Journal of Rural and Community Development

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Citation:
Adegun, A., & Thompson, S. (2021). Higher COVID-19 rates in Manitoba's First Nations compared to non-First Nations linked to limited infrastructure on reserves. *The Journal of Rural and Community Development*, *16*(4), 28–53.

Publisher:
Rural Development Institute, Brandon University.

Editor:
Dr. Doug Ramsey

ISSN: 1712-8277 © Authors
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Higher COVID-19 Rates in Manitoba's First Nations Compared to Non-First Nations Linked To Limited Infrastructure on Reserves

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Abstract

The relationship of COVID-19 rates to community infrastructure is explored through a literature review, mapping, and an ecological-level statistical analysis in this paper. The analysis was undertaken with data from Manitoba, Canada, for 23 of 63 First Nations and 67 non-First Nations communities. COVID-19 community-level per capita rates were estimated by dividing total cases, including active cases,—obtained from the COVID-19 Manitoba Open Data portal of the Public Health Information Monitoring System, PHIMS—for the community areas of Regional Health districts by the community 2021 Manitoba population report numbers. The geographical areas for COVID-19 data were identical to the census subdivision levels available from Statistics Canada, used for housing and other infrastructure data. COVID-19 per capita rates in Manitoba communities have a positive significant strong relationship with community rates for (a) overcrowded housing ($r = 0.532$, $p < 0.05$), (b) unsuitability of housing ($r = 0.623$, $p < 0.05$), (c) houses needing major repairs ($r = 0.561$, $p < 0.05$), (d) no access roads ($t = 2.281$, $p < 0.05$), and (e) lack of hospitals ($t = 2.024$, $p < 0.047$). The highest rates for COVID-19 and the worst infrastructure are located in First Nations, particularly in special access communities. This preliminary research signals a need to improve infrastructure in First Nations reserves to realize health equity. Further research on built environment conditions in all Manitoba communities with age- and sex-adjusted analysis of COVID-19 data is needed to comprehend the role of infrastructure more fully.

Keywords: COVID-19, infrastructure, Indigenous communities, First Nations, health inequity

ISSN: 1712-8277

Des taux de COVID-19 plus élevés chez les Premières Nations du Manitoba que chez les non-Premières Nations du fait de l'infrastructure limitée Dans les réserves

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Résumé

La relation entre les taux de COVID-19 et les infrastructures communautaires est explorée à travers une revue de la littérature, une cartographie et une analyse statistique au niveau écologique dans cet article. L'analyse a été entreprise avec des données du Manitoba, au Canada, pour 23 des 63 communautés des Premières Nations et 67 non-Premières Nations. Les taux de COVID-19 par habitant au niveau communautaire ont été estimés en divisant le nombre total de cas, y compris les cas actifs, - obtenus à partir du portail de données ouvertes de COVID-19 du Manitoba du système de surveillance de l'information sur la santé publique (PHIMS). pour les zones communautaires des districts de santé régionaux par les chiffres du rapport sur la population du Manitoba en 2021. Les zones géographiques pour les données de COVID-19 étaient identiques aux niveaux de subdivision de recensement disponibles auprès de Statistique Canada, utilisés pour les données sur le logement et autres infrastructures. Les taux de COVID-19 par habitant dans les communautés du Manitoba ont une relation positive significative et forte avec les taux communautaires pour (a) les logements surpeuplés ($r = 0,532$, $p < 0,05$), (b) l'inadéquation des logements ($r = 0,623$, $p < 0,05$), (c) les maisons nécessitant des réparations majeures ($r = 0,561$, $p < 0,05$), (d) aucune route d'accès ($t = 2,281$, $p < 0,05$), et (e) le manque d'hôpitaux ($t = 2,024$, $p < 0,047$). Les taux les plus élevés de COVID-19 et les pires infrastructures se trouvent dans les Premières Nations, en particulier dans les communautés à accès spécial. Cette recherche préliminaire signale un besoin d'améliorer l'infrastructure dans les réserves des Premières Nations pour réaliser l'équité en santé. Des recherches supplémentaires sur les conditions de l'environnement bâti dans toutes les collectivités du Manitoba avec une analyse ajustée en fonction de l'âge et du sexe des données de COVID-19 sont nécessaires pour mieux comprendre le rôle de l'infrastructure.

Mots clés: COVID-19, infrastructure, communautés autochtones, Premières Nations, iniquité en santé

ISSN: 1712-8277

1.0 Introduction

Statistics show the health impact of COVID-19 is far greater in Manitoba's First Nations than for other Manitobans. The First Nations total for COVID-19 cases was three times higher for First Nations people than non-First Nations people in Manitoba, two times for deaths, and four times as many patients in the Intensive Care Unit (ICU) during the third wave (First Nations Health and Social Secretariat of Manitoba [FNHSSM], 2021). During the second wave, in December 2020, rates for First Nations people were even higher, representing 42% of all people in intensive care with the illness, despite First Nations people being only 10% of the population in Manitoba (Hoye, 2020). The COVID-19 per capita rate for First Nations people living on reserves in Pukatawagan and the Island Lake communities was approximately ten times higher than the rate of the remainder of Manitoba on March 18, 2021 (Government of Manitoba, 2021a).

COVID-19 data shows that First Nations people have much higher hospitalization, death, transmission rates, and years lost than non-First Nations people, particularly in Manitoba (Government of Manitoba, 2021a, Hoye 2020). As of this study, the median age of death in Manitoba from COVID-19 is substantially different for First Nations at 63 years old (FNHSSM, 2021) compared to other Manitobans at 83 years old (Mosby & Swidrovich, 2021). These differences demand research to determine the cause of this inequity. The research explores whether inequities at the community level for COVID-19 rates are related to their infrastructure. The built environment is interchanged with infrastructure, as both mean the man-made facilities, structures, and features where people live and work (Centers for Disease Control and Prevention, n.d.).

The higher risks from COVID-19 for First Nations people resulted in their prioritization for vaccines for COVID-19. The higher rates of intensive care unit admissions from COVID-19 for First Nations people warranted this intervention:

> Throughout the second and third waves of this pandemic, we have seen First Nations people make up 40 to 60 % of all COVID-19 admissions to intensive care units….that is why it is so important to get our communities —both on and off-reserve—fully vaccinated as soon as possible (Anderson as quoted in Manitoba Government, 2021b, p. 1).

Indigenous leaders draw attention to the intersection of higher COVID-19 rates with the underdevelopment of the built environment on First Nations reserves. Provincial opposition leader Wab Kinew blames COVID-19 elevated rates on poor infrastructure and lack of health services:

> …Indigenous people are more likely to have poor housing, less likely to have access to a family doctor and less likely to have access to clean drinking water…the pandemic is now revealing how the lack of access to health care for First Nations people is a major issue that needs to be addressed (Kinew quoted in Hoye 2020, para 11).

National Chief Bellegarde of the Assembly of First Nations attributes 'apartheid government services, policies and funding' to higher COVID-19 rates:

> Existing systemic issues make Indigenous populations more vulnerable to contracting the virus, including overcrowded housing, inadequate health services in many communities, food insecurity, lack of clean water, and the remoteness of northern fly-in communities (Bellegarde as quoted in Wright 2020, para. 6).

Despite the general awareness of the important role of infrastructure in COVID-19 rates no quantitative analysis has been carried out to explore this relationship.

Empirical analysis is needed to determine the factors impacting COVID-19 rates within the context of health inequities, considering the much higher rates for First Nation people living on reserves (Blacksmith et al., 2021; Hill et al., 2020).This paper analyzes the role of various infrastructure in Manitoba communities on COVID-19 rates considering health equity. We start the literature review by discussing the need to assess and discuss differences in infrastructure that systematically disadvantage people within a health equity framework. Then, the different built-environment factors of housing, access roads to service centres, and hospitals are discussed, considering the limited infrastructure issues in First Nations. The mapping and ecological analysis are described in the methods, stating the limitations of using the COVID-19 Government of Manitoba Open portal data, with available data provided at the five Regional Health Authority (RHA) levels subdivided into 84 community areas. We display the intersection of community-level data for COVID-19 rates and the quality of the built environment through different maps. The statistical significance of the ecological analysis at the community level for built environment quality indicates relationships with COVID-19 rates. This analysis of infrastructure with COVID-19 implicates regional disparities with health inequity. Finally, we discuss the need to eradicate health inequity by building back better after the pandemic focused on factors of most significance and the most infrastructure poor communities.

1.1 Health Equity Lens Applied to the Built Environment and Other Social Determinants of Health

Health equity is the equal ability for all people to attain their full health potential uncompromised by socially determined aspects or social position (World Health Organization [WHO], 2008). Health inequities are disparities that systematically limit the health of some groups and populations. Health inequities exist when disparities in disease vulnerability, mortality rates, disability, life expectancy, and access to healthcare occur based on social position and socially determined aspects. Health inequity shapes people's general health outcomes and wellbeing, including the susceptibility of people and communities to COVID-19 (Maness et al., 2021; Upshaw et al., 2021).

Health inequity is shaped by social factors, such as access to resources and environmental exposures, impacted by our built environment (Schulz, 2004, WHO, 2008). Non-medical factors, such as education, clean water, housing, income, employment status and social services, significantly impact health; and these factors are called the social determinants of health (Abrams, 2020; Butler-Jones & Wong, 2016; Green et al., 2021; Lavoie et al., 2021; WHO, 2008). The built environment

profoundly influences health rates by shaping our healthy behaviours and impacting our ability to live healthy lives (Centers for Disease Control and Prevention, n.d.). Health disparities negatively affect people who have systemically experienced major challenges to health because of socioeconomic factors such as race, sexual orientation, disability (Davis et al., 2021).

Health inequities persist over decades for First Nation people living on reserves because of structural policies and practices that systematically limit health access and constrain infrastructure on First Nations. The Indian Act is a determinant of health, human, and economic inequities. The Indian Act defines First Nations people as less than a person under the law by stating "a person means an individual other than an Indian" (Indian Act 1876, sec. 12). The Act reduces First Nations peoples to wards of the state and has created human rights abuse based on the bias of racial superiority (Cannon, 2007). The Indian Act legislated an uneven playing field for First Nations people in Manitoba and Canada by having the Crown own Indian reserves rather than the people living there. These views and actions led to genocide, perpetuated through Indian Residential School. An estimated 150,000 Indigenous children were forcibly removed from their families to schools designed to 'take the Indian out of the child' (Milloy, 2017). The racist policies are also evident in the government severely underfunding of hospitals, housing, and access roads.

Evident in previous health crises, socially disadvantaged populations, such as the poor, Indigenous people, and people of colour, are more vulnerable to infectious diseases than advantaged populations (Aguilar-Palacio et al., 2021; Hassen, 2021). The health inequity of disadvantaged communities has further deteriorated during the COVID-19 pandemic (Shah et al., 2020), revealing existing social and health inequities (Clouston et al., 2021). Sundaram et al. (2021) concluded that COVID-19 responses should consider structural measures that recognize differences in socioeconomic conditions of populations, specifically focusing on crowded housing.

1.2 Housing

The housing situation in Manitoba and Canada generally shows a lack of sufficient housing to meet the human need for decent, adequate housing accommodation. Lack of housing supply and the lack of a right to housing contributes to people being homeless and under-housed in Canada (Belanger, 2016). Poor housing impacts health. According to the United States Centre for Disease Control and Prevention, poor housing conditions are defined by overcrowding, lack of plumbing and kitchen facilities, and high housing cost (Ahmad et al., 2020).

In this study, we focus on three housing variables, namely (a) not suitable housing, (b) houses in need of major repairs, and (c) average household size. Not suitable housing refers to whether a private household has enough bedrooms for the size and composition of the household (Statistics Canada, 2019a). In 2016, 7% of non-First Nations in Manitoba lived in unsuitable housing, with rates five times higher at 37% for First Nations people on reserves (Statistics Canada 2019c). Major repairs in housing include defective plumbing or electrical wiring, structural repairs to walls, floors, and ceilings (First Nations Information Governance Centre [FNIGC], 2020). FNIGC (2020) noted that almost three-quarters (70.8%) of all on-reserve homes need some level of repair. Average household size is the average number of persons per household. For First Nations living on reserve, the average number of family members living in a household is 3.7 compared to the national average of 2.5 (Canadian Institute of Child Health, 2021).

Overcrowding on reserves results in First Nations people having a higher rate of homelessness (Statistics Canada, 2020) and contributes to disease. Overcrowding is blamed for a 50 times higher prevalence of tuberculosis for First Nations people on reserves than those living off reserve (Indigenous Services Canada, 2020; Thompson et al. 2020). With COVID-19 being more contagious than tuberculosis, the overcrowded housing crisis on First Nations reserves poses unacceptable risks for COVID-19 transmission (Statistics Canada 2020), particularly for the elderly. With limited housing available on First Nations reserves, one-quarter (25 %) lived in multigenerational households in 2016, which is four times the rate off-reserve (6 %) (Statistics Canada, 2020). Multigenerational families create a greater risk of viral exposure to the at-risk elderly group for severe COVID-19 symptoms.

First Nations houses also contribute to disease. The environmentally and "culturally inappropriate housing designs" imposed upon First Nations communities (MacTavish et al., 2012, p. 208) deteriorate quickly into unhealthy housing. A home's state of repair, allergens, and mould are associated with an increased risk of disease on First Nations reserves (Boutilier, 2014; FNIGC, 2020; Kovesi, 2012; Moffatt et al., 2013; Statistics Canada, 2020; Weichenthal et al., 2013). As well, 9% of Manitoba households lived in houses needing major repair, but 44% of on-reserve homes needed major repairs (Statistics Canada, 2019c).

Manitobans living off-reserve can apply to a bank to get a mortgage to build or buy a house, increasing the housing supply. However, people living on Indian reserves cannot get mortgages due to the Crown controlling First Nations land under the Indian Act land trust. Inequitable housing policies restrict housing funding on First Nations reserves, which means most First Nations people on reserves cannot own a house (Zingel, 2020). Without access to a mortgage for people living on reserves, First Nations bands must apply for loans solely through the Canada Mortgage and Housing Corporation, limited to a few for each community. First Nations reserve housing deficit surpasses $3 to $5 billion (Standing Committee on Indigenous and Northern Affairs, 2017), with almost a hundred thousand new homes needed. The total infrastructure deficit, including schools, roads and hospitals, amounts to $45 billion to $50 billion, according to Calla’s estimates (Standing Committee on Indigenous and Northern Affairs, 2017).

1.3 Hospital Access Differential

In Manitoba, provincial communities generally have access to nearby hospitals (Government of Manitoba, n.d.). For this research, we adopt the definition of hospitals used by Black et al., 1993 in their study. Hospitals in Manitoba provide specialized medical services, ranging from smaller institutions with less than 15 beds to teaching hospitals with hundreds of beds (Black et al., 1993). Rural communities with a few hundred people have hospitals in dozens of provincial communities, including (a) Lynne Lake, (b) Sainte Rose du Lac, (c) Ste. Anne, (d) Morris, (e) Arborg, (f) Ashern, (g) Beausejour, (h) Eriksdale, (i) Hodgson, (j) Gimli, (k) Pinawa, (l) Pine Falls, (m) Crystal City, (n) Stonewall, (o) Teulon, (p) Gillam, (q) Flin Flon, (r)The Pas, and (s) Carman (Government of Manitoba, n.d.). Other provincial towns without hospitals have nearby road access to a hospital, typically within an hour's drive. However, First Nations reserve communities, except Norway House, lack hospitals (Government of Manitoba, n.d.). First Nations with several thousand people, such as Cross Lake, Nelson House, and the Island Lake communities, have no hospitals. In Manitoba, all the remote northern First Nation

communities—with no permanent access road—access their public health services through nursing stations. In contrast, most southern First Nation communities are serviced by health centres (Lavoie et al., 2021). The services provided by nursing stations are limited to the delivery of public health programs, including minor medical conditions, immunization, diabetes, and the delivery of low-risk babies (Government of Canada, 2020; Lavoie et al., 2021). Health centres are designed to offer healthcare information and offer minimal public health services (Kyoon-Achan et al., 2019).

Health services on First Nations reserves are limited to non-complex and non-critical care (Kyoon-Achan et al., 2019). First Nations lack local or regional health care access requiring people living on First Nations reserves to travel great distances for health care (FNIGC, 2020; Statistics Canada, 2020). People from the 17 fly-in First Nations in Manitoba typically have to be born and die far from home due to lack of health care in their communities. Without easy access, many First Nations people—one in ten in the preceding 12 months—living on reserves have unmet health care needs (FNIGC, 2020). These unmet health care needs pose risk factors for developing COVID-19 complications (Statistics Canada, 2020).

The lack of hospitals in First Nations reserves reduces health services available to First Nations living on-reserve, compared to other Canadians. Aimee Craft questions why First Nations receive limited health care services: "We talk about universal health care in Canada. Well, why is it Universal, except for Indigenous kids?" (Craft quoted in Obomsawin, 2019). For example, Jordan River Anderson experienced inequitable treatment in the medical system during his short life (Blackstock, 2012). Jordan River Anderson, whose family lived in Norway House First Nations, was born with complex health needs and died at five years old. Limited healthcare services required Jordan to remain in Winnipeg his entire life to handle complex health care issues (Obomsawin, 2019). Towards health equity, Jordan's Principle was passed in December 2007 by Canada, for "a child first principle calling on the government of the first contact to ensure First Nations children can access public services on the same terms as other children" (First Nations Child & Family Caring Society of Canada 2014, p. 1). However, First Nations children with disabilities face health inequities without health care or school to support them on reserve (Obomsawin, 2019).

1.4 Access Roads to Service Centres in Manitoba

Most communities throughout Manitoba have paved provincial roads to access service centres. However, 17 First Nations communities are considered isolated special access, without all-weather roads to service centres (Statistics Canada, 2019c). A service centre is the nearest community to which a First Nation can access government services, banks, and suppliers (Government of Canada, 2019). Across Canada, 27% of Canadian First Nations communities require special access, lacking any road to access a service centre (Government of Canada, 2019). The isolation of these communities requires access by plane and/or boat with ice roads during a short winter period. Many of these fly-in reserves contain thousands of people in Manitoba, including the four Island Lake First Nations (Government of Manitoba, 2020). Adjacent to fly-in reserves, small Metis or government communities typically have a few dozen homes or less and typically house the airport (Government of Canada, 2019).

Stout (2018) explains that communities having no roads experience health inequity and many other deprivations. Communities without access roads suffer from very high food insecurity (Thompson et al., 2012), particularly during COVID-19 (Carling & Mankani, 2020). In northern Manitoba's communities, 79% of households experience food insecurity, which is higher than the remote communities in northern Manitoba with road access (Thompson et al., 2012).

1.5 Study Area

The study area of Manitoba, Canada has 1.38 million people, with more than half of these people located in Winnipeg (Government of Manitoba, 2020). Except for Winnipeg and nine other small cities, Manitoba consists of rural, remote, and special access communities (Government of Manitoba, 2020). Special access communities have no year-round road access to a service centre (Government of Canada, 2019). Manitoba organizes regional health authorities (RHA) into five regions: Interlake–Eastern, Northern, Prairie–Mountain Health, Southern Health, and Winnipeg. Further, these RHA are divided into 84 areas with daily discrete COVID-19 statistics. Each RHA is responsible for the delivery of health services in specified regions of the province. Figure 1 shows the location of First Nations communities in Manitoba superimposed on the geographical boundaries of the Province's RHA with the cities also shown.

In Manitoba, the average age of people is 39 years old, which is much higher than the average age of 26 years old for First Nations people with registered Indian status (Statistics Canada, 2021). Manitoba's 41,995 First Nations children represent almost 37% of First Nations people, compared to less than half of that at 18% for children within the overall Manitoba population (Statistics Canada, 2021).

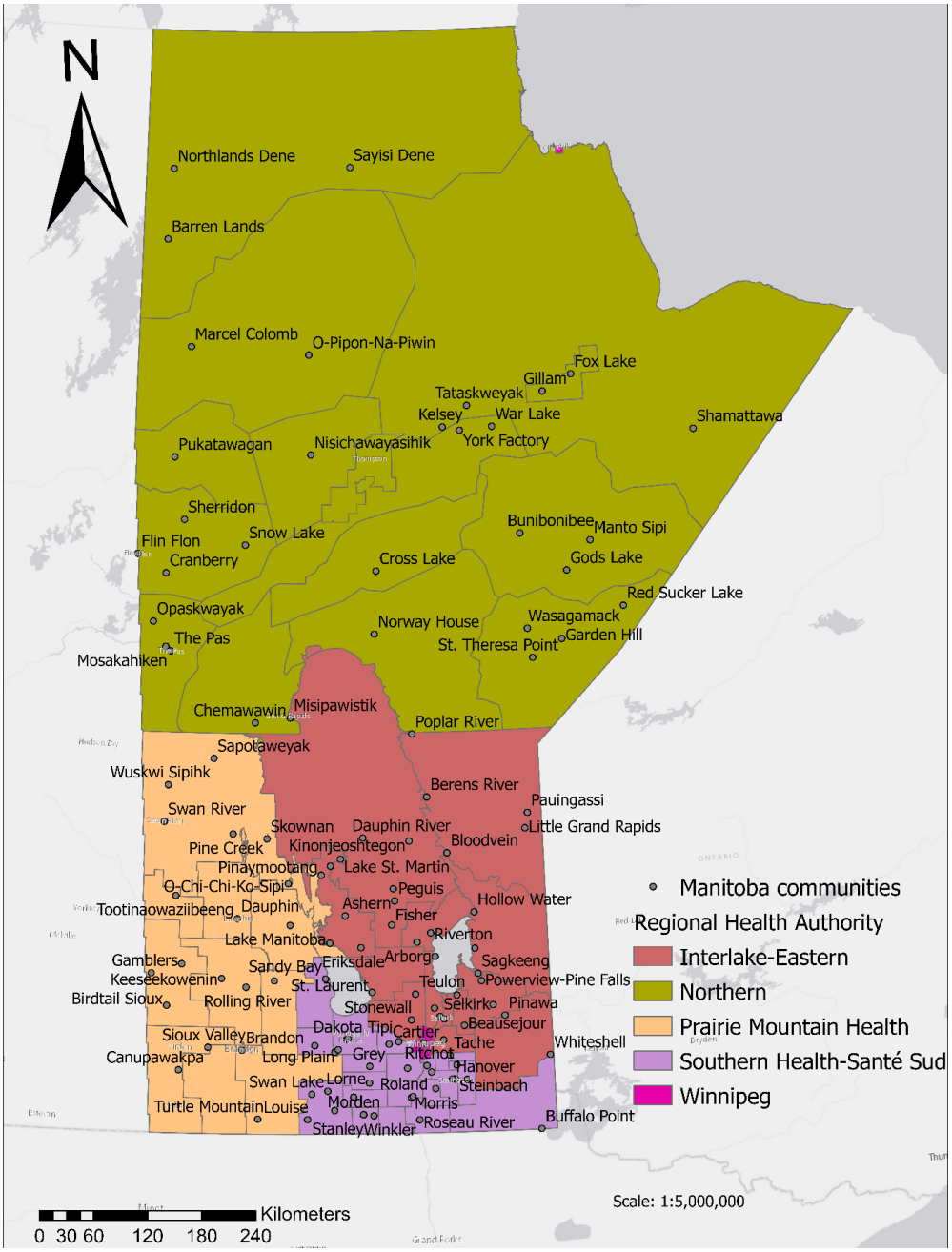
Approximately 11% (164,289) of Manitobans register as First Nations (Government of Canada, 2021), with slightly more First Nations people living on-reserve than off-reserve. More than one-third (41%) of the First Nations population lives in the Northern Health region (Northern Health Region Community Health Assessment, 2019). First Nations communities in Manitoba are diverse, having five Indigenous linguistic groups: Nēhiyawēwin, Ojibwe, Dakota, Oji-Cree and Dene (Government of Canada, 2021). The population of many First Nations communities is over 5,000 people, including 5,944 at Norway House and 5,444 at Cross Lake (Government of Manitoba, 2020), with more than a dozen Manitoba First Nations over 3,000.

2.0 Methods

We undertook an ecological analysis to identify factors contributing to COVID-19 rates. This analysis is at the community level rather than at the individual level. A community-level analysis cannot find cause and effect at the individual level (Stieb et al., 2020). The data for this ecological study came from different sources. COVID-19 data were obtained from the COVID-19 Manitoba Open Data portal, which is part of the Public Health Information Monitoring System (PHIMS) database (Government of Manitoba, 2021a). The PHIMS database includes COVID-19 (a) total cases, (b) active cases, (c) deaths, (d) rate cases per capita—per 100,000 population, (e) current hospitalizations, (f) intensive care unit patients, (g) daily tests, and (h) population for all the five RHAs (Government of Manitoba, 2021a). The five RHAs are further divided into RHA districts, and the RHA districts are subdivided into 15 community areas, representing 23 First Nations

communities and 87 provincial communities (Government of Manitoba, 2021a). The community-level variable of COVID-19 total rates are estimated from the COVID-19 total cases, including active cases for the community area, from the PHIMS database records, divided by the current community population number available from the Manitoba population report (Government of Manitoba, 2020).

Figure 1. Map of communities in Manitoba and locations of the five regional health authorities



Source: Ajarat and Thompson, 2021 using data from Government of Manitoba, 2021c.

The geographical areas for COVID-19 estimates were identical to the census subdivision level available from Statistics Canada (2019c), used for housing and other infrastructure data. Data on housing was from the Statistics Canada 2016 Census profile for not suitable housing (%), major repairs in housing needed (%), and average household size. Also, data on the presence of roads and hospitals in Manitoba communities were identified from various sources (Government of Canada, 2019; Government of Manitoba, n.d.; Statistics Canada, 2019c). Research ethics board approval was not required for the study because only publicly available data was applied.

2.1 Geo-epidemiological Analysis

ArcGIS Pro 2.8.0 software was used to create thematic maps. The thematic maps are used to analyze the spatial distribution of COVID-19 cases according to sociodemographic indicators of Manitoba communities. The COVID-19 rate per capita as of May 31, 2021 was plotted to generate choropleth maps. The sociodemographic indicators by First Nations communities were geocoded to create dot distribution maps. The dot distribution maps for different indicators, including rates for not suitable housing, rates of major repairs in housing and average household size, were superimposed on the COVID-19 rate per capita layer.

This juxtaposition of COVID-19 rates and housing conditions provided a visual indicator of relationships. Fifty-eight First Nations communities had data on average household size and 57 non-First Nations communities or neighbourhoods. In total, 114 Manitoba communities had data on major repairs in housing needed, and 111 communities had data on not suitable housing. All communities but 17 First Nations communities had year-round access to a service centre (Indigenous and Northern Affairs Canada, 2019). Twenty-five hospitals were operating in Manitoba, all in provincial communities, except for a small hospital in Norway House (Government of Manitoba, n.d.).

2.2 Data Analysis

The study data applied two inferential statistical techniques using SPSS version 26.0. Correlation analysis investigated the relationship between dependent (COVID-19 rates) and independent variables (infrastructure of either house suitability, housing repair, hospitals, and road access) for a cross-sectional study of Manitoba communities (Cao et al., 2020; Citak & Pekdemir, 2020; Montalban et al., 2020; Zhou et al., 2021). Pearson's correlation coefficient (r) was used to determine the strength of the relationship (bivariate correlation) between the COVID-19 rates and housing variables—not suitable housing, major repairs in housing needed, and average household size. Then, an independent t-test analysis was employed to determine the difference between the COVID-19 rates between communities with and without year-round road access to a service centre and also between communities having a community hospital.

2.3 Null Hypothesis

H_0: COVID-19 rate per capita in Manitoba community is not significantly related to infrastructure (i.e., housing, all weather road, hospital).

3.0 Findings

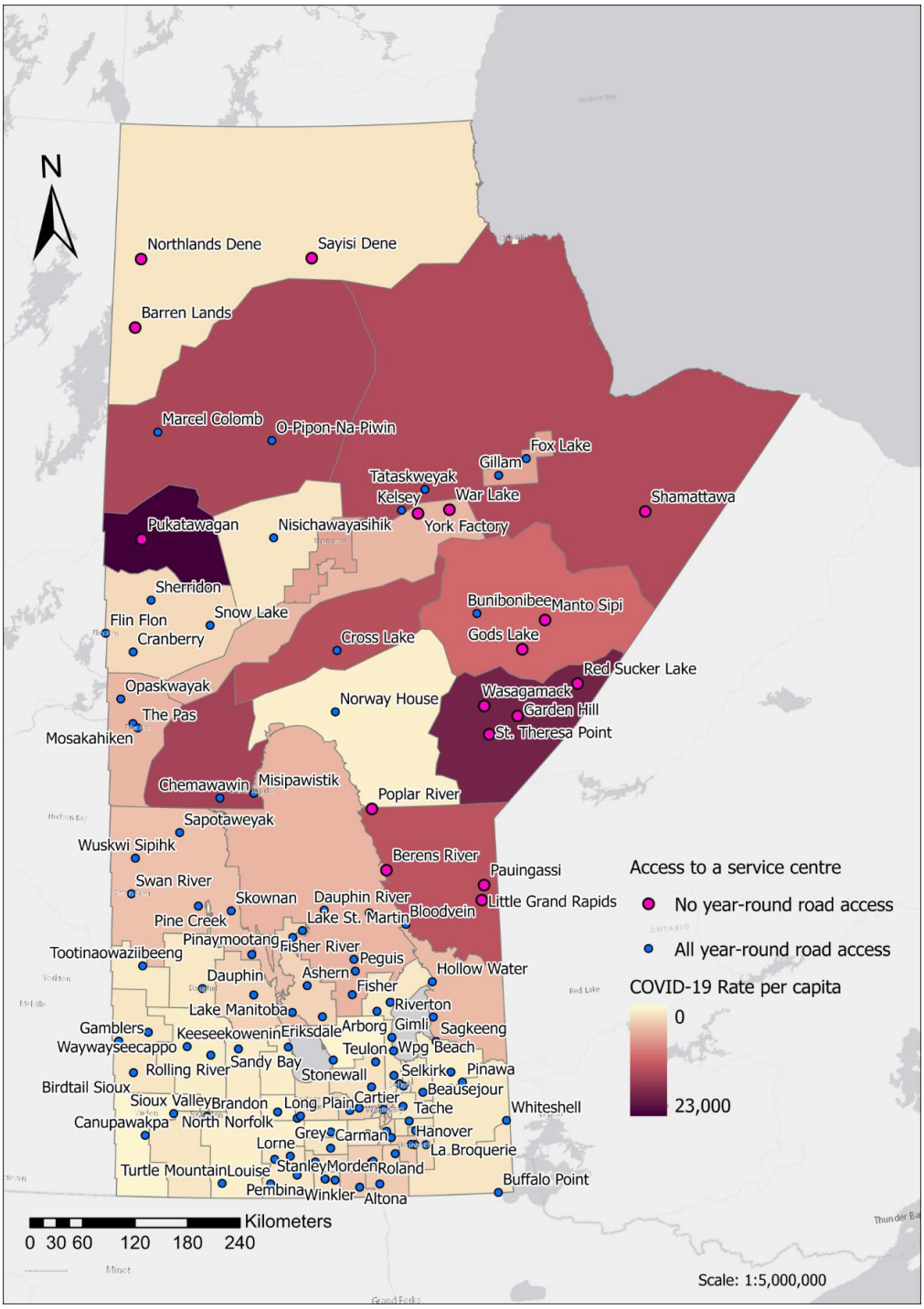
A p-value of 0.05 was considered statistically significant, rather than random, at the 95% confidence interval, with the 99% confidence interval considered highly statistically significant. The null hypothesis is rejected according to the statistically significant findings for the five infrastructure measures, including all weather road, hospitals, and three indicators for housing. The thematic map of COVID-19 data for RHA districts shows a disproportionate amount of the COVID-19 cases are in the Northern RHA areas. Figure 2 shows the COVID-19 rate per capita across Manitoba with 1% in Norway House First Nations, 4% in Winnipeg and 37% in Garden Hill First Nations. COVID-19 rates are higher in most fly-in northern communities, particularly the four Island Lake communities and Pukatawagan. However, the Dene communities of Barren Lands, Northlands Dene and Sayisi Dene all had low COVID-19 rates. Lack of road access had a strong positive statistically significant analysis with COVID-19 rates according to the independent group t-test ($t = 2.28$, $p < 0.05$), as shown in the independent group t-test results.

COVID-19 rates in Manitoba communities reflect the different indicators of poor housing, according to Figures 3–6. Figure 3 shows not suitable housing rates in Manitoba communities superimposed with COVID-19 rates. The map shows that communities with a very high proportion of not suitable housing visibly coincide with the communities having very high COVID-19 cases per capita. This combined higher incidence of not suitable housing and COVID-19 rates are most noticeable in the special access communities of Bunibonibee, Shamattawa, Pukatawagan, Tataskweyak and the four Island Lake communities. The mean percentage of not suitable housing within First Nations communities is 28% (ranges from 9%–59%), compared to Manitoba's non-First Nations rural communities average of 4%. Statistical analysis of the relationship between Pearson's correlation coefficient ($r = 0.623$, $p < 0.001$) findings show a highly significant relationship between COVID-19 rates with not suitable housing rates.

The average household size for communities is much higher at four people per home for First Nations (ranges from 2.5–5.9) compared to 2.5 for both overall Manitoba and non-First Nations rural communities. Figure 4 displays higher COVID-19 rates coinciding with communities having higher average household size. A statistically significant relationship ($r = 0.532$, $p < 0.001$) was found between COVID-19 rates and Manitoba communities with an average household size greater than 4.0.

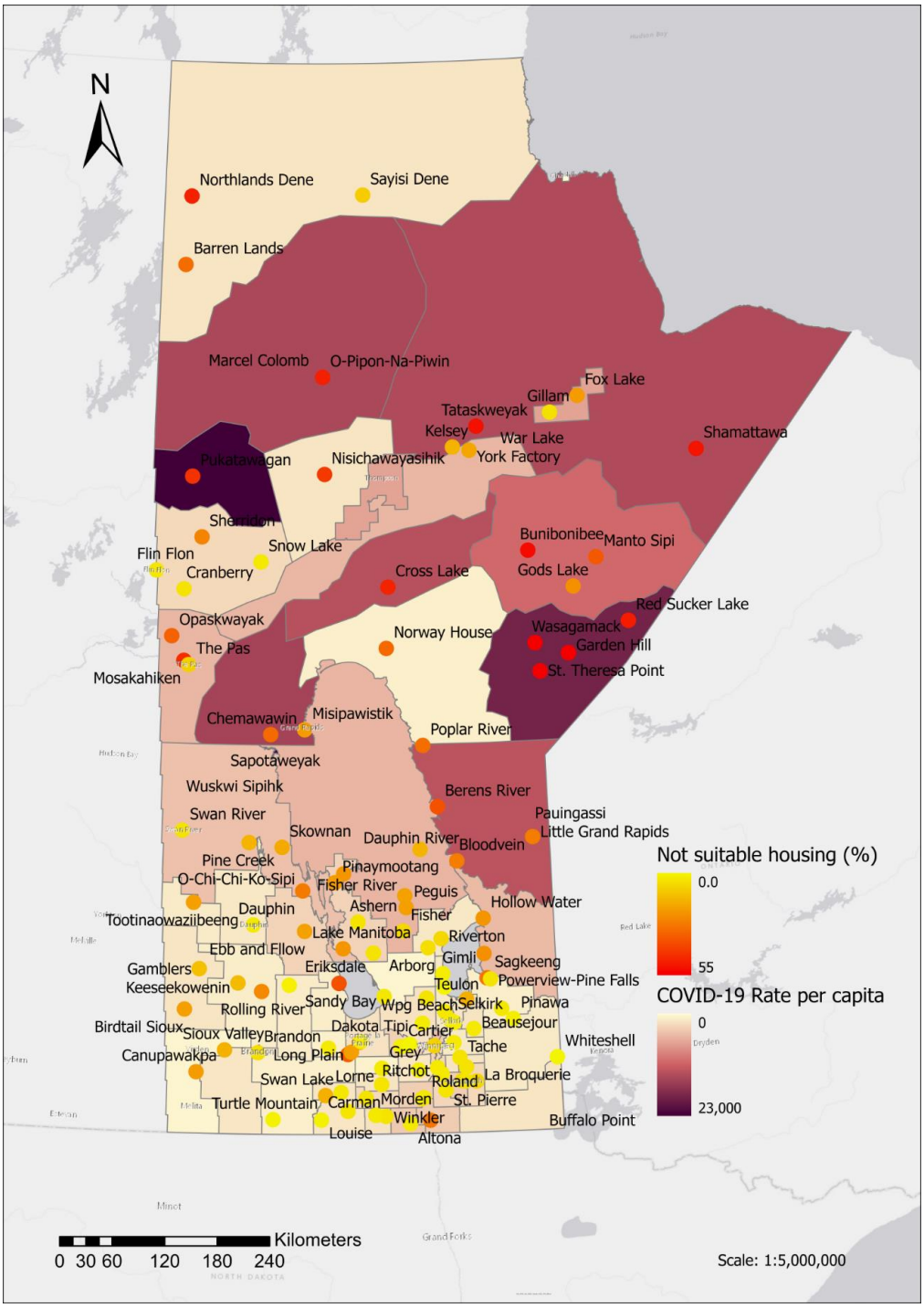
The housing stock in a community needing major repairs had an average of 48% (ranges from 16%–91%) in First Nations reserves compared to Manitoba overall average of 9% and other Manitoba rural communities of 8.5%. Higher COVID-19 rates in Figure 5 coincide with communities requiring more major repairs to housing. A statistically significant relationship ($r = 0.561$, $p < 0.001$) was found between COVID-19 rates and the rates of housing needing major repairs for Manitoba communities.

Figure 2. Map of road access to a service centre juxtaposed with COVID-19 rates for Manitoba communities.



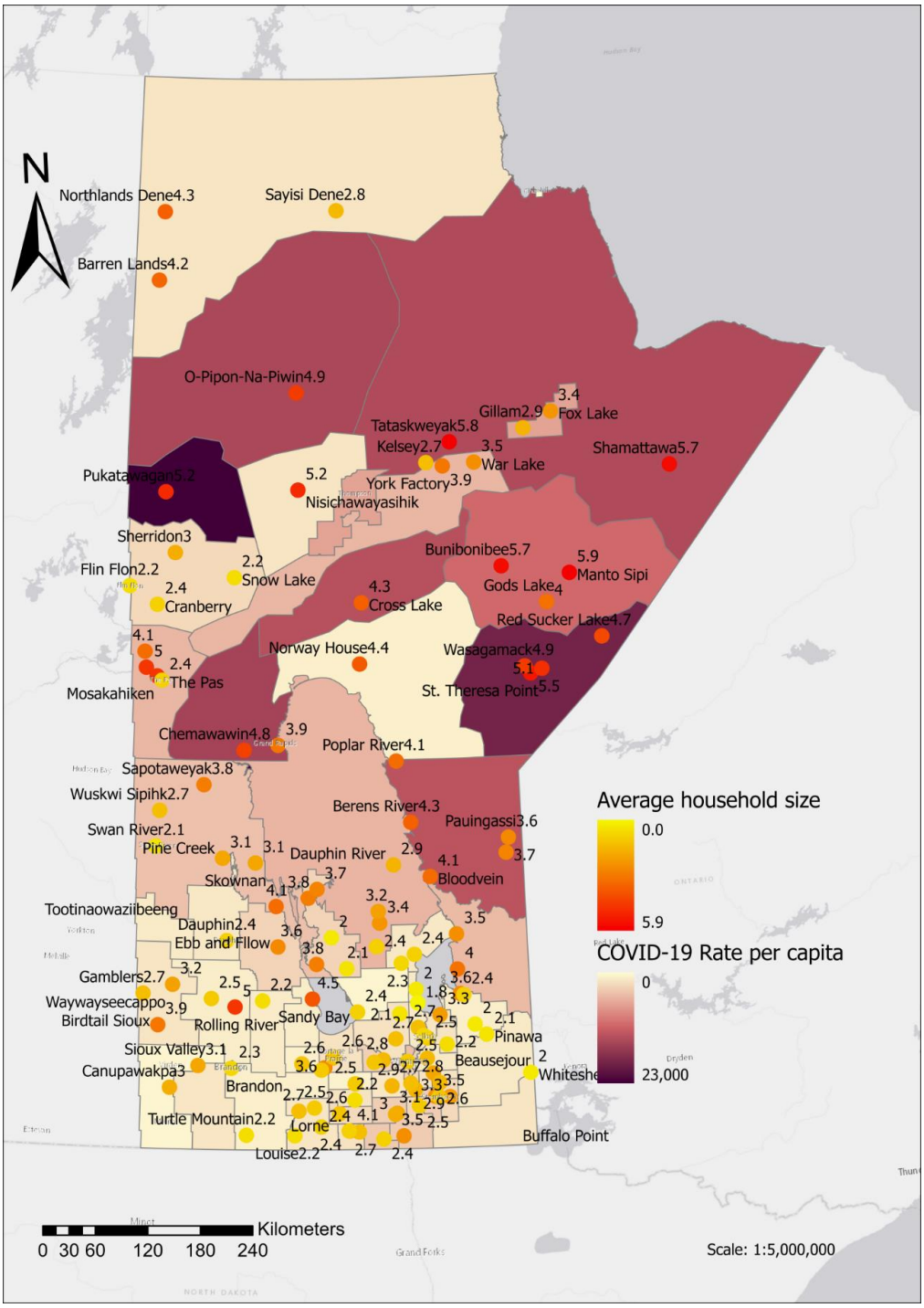
Source: Ajarat and Thompson, 2021 using data from Government of Manitoba, 2021a.

Figure 3. Map of not suitable housing rates juxtaposed with COVID-19 rates for Manitoba communities.



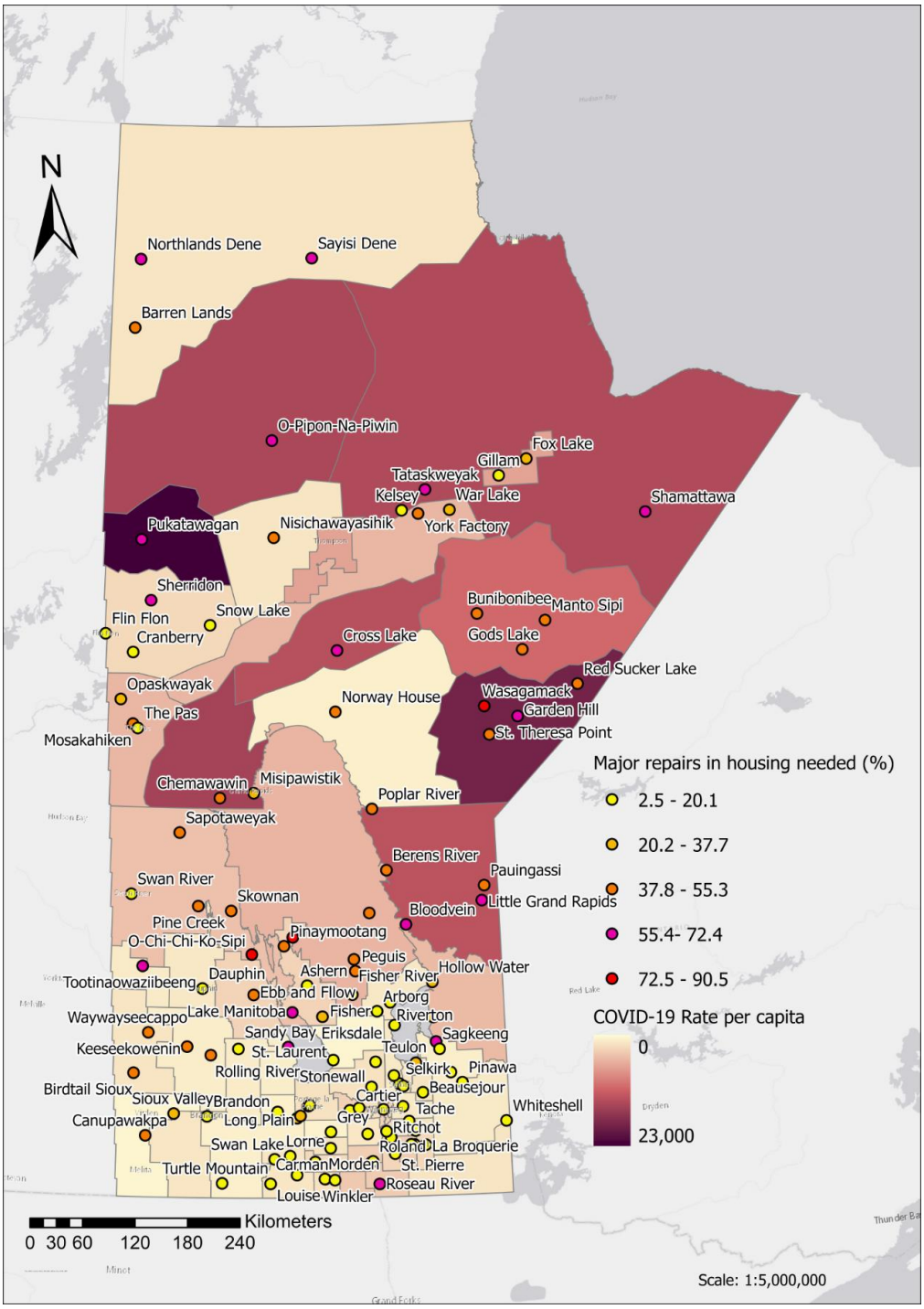
Source: Ajarat and Thompson, 2021 using data from Government of Manitoba, 2021a.

Figure 4. Map of average household size juxtaposed with COVID-19 rates for Manitoba communities.



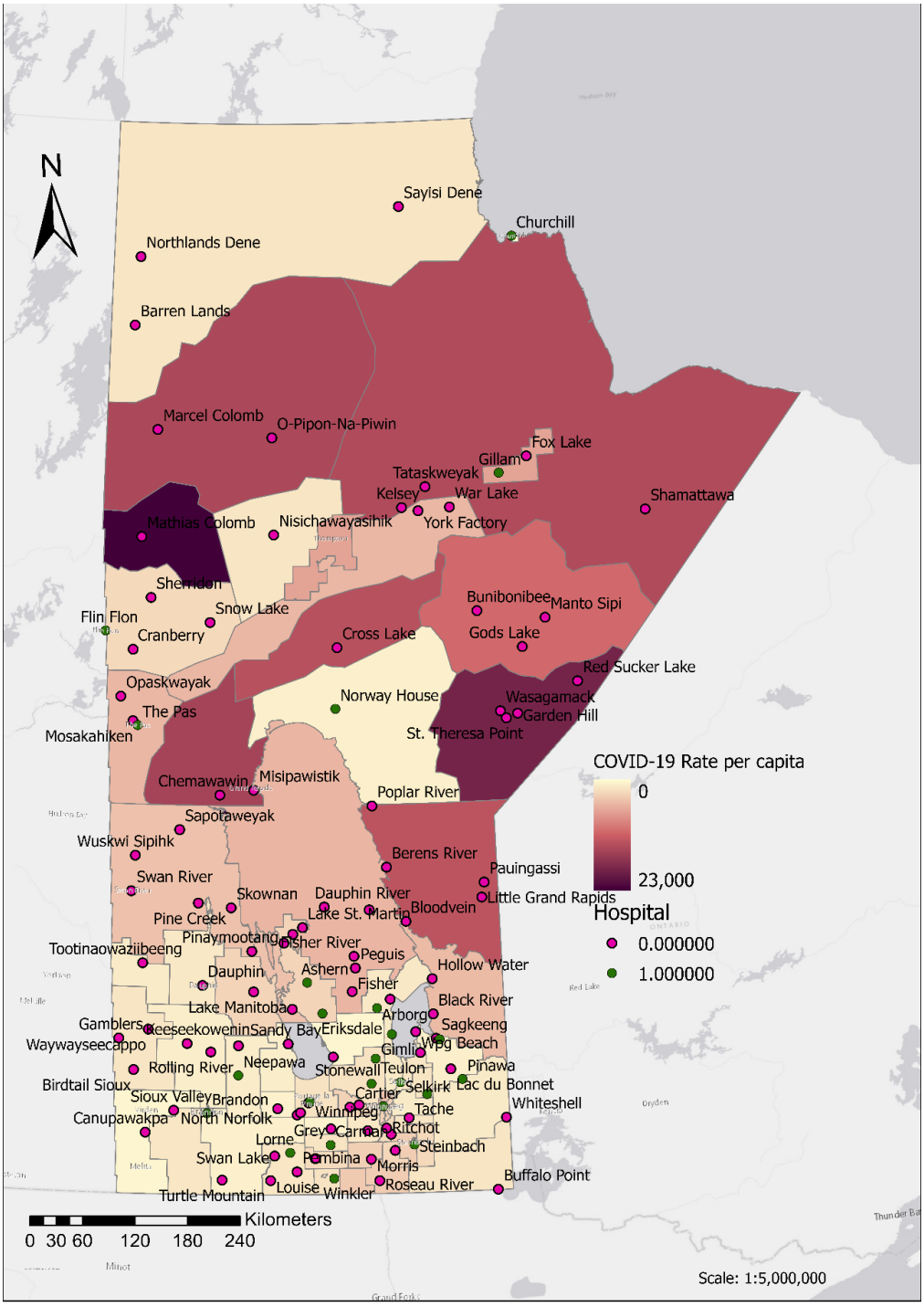
Source: Ajarat and Thompson, 2021 using data from Government of Manitoba, 2021a.

Figure 5. Map of rates of major repairs in housing needed juxtaposed with COVID-19 rates in Manitoba communities.



Source: Ajarat and Thompson, 2021 using data from Government of Manitoba, 2021a.

Figure 6. Map of COVID-19 rates juxtaposed with the availability of hospitals in Manitoba communities.



Source: Ajarat and Thompson, 2021 using data from Government of Manitoba, 2021a.

3.1 Statistical Results

Table 1 shows the Pearson correlation results for the COVID-19 rates related to not suitable housing, major repairs in housing needed, and average household size, respectively.

Table 1. *Correlation of COVID-19 Rates With Housing Variables—Not Suitable Housing, Major Repairs in Housing Needed, and Average Household Size*

Correlations			
Housing not suitable (%) relationship with COVID-19 rates		Rate (cases per 100,000)	Housing not suitable (%)
COVID-19 Rates (cases per 100,000)	Pearson Correlation	1	.623**
	Sig. (2-tailed)		.000
	N	80	80
Major repairs in housing needed (%) relationship with COVID-19 rates		Rate (cases per 100,000)	Major repairs in housing needed (%)
COVID-19 Rates (cases per 100,000)	Pearson Correlation	1	0.561**
	Sig. (2-tailed)		.000
	N	80	80
Average household size relationship with COVID-19 rates		Rate (cases per 100,000)	Average household size
COVID-19 Rates (cases per 100,000)	Pearson Correlation	1	0.532**
	Sig. (2-tailed)		.000
	N	80	80

**Correlation is significant at the 0.001 level (2-tailed)

3.2. T-Test – Independent Group Test

Tables 2 and 3 shows the t-test results for COVID-19 rates related to community access roads and community hospitals, respectively. The COVID-19 rates per capita were statistically significantly higher for communities without all year-round road access ($t = 2.281$, $P < 0.05$) and those without hospitals ($t = 2.024$, $P < 0.05$). The difference between the mean of the two groups demonstrates that communities without all year-round access to a service centre or hospital had higher rates of COVID-19.

Table 2. *Results of the Independent Group T-test of the COVID-19 Rates for Communities With and Without All-year-round Road Access to a Service Centre and Hospitals*

	Groups	N	x̄	Ss	T-test		
					Df	T	P
Rate (cases per 100,000)	Communities without all year-round road access	12	9223.372	9223.372			
	Communities with all year-round road access	66	2288.842	2188.3883	11.135	2.281	0.043

*p < .05

Table 3. *Results of the Independent Group T-test of COVID-19 Rates Comparing Communities With and Without Hospitals*

	Groups	N	x̄	Ss	T-test		
					Df	T	P
Rate (cases per 100,000)	Communities without hospitals	61	3875.627	6292.130			
	Communities with hospitals	19	2104.592	1490.340	75.406	2.024	0.047

*p < .05

4.0 Limitation

The COVID-19 database publicly available on the Government of Manitoba geoportal had a limited breakdown of data at the community level. This database thus underestimated the COVID-19 cases in First Nations communities reported by the First Nations Health and Social Secretariat of Manitoba (FNHSSM, 2021). The Government of Manitoba provides data based on the RHA districts, while FNHSSM provides reports at the Tribal Council aggregate level. Also, our study analysis was done at the regional health community area level—not individual-level data—based on the available open access COVID-19. As a result, adjusting COVID-19 rates for age and sex was not possible. Future research work is needed that adjusts for age and sex to determine their influence on COVID-19 rates. Lastly, the sociodemographic variables used in our analysis were obtained from the 2016 Statistics Canada census data, which are not the 2020–2021 situation for the studied population during COVID-19.

5.0 Discussion and Conclusion

The maps and statistics show the overlap of high COVID-19 per capita rates with poor infrastructure in Manitoba's communities for access roads, hospitals and housing. Compared to other communities in Manitoba, First Nations have higher rates of COVID-19; these higher per capita rates of COVID-19 are statistically significantly related to the underdevelopment of infrastructure in First Nations for roads, hospitals, and houses.

This study found COVID-19 per capita rates have a strong, statistically significant relationship with limited infrastructure in First Nations, particularly related to poor housing. Similar findings of overcrowded housing were found by Weaver (2020), who reported that the high incidence of overcrowded housing and pre-existing health conditions resulted in a higher COVID-19 toll on the Navajo Nation in the United States. Similarly, Ahmad et al. (2020), in their cross-sectional analysis of COVID-19 in 3,135 counties across the United States, found a higher percentage of households with poor housing conditions reported a higher COVID-19 incidence and death rate.

These findings for COVID-19 echo the findings that poor infrastructure and crowded housing increase the risk of exposure to infectious diseases (WHO, 2018). Poor housing brings a domino effect to COVID-19 transfer within crowded households (Rollston & Galea, 2020). One COVID-19 case on a reserve provides a high risk for community transmission due to overcrowded homes without the ability of those with COVID-19 to self-isolate or receive health care. The predominance of COVID-19 cases in areas with overcrowded housing repeats the incidence pattern seen for the H1N1 pandemic, where higher rates occurred in Garden Hill First Nation and other isolated First Nations communities in Canada (Pollock et al., 2012). The overcrowded housing creates risk factors for transmitting infectious diseases. Healthy, sufficient housing is needed in First Nation to reduce health inequities for First Nation people living on reserve.

This research found a significant relationship between poor health, as indicated by COVID-19 rates, geographic location and the built environment. This finding shows the built environment is a social determinant of health, in addition to access to healthcare (Abrams, 2020; Butler-Jones & Wong, 2016). Infrastructure inequities lead to poorer health outcomes, including COVID-19 per capita rates, exacerbating

the vulnerability of First Nations. Worse health outcomes in First Nations communities for COVID-19 are clearly linked to the infrastructural inequalities and regional underdevelopment on First Nations reserves. This preliminary research signals a need for improved infrastructure in First Nations reserves to ensure health equity across Manitoba.

This preliminary research provides compelling results based on the available data for 23 First Nations and other Manitoba communities without age-standardized results to encourage further research focused on the built environment's impact on COVID-19. Our analysis was limited to the data available to the public, without specific rates for all First Nations in Manitoba and for age-standardized and sex-disaggregated data, as the age-standardized and sex-disaggregated data for all First Nations in Manitoba could not be obtained in a timely manner for this paper. The standardized COVID-19 data is housed in the Data Repository held at the Manitoba Centre for Health Policy (MCHP). The review to get non-publicly available age-and sex-adjusted community-level data for all communities is a long, careful process through MCHP to ensure all data protocols and partner wishes will be met. To get access to this community-level data requires many stages over a length of time greater than six months or a year. While undertaking this process to get standardized data extending into 2022, the best publicly available data was explored to explore the need for further research. Research is needed regarding the impact of built environment conditions in all Manitoba communities with age- and sex-adjusted analysis of COVID-19 data to comprehend the relationship more fully. Analyzing age-standardized data for all communities is predicted to strengthen these findings further, as higher First Nations COVID-19 age-standardized rates are predicted due to the younger demographics in First Nations compared to other Manitoba communities (Statistics Canada, 2019b). This adjusted data is expected to show an even stronger relationship between underdevelopment and COVID-19 rates.

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