The Impact of Greenery on Indigenous Mental Health in Canada

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Abstract

Recent research shows that residential greenness has a significant impact on mental health in urban areas and that residents of high socio-economic class are more likely to have more exposure to greenspace. As a result, this represents a factor contributing to health inequities to the detriment of marginalized populations such as Indigenous communities. Given that their culture is built upon a deep connection to nature and the negative impacts of colonization are still enduring in Canada, we hypothesize that the absence of exposure to greenery could worsen their mental health significantly more compared to the rest of the population in urban cities of Canada. For this reason, the objective of this study is to determine whether greenspace is a significant factor especially for Indigenous mental health, with a focus on Canada. By examining this relationship, we aim to provide insight on whether equitable urban greenspace housing accommodations are effective in reducing injust mental health disparities.

For our study, the gathered data of mental health, Indigenous identity and region of residence of each participant was found in a Statistic Canada survey from 2018; on top of which was added their given geographic position's NDVI values of 2018, assessing residential greenness. A Chi-squared test was used for our ordinal and categorical independent variables, and was run on 250 random samples for a countrywide analysis. We've observed that only a minority of samples demonstrated significant relationships between our independent variables and mental health. For this reason, our results disproves our hypothesis by suggesting there is no significant impact of greenery nor Indigenous identity on mental health, and more specifically, that greenery doesn't

level Indigenous identity more than the rest of the population in Canada in 2018. A possible interpretation of our results is that policies should shift their focus on implementing additional green spaces in cities to other alternatives in order to resolve health inequities in specific areas containing some in Canada.

Our study also significantly contrasts with previous studies. For this reason, further research on the topic addressing our study's limitations is necessary in order to establish whether our results are conclusive.

Introduction

In recent years, light has been shed upon the consequences of colonization on multiple spheres of Indigenous people's lives, especially regarding their health and well-being. The issue is particularly relevant in Canada, home to a population of 1,807,250 Indigenous people as of 2021 (Statistics Canada, 2021). For instance, a common mental health challenge amongst Indigenous youth is depression which constitutes an important suicide risk factor and could have severe educational and social consequences. (Logie et al., 2021). These socio-historical and contextual determinants have been used to demonstrate that Indigenous mental health is significantly worse compared to the rest of Canada's population. Using crowdsourced data, it has been determined that larger numbers of Indigenous people have reported poorer mental health than the rest of the population in Canada (Arriagada et al., 2020).

To further explore the factors that could potentially better the significantly worse mental health of Indigenous communities, this study aims to investigate the impact of greenery on Indigenous population's mental health. In particular, it is apparent that Indigenous people's traditions and bel

revolve around a strong sense of belonging to nature and deep respect regarding their land and green environment (Niigaaniin et al. 2022). However, not enough studies have shown the possibly significant relationship between Indigenous mental health and exposure to nature for Indigenous communities. The only study that examined this relationship is a study using photovoice. It demonstrated that viewing images of land and nature had a higher significant positive effect on stress, anger and fear in Indigenous youth compared to other participants. (Hatala et al., 2020) Nonetheless, photovoice only generates qualitative data, so additional more objective research is necessary to confirm their results. Our study aims to address this topic from a quantitative perspective. Similarly, we hypothesize that Indigenous mental health is significantly more impacted by residential greeness compared to the rest of the population.

Furthermore, it has been demonstrated that among the 5.3 million urban residents across the canadian territory, residential greeness is unevenly distributed depending on historical, sociocultural, economic and demographic factors (Pinault et al., 2021). In the same study, lower levels of greenery were correlated with populations of lower socioeconomic status and appointed as visible minorities, notably the Indigenous.

The purpose of this study is to investigate whether the lack of greenery in urban neighborhoods has had a significant impact specifically on the mental health of Indigenous Canadians. By examining this relationship, this study aims to elucidate the potential consequences of unequal access to natural environments, hopes to inform future policy decisions and provide additional valuable data on Indigenous populations as there is too little data focusing on these in scientific

research. In this way, this study adds on top of previous research to help improve mental health outcomes for all Canadians, regardless of their background or socioeconomic status.

Methods

Data collection

From Statistics Canada's catalog, we used two databases that contained the relevant metrics.

First, the Canadian Community Health Survey (CCHS) (Canada, 2018) notably assesses whether the participant is Indigenous, each participant's self-perceived mental health over an ordinal scale from one to five and the health region in which they are located. The collection period of CCHS from January 2 to December 24 of the year 2018 was selected for this cross sectional study to avoid the cohort of confounding variables introduced by Covid-19 (Pandey et al., 2021).

Second, the normalized difference vegetation index (NDVI), a continuous greenery scale, acquired from the Crop Condition Assessment Program (Canada, 2022) was used. The greenery levels of the same year were consequently associated with each person of the previous dataset (CCHS) depending on their location, precisely down to their health region. In total, we gathered NDVI values for 77 health regions[1], representing smaller districts within each of the canadian provinces, or counties within populated cities. Afterward, the continuous values of the NDVI scale were categorized into three groups of low, medium and high greenery[2] using equal width binning for ease of testing.

After the combination of the aforementioned datasets, there are a total of n=72,933 effective participants[3] of all age groups spread across all provinces and territories except for Nova Scotia, Yukon, Nunavut and Northwest Territories due to missing data from either survey. For the

[1]Health regions visualized with an online map at https://observablehq.com/@greenery/greenery.
[2]The NDVI ranges of [0.40255, 0.53163[, [0.53163, 0.66072[and [0.66072, 0.78980] were used correspondingly.
[3]See Appendix A. Combined dataset used for the tests can be found at https://github.com/ThatAquarel/greenery/tree/chi2/dataset.

upcoming tests, three categorical variables are relevant (figure 1), the demography of the participants (Indigenous or Non-Indigenous), the NDVI of their respective regions and their self-rated mental health.

Statistical Analysis

The Chi-Square test of independence was deemed the most appropriate given the three categorical variables and the goal to prove their correlation. Consequently, three different Chi-Square tests were chosen to assess the effect of demography on mental health (DM), greenery on mental health (GM) and the interaction of demography and greenery on mental health (DGM) using two two-way and one three-way contingency table respectively. From this point on, the tests will be abbreviated to DM, GM and to DGM to simplify the text.

Before the tests could be executed, the assumptions had to be met. Demography is a boolean variable while both greenery and self-perceived mental health are ordinal variables; therefore, the assumption of categorical variables is met. As each participant belongs to only one group of each variable, mutual exclusivity within each metric is thus ensured, and because they are selected from the n=72,933 subjects at random without replacement, a single participant may only be counted once in one cell of each contingency table[4] generated before any Chi-Square test. As per the random sampling, participants also have an equal chance of being selected; the samples are consequently independent. Moreover, the contingency tables contain frequencies as selected participants are cumulated and counted into those. In addition, at least 80% of the counts

[4]Contingency tables generated with SciPy (version 1.10.1) using the *scipy.stats.contingency.crosstab* method.

within each contingency table are above five because of the sufficient sample sizes selected for each of three different Chi-Square tests[5].

With all the assumptions of the Chi-Square test achieved, the actual tests will follow. A control for the participants' age and biological sex was done, but no significant changes were noted; all the age and sex groups were thus used. Sample sizes of n=134, n=195, n=282 were determined for each of the DM, GM and DGM tests respectively. As sample sizes are quite small compared to the available dataset containing a total n=72,933 subjects, each of the DM, GM and DGM tests were executed 250 times each on different random samples to get a more complete overview of the database[6]. 250 is an adjustable number chosen for ease of calculation.

Statistical significance p-values resulting from the DM, GM and DGM Chi-Square tests[7] were compiled into three separate distributions. Similarly, practical significance effect sizes for the DM and GM tests were computed using Cramér's V method[8] and compiled into two distributions. Cramér's V method does not generalize to three variables; therefore, no practical significance distribution was generated for the DGM test.

Results

After running 250 times each of the three Chi-Square tests of independence (DM, GM and DGM), a box-plot was made in order to give a simplified overview of the distribution of the

[5]Sample sizes were determined using GPower (version 3.1.9.7) with an effect size of 0.3, an alpha of 0.05, a power of 0.80 and degrees of freedom varying depending on the test.
[6] Dataset sampling was done using Pandas (version 1.5.3) and NumPy (version 1.24.1) on Python (version 3.11).
[7] Chi-square tests performed with SciPy (version 1.10.1) using the *scipy.stats.chi2_contingency* method without Yates' correction for continuity.
[8] Cramér's V tests performed with SciPy (version 1.10.1) using the *scipy.stats.contingency.association* method.

p-values (figure 2.A). Similarly, for the DM and GM tests, effect sizes were computed using Cramér's V method (figure 2.B).

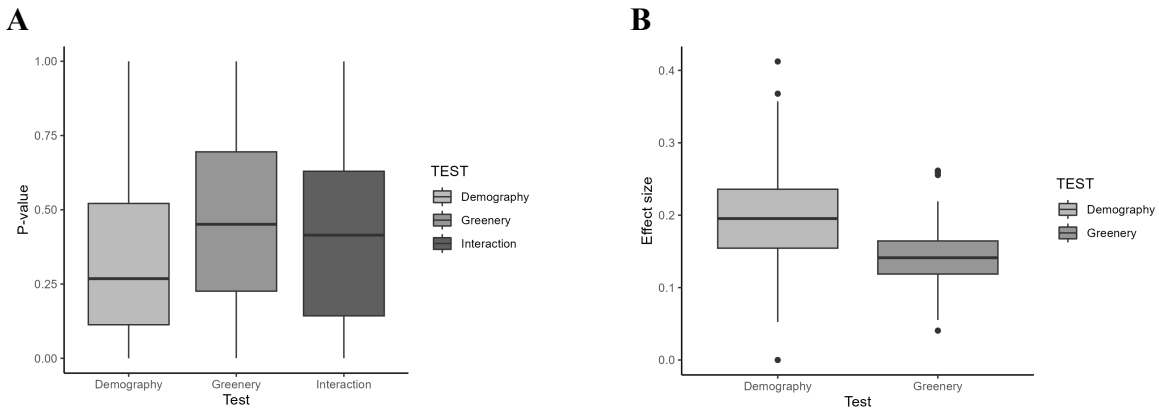

Figure 2: Insignificant p-values and weak to medium effect sizes for DM, GM and DGM. (**A**) Cumulated p-values collected for the DM, GM and DGM tests executed 250 times and (B) cumulated effect sizes collected for the DM and GM tests executed 250 times.

Insignificant correlation between demography and mental health

For the DM tests, 27 out of 250 p-values are significant below an alpha of 0.05 while 59 out of 250 are significant below 0.10. Although the mean of the p-values yielded 0.29, proving overall insignificance, the histogram resembles that of an exponential distribution (figure 3.A). Further tests are required to assess the reason that is. In order to verify every possibility, we also decided to assess practical significance using the Cramer's V method. Out of the 250 tests, 131 of them had an effect size inferior or equal to 0.2, meaning a weak association, while the remaining 119 yielded an effect size larger than 0.2 but inferior or equal to 0.6, representing a moderate association. In addition, the mean of the effect size distribution is 0.20, proving a low association (figure 4.A).

Insignificant correlation between greenery and mental health

For the GM tests, the Chi-Square test indicated that 9 out of 250 p-values are significant below an alpha of 0.05 while 23 out of 250 are significant below 0.10. This time, however, the p-value

average was 0.45 which was 55.17% larger than the previous DM tests (figure 3.B). Correspondingly, effect size yielded similar results. 241 out of 250 tests returned a low association rating and only 9 had a medium association. Both statistical and practical significance prove a weakened correlation between mental health and greenery, added on to the fact the mean of the effect size distribution was 0.14 (figure 4.B).

Insignificant correlation between demography and greenery on mental health

Finally, the three-way Chi-Square test of independence for the DGM tests gave a result of only 17 out of 250 p-values being significant values below the alpha value of 0.05 and 33 out of 250 below 0.10. (Figure 2.A) This is accompanied by a insignificant p-value mean of 0.39 (figure 3.C).

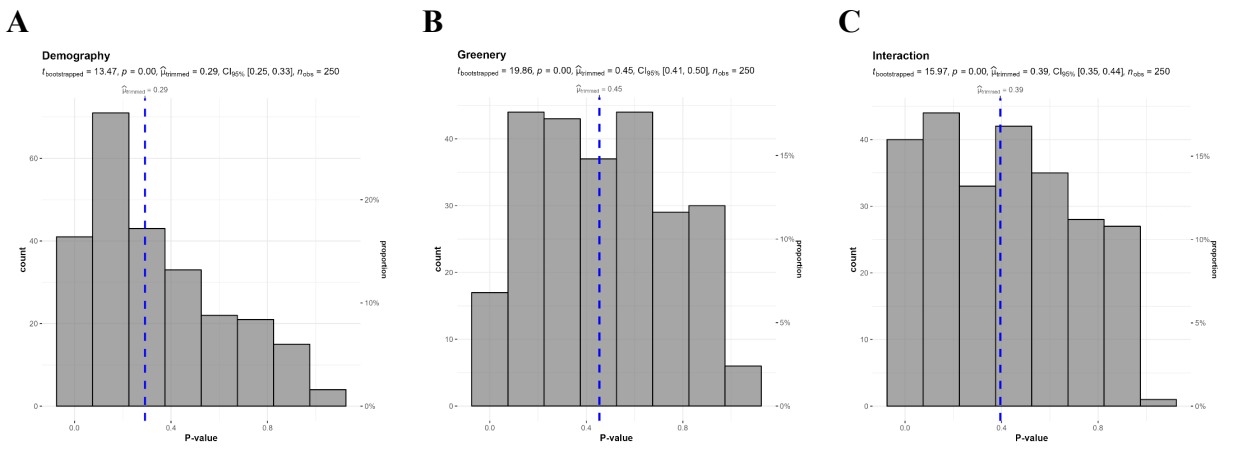

Figure 3: Insignificant p-values distribution for (**A**) DM, (**B**) GM and (**C**) DGM Chi-Square tests, all three of which were executed 250 times over different randomized samples.

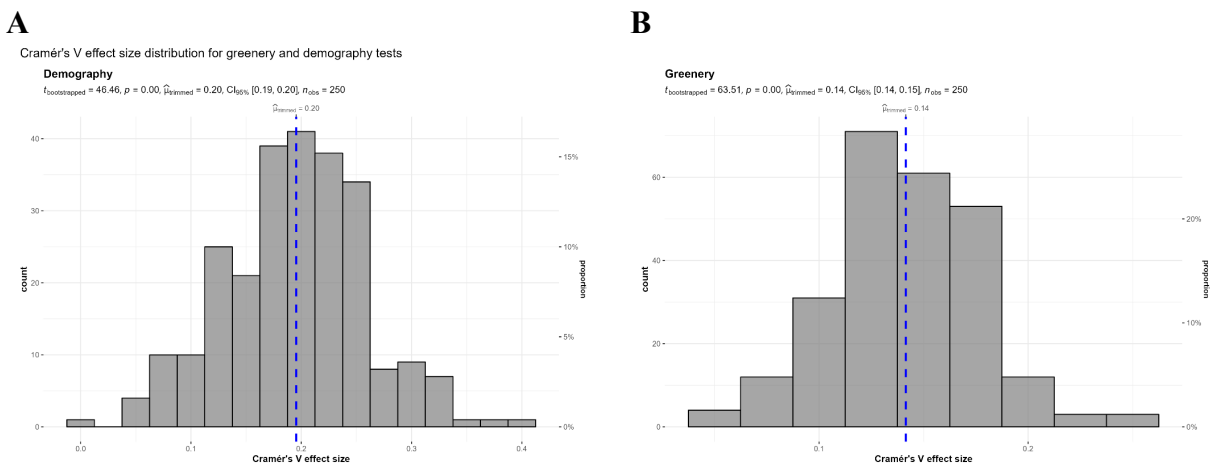

Figure 4: Medium to weak association effect size distribution for (**A**) DM and (**B**) GM Cramér's V tests, both of which were executed 250 times each over different randomized samples.

Discussion

The results of our tests seem to demonstrate that there is no significant interaction nor effect of greenery and Indigenous identity on mental health.

These results significantly contrast with previous studies, and go against our hypothesis. However, this might be explained by a gap in research and limitations in our study. For instance, our data for the assessment of mental health highly relied on self-report, which requires participants to introspect and this leads to highly subjective results. In other studies, Indigenous and non-Indigenous mental health was assessed on specific factors of mental health such as depression or substance use, and used standardized tests for objective results. Additionally, Indigenous participants' data all over Canada only represented 5.22% of the datasets used and excluded Indigenous communities living in reserves, so results might not be as representative of the whole population. Moreover, there are cultural differences between Indigenous groups and the specific Aboriginal identity of each participant was not specified.

Furthermore, in terms of data on residential greenness, the geographic region used to assess each participant's NDVI value is at the level of a large region within a city. This is possibly too wide-scaled and imprecise to truly determine whether exposure to greenery has an effect on mental health, as greenery is unequally distributed and we didn't control for each participant's time spent outdoors. Out of privacy concerns, the precise postal code of each participant is kept secret. However, future studies could only include NDVI values of residential greenness in the dataset to remedy this issue.

In conclusion, while our study has multiple limitations, it still represents a good database for further research and encourages addressing these limitations in future studies as Indigenous wellbeing is an underrepresented research topic. While most Chi-Square tests were insignificant, mental health for some random samples still proved to be significantly impacted by the studied factors. Additionally, since Indigenous mental health doesn't seem to be significantly leveled by urban greenery on a wide scale, our results suggest that it might be important to investigate whether there should be a shift in focus from greening cities to other alternatives to effectively resolve health inequities in urban cities.

Overall, this study highlights the importance of evaluating factors that could affect mental health especially in marginalized communities as they are underrepresented. By addressing the unequal distribution of green spaces and investigating its effects, our study as well as future studies can help to offer insight on the most effective ways to improve mental health outcomes for all Canadians, regardless of their background or socioeconomic status.

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Appendix A

Dataset overview

Box plots representing n=72,933 effective participants categorized by demography (Indigenous or Non-Indigenous), greenery levels (NDVI) and self-perceived mental health.