# NEIGHBOURHOOD MODELS TO IDENTIFY MAUP EFFECTS USING SPATIAL REGRESSION

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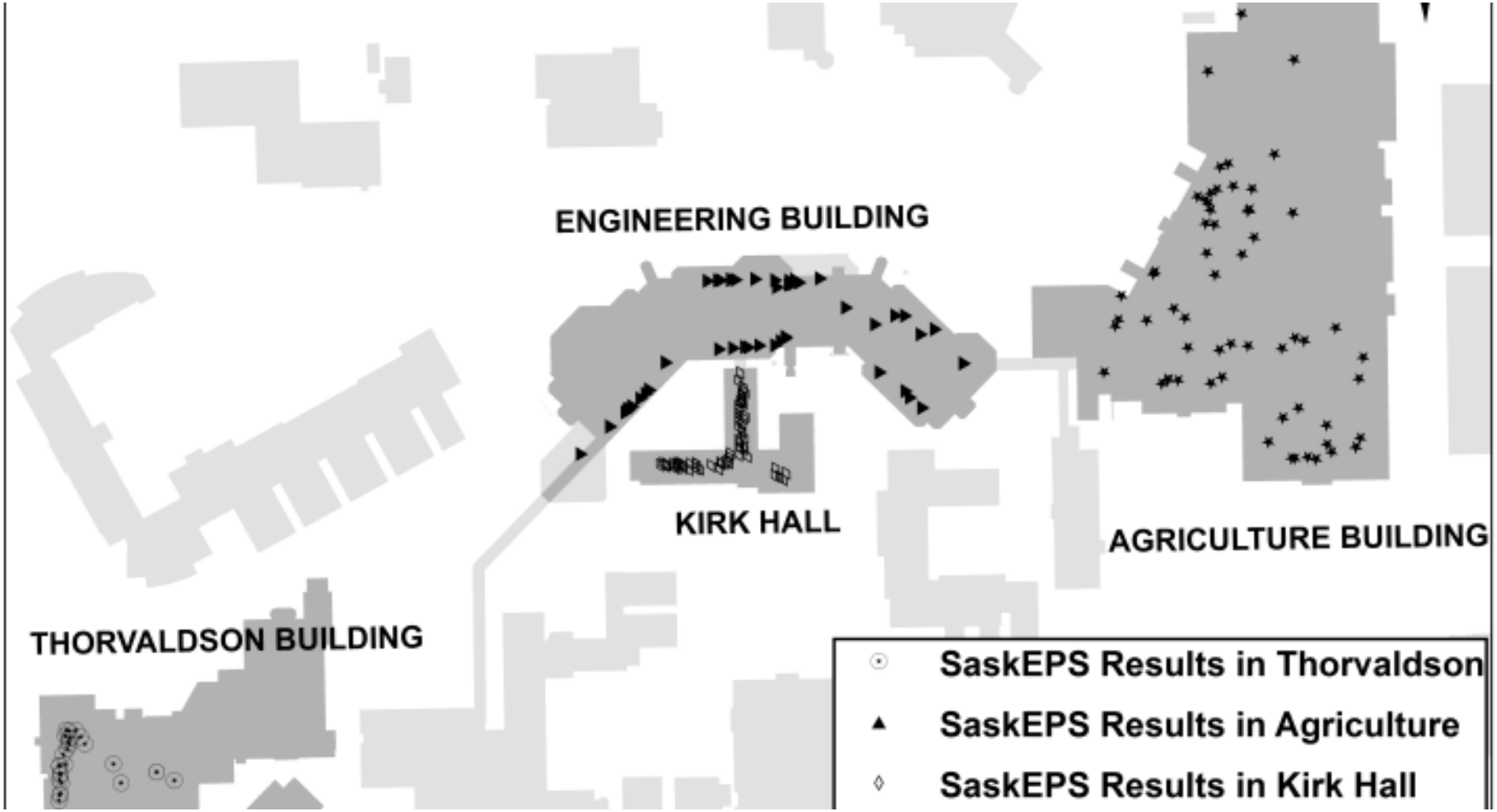
# My Background and Research

- Scientific Geography
- Human Navigation and Wayfinding
  - Spatial Cognition
  - Leverage WiFi Technology for Indoor Positioning
- Health Geography
  - Access to Primary Health Care
  - Environment and Health


ENGINEERING BUILDING
KIRK HALL
AGRICULTURE BUILDING
THORVALDSON BUILDING
SaskEPS Results in Thorvaldson
SaskEPS Results in Agriculture
SaskEPS Results in Kirk Hall

# In Canada

- Canada Health Act
  - Access to health care services shall be Universal and Equitable (comprehensive too)
  - Health services are managed provincially (10 to 13 difference health care providers)
- In this study
  - Primary Health Care: family doctors, GPs, urgent care clinics, after-hours clinics
    - Not: nurse practitioners, health vans/buses, ER, Hosptial based GP

The objective of this study

- Uses the three step floating catchment area method (3SFCA) to determine potential (geographical) access to primary health care we will explore differences in different units of analysis (natural or locally defined neighborhoods, census tracts, and census dissemination areas)

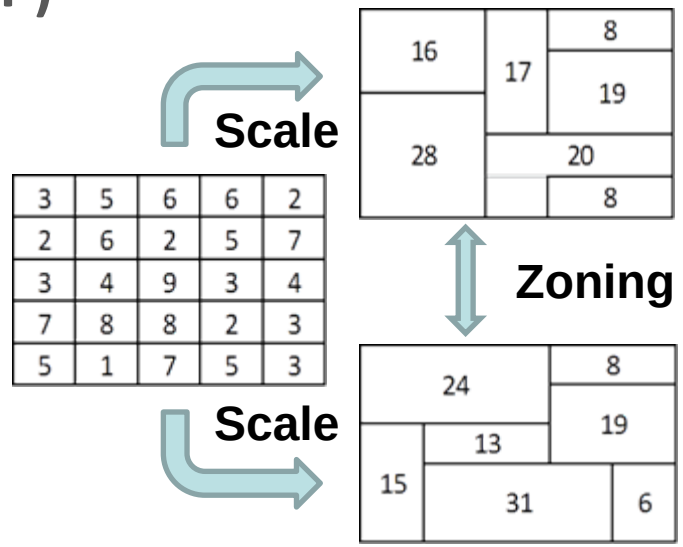
# MODIFIABLE AREAL UNIT PROBLEMS (MAUP)

In geographical studies, analytical results can be influenced by:

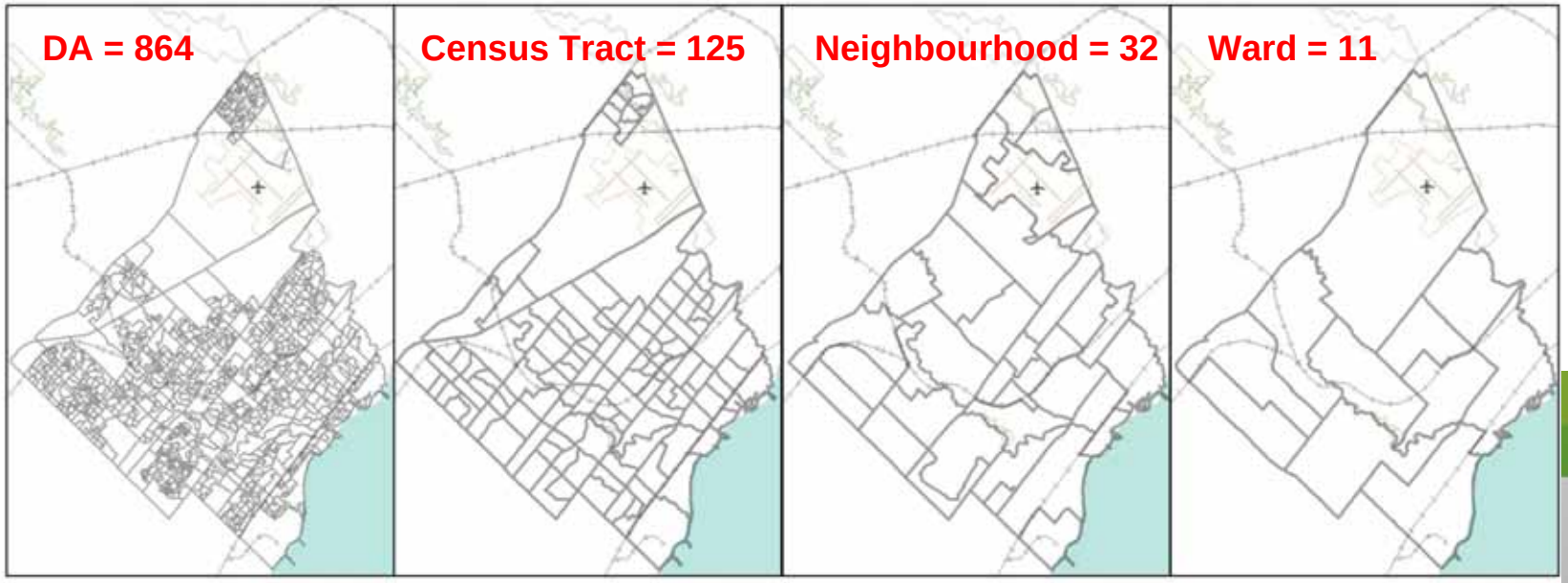
- the number of areal units used—scale effect
- the choice of boundaries (or aggregation) –zonation effect

Many spatial datasets are collected on a larger scale (household) but are released and shared only after being aggregated at smaller scale (In Canada, Census data are collected from every household, but provided at dissemination areas-DA).

In the process of data aggregation at lower scales (e.g. Census Tracts, Census sub-divisions, etc.), variability in the dataset and statistical estimation using such data can be different.




## SCALE EFFECT



# ACCESS TO PRIMARY CARE

- Access to primary care is an important and growing issue regarding health care delivery in Canada
- It has a direct impact on the burden of disease
- It is an important performance indicator of national health systems
- Access dimensions: Potential vs. Revealed
  - *Potential* access incorporates factors such as the geographic distribution and supply of health care services
  - Revealed accessibility refers to actual utilization patterns of consumers

# METHODS FOR ESTIMATING ACCESS TO HEALTHCARE

- Straight Ratios
- Kernel Density Model
- Gravity Model
- Modified Gravity Model
  - spatial decomposition model
  - two-step floating catchment area method
  - three-step floating catchment area method (3SFCA)

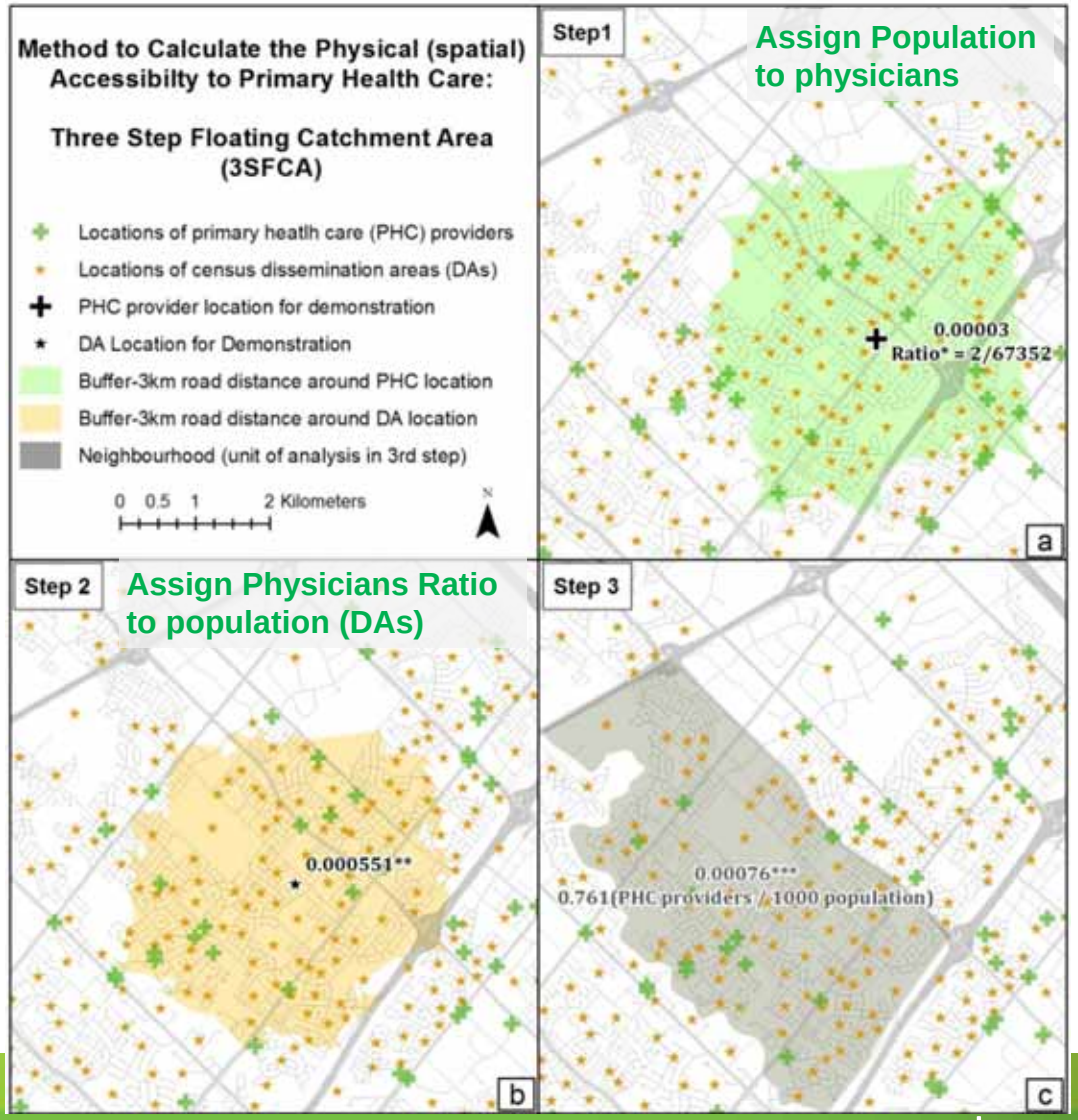
# MEASURING SPATIAL ACCESS TO PRIMARY HEALTHCARE

An index of spatial access to primary healthcare at neighbourhood and census tract levels, determined through 3SFCA method

**Buffers: (**Type: Road network; Size: 3km)

First, geocode all family doctors, general practitioners, and clinic locations using reference dataset (DMTI CanMap streetfiles 2010 and platinum postal code suite).

This method provides an accessibility score for each unit of analysis in the study area (number of physicians per 1000 individuals)



# STUDY AREA

**Population (2006 Census):**

Saskatoon = 202,042

Mississauga = 667,901

**Households(2006 Census):**

Saskatoon = 83,680

Mississauga = 214,380

**Neighbourhoods:**

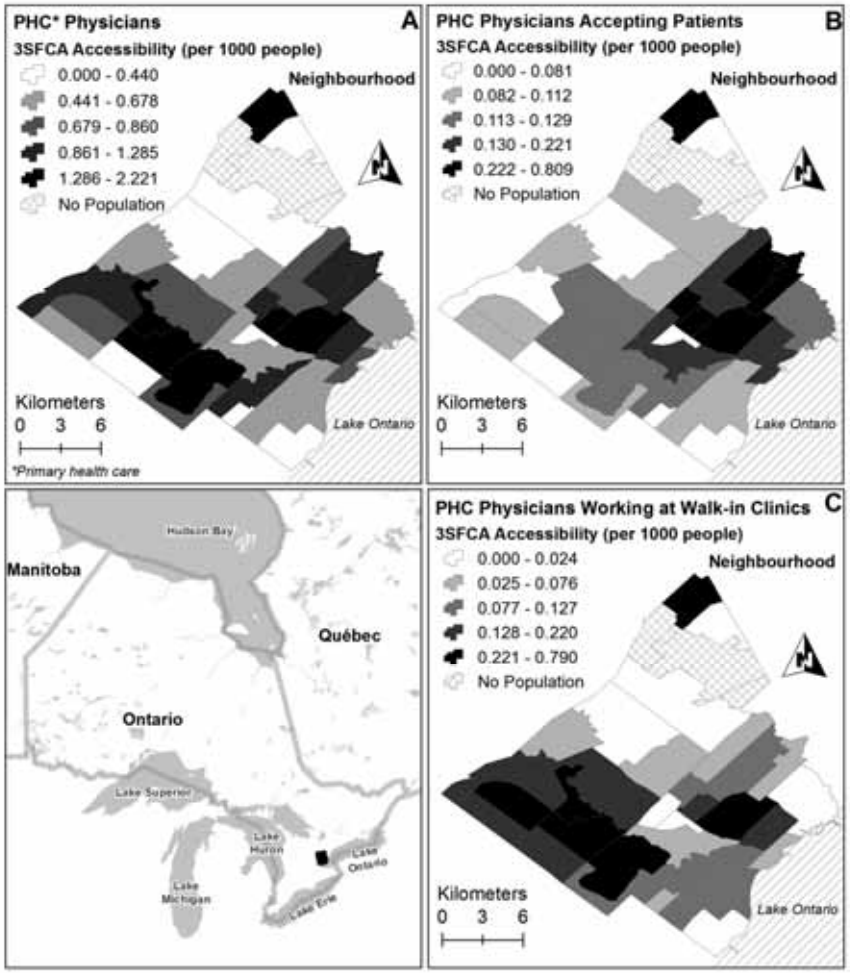
Saskatoon = 83 (74*)

Mississauga = 32

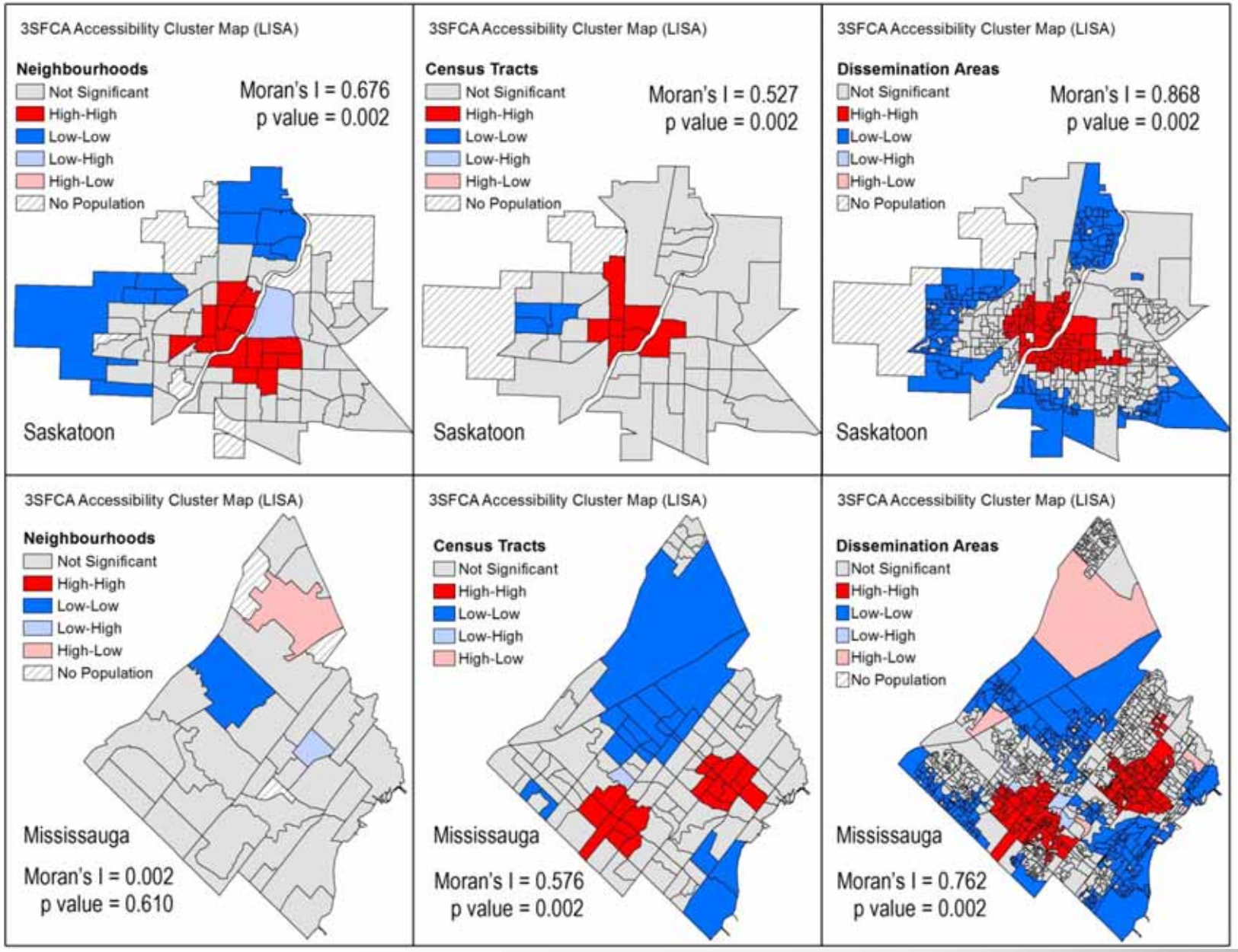



* having population

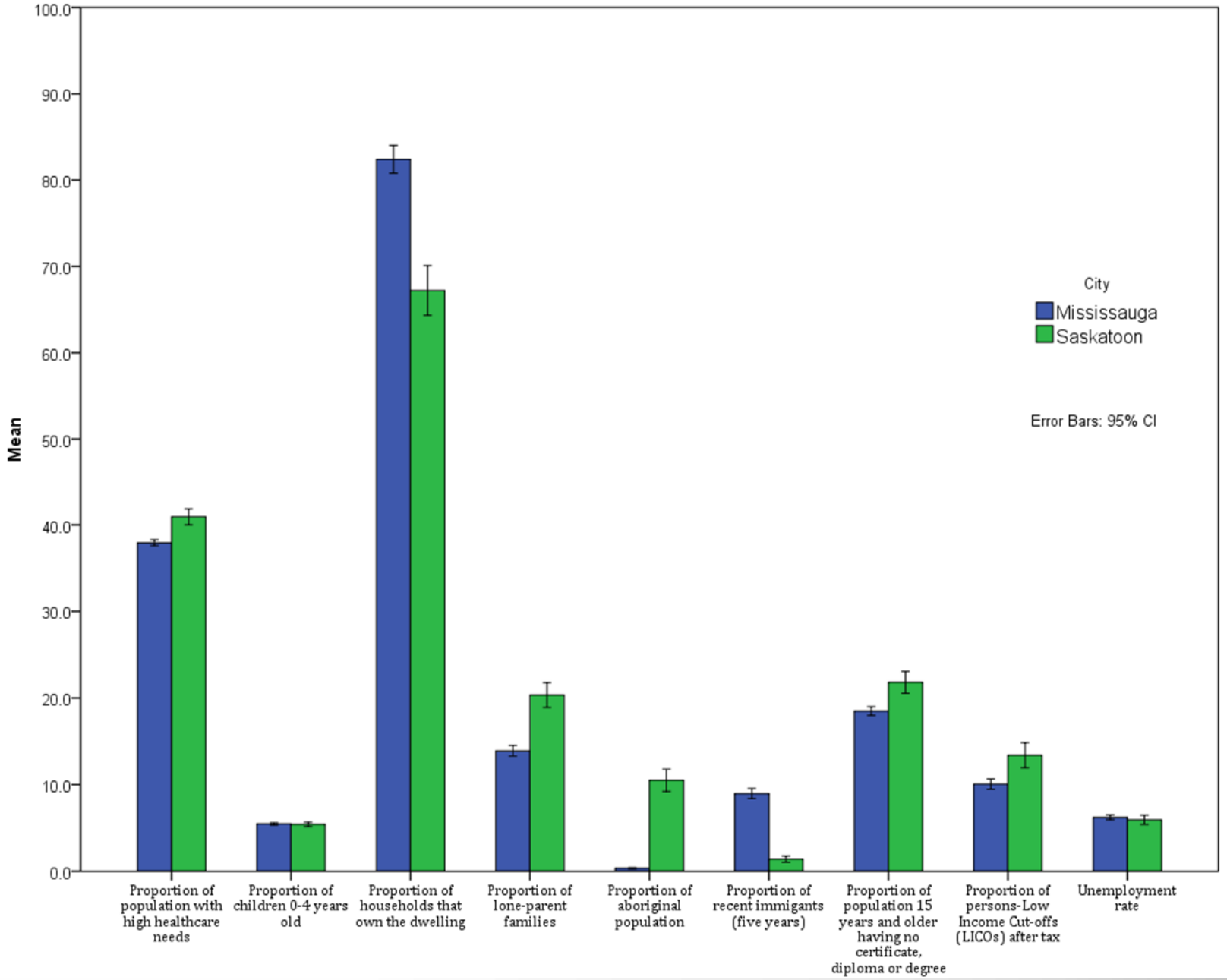
# ACCESS IN MISSISSAUGA, NEIGHBOURHOODS, THREE BUFFER SIZES



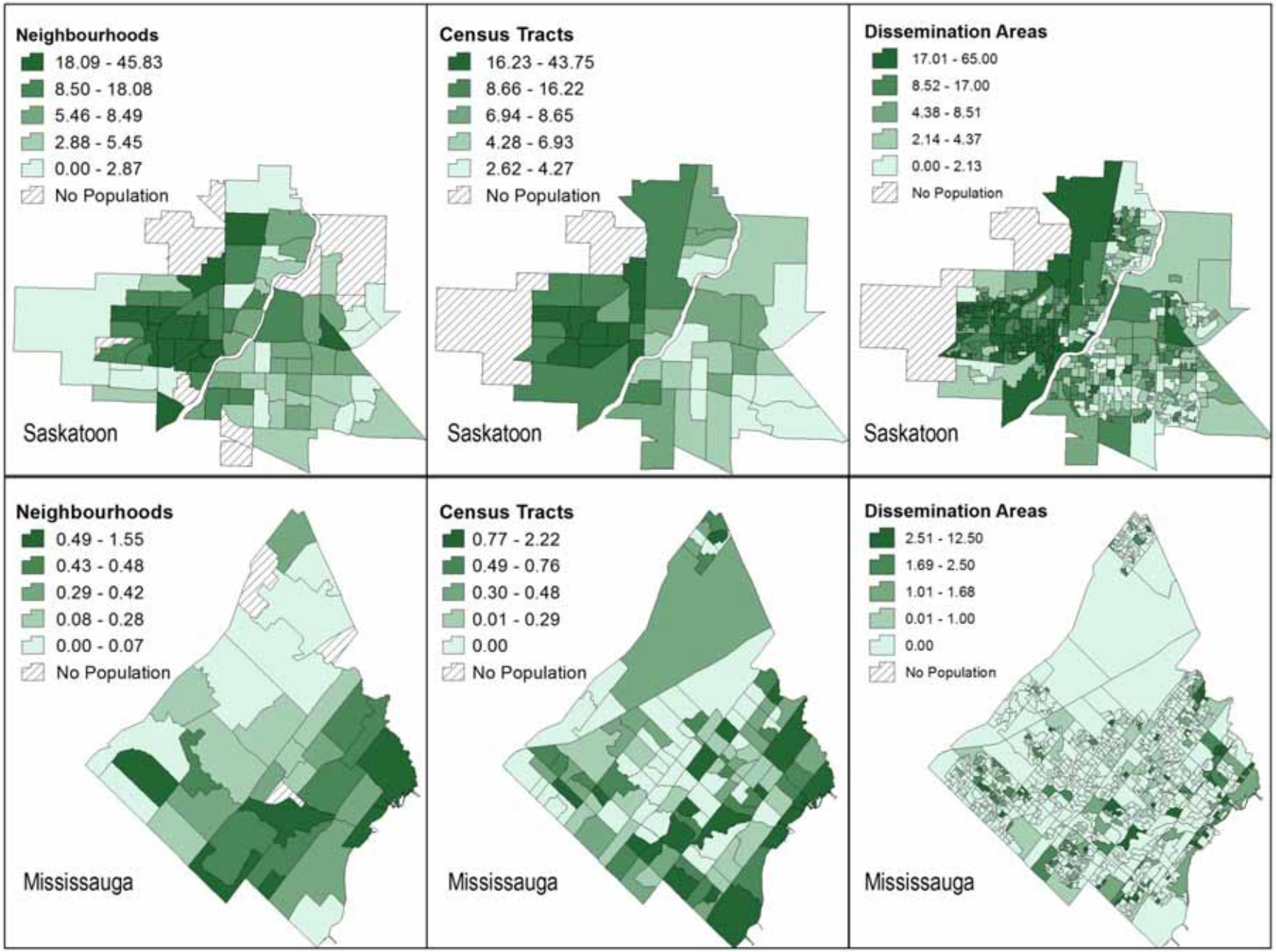
# LOCAL INDICATORS OF SPATIAL AUTOCORRELATION



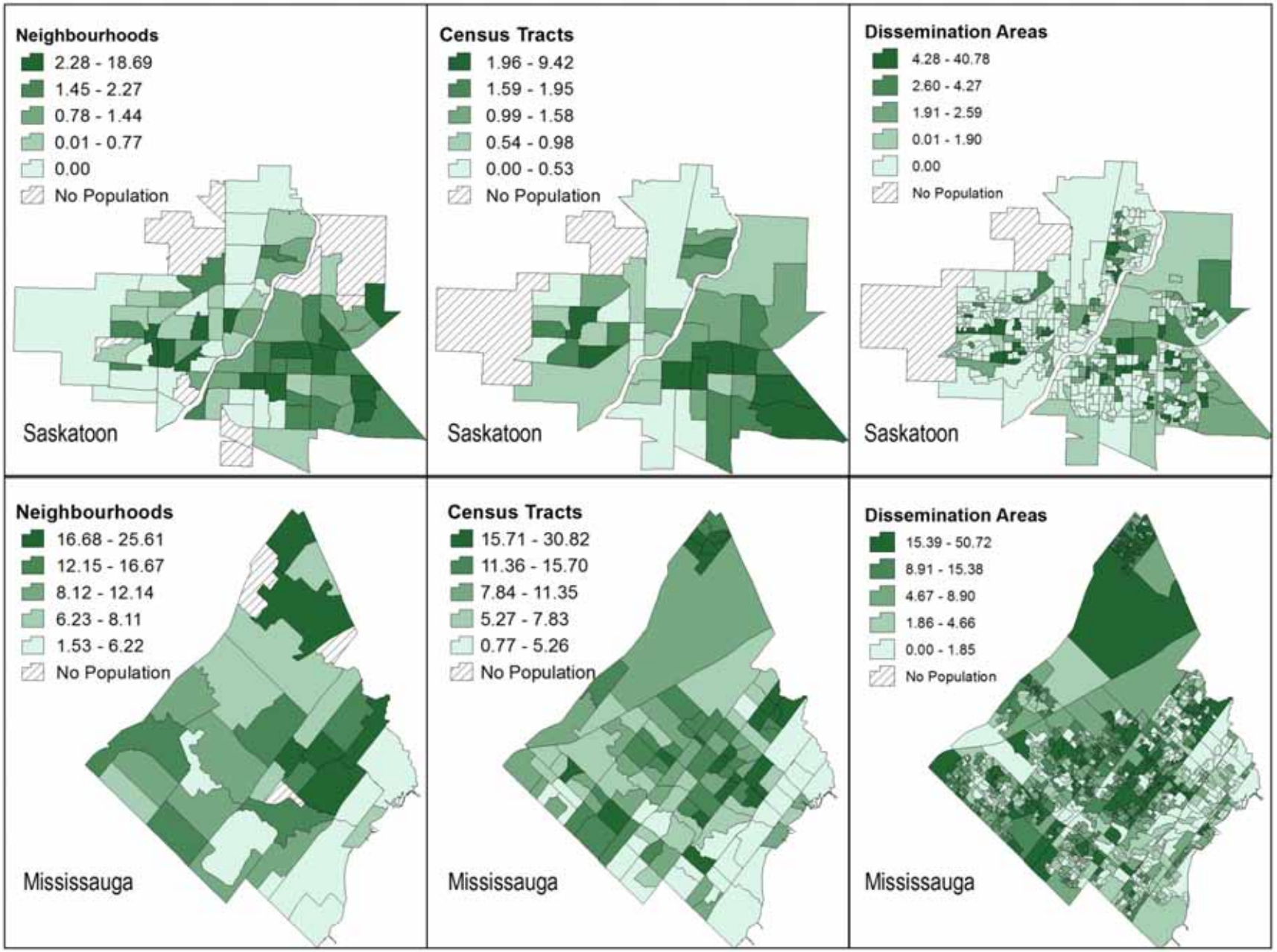
# SOCIO-ECONOMIC VARIABLES



# PROPORTION OF ABORIGINAL POPULATION



# RECENT IMMIGRANTS (2001-2006)



# SIGNIFICANT PREDICTORS

| | Variables (forward stepwise linear regression - ( 95% CI)) | Mississauga | | | Saskatoon | | |
|---|---|---|---|---|---|---|---|
| | | *NH* | *CT* | *DA* | *NH* | *CT* | *DA* |
| 1 | Proportion of population with high need of healthcare | x | | x | | | |
| 2 | Proportion of Children 0-4 years old | | x | x | x | x | x |
| 3 | Proportion of households that Own the dwelling | x | | x | | | x |
| 4 | Proportion of Lone-Parent Families | x | | | | | |
| 5 | Proportion of aboriginal population | | | | x | | |
| 6 | Proportion of recent Immigrants (five years) | | | x | | | |
| 7 | Population 15 years and older having no certificate, diploma or degree | | | | | x | x |
| 8 | Low Income Cut-offs (LICOs) after tax (Persons) | x | x | | x | x | x |
| 9 | Unemployment rate | x | | | | | |

## OLS REGRESSION- RESULTS

| City | Unit | R-squared | Adjusted R-squared | um squared residual | Sigma-square | S.E. of regression | Sigma-square ML | S.E of regression ML | F-statistic | Prob(F-statistic) | Akaike info criterion |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mississauga | *NH* | 0.653 | 0.587 | 3.58 | 0.138 | 0.371 | 0.112 | 0.334 | 9.81 | <0.001 | 32.7 |
| | *CT* | 0.119 | 0.104 | 42.16 | 0.346 | 0.588 | 0.337 | 0.581 | 8.26 | 0.0004 | 224.9 |
| | *DA* | 0.073 | 0.069 | 341.06 | 0.398 | 0.630 | 0.395 | 0.629 | 16.92 | <0.001 | 1657.9 |
| Saskatoon | *NH* | 0.403 | 0.378 | 55.36 | 0.791 | 0.889 | 0.748 | 0.865 | 15.77 | <0.001 | 196.5 |
| | *CT* | 0.667 | 0.641 | 19.44 | 0.498 | 0.706 | 0.452 | 0.672 | 26.05 | <0.001 | 95.9 |
| | *DA* | 0.289 | 0.281 | 352.14 | 1.033 | 1.016 | 1.018 | 1.009 | 34.68 | <0.001 | 998.0 |

# DIAGNOSTICS - OLS REGRESSION

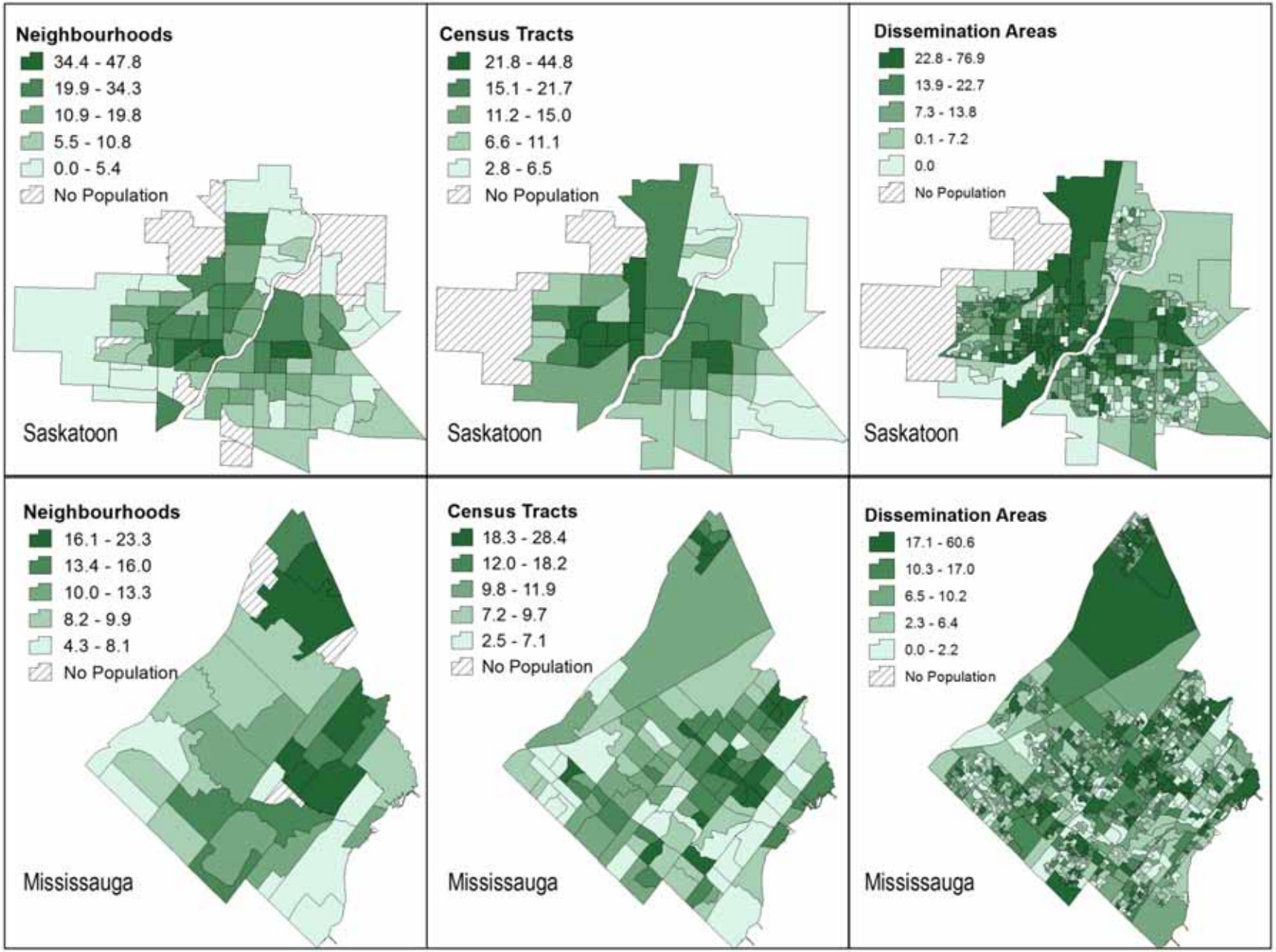
| City | Unit | Heteroskedasticity Breusch-Pagantest Test Value (prob) | Moran's I (prob) | Lagrange Multiplier (lag) | Robust LM (lag) | Lagrange Muliplier (error) | Robust LM (error) | Lagrane Multiplier (SARMA) |
|---|---|---|---|---|---|---|---|---|
| Mississauga | NH | 5.855 (0.3205) | 0.007 (0.5828) | 0.681 (0.4091) | 1.693 (0.1933) | 0.003 (0.9586) | 1.014 (0.3139) | 1.695 (0.4284) |
| | CT | 5.869 (0.0531) | 0.540 (<0.001) | 110.069 (<0.001) | 5.022 (0.0250) | 105.659 (<0.001) | 0.612 (0.4339) | 110.681 (<0.001) |
| | DA | 22.125 (0.0002) | 0.715 (<0.001) | 1286.457 (<0.001) | 43.368 (<0.001) | 1250.944 (<0.0001) | 7.854 (0.0051) | 1294.311 (<0.001) |
| Saskatoon | NH | 8.738 (0.0330) | 0.402 (<0.001) | 47.154 (<0.001) | 19.856 (<0.001) | 27.936 (<0.001) | 0.639 (0.4241) | 47.792 (<0.001) |
| | CT | 3.028 (0.3874) | 0.222 (0.0024) | 9.313 (0.0023) | 5.072 (0.0243) | 4.638 (0.0313) | 0.397 (0.5286) | 9.710 (0.0078) |
| | DA | 63.412 (<0.0001) | 0.590 (<0.001) | 484.301 (<0.001) | 155.212 (<0.001) | 331.294 (<0.001) | 2.205 (0.1375) | 486.506 (<0.001) |

## COMPARISON (OLS & Spatial Regression between Neighbourhood and Census Tract)

| City | Unit | Model | R-squared | Adjusted R-squared | Sigma-square | S.E. of regression | F-statistic | Prob(F-statistic) | Akaike info criterion |
|---|---|---|---|---|---|---|---|---|---|
| Mississauga | NH | OLS | 0.653 | 0.587 | 0.138 | 0.371 | 9.81 | <0.001 | 32.7 |
| | | LAG | - | - | - | - | - | - | - |
| | CT | OLS | 0.119 | 0.104 | 0.346 | 0.588 | 8.26 | 0.0004 | 224.9 |
| | | ERROR | 0.694 | - | 0.117 | 0.342 | - | - | 123.1 |
| Saskatoon | NH | OLS | 0.403 | 0.378 | 0.791 | 0.889 | 15.77 | <0.001 | 196.5 |
| | | LAG | 0.807 | - | 0.242 | 0.492 | - | - | 132.1 |
| | CT | OLS | 0.667 | 0.641 | 0.498 | 0.706 | 26.05 | <0.001 | 95.9 |
| | | LAG | 0.766 | - | 0.318 | 0.564 | - | - | 86.7 |

| Variables | Unit | Model | Mississauga | | | Saskatoon | | |
|---|---|---|---|---|---|---|---|---|
| | | | Coefficient | Std.Error | t-Statistic | Coefficient | Std.Error | t-Statistic |
| Constant | *NH* | **OLS** | 7.274 | 1.352 | 5.381 | 1.618 | 0.298 | 5.426 (<0.001) |
| | | Spatial | - | - | - | 0.3948 | 0.177 | 2.227 (0.0259) |
| | *CT* | OLS | 0.545 | 0.126 | 4.335 | 2.637 | 0.374 | 7.051 (<0.001) |
| | | Spatial | 0.926 | 0.359 | 2.583 (0.0098) | 1.183 | 0.424 | 2.789 (0.0053) |
| W_Accessibility | *NH* | Lag | No spatial model | | | 0.878 | 0.0433 | 20.267(<0.001) |
| Lambda/W_Accessibility | *CT* | Error/Lag | 0.907 | 0.036 | 25.284 (<0.0001) | 0.577 | 0.122 | 4.729 (<0.001) |
| Proportion of population with high need of healthcare | *NH* | OLS | -0.121 | 0.029 | -4.234 | - | - | - |
| | | Spatial | - | - | - | | | |
| Proportion of Children 0-4 years old | *NH* | OLS | - | - | - | -0.196 | 0.054 | -3.653 (0.0005) |
| | | Spatial | - | - | - | -0.094 | 0.029 | -3.197 (0.0014) |
| | *CT* | OLS | -0.087 | 0.035 | -2.461 | -0.331 | 0.068 | -4.869 (<0.001) |
| | | Spatial | -0.057 | 0.028 | -2.071 (0.0384) | -0.187 | 0.061 | -3.074 (0.0022) |
| Proportion of households that Own the dwelling | *NH* | OLS | -0.014 | 0.006 | -2.230 | | | |
| | | Spatial | No spatial model | | | - | - | - |
| Proportion of Lone-Parent Families | *NH* | OLS | -0.039 | 0.013 | -2.888 | - | - | - |
| | | Spatial | No spatial model | | | - | - | - |
| Proportion of aboriginal population | *NH* | OLS | - | - | - | -0.041 | 0.017 | -2.435 (0.0174) |
| | | Spatial | - | - | - | variable not included in Spatial model | | |
| Population 15 years and older having no certificate, diploma or degree | *CT* | OLS | - | - | - | -0.047 | 0.016 | -2.971 (0.0051) |
| | | Spatial | - | - | - | -0.035 | 0.013 | -2.641 (0.0083) |
| Low Income Cut-offs (LICOs) after tax (Persons) | *NH* | OLS | 0.119 | 0.030 | 3.996 | 0.084 | 0.015 | 5.696 (<0.001) |
| | | Spatial | No spatial model | | | 0.018 | 0.006 | 3.195 (0.0014) |
| | *CT* | OLS | 0.038 | 0.010 | 3.893 | 0.119 | 0.015 | 7.805 (<0.001) |
| | | Spatial | 0.019 | 0.007 | 2.635(0.0084) | 0.082 | 0.014 | 5.765 (<0.001) |
| Unemployment rate | *NH* | OLS | -0.220 | 0.072 | -3.063 | - | - | - |
| | | Spatial | No spatial model | | | - | - | - |

# LOW INCOME CUT-OFFS (LICOs) AFTER TAX (PERSONS)



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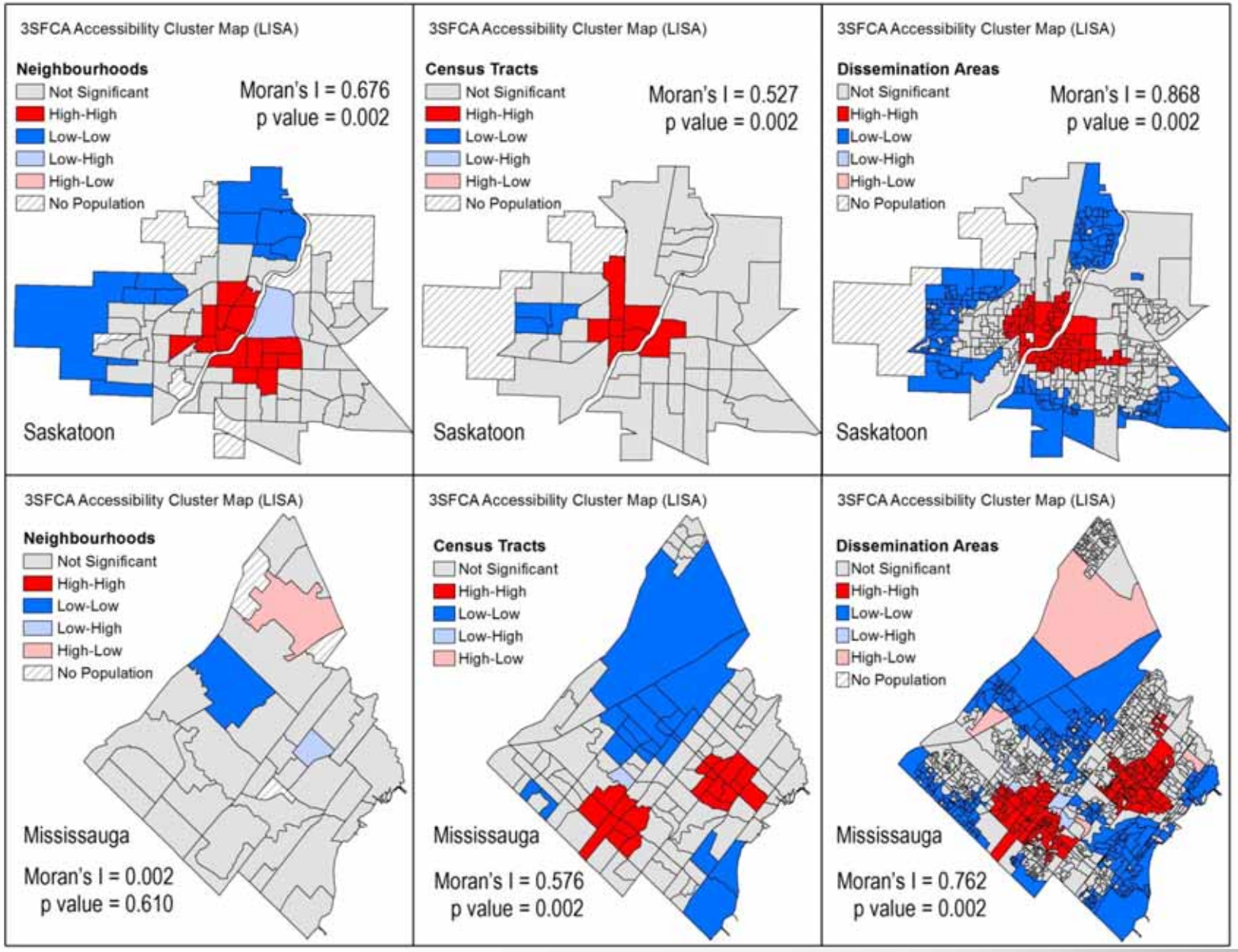
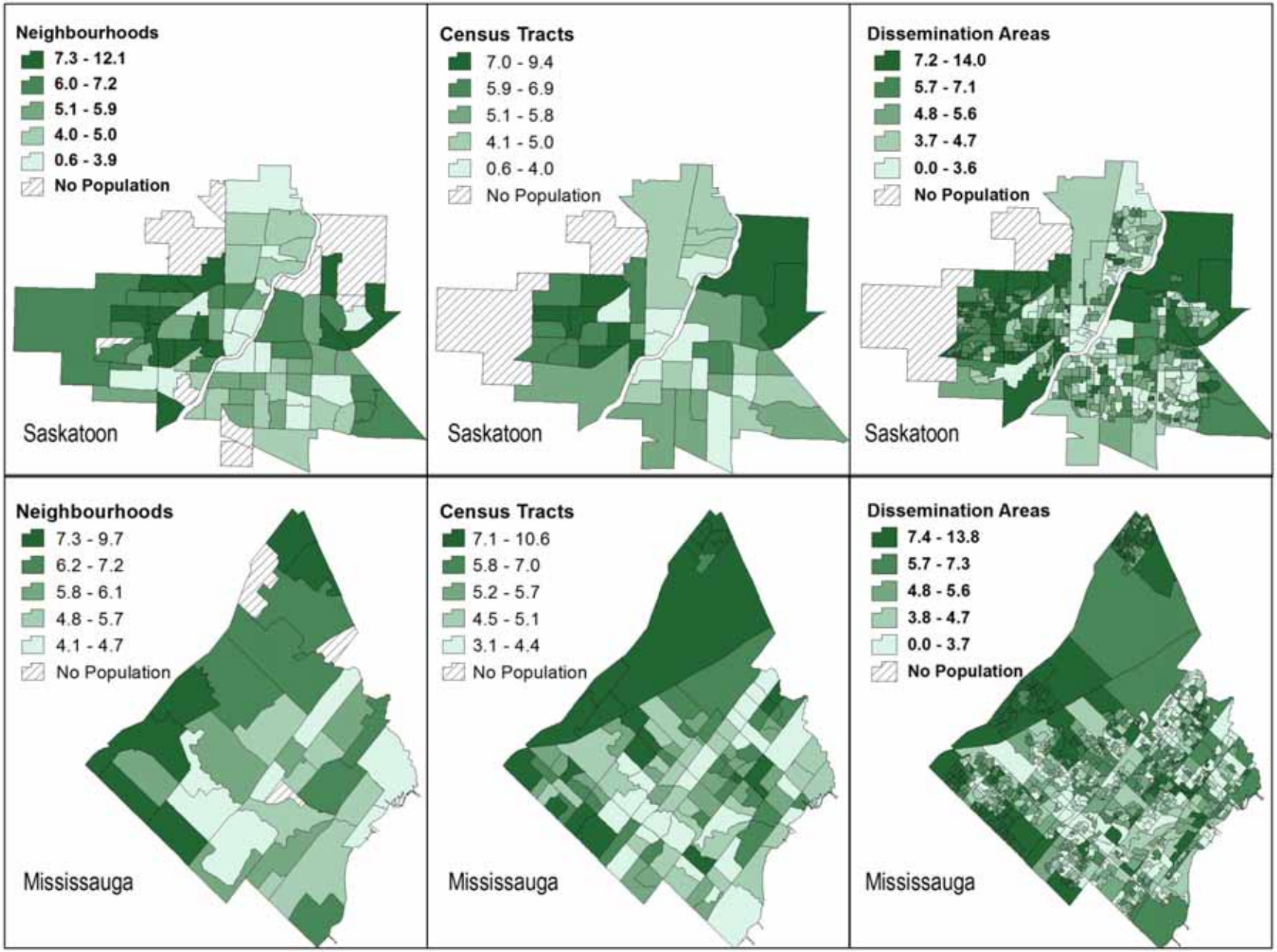
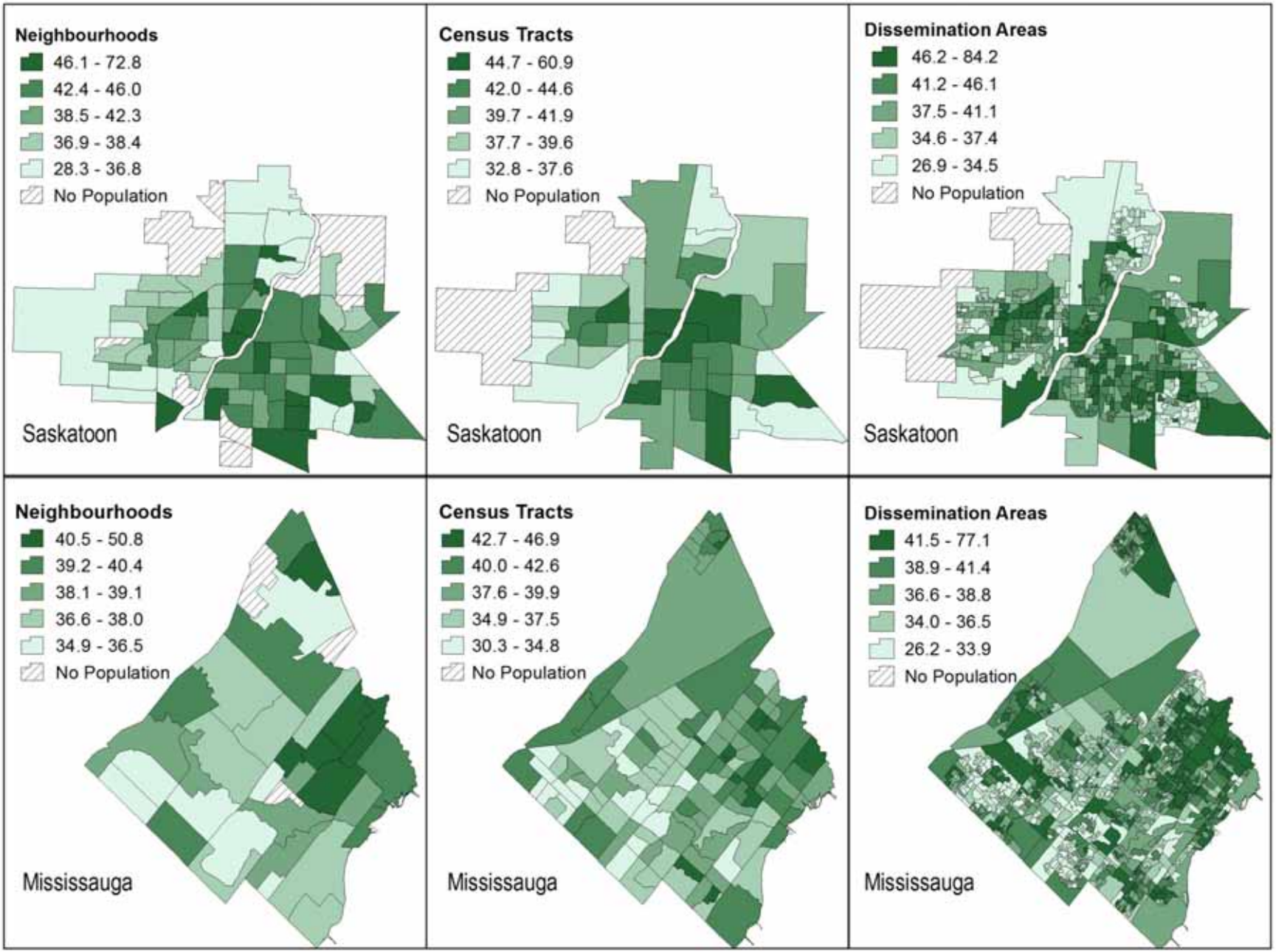


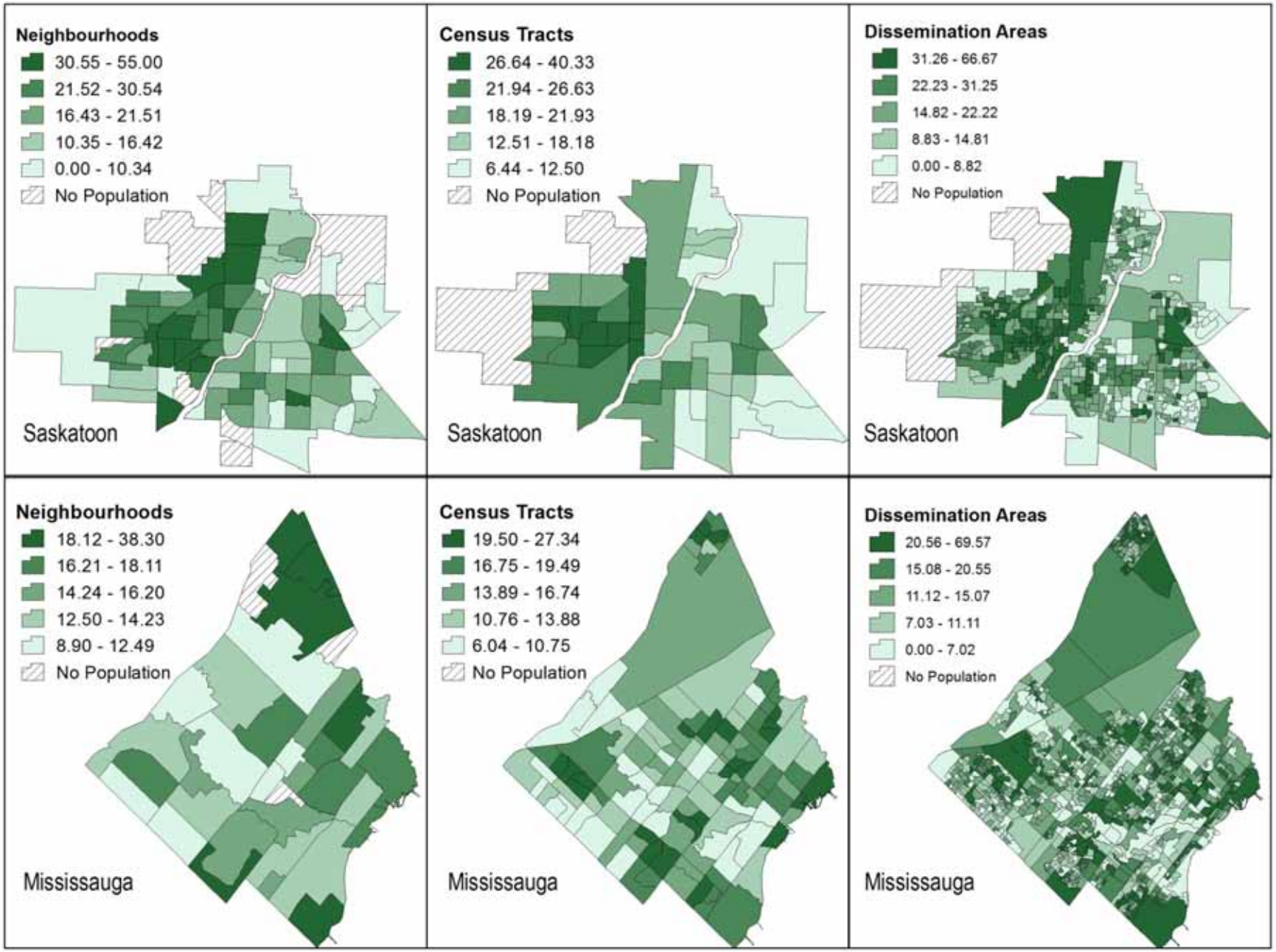
# CHILDREN 0-4 YEARS OLD



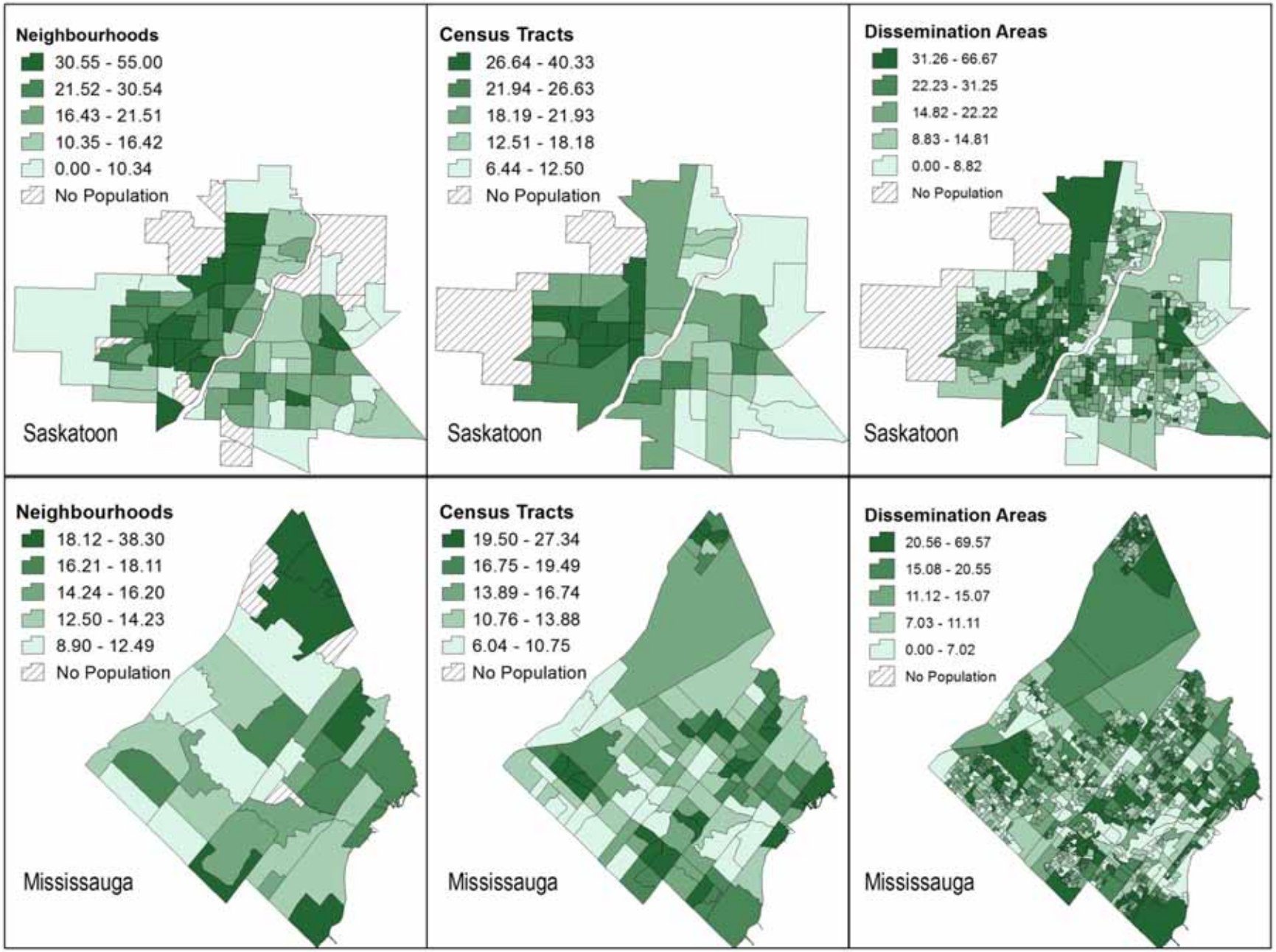
# POPULATION WITH HIGH NEED OF HEALTHCARE



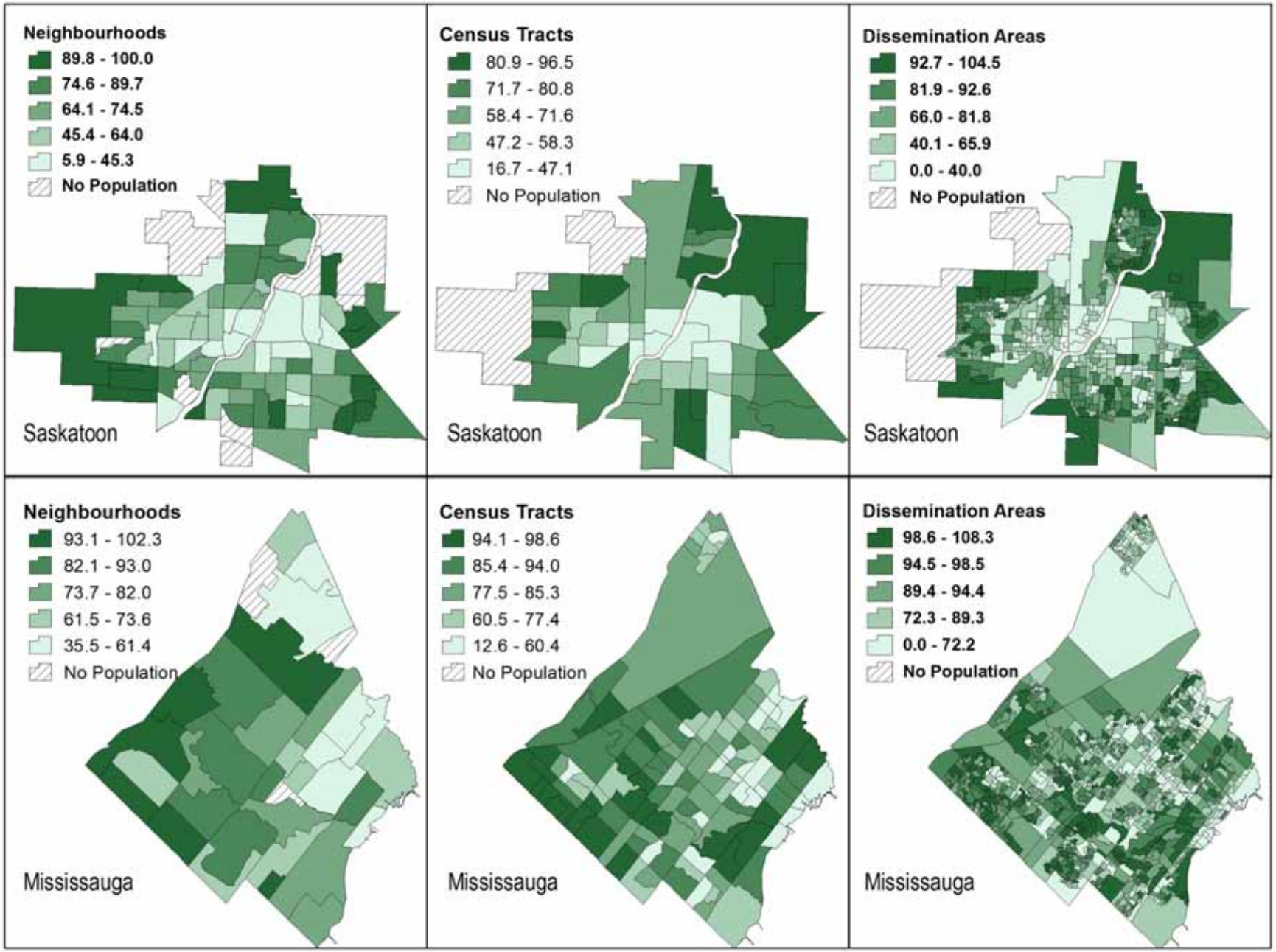
# LONE-PARENT FAMILIES



# POPULATION 15 YEARS & OLDER - NO CEFTIFICATE, DIPLOMA OR DEGREE



# HOUSEHOLDS THAT OWN DWELLING



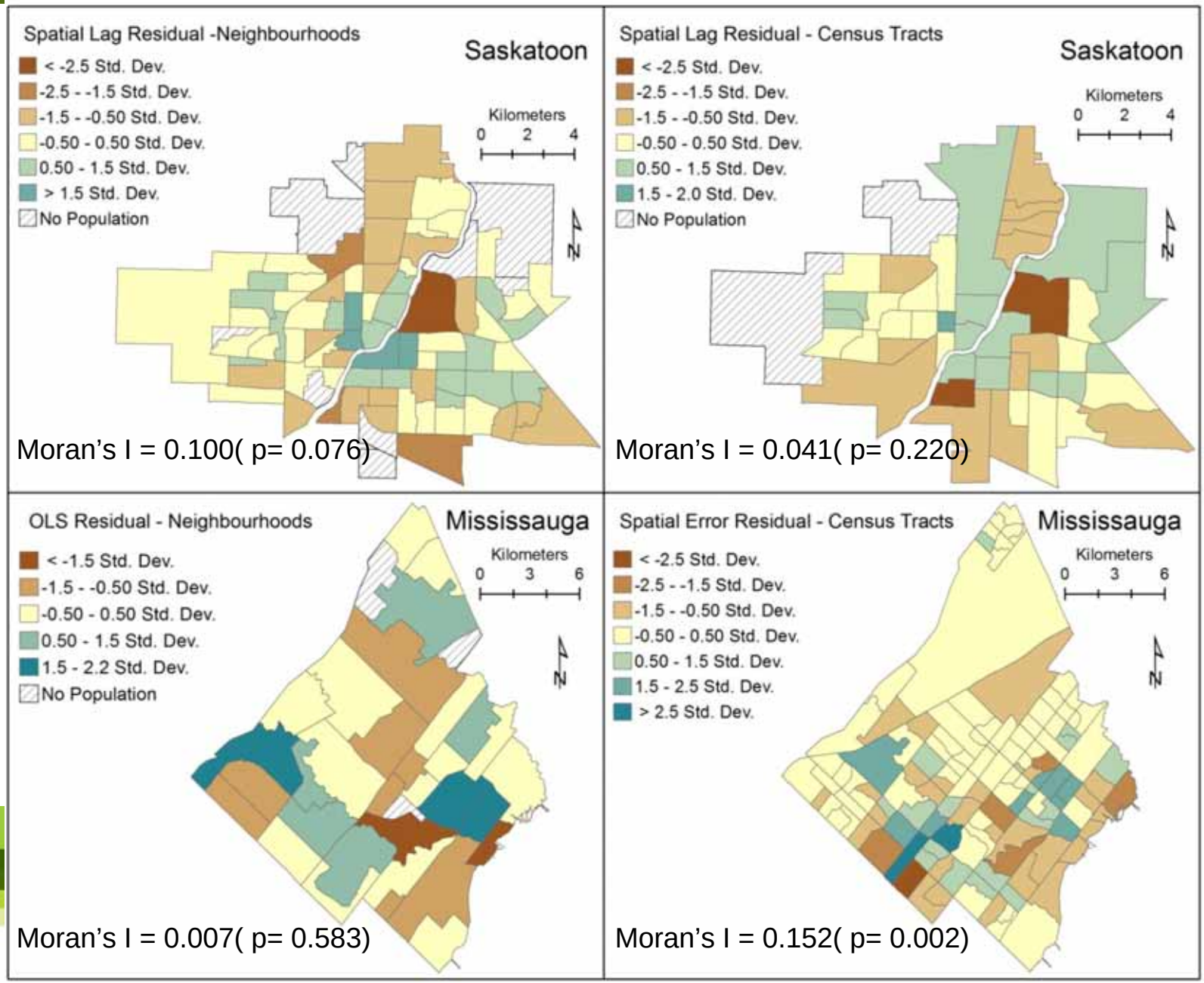
# COMPARING DIFFERENT REGRESSION MODELS

| City | Unit | Akaike info criterion (AIC) | |
|---|---|---|---|
| | | Linear Regression (OLS) | Spatial Regression (Lag & Error) |
| Mississauga | *NH* | 32.7 | -- |
| | *CT* | 224.9 | 123.1* |
| Saskatoon | *NH* | 196.5 | 142.1** |
| | *CT* | 95.6 | 86.7** |

* Spatial Error Regression
** Spatial Lag Regression

**Negative residuals** – actual values are smaller than estimated values

**Positive residuals** – actual values are larger than estimated values



# CONCLUSION

- It is concluded that multivariate spatial regression can be used effectively in the Spatial accessibility to healthcare research as it may provide a great local insight to the varying relationships.

- One should not use conclusions derived from data at one spatial units to units at another.

- This research contributes to the existing body of literature on health care accessibility and highlights the importance of choosing an appropriate neighbourhood definition.