age was the proportion who received an angiogram higher for FN patients (a lower proportion was observed among patients under 65 years old in the FN group). Although these findings did not support our initial hypothesis that a bias in healthcare would result in a lower proportion of angiograms performed in the two cohorts (except for FN IHD patients under 65 years of age), it may suggest that FN patients are less likely to seek care until an acute event occurs. As a consequence, IHD may not be diagnosed until later in the disease process which may diminish the effectiveness of any subsequent treatment. A previous study reported that FN people in Manitoba have higher rates of primary care and hospitalizations, yet lower rates of specialty referral care,⁴³ which may indicate that FN patients delay seeking care to the point that specialty care for their condition may not benefit them and is not referred, or that a referral bias exist within the healthcare system. Both occurrences may contribute to the lower angiography rates observed in this study.

Physician-patient relationships, related societal biases, and patient preferences and health beliefs all likely influence whether a patient undergoes angiography.^{19, 22-24,44-46} Underpinning these factors, and those described above, is the historical and persistent impact of colonization and structural racism embedded in post-colonial institutions such as healthcare.^{14, 47-52} Moreover, a substantive base of evidence exists regarding experiences of systemic racism being clearly linked to compromised cardiac outcomes; racism has significant negative and measureable impacts on human biophysiological processes and outcomes.⁵³⁻⁵⁹ Furthermore, many social disparities related to income, education, employment, and housing, exist between FN and non-FN people, which are rooted in colonial policies and practices⁴⁹ Given the inextricable link between health and social indicators, it has been suggested that a nationwide, holistic FN health strategy that addresses the social conditions of FN people is necessary to improve health and healthcare access for the FN population.⁵¹

Several study limitations are notable. First, only FN people who were registered under the Indian Act were included in the FN group, which means unregistered FN people were included in the non-FN group. However, 93% of self-reported Manitoba FN people are registered,³⁷ therefore, the misclassification bias was small. Second, the non-FN group included other Indigenous people (i.e. Métis and Inuit) who also experience a greater burden of CVD.⁶⁰ If their angiography rates are similar to the FN group, their inclusion in the non-FN group would lead to an underestimation of the rate difference between FN and non-FN populations. Third, administrative data does not contain information that would allow for an analysis of the appropriateness of angiography. Therefore, it is not known whether angiography was employed more appropriately for one group or the other.

Conclusion

Lower angiography rates among Manitoba’s FN people compared to the non-FN population were observed, which raises concerns given the higher burden of IHD experienced by the FN population. Notable utilization rate differences imply that service availability is not the same between these two Manitoba populations. Further research is needed to explore the impact of patient, physician, and healthcare system factors rooted in colonialism, which may be used to inform strategies and policies for reducing racial disparities in cardiovascular health for FN people.

Statement of author contributions

The lead author (AS) and second author (LD) co-created the initial manuscript draft; and we have been responsible for integrating critical feedback from all the co-authors (EM, RJB, CC, BE, AK, TN, JS, MS, KT and RF). All authors are co-investigator on the larger study and with this manuscript each co-author (AS, LD, EM, RJB, CC, BE, AK, TN, JS, MS, KT, and RF) have had involvement from conceptualization of the three objectives to interpretation of findings. Their involvement includes, reviewing the manuscript several times and providing feedback at least once on previous drafts. In addition, the third author (EM) has been a significant contributor regarding systemic issues and racism within healthcare, and the final author (RF) oversaw all statistical analysis on this study.

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Studying angiogram trends among Status First Nations people and all other Manitobans

Table 1: ICD and CCI procedural code definitions

Procedure/ Condition	Codes	Definition
Angiography	CCI	
	3.IP.10	Coronary angiography
IHD	ICD-9-CM	
	410	Acute myocardial infarction
	411	Other acute and sub-acute forms of ischemic heart disease
	412	Old myocardial infarction
	413	Angina pectoris
	414	Other forms of chronic ischemic heart disease
	ICD-10-CA	
	I20	Angina pectoris
	I21	ST elevation and non-ST elevation myocardial infarction
	I22	Subsequent ST elevation and non-ST elevation myocardial
	I24	infarction
	I25	Other acute ischemic heart diseases
		Chronic ischemic heart disease
AMI	ICD-9-CM	
	410	Acute myocardial infarction
	ICD-10-CA	
	I21	ST elevation and non ST elevation myocardial infarction

Studying angiogram trends among Status First Nations people and all other Manitobans

Table 2: Characteristics of index angiogram patients by First Nation's status (2000/01-2008/09)

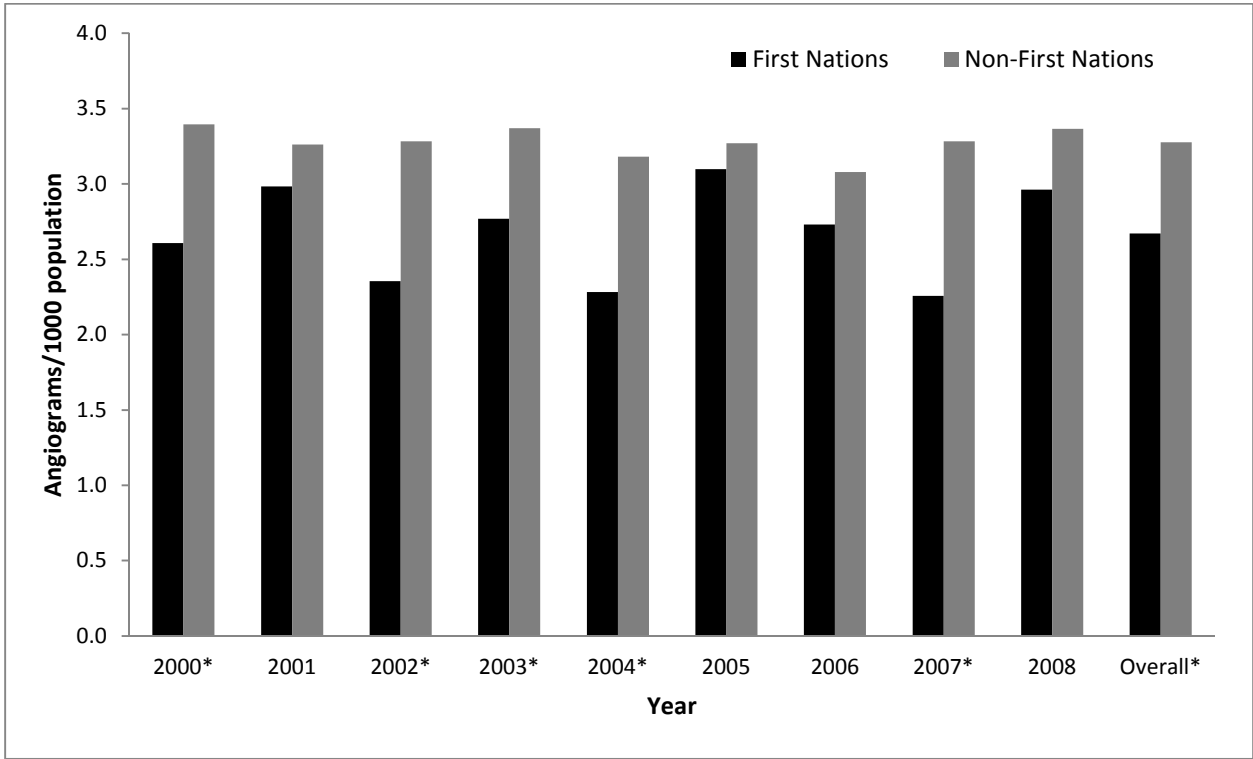
Characteristic	Patient characteristic at index admission, n (%)*				p-value
	First Nations n = 1499		Non-First Nations n = 24317		
Age, years, mean ± SD	56.2	11.3	63.8	11.9	<.0001
Male sex	880	(58.7)	15989	(65.8)	<.0001
Rural Residency	1108	(75.8)	8826	(36.4)	<.0001
Average household income quintiles					<.0001
Rural 1 (lowest rural stratum)	650	(43.4)	1244	(5.1)	
Rural 2	201	(13.4)	1819	(7.5)	
Rural 3	103	(6.9)	2014	(8.3)	
Rural 4	96	(6.4)	1961	(8.1)	
Rural 5 (highest rural stratum)	58	(3.9)	1788	(7.4)	
Urban 1 (lowest urban stratum)	229	(15.3)	3084	(12.7)	
Urban 2	67	(4.5)	3190	(13.1)	
Urban 3	45	(3.0)	3279	(13.5)	
Urban 4	23	(1.5)	3019	(12.4)	
Urban 5 (highest urban stratum)	9	(0.6)	2842	(11.7)	
Charlson Comorbidity Index Score, mean ± SD	1.3	1.3	0.8	1.0	<.0001

Note: SD = standard deviation, Total counts from the rural and urban income quintiles do not equal the total count of angiograms because some incomes could not be found.

^{*}Unless otherwise indicated.

Studying angiogram trends among Status First Nations people and all other Manitobans

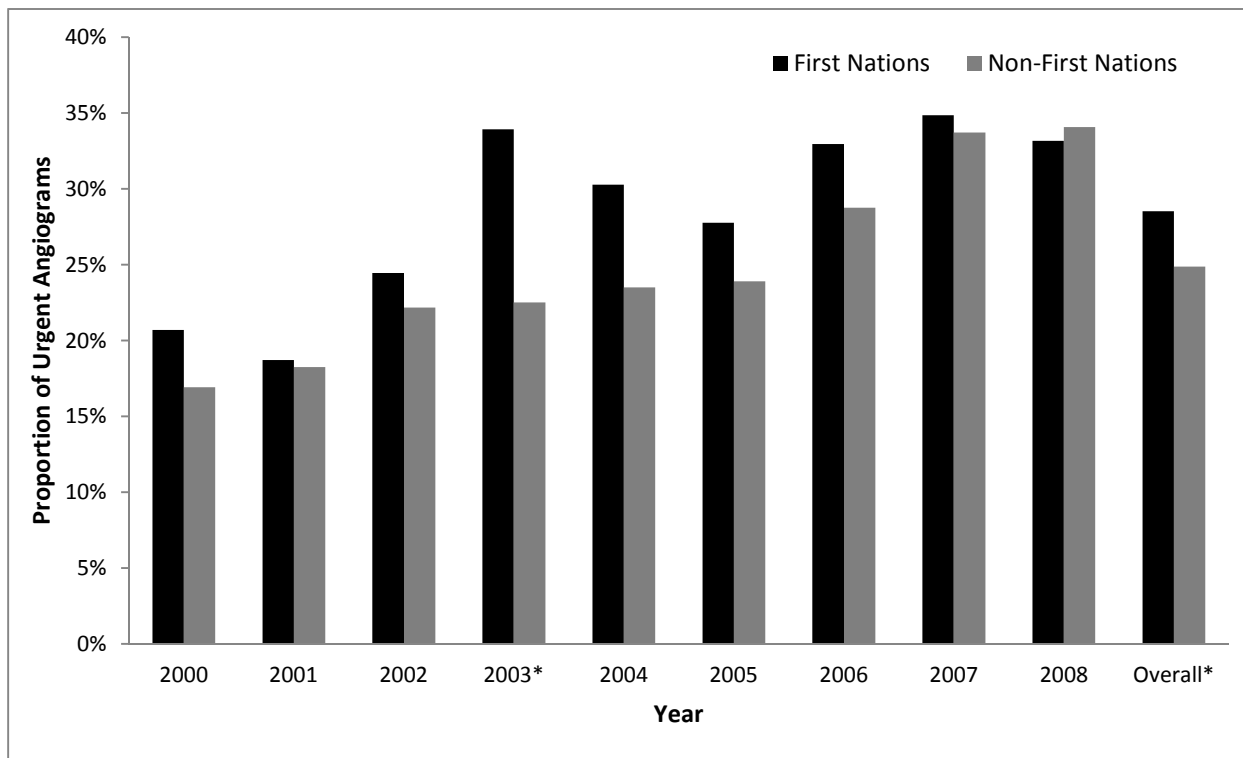
Figure 1: Population-based rates of index coronary angiography between 2008/09 and 2008/09, by First Nation status



*Significant difference between groups ($p < .05$).

Studying angiogram trends among Status First Nations people and all other Manitobans

Figure 2: Proportion of angiograms categorized as urgent (related to an AMI hospitalization) between 2000/01 and 2008/09, by First Nation status.



*Significant difference between groups ($p < .05$).

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Table 3: Angiogram status among IHD and CVD death cohorts

Age, year	N (%) with IHD who received angiogram*			N (%) of CV deaths who received angiogram**		
	First Nations	Non-First Nations	P-value	First Nations	Non-First Nations	P-value
< 65	1318 (47.8)	10805 (53.1)	<.01	273 (19.7)	2073 (16.4)	<.01
≥ 65	1054 (50.9)	26534 (48.2)	<.03	298 (16.3)	10731 (12.0)	<.01
Total	2372 (49.1)	37339 (49.2)	>.10	571 (17.8)	12804 (12.5)	<.01

Note: IHD = ischemic heart disease, CV = cardiovascular

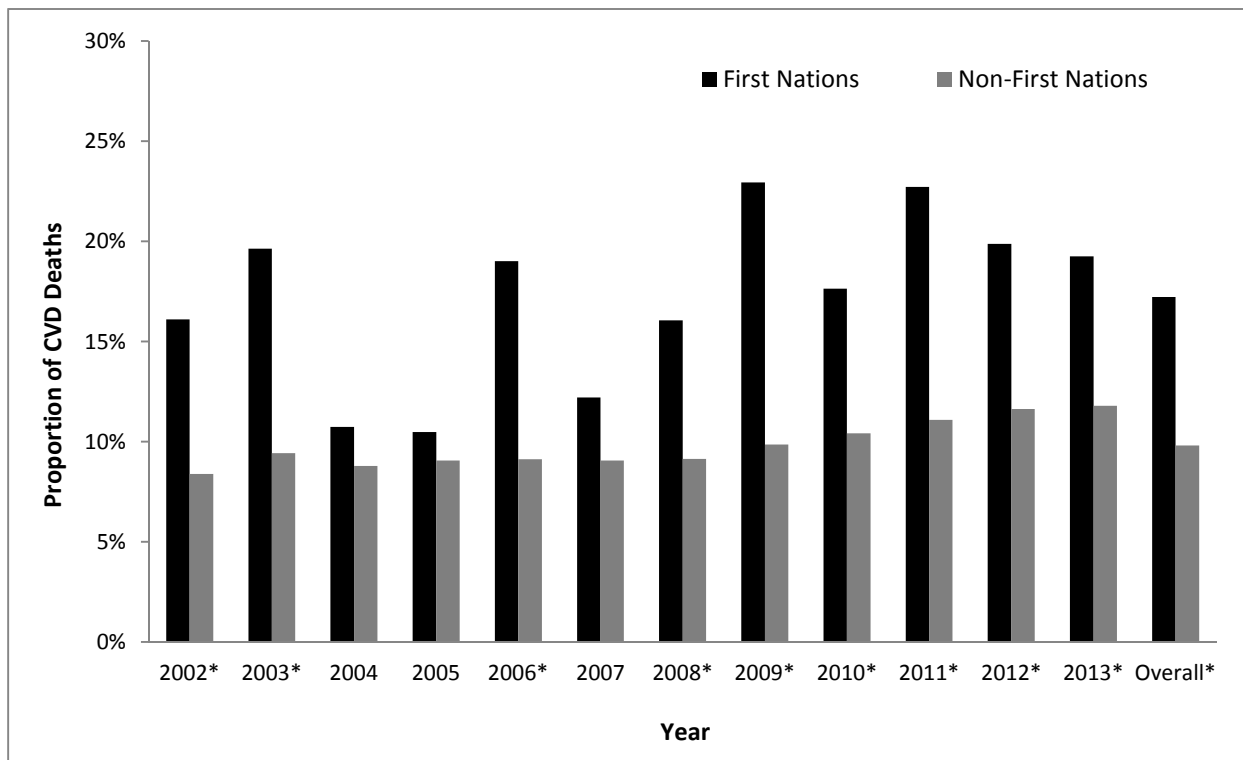
*anytime between 1984/85 and 2014/15

** within 20 years of death.

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Studying angiogram trends among Status First Nations people and all other Manitobans

Figure 3: Proportion of cardiovascular deaths occurring between 2002/03 and 2013/14 where an angiogram was performed within 5 years before death, by First Nation status.



*Significant difference between groups ($p < .05$).

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Index coronary angiography utilization in Manitoba, Canada: a population-level descriptive analysis of First Nation and non-First Nation recipients

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Manuscripts

Index coronary angiography utilization in Manitoba, Canada: a population-level descriptive analysis of First Nation and non-First Nation recipients

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Abstract (299 words)

Objectives: To investigate recipient characteristics and rates of index angiography among First Nations (FN) and non-FN populations in Manitoba, Canada.

Setting: Population-based, secondary analysis of provincial administrative health data.

Participants: All adults 18 years or older who received an index angiogram between 2000/01-2008/09.

Primary and Secondary outcome measures: (1) Descriptive statistics for age, sex, income quintile by rural and urban residency, and Charlson Comorbidity Index for FN and non-FN recipients. (2) Annual index angiogram rates for FN and non-FN populations, and among those, rates of ‘urgent’ angiograms based on AMI-related hospitalizations during the previous seven days. (3) Proportions of people who did not received an angiogram in the 20 years preceding an IHD diagnosis or a cardiovascular death; stratified by age (<65 or ≥65 years old).

Results: FN recipients were younger (56.3 vs. 63.8 years; $p<.0001$), and had higher Charlson Comorbidity scores (1.32 vs. 0.78; $p<.001$). During all years examined, index angiography rates were lower among FN people (2.67 vs. 3.33 per 1,000 population per year; $p<.001$) with no notable temporal trends. Among the index angiogram recipients, a higher proportion was associated with an AMI-related hospitalization in the FN group (28.8% vs. 25.0%; $p<.01$) and in both groups rates significantly increased over time. FN people who died from cardiovascular disease, or were older (65+ years old) diagnosed with IHD, were more likely to have received an angiogram in the preceding 20-30 years (17.8% vs. 12.5%; $p<.01$ and 50.9% vs. 49.5%; $p<.03$, respectively). FN people diagnosed with IHD who were under the age of 65 were less likely to have received an angiogram (47.8% vs. 53.1%; $p<.01$)

Conclusions: Index angiogram utilization differences are suggested between FN and non-FN populations, which may contribute to reported IHD disparities. Investigating factors driving these rates will determine any association between ethnicity and angiography services.

Strengths and Limitations of this study

1. Population-based study of all index coronary angiograms performed between 2000/01 and 2008/09 within a universal healthcare system.
2. Study of differences in coronary angiography between First Nations and non-First Nation’s populations in Canada are novel.
3. Investigation of angiography utilization trends among First Nations and non-First Nation’s populations is multi-faceted by addressing three objectives.
4. Retrospective analysis of administrative data is unable to identify clinical appropriateness of the angiograms performed, but can identify differences in rates.
5. Crude rates of index angiography reported, which did not adjust for demographic or clinical differences between the two populations.

Introduction (words 3965)

Globally, ischemic heart disease (IHD) remains the single most frequent cause of mortality.¹

While still responsible for approximately 13% of deaths in Canada in 2013, rates of IHD deaths have been decreasing.² This trend is due to multiple factors, including reduction of risk factors, advances in evidence-based medical therapies, such as statins, and revascularization procedures, such as percutaneous coronary intervention (PCI) and coronary artery bypass graft (CABG) surgery.³⁻⁷ Despite these improvements, First Nations (FN) populations in Canada, have a higher burden of IHD,^{8,9} and have not experienced the same rate of reduction in mortality over the last few decades.^{10,11} In this article, our goal is to advance an understanding of cardiac health disparities reported among FN peoples in Canada by presenting the first phase of a larger study focused on heart health among FN people living in Manitoba, Canada.

Conventional risk factors such as obesity, hypertension, atherosclerosis, diabetes, smoking, and diet,^{8-10, 12-14} are most often cited as causes of cardiovascular health outcomes among FN populations. These risk factors are often attributed to individuals and their lifestyle choices, rather than the persistent effects of colonization, and related impacts on health and health services.¹⁵ Racial differences have also been demonstrated in rates of important cardiovascular therapies, such as surgery and medications.^{16, 17} Assessing the state of the coronary arteries through an initial angiogram is an important component of cardiovascular care to inform treatment decisions to manage IHD symptoms.¹⁸ This procedure reveals the presence and severity of vascular occlusion among coronary arteries, informing the potential need for, and feasibility of, revascularization procedures. It can be performed on an elective basis, such as in patients with suspected IHD, or urgently, such as when hospitalized for an acute myocardial infarction (AMI).

Two recent Canadian studies revealed lower rates of angiography following an AMI in FN patients when compared to non-FN counterparts.^{11, 19} However, among patients who received an angiogram, there was no difference between the two groups in the likelihood of undergoing PCI or CABG.¹⁹ Therefore, the initial decision to perform an angiogram may play a significant role in cardiovascular health disparities between FN and non-FN people who experience as AMI. In the United States, the complex pathways of causation and clinical decision-making in terms of cardiac care have been investigated, and findings consistently indicate racial disparities in access

to treatment.²⁰⁻²⁵ Given evidence of racialized differences in receiving an angiogram, and knowing that angiograms are performed at times unrelated to an AMI investigating population-level angiogram utilization may contribute important new evidence about cardiac care access, along with health services influence on CVD burden.

This study is part of a larger research project that investigates various health and health service utilization outcomes among index angiogram recipients in Manitoba. In this article, we report the results of a retrospective population-based investigation of all index angiograms among FN and non-FN recipients in Manitoba over a nine year period (2000/01 to 2008/09). The three study objectives were: 1) to describe demographic and comorbidity characteristics of both FN and non-FN index angiogram recipients; 2) to investigate trends in FN and non-FN index angiogram utilization rates over time, including angiograms associated with a recent AMI; and 3) to compare the proportions of FN and non-FN Manitobans who did not receive an angiogram, specifically among those with an IHD diagnosis, or those who died from cardiovascular disease. The first two objectives aimed to extend our understanding of angiography utilization and illustrate differences between the two groups. The third addressed a concern raised by Elders regarding racialized biases within healthcare that may result in some patients not receiving angiography despite being suitable candidates. We designed the third objective based on this concern, as well as the knowledge that previous studies demonstrate racialized referral and treatment preferences.²⁰

Methods
Canadian and Manitoba Context

In Canada, the term ‘Indigenous’ commonly represents people who self-report as either First Nation, Métis, or Inuit. Of the approximately 36 million people in Canada, 4% identify as Indigenous and more than half (61%) of the Indigenous population are FN.²⁶ There were 195,900 Indigenous people living in Manitoba in 2011, comprising 17% of the total provincial population, which is the largest proportion among Canadian provinces.²⁷ Approximately 58% (114,230) of the Manitoba Indigenous population is FN, of which 93% (105,820) are Registered Status Indians under the Indian Act.

In Canada, healthcare services are publicly funded, providing universal coverage for all medically necessary hospital, physician and specialist services. Identification of medically

necessary services is made at the provincial and territory level, through consultations between government and various health professional colleges. Healthcare services for status FN peoples living on-reserve (primarily public health services and limited primary healthcare) are funded, and in many cases delivered, through federal programs.²⁸ Meanwhile, hospital, physician and specialist services are funded by provincial governments regardless of FN status.²⁸ In Manitoba, this includes all cardiac services, and angiogram procedures are available at a tertiary hospital located in the provincial capital city of Winnipeg. Thus, all angiogram procedures provided to FN and non-FN patients in Manitoba are captured in the provincial administrative data system.

Design

This study analyzed health administrative data from the province of Manitoba (population 1.3 million). The Manitoba Population Research Data Repository, housed at the Manitoba Centre for Health Policy (MCHP), contains records of all healthcare services provided through the Manitoba healthcare system, as well as a variety of datasets from other domains (i.e. education, social services). Repository data remains linkable at the individual level using a scrambled identifier to ensure privacy. The specific data files used in this study included:

- (1) The Manitoba Health Insurance Registry, which includes person-level demographic information, and residential postal codes for virtually all Manitobans (FB and other).
- (2) Hospital Discharge Abstracts, which contain information on all hospitalizations in Manitoba, including diagnoses and procedures provided (i.e., International Classification of Diseases [ICD]-10-CA codes).
- (3) Medical Services, which contains information on ambulatory physician visits in Manitoba and the associated ICD code for each visit.
- (4) The Vital Statistics Mortality Registry, which includes everyone who has died in Manitoba and the primary cause of death, as well as other underlying causes or external causes of death.
- (5) The Indian Registry System (IRS), which is a national database maintained by Indian and Northern Affairs Canada (INAC), and contains information on all registered Treaty FN people to determine eligibility for benefits under the Non-Insured Health Benefits Program. Since ethnic information is not available in Manitoba hospital abstracts,

identification of FN patients within administrative data requires linkage of the INAC Indian Status Registry with the Personal Health Information Number held by Manitoba Health.

(6) The Drug Program Information Network (DPIN), which contains information on all prescription drugs dispensed from community-based pharmacies in Manitoba.

As part of a larger research project, this study is supported by an interdisciplinary research team and collaborations with FN Elders. Study approval was obtained from the University of Manitoba’s Education and Nursing Research Ethics Board, the Manitoba Health Information Privacy Committee, and the Health Information Research Governance Committee at Nanaandawewigamig, the First Nations Health and Social Secretariat of Manitoba (FNHSSM). The linkage of the IRS data file and Health Registry was approved through the research protocols of Assembly of Manitoba Chiefs prior to 2014, and Nanaandawewigamig FNHSSM thereafter.

Study Population and Cohort Definitions

The first two objectives included all adult Manitobans (18+ years) who received an index angiogram between 2000/01 and 2008/09. Angiograms were identified from the Hospital Discharge Abstracts data file using specific Canadian Classification of Health Interventions (CCI) procedure codes (Table 1), and were considered “index” if the patient had not previously received an angiogram or invasive cardiac procedure in the preceding 365 days. Index angiograms indicate entry into cardiac care services through initial assessment of coronary anatomy, and are used to inform treatment decisions.

Table 1. ICD and CCI procedural code definitions

Procedure/ Condition	Codes		Definition
Angiography	CCI	3.IP.10	Coronary angiography
IHD	ICD-9-CM	410	Acute myocardial infarction
		411	Other acute and sub-acute forms of ischemic heart disease
		412	Old myocardial infarction
		413	Angina pectoris
		414	Other forms of chronic ischemic heart disease
	ICD-10-CA	I20	Angina pectoris
		I21	ST elevation and non-ST elevation myocardial infarction
		I22	Subsequent ST elevation and non-ST elevation myocardial infarction
		I24	Other acute ischemic heart diseases
		I25	Chronic ischemic heart disease
AMI	ICD-9-CM	410	Acute myocardial infarction
	ICD-10-CA	I21	ST elevation and non ST elevation myocardial infarction

Health services administrative data are ideal for investigating index angiogram recipients; however data use can be challenging when the aim is to investigate patients who did not receive an angiogram but who may have benefitted from receiving one. To address the third study objective, and the issue raised by Elders, two cohorts were formed in an attempt to identify individuals who have not received an index angiogram but in the health administrative data appeared to have cardiac health conditions. The first cohort included all adult Manitobans identified as having IHD between 2010/11 and 2014/15. IHD cases were identified with a validated algorithm that included patients who had: 1) one or more hospitalizations, or had two or more physician visits that resulted in specific ICD-9-CM or ICD-10-CA diagnostic codes (Table 1), or 2) one physician visit with these codes, and two or more prescriptions dispensed for medications to treat IHD symptoms.²⁹ The second cohort included all adult Manitobans who were coded in Vital Statistics as having died between 1984 and 2015 with a primary cause of death in the cardiovascular chapter of the ICD-10-CA diagnostic system.

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Statistical Analysis

All analyses related to the three study objectives were done on the secure server at MCHP, using SAS® statistical analysis software, version 9.4 (SAS Institute Inc., 2011). Statistical significance for all tests was set at $p<0.05$.

Angiogram recipient characteristics: Descriptive characteristics of FN and non-FN people who received an index angiogram between 2000/01 and 2008/09 were measured at the time of the angiogram, and included: age, sex, area of residence, area-level income group (quintiles), and Charlson Comorbidity Index scores. Urban residency included those residing in Winnipeg, the only urban Manitoba setting where angiogram services are available. Rural residency included all other Manitoba areas. Income quintiles were calculated for urban and rural residence separately, using postal codes and 2006 Canadian census average household incomes, which has been used in previous research as a predictor of health and health service use.³⁰⁻³² The Charlson Comorbidity Index provided a valid measure of each patient’s comorbidity status, and was calculated based on ICD codes from the hospital discharge abstract and physician claims databases.³³ The frequencies for each condition listed in the Charlson Comorbidity Index are presented, but statistical tests for differences between groups were not conducted for this study. Differences for all other characteristics between FN and non-FN recipients were tested for significance using t-tests and chi-square tests.

Index Angiography Trends: Annual crude rates of index angiograms were calculated among FN and non-FN populations for each year from 2000/01 to 2008/09 along with an overall average of annual rates. Annual FN and non-FN population counts of adults 18 years of age or older as of December 31 were obtained and used as the denominators for each rate calculation. Angiograms performed within seven days of the patient being hospitalized for an AMI were identified and categorized as urgent. An AMI was defined using the following validated definition: a hospitalization with a specific ICD-9-CM or ICD-10-CA code (Table 1) listed as the most responsible diagnosis, and a length of stay of three or more days (unless the patient died in hospital, in which case length of stay was not relevant).³⁴ All differences in annual angiography rates and proportions of urgent angiograms between FN and non-FN populations were tested for significance using chi-square tests. Trends over time were analyzed with linear regression

models fit to the annual rates and 95% confidence intervals were calculated around the regression slopes.

Angiography among IHD and CVD death cohorts: The IHD cohort was stratified by FN status and age (<65, 65+ years as of December 31, 2012) and examined to determine if an angiogram was performed anytime between 1984/85 and 2014/15. The cohort of individuals who died from CVD were also stratified by FN status and age (<65, 65+ years at the time of index angiogram), and examined for receipt of an angiogram in the 20 years prior to death. Proportions of FN and non-FN people in both cohorts who did not receive an angiogram were compared and tested for differences using chi-square tests.

Results

Recipient characteristics

In total, 25,816 adult Manitobans received an index angiogram between 2000/01 and 2008/09, of which 1,499 (5.8%) were FN (Table 2). FN recipients were younger (56.2 vs. 63.8 years; $p<.0001$), less likely to be male (58.7% vs. 65.8%; $p<.0001$), more likely to reside in rural areas (75.8% vs. 36.4%; $p<.0001$), and had higher Charlson Comorbidity Index scores (1.3 vs. 0.78; $p<.0001$). Among rural and urban FN recipients, the proportions were highest for those living in the lowest income areas and decreased in each subsequent income quintile. Among the non-FN group, the proportions of index angiograms were more evenly distributed across the five income levels regardless of residence.

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Table 2. Characteristics of index angiogram patients by First Nation’s status (2000/01-2008/09)

Characteristic	Patient characteristic at index admission, n				p-value
	(%)*				
	First Nations n = 1,499		Non-First Nations n = 24,317		
Age, years, mean ± SD	56.2	11.3	63.8	11.9	<.0001
Male sex	880	(58.7)	15,989	(65.8)	<.0001
Rural Residency	1,108	(75.8)	8,826	(36.4)	<.0001
Average household income quintiles ^a					<.0001
Rural 1 (lowest rural stratum)	650	(58.7)	1,244	(14.1)	
Rural 2	201	(18.1)	1,819	(20.6)	
Rural 3	103	(9.3)	2,014	(22.8)	
Rural 4	96	(8.7)	1,961	(22.2)	
Rural 5 (highest rural stratum)	58	(5.2)	1,788	(20.3)	
Urban 1 (lowest urban stratum)	229	(61.4)	3,084	(20.0)	
Urban 2	67	(18.0)	3,190	(20.7)	
Urban 3	45	(12.1)	3,279	(21.3)	
Urban 4	23	(6.2)	3,019	(19.6)	
Urban 5 (highest urban stratum)	9	(2.4)	2,842	(18.4)	
Charlson Comorbidity Index Score ^b , mean ± SD	1.3	1.3	0.8	1.0	<.0001
Myocardial Infarction	123	(8.2)	1,184	(4.9)	
Congestive Heart Failure	210	(14.0)	2,642	(10.9)	
Peripheral Vascular Disease	82	(5.5)	1,222	(5.0)	
Cerebrovascular Disease	67	(4.5)	1,065	(4.4)	
Dementia	7	(0.5)	148	(0.6)	
Chronic Pulmonary Disease	307	(20.5)	3,675	(15.1)	
Connective Tissue Disease	68	(4.5)	570	(2.3)	
Peptic Ulcer Disease	49	(3.3)	327	(1.3)	
Mild Liver Disease	37	(2.5)	217	(0.9)	
Diabetes without complications	663	(44.2)	4,961	(20.4)	
Diabetes with complications	132	(8.8)	438	(1.8)	
Paraplegia and Hemiplegia	10	(0.7)	76	(0.3)	
Renal Disease	161	(10.7)	706	(2.9)	
Cancer	47	(3.1)	1,737	(7.1)	
Moderate or Severe Liver Disease	8	(0.5)	36	(0.2)	
Metastatic Carcinoma	0	(0.0)	65	(0.3)	
HIV/AIDS	s	s	s	s	

Note: SD = standard deviation, Total counts from the rural and urban income quintiles do not equal the total count of angiograms because some incomes could not be found. s = suppressed due to small cell size (n ≤ 5).

*Unless otherwise indicated.

a.Percentages are calculated for rural and urban areas separately.

b. Statistical comparisons were not conducted on each condition used in the Charlson Comorbidity Index Score calculation.

Trends in angiogram and urgent angiogram rates

The overall average angiogram rate between 2000/01 and 2008/09 was significantly lower in the FN population (2.67 vs. 3.33 per 1000 population per year; $p < .0001$; Table 3). Annual angiogram rate, were lower in the FN population each year, and statistically different in five of the nine years analyzed. Figure 1 shows no significant temporal trends in angiogram rates in either group.

Table 3. Crude rates of index angiograms per 1,000 population by FN status (2000/01 - 2008/09)

Year	FN		Non-FN		P-value
	No.	Rate	No.	Rate	
2000/01	145	2.61	2,735	3.40	0.0019
2001/02	171	2.98	2,635	3.26	0.2578
2002/03	139	2.35	2,666	3.28	0.0001
2003/04	168	2.77	2,759	3.37	0.0133
2004/05	142	2.28	1,620	3.18	0.0001
2005/06	198	3.10	1,706	3.27	0.4666
2006/07	179	2.73	2,562	3.08	0.1207
2007/08	152	2.26	2,767	3.28	<.0001
2008/09	205	2.96	2,867	3.37	0.0778
Overall	1,499	2.67	24,317	3.28	<.0001

Of all index angiograms performed between 2000/01 and 2008/09, a higher proportion were related to a hospitalization for AMI (i.e., categorized as urgent) among FN recipients compared to non-FN recipients (28.8% vs. 25.0%; $p = 0.006$; Table 4). Higher proportions among FN recipients were observed for most years studied, although only the rates in 2003/04 were significantly different (33.9% v. 22.5%; $p = 0.03$). Figure 2 shows the proportion of urgent angiograms significantly increased from 2000/01 to 2008/09 among both FN recipients (slope = 1.82% per year; 95% CI, 0.73% to 2.91%) and non-FN recipients (slope = 2.16% per year; 95% CI, 1.63% to 2.69%). Although the increase occurred steadily over time among non-FN population, the pattern among FN population was more variable.

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Table 4. Proportion of urgent index angiograms by FN status (2000/01 - 2008/09)					
Year	FN		Non-FN		P-value
	No.	Percent	No.	Percent	
2000/01	30	20.7	463	16.9	0.2869
2001/02	32	18.7	481	18.3	0.8918
2002/03	34	24.5	591	22.2	0.5769
2003/04	57	33.9	621	22.5	0.0030
2004/05	43	30.3	616	23.5	0.1086
2005/06	55	27.8	647	23.9	0.2857
2006/07	59	33.0	737	28.8	0.3144
2007/08	53	34.9	933	33.7	0.8123
2008/09	68	33.2	977	34.1	0.8297
Overall	431	28.8	6,066	25.0	0.0061

Angiography among IHD and CVD-related death cohorts

The proportion of adult Manitobans with an IHD diagnosis between 2010/11 and 2014/15 who had not received an angiogram anytime since 1984/85 were not significantly different between FN and non-FN groups (Table 5). However, significant differences were observed with age stratification, where higher proportion of FN patients in the younger age group (52.2% vs. 46.9%, $p<.01$) and a lower proportion in the older age group (49.1% v. 51.8%, $p<.003$) had not received an angiogram.

Table 5: Proportion of individuals with IHD between 2010/11 - 2014/15 who did not receive an angiogram anytime since 1984/85.					
Age, year	FN		Non-FN		P-value
	No. of IHD patients	No angiogram	No. of IHD patients	No angiogram	
< 65	2,758	1,440 (52.2%)	20,341	9,536 (46.9%)	<.01
≥ 65	2,069	1,015 (49.1%)	55,093	28,559 (51.8%)	<.03
Total	4,827	2,455 (50.9%)	75,434	38,095 (50.5%)	>.10

Note: IHD = ischemic heart disease

Among Manitobans who died from CVD, a significantly lower proportion of FN people had not received an angiogram within the 20 years before death compared to non-FN people (82.2% vs. 87.5%, $p<.01$; Table 6). This difference persisted when the groups were stratified by age (<65 years, 80.3% vs. 83.6%, $p<.01$; ≥65 years, 83.7% vs. 88.1%, $p<.01$).

Table 6: Proportion of cardiovascular-related deaths between 1984/85 and 2014/15 where the patient did not received an angiogram anytime within 20 years of death.

Age, year	FN		Non-FN		P-value
	No. of CV deaths	No angiogram	No. of CV deaths	No angiogram	
< 65	1,384	1,111 (80.3%)	12,682	10,609 (83.6%)	<.01
≥ 65	1,830	1,532 (83.7%)	89,819	79,088 (88.1%)	<.01
Total	3,214	2,643 (82.2%)	102,501	89,697 (87.5%)	<.01

Note: CV = cardiovascular

Discussion

Study findings describe FN and non-FN index angiogram recipient socio-demographic and comorbidity characteristics, and reveal between group differences. Lower rates of index angiograms among the FN population were demonstrated but no temporal trends were observed over time in either group. Among Manitobans who received an index angiogram within seven days of being hospitalized for an AMI, there was a higher proportion in the FN group compared to the non-FN group, and the proportions of these urgent angiograms significantly increased over time in both groups. Approximately 50% of Manitobans with an IHD diagnosis in 2010/11 to 2014/15 had not received an angiogram anytime in the preceding 25-30 years, and there was no significant difference between FN and non-FN groups. Lastly, among Manitobans who died of a CVD, a higher proportion of non-FN people had not received an angiogram in the preceding 20 years. By addressing angiography utilization from a population level, this study is a first step in approaching CVD disparities among FN people that moves beyond focusing on a specific cardiovascular disease group and/or on individual choices and lifestyle factors.

At the time of index angiography, FN recipients were younger by an average of 7.6 years, less likely to be male, had higher Charlson comorbidity index scores, and were more likely to reside in rural and lower income areas compared to non-FN recipients. These population rate differences in recipient characteristics are similar to those reported among other Indigenous and non-Indigenous populations at the time of cardiovascular-related hospitalizations.^{19, 22, 35-38}

While it is concerning that FN recipients were younger and had worse health at the time of their index angiogram, at least they had entered the cardiovascular healthcare system.

Although the annual rates of index angiograms varied slightly for both groups, the FN population consistently demonstrated lower rates than the non-FN population. The trend analysis revealed angiography utilization in both populations remained unchanged during the study period, with the exception of increased rates among those who had an AMI within the seven days prior to their angiogram. The proportion of these urgent index angiograms among the FN group was consistently higher than that of the non-FN group, though the difference between the two groups decreased over time. The increasing proportion of urgent angiograms in both groups suggests a practice change away from performing elective angiograms.

While study objectives did not include investigation of factors to explain differences in rates of angiography between FN and non-FN groups, we speculate on two plausible explanations: (1) a lower proportion of FN people who visited a physician for CVD-related symptoms were referred for angiography, and/or; (2) a lower proportion of FN people experiencing CVD symptoms visited physicians. For the first explanation, there are many clinical and non-clinical factors that influence clinical decisions regarding angiography. First, older age (>65 years of age) has been associated with a lower likelihood of angiography,³⁹ which can be related to higher level of comorbidities that preclude angiography or revascularization procedures. Guidelines indicate pre-existing conditions such as renal insufficiency and diabetes may increase the risk of subsequent complications.¹⁷ The FN population in Manitoba is younger than the general population, but have a higher level of comorbidity, especially diabetes.^{40, 41} Therefore, pre-existing conditions among FN patients may result in a lower proportion for which angiography is deemed appropriate. Alternately, geographical residence may affect rates of angiograms, as the only facilities performing angiograms were in Winnipeg, and a higher proportion of the FN population live in rural Manitoba areas. However, previous studies suggest age and sex-adjusted rates of cardiac surgeries are higher for Indigenous people (compared to non-Indigenous) in northern rural areas, and lower among those living in urban areas.¹⁶ Given that angiography and cardiac surgery are intertwined, the lower overall rates of angiography for FN compared to non-FN residents is unlikely explained by living further from the catheterization facilities. Finally,

physician-patient relationships, related societal biases, along with patient preferences and health beliefs all likely influence whether a patient undergoes angiography.^{20, 23-25, 42-44}

The second possible explanation suggests that the lower rates of angiography among the FN population may be due to a lower proportion of FN people with cardiac symptoms visit physicians for these symptoms. For various reasons, many FN people view the healthcare system as racist and untrustworthy, with poor communication and care continuity, which influences how they access and utilize health services.⁴⁵⁻⁴⁷ Such system-level barriers to access may result in FN people postponing cardiac care until an acute event has occurred. This may also be further exacerbated by higher rate of socioeconomic disadvantage experienced among FN populations, as evidence suggests individuals living with SES disadvantage and have IHD symptoms are more likely to prolong seeking healthcare until an AMI.⁴⁸

Underpinning these speculative explanations for angiogram rate differences, is the historical and persistent impact of colonization and structural racism embedded in post-colonial institutions such as healthcare.^{15, 49-54} Moreover, a substantive base of evidence exists regarding experiences of systemic racism being clearly linked to compromised cardiac outcomes;^{15, 52} racism has significant negative and measureable impacts on human biophysiological processes and outcomes.⁵⁵ Furthermore, many social disparities related to income, education, employment, and housing, exist between FN and non-FN people, which are all rooted in colonial policies and practices.⁵¹ Given the inextricable link between health and social indicators, it has been suggested that a nationwide, holistic FN health strategy that addresses the social conditions of FN people is necessary to improve health and healthcare access for the FN population.⁵³

Finally, the third study objective investigated when angiograms were not performed on individuals with cardiac conditions. During the study time period, among proportion of Manitobans who died of a cardiovascular disease or who had an IHD diagnosis but had not received an angiogram did not confirm the concern raised an Elder. FN people, who died of a cardiovascular death, were actually more likely to have received an angiogram in comparison to non-FN Manitobans. While unanticipated, it is possible there were individuals who died of a cardiovascular disease but their death certificate indicated another cause. Regarding Manitoban's with an IHD diagnosis, FN people under the age of 65 were less likely to receive an angiogram in the previous 25-30 years. This finding raises concerns because more than half of the total FN

patients in the IHD cohort were less than 65 years. However, it is important to note that these proportions represent the prevalence of IHD during 2010/11 to 2014/15 but are unable to reveal the length of time since IHD diagnosis. Furthermore, it is not known whether there are differences in the amount of non-invasive testing for IHD between the groups. If IHD diagnosis was through that form of testing and a path of medical therapy was chosen, then angiogram might not have been necessary.

Several study limitations are notable. First, only FN people registered under the Indian Act were included in the FN group, which means unregistered FN people were included in the non-FN group. However, 93% of self-reported Manitoba FN people are registered,²⁶ therefore, the misclassification bias was small. Second, the non-FN group included other Indigenous people (i.e. Métis and Inuit) who also experience a greater burden of CVD.⁵⁶ If their angiography rates are similar to the FN group, their inclusion in the non-FN group would lead to an underestimation of the rate difference between FN and non-FN populations. Third, administrative data does not contain information that would allow for an analysis of the appropriateness of angiography. Therefore, it is not known whether angiography was employed more appropriately for one group or the other. The lower rates of angiography in the FN population may be a result of an overuse of the procedure in the non-FN group, which has been reported among African-American and white patients in the United States.⁵⁷ Lastly, the proportion of FN people in Manitoba's total population is highest among all Canadian provinces, which may affect generalizability of study findings. However, overall health status resulting from deteriorating social conditions and the transition from traditional to modern lifestyles has been experienced similarly by FN populations across Canada, and is likely that this also applies specifically to cardiovascular health.^{10,58}

An additional cautionary note, the analysis of crude and unadjusted rates for underlying differences between the populations influences the interpretation of findings. This is to say that although the rates were lower in the FN population, it is not known whether this is due to their ethnicity or some other factor, such as age or the remoteness of the area they live. Still the results from this study provide important background and context for a future study examining the outcomes of all index angiogram recipients in Manitoba.

Conclusion

Lower crude angiography rates among Manitoba's FN people compared to the non-FN population were observed, which raises concerns given the higher burden of IHD experienced by the FN population. A variety of factors may be contributing to the lower rates and further research is needed to determine if FN status is associated with index coronary angiogram access. Whether or not a difference truly exists in the rates of index angiograms, the level of angiogram use among both populations in general has gone unchanged, with the exception of elective versus urgent timing of the angiogram. Findings from this study and future studies may inform health program and planning, as well as strategies and policies aimed at reducing racial disparities in cardiovascular health and healthcare services.

Statement of author contributions

The lead author (AS) and second author (LD) co-created the initial manuscript draft; and we have been responsible for integrating critical feedback from all the co-authors (EM, RJB, CC, BE, AK, TN, JS, MS, KT, and RF). All co-authors (AS, LD, EM, RJB, CC, BE, AK, TN, JS, MS, KT, and RF) are co-investigators on the larger study and with this manuscript have had involvement from conceptualization of the three objectives to interpretation of findings. Each co-author (AS, LD, EM, RJB, CC, BE, AK, TN, JS, MS, KT, and RF) has reviewed this manuscript and has provided feedback at least once on previous drafts. In addition, the third author (EM) has been significant contributor regarding systemic issues and racism within healthcare, and the final author (RF) oversaw all statistical analysis on this study.

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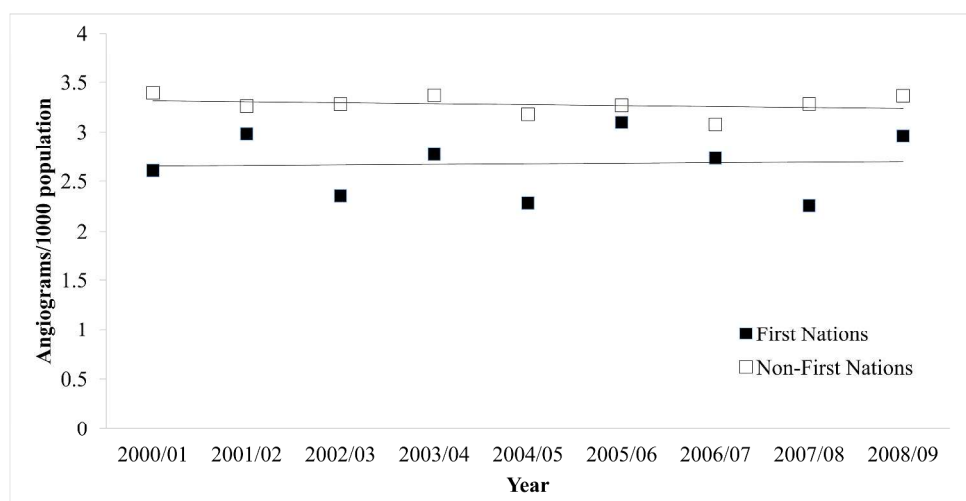
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Table Legend

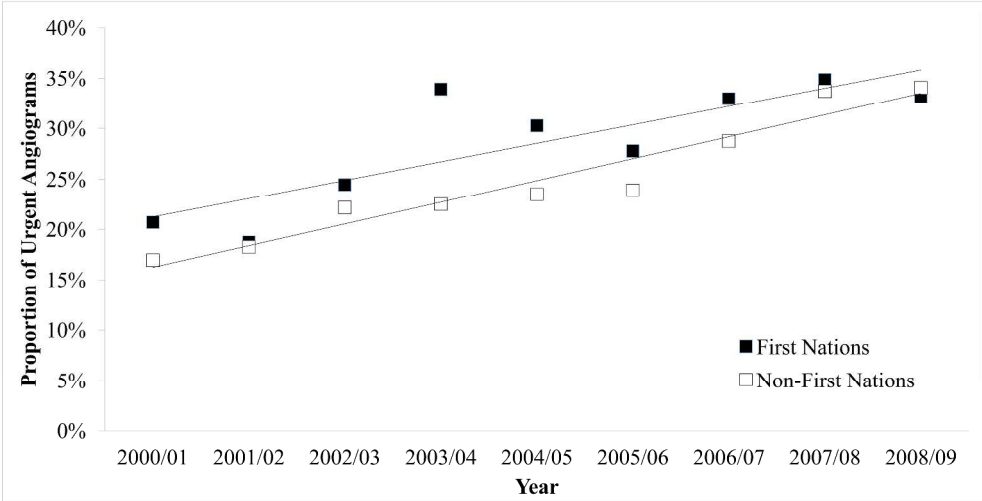
- Table 1. ICD and CCI procedural code definitions
- Table 2. Characteristics of index angiogram patients by First Nation’s status (2000/01-2008/09)
- Table 3. Crude rates of index angiograms per 1,000 population by FN status (2000/01 - 2008/09)
- Table 4. Proportion of urgent index angiograms by FN status (2000/01 - 2008/09)
- Table 5: Proportion of individuals with IHD between 2010/11 - 2014/15 who did not receive an angiogram anytime since 1984/85.
- Table 6: Proportion of cardiovascular-related deaths between 1984/85 and 2014/15 where the patient did not received an angiogram anytime within 20 years of death.

Figure Legend

- Figure 1. Trends in population-based annual rates of index coronary angiography between 2008/09 and 2008/09, by First Nation status.
- Figure 2. Trends in the proportions of angiograms categorized as urgent (related to an AMI hospitalization) between 2000/01 and 2008/09, by First Nation status.



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431x279mm (300 x 300 DPI)

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract [within the title page 1 and method section of the abstract page 3] (b) Provide in the abstract an informative and balanced summary of what was done and what was found [See method section and result section of abstract page 3]
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported [pages 4-5]
Objectives	3	State specific objectives, including any prespecified hypotheses [pages 5]
Methods		
Study design	4	Present key elements of study design early in the paper [pages 6-7]
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection [See page 6 for setting and location; see page 8 for relevant dates]
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up [pages 7-8] (b) For matched studies, give matching criteria and number of exposed and unexposed [N/A]
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable [pages 9-10]
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group [See pages 6-7 for data sources; See pages 7-10 and Table 1 for data source used for each variable and method of measurement]
Bias	9	Describe any efforts to address potential sources of bias [N/A]
Study size	10	Explain how the study size was arrived at [pages 7-8]
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why [pages 9-10; N/A for groupings]
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding [See pages 9-10 for statistical methods; N/A for confounding as the analyses were descriptive] (b) Describe any methods used to examine subgroups and interactions [N/A] (c) Explain how missing data were addressed [N/A] (d) If applicable, explain how loss to follow-up was addressed [N/A] (e) Describe any sensitivity analyses [N/A]
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed [page 10 and Table 2] (b) Give reasons for non-participation at each stage [N/A] (c) Consider use of a flow diagram [N/A]
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders [page 10 and Table 2] (b) Indicate number of participants with missing data for each variable of interest [N/A] (c) Summarise follow-up time (eg, average and total amount) [N/A]

Outcome data	15*	Report numbers of outcome events or summary measures over time [pages 10-14 and Tables 3-6]
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included [pages 10-14 and Tables 3-6; no adjusted analyses were done] (b) Report category boundaries when continuous variables were categorized [N/A] (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period [N/A]
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses [N/A]
Discussion		
Key results	18	Summarise key results with reference to study objectives [pages 14-16]
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias [page 17]
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence [page 18]
Generalisability	21	Discuss the generalisability (external validity) of the study results [page 17]
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based [page 2]

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.