Hospital Distribution Analysis Comparing Canada and Saskatchewan

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GEOG 203: Introduction to GIS

December 20, 2015

Table of Contents

<center>*__Part A: Data Analysis__*</center>

Introduction

This report looks at population, hospital and health region data for Saskatchewan and Canada. The data was derived from database files and ArcMap shape files containing valuable information such as tables, polygonal shapes and coordinates relating the information. These files were provided to complete the project. The data related to hospital locations in Canada is from DMTI Spatial. All other data is from Statistics Canada's *2006 Canadian Census*.

In total, three maps were produced, two spatial autocorrection reports were performed, two average nearest neighbour reports were performed and two multi-distance spatial cluster analyses were performed. Additionally, statistical information was gathered calculating the minimum values, maximum values, counts, means and standard deviations for hospitals per 10,000 persons and populations in health regions. Essentially each of these products represents information for Canada as a whole and Saskatchewan in isolation. These maps and reports are found in later sections (see Table of Contents).

Description

Health region and hospital data for the 127 health regions in Canada were analyzed using ArcMap 10.2 and ArcMap 10.3. The majority of the products or the analysis are found in later sections of this report and such, were be referenced accordingly. In Canada, there are six health regions with no hospitals. Two of these health regions occur in northern Saskatchewan. To prevent skewing the data, these values were excluded from most analyses.

Three maps were produced. The third map (Figure 3) represents a simplified map of Canada and the locations of all hospitals. The first map (Figure 1) shows a graduated representation based on hospitals per 10,000 persons in Canada. These values range from a minimum value of 0.00 to a maximum value of 3.04 hospitals per 10,000 persons. The shade of green darkens as this value increases, thus health regions that are darker green signifies a higher hospitals per 10,000 persons value relative to lighter shades of green. The second map (Figure 2) simply shows the same information for Saskatchewan. The minimum values here are again 0.00, while the maximum value is 2.16 hospitals per 10,000 persons.

<div align="right">2</div>

Two spatial autocorrection reports were performed for Canada and Saskatchewan. The report for Canada (Figure 4) lists a z-value of 9.462168 and a Moran's Index of 0.270619. The distribution is clustered. The Saskatchewan report (Figure 5) indicates a z-value of -0.102456 and a Moran's Index of -0.131449. This distribution is random.

Two average nearest neighbour summary's were performed for Canada and Saskatchewan. The summary for data for Canada (Figure 6) shows a Nearest Neighbour Ratio of 0.384501 and a z-value of -38.875068. This distribution is clustered. The average nearest neighbour summary for Saskatchewan (Figure 7) shows a Nearest Neighbour Ratio of 0.947309, a z-value of -0.950961 and a p-value of 0.341624. This was the only report that displayed a p-value that was not 0.0.

The two multi-distance spatial cluster analyses performed for Canada and Saskatchewan (Figures 15 and 16) both indicate clustering patterns. The clustering for Canada is relatively higher than what is found in Saskatchewan which hovers around the expected K slope.

Statistical information for hospitals per 10,000 persons and population characteristics of high density regions was gathered and these results can be found in tables 2 and 3 as well as figures 8–14.

Interpretation

Surprising to the author, the amount of hospitals per 10,000 persons is not where populations are highest. In fact, the information would seem to indicate the opposite, disregarding health regions with no hospitals. In Saskatchewan, 39% of the health regions have greater than 1.1 hospitals per 10,000 persons and roughly 15% regions have greater than about two hospitals per 10,000 persons. Neither the health regions that include Saskatoon nor Regina are included here. Thus a trend arises that suggests that the higher the population, the fewer hospitals per 10,000 persons that exist. But perhaps, this is what should have been expected. The variation of population density in Canada is such that there are many regions in Canada where the population is very large in small areas. The relatively small population of a large province such as Saskatchewan, would not require as much hospitals as Toronto for example. However because of dispersion of the Saskatchewan population, it is appropriate to have many hospitals throughout the region to meet the demands of rural areas.

Procedure

Using the provided shape files and tables, information for population data was joined to information for the provinces and health regions in Canada. A spatial join was performed to combine information from the health regions and locations of hospitals into a new shape file called `Hospitals_in_HealthRegions.shp`. A new field was created and was titled `hosp_10_k` and then using the Field Calculator tool, values were calculated using the following formula: `[Count_]/([POP2006]*0.0001)`. These values represent the number of hospitals that exist per 10,000 persons. A gradient of progressively darker greens to represent increasing number of hospitals per 10,000 persons was used as the symbology to represent the data. `hosp_10_k` that were equal to zero were excluded and coloured yellow. From here two maps were produced, one for Canada and one for Saskatchewan using similar symbology between maps. A third map was produced to simply show the location of hospitals in Canada. Afterwards, several analytic tools were performed generating four reports. Statistical information was tabulated into a Microsoft® Excel spreadsheet.

Maps

The following three pages include the maps that were produced for the report. The first map represents the hospitals and health regions in Canada for population data from the 2006 Canadian Census. The health regions are shown in graduated colours that represent the amount of hospitals per 10,000 persons. The colour becomes darker as the relative abundance of hospitals per 10,000 persons increases. Regions that are yellow indicate that there are no hospitals in the health region. The second map shows this same information, however for the province of Saskatchewan. The final map simply indicates the locations of hospitals in Canada. The locations of Canadian hospitals is from DMTI (`http://dmtispatial.com`).

Hospitals and Health Regions in Canada (2006)
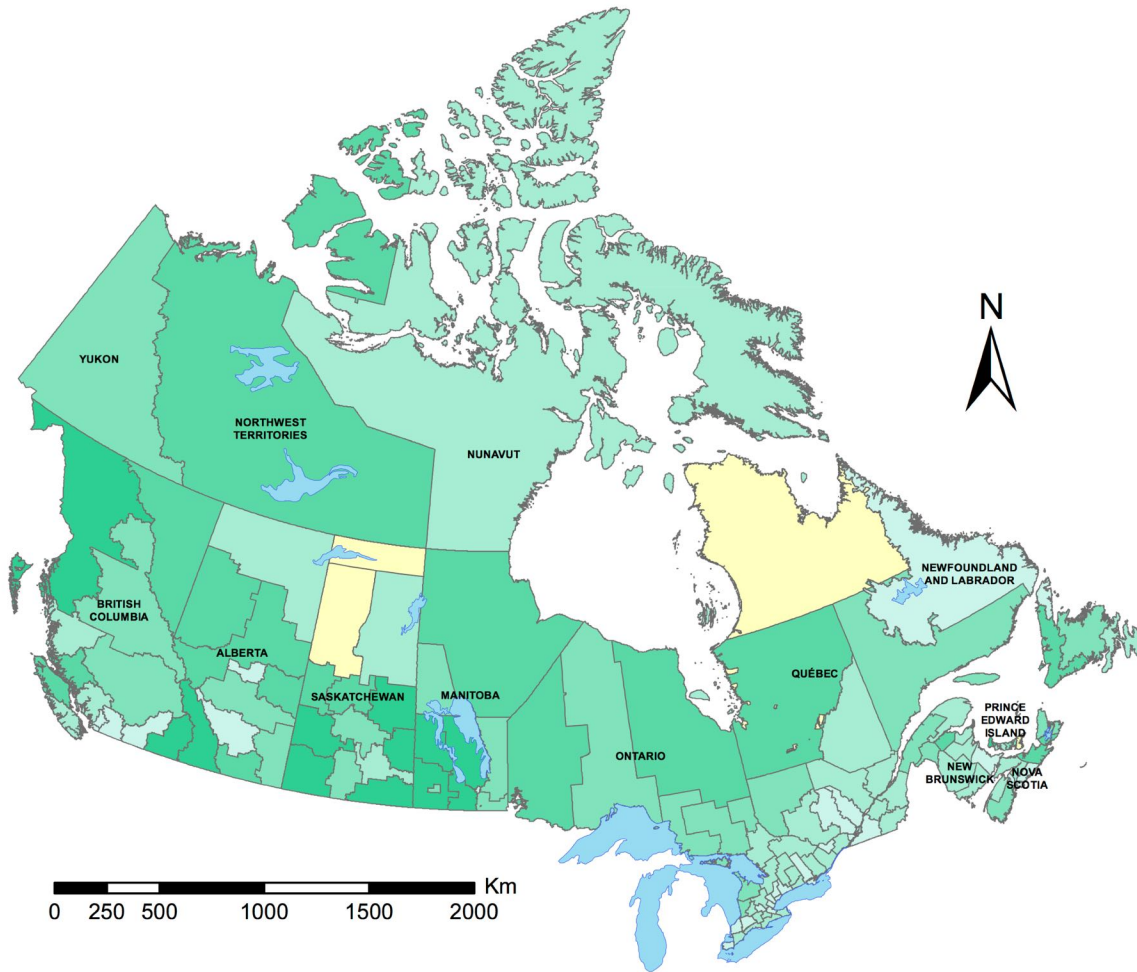
Legend

Canadian_Lakes

Hospitals_in_HealthRegions

hosp_10k_p

- 0.0304 - 0.2760
- 0.2761 - 0.5309
- 0.5310 - 0.8937
- 0.8938 - 1.3477
- 1.3478 - 3.0441
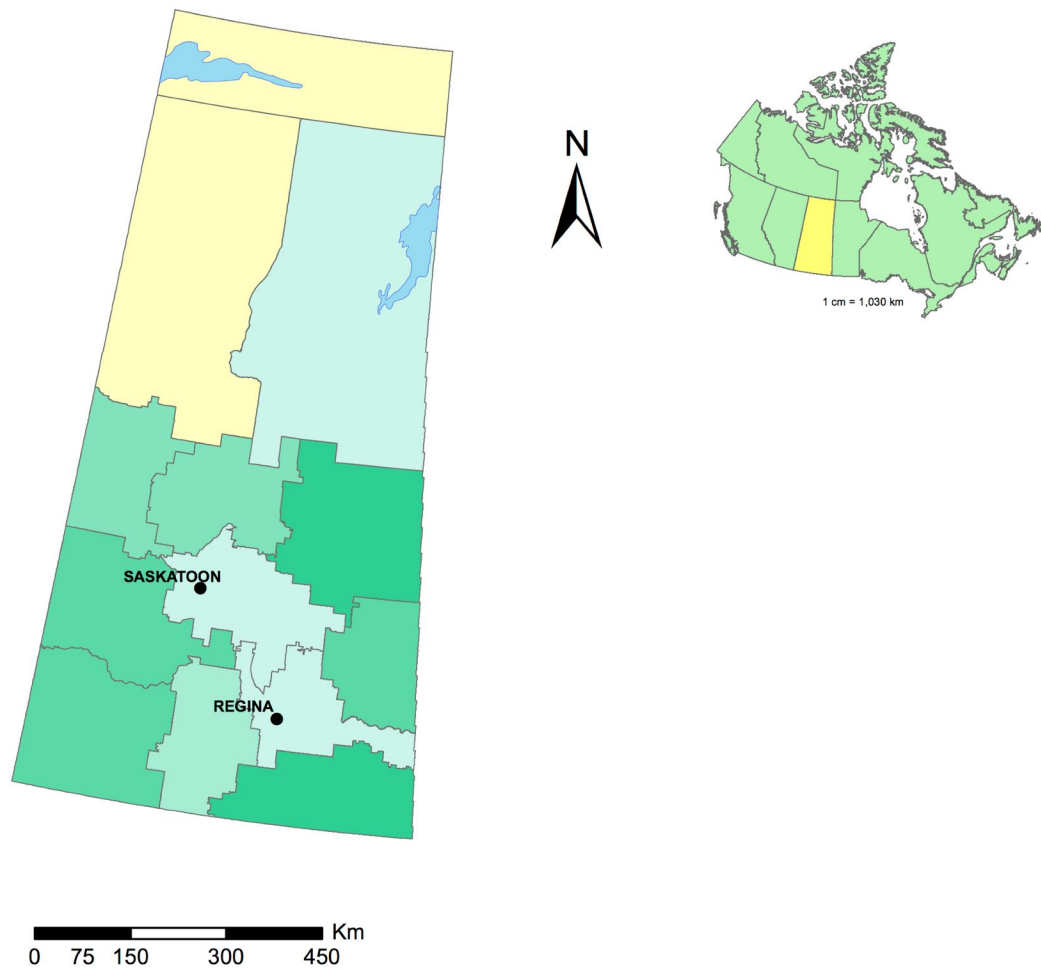- No Hospitals in Health Region

Hospitals in health regions statistics

STUDY_AREA_NAME	COUNT	MIN	MAX	SUM	MEAN	STD_DEV
All Health Regions	127	955.00	2,456,805.00	29,639,030.00	233,378.19	330,377.63
Values of 0	6	955.00	21,160.00	56,300.00	9,383.33	6,744.43
Values less than 1.0 and greater than 0	96	18,835.00	2,456,805.00	27,932,815.00	290,966.82	361,101.27
Values 1.0 or greater	25	14,125.00	165,130.00	1,649,915.00	65,996.60	31,000.49

Hospitals per 10,000 persons statistics

STUDY_AREA_NAME	COUNT	MIN	MAX	SUM	MEAN	STD_DEV
Canada	127	0.00	3.04	81.97	0.65	0.57
Canada w/o Saskatchewan	114	0.00	3.04	68.10	0.60	0.53
subset_Saskatchewan	13	0.00	2.16	13.86	1.07	0.73

Figure 1 – Hospitals and health regions in Canada (2006)

Hospitals and Health Regions in Saskatchewan (2006)

Legend

- ● SK_MajorCities
- ▮ SK_Lakes

hosp_10k_p
- ▮ 0.3876 - 0.5511
- ▮ 0.5512 - 0.7542
- ▮ 0.7543 - 1.1165
- ▮ 1.1166 - 1.8493
- ▮ 1.8494 - 2.1572
- ▮ No Hospitals in Health Region

Hospitals in health regions statistics

STUDY_AREA_NAME	COUNT	MIN	MAX	SUM	MEAN	STD_DEV
All Health Regions	127	955.00	2,456,805.00	29,639,030.00	233,378.19	330,377.63
Values of 0	6	955.00	21,160.00	56,300.00	9,383.33	6,744.43
Values less than 1.0 and greater than 0	96	18,835.00	2,456,805.00	27,932,815.00	290,966.82	361,101.27
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Hospitals per 10,000 persons statistics

STUDY_AREA_NAME	COUNT	MIN	MAX	SUM	MEAN	STD_DEV
Canada	127	0.00	3.04	81.97	0.65	0.57
Canada w/o Saskatchewan	114	0.00	3.04	68.10	0.60	0.53
subset_Saskatchewan	13	0.00	2.16	13.86	1.07	0.73

Figure 2 – Hospitals and health regions in Saskatchewan (2006)

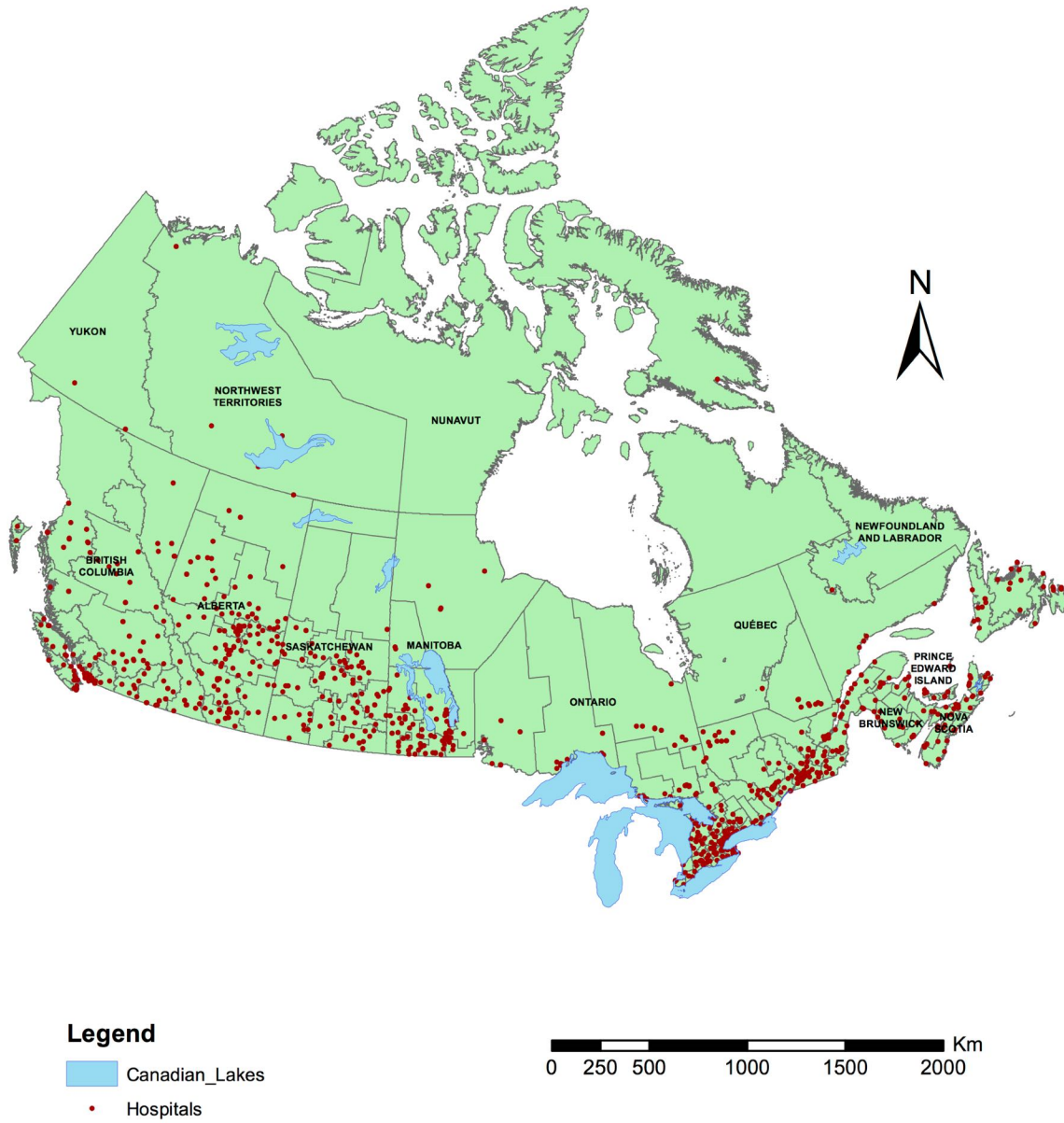# Hospitals and Health Regions in Canada (2006)

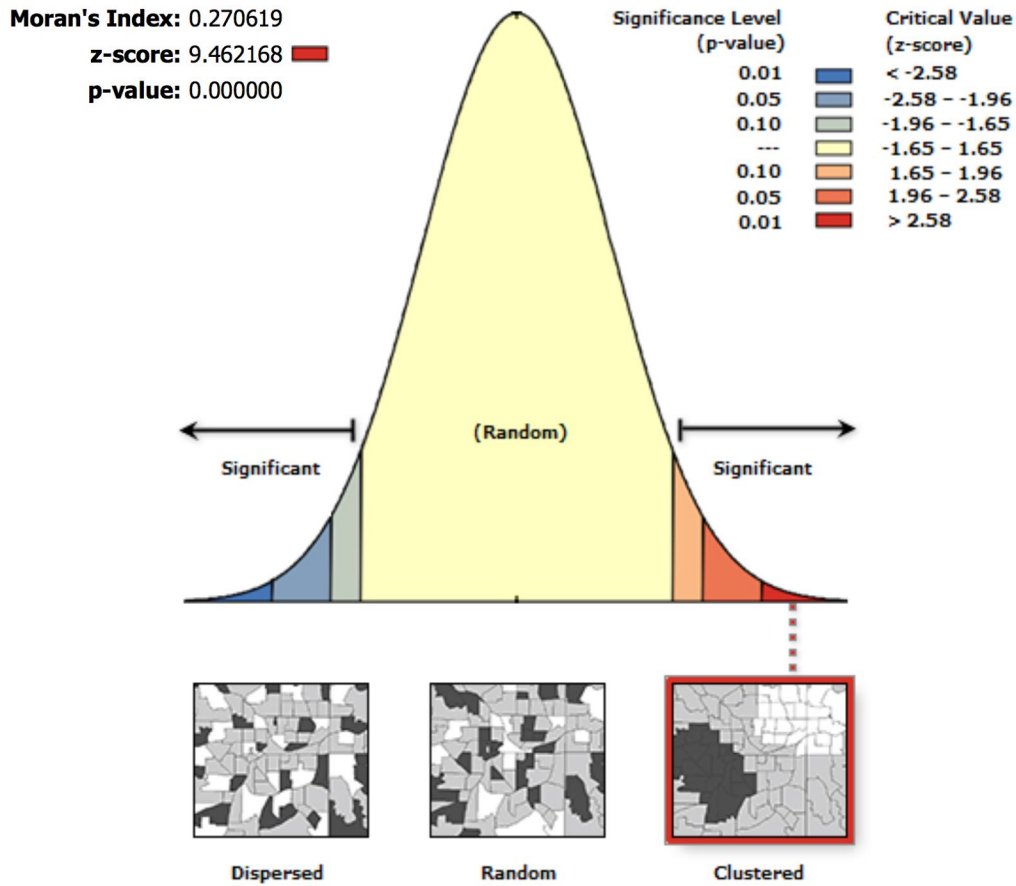**Figure 3** – Hospital locations in Canada for reference (2006)

Table 1 – List of files used to complete project

File name and directory	*File type*	*Description*
GEOG203Project_RaiwetMichael.mxd /GEOG203Project_RaiwetMichael.mxd	ArcMap file	Found in root folder; the main ArcMap file used to complete the project
GEOG203Project_RaiwetMichael_SK.mxd /GEOG203Project_RaiwetMichael_SK.mxd	ArcMap file	Found in root folder; used primarily for information and analysis specific to Saskatchewan
GEOG203Project_RaiwetMichael_Analysis.mxd /GEOG203Project_RaiwetMichael_Analysis.mxd	ArcMap file	Found in root folder; used to perform additional analysis in order to not interfere with layout design in GEOG203Project_RaiwetMichael.mxd
CanadianProvinces.shp /ProjectData/CanadianProvinces.shp	Shape file	Shape file containing data for the Canadian provinces that was provided for the project
HealthRegions.shp /ProjectData/HealthRegions.shp	Shape file	Shape file containing data for health regions in Canada that was provided for the project
Hospitals.shp /ProjectData/Hospitals.shp	Shape file	Shape file containing data for hospitals located in Canada that was provided for the project
Pop2006_HealthRegion.dbf /ProjectData/Pop2006_HealthRegion.dbf	Database file	Database file that contained important population data to complete the project by health regions
Pop2006_Province.dbf /ProjectData/Pop2006_Province.dbf	Database file	Database file that contained important population data to complete the project by the Canadian provinces
Canadian_Lakes.shp /MyData/Canadian_Lakes.shp	Shape file	Shape file containing polygon data for the Canadian lakes; was used to add detail to the map; created from data from Canada.shp
Hospitals_in_HealthRegions.shp /MyData/Hospitals_in_HealthRegions.shp	Shape file	Shape file created from a spatial join of the Hospitals.shp and the HealthRegions.shp, used for majority of the projects analysis
Hospitals_in_SK_HealthRegions.shp /MyData/Hospitals_in_SK_HealthRegions.shp	Shape file	Shape file created from a spatial join of the Hospitals.shp and the HealthRegions.shp specific to Saskatchewan
SK_Hospitals.shp /MyData/SK_Hospitals.shp	Shape file	Shape file created from data from Hospitals.shp specific to Saskatchewan
SK_Lakes.shp /MyData/SK_Lakes.shp	Shape file	Shape file created from Canadian_Lakes.shp specific for lakes in Saskatchewan
SK_MajorCities.shp /MyData/SK_MajorCities.shp	Shape file	Shape file created from data from Major_settlements.shp to extract data for Regina and Saskatchewan
ripleyk_Canada.dbf /MyData/ripleyk_Canada.dbf	Database file	Database file created from 'Multi-Distance Spatial Cluster Analysis' tool for Canada
ripleyk_SK.dbf /MyData/ripleyk_SK.dbf	Database file	Database file created from 'Multi-Distance Spatial Cluster Analysis' tool for Saskatchewan

File name and directory	File type	Description
Canada.shp /OtherData/Canada.shp	Shape file	Primarily used to extract data related to Canadian lakes
Major_settlements.shp /OtherData/Major_settlements.shp	Shape file	Primarily used to extract data for Saskatoon and Regina
Hospital_Statistics.xlsx /OtherData/Hospital_Statistics.xlsx	Excel file	Microsoft Excel file created to collect statistical data for this project; data was later added to finished maps
Map_HealthRegionsCanada.pdf /ExportedData/Maps/Map_HealthRegionsCanada.pdf	PDF file	Detailed map showing graduated representations for hospitals per 10,000 persons in Canada
Map_HealthRegionsCanada.png /ExportedData/Maps/Map_HealthRegionsCanada.png	PNG image file	Detailed map showing graduated representations for hospitals per 10,000 persons in Canada
Map_HealthRegionsSK.pdf /ExportedData/Maps/Map_HealthRegionsSK.pdf	PDF file	Detailed map showing graduated representations for hospitals per 10,000 persons in Saskatchewan
Map_HealthRegionsSK.png /ExportedData/Maps/Map_HealthRegionsSK.png	PNG image file	Detailed map showing graduated representations for hospitals per 10,000 persons in Saskatchewan
Map_HospitalsCanada.pdf /ExportedData/Maps/Map_HospitalsCanada.pdf	PDF file	Map showing hospital locations in Canada
Map_HospitalsCanada.png /ExportedData/Maps/Map_HospitalsCanada.png	PNG image file	Map showing hospital locations in Canada
ANNS_Canada.htm /ExportedData/Webpages/ANNS_Canada.htm	HTML file	Webpage saved from 'Average Nearest Neighbour Summary' report created from data from Canada
ANNS_SK.htm /ExportedData/Webpages/ANNS_SK.htm	HTML file	Webpage saved from 'Average Nearest Neighbour Summary' report created from data from Saskatchewan
SAR_Canada.htm /ExportedData/Webpages/SAR_Canada.htm	HTML file	Webpages saved from 'Spatial Autocorrection' report for Canada
SAR_SK.htm /Exported/Webpages/SAR_SK.htm	HTML file	Webpages saved from 'Spatial Autocorrection' report for Saskatchewan
Screenshots /ExportedData/Images/Screenshots.zip	Compressed Zip file	Compressed zip file containing several screenshots taken to collect statistical data for this project
1_All.png /ExportedData/Images/1_All.png	PNG image file	Statistical bar graph for hospitals per 10,000 persons in Canada
1_AllButSask.png /ExportedData/Images/1_AllButSask.png	PNG image file	Statistical bar graph for hospitals per 10,000 persons in all of Canada except Saskatchewan
1_Sask.png /ExportedData/Images/1_Sask.png	PNG image file	Statistical bar graph for hospitals per 10,000 persons in Saskatchewan

File name and directory	File type	Description
`2_All.png` `/ExportedData/Images/2_All.png`	PNG image file	Statistical bar graph for hospitals in health regions in Canada
`2_EqualsZero.png` `/ExportedData/Images/2_EqualsZero.png`	PNG image file	Statistical bar graph for hospitals in health regions with values that equal 0
`2_GreaterThanOne.png` `/ExportedData/Images/2_GreaterThanOne.png`	PNG image file	Statistical bar graph for hospitals in health regions with values greater than or equal to 1.0
`2_GreaterThanZero.png` `/ExportedData/Images/2_GreaterThanZero.png`	PNG image file	Statistical bar graph for hospitals in health regions with values greater than 0 less than 1.0
`ripleyk_Canada.png` `/ExportedData/Images/ripleyk_Canada.png`	PNG image file	Ripley K graph obtained from 'Multi-Distance Spatial Cluster Analysis' tool for data from Canada
`ripleyk_SK.png` `/ExportedData/Images/ripleyk_SK.png`	PNG image file	Ripley K graph obtained from 'Multi-Distance Spatial Cluster Analysis' tool for data from Saskatchewan
`GEOG203_Report.pages` `/Report/GEOG203_Report.pages`	Pages document file	Pages document used to write project
`GEOG203_Report.pdf` `/Report/GEOG203_Report.png`	PDF file	PDF copy of the completed report

Figure 4 – Spatial Autocorrection Report for Canada

Moran's Index: 0.270619
z-score: 9.462168
p-value: 0.000000

Significance Level (p-value)		Critical Value (z-score)
0.01		< -2.58
0.05		-2.58 – -1.96
0.10		-1.96 – -1.65
---		-1.65 – 1.65
0.10		1.65 – 1.96
0.05		1.96 – 2.58
0.01		> 2.58

(Random)

Significant   Significant

Dispersed   Random   Clustered

Given the z-score of 9.46216793531, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

| Global Moran's I Summary		Dataset Information	
Moran's Index:	0.270619	*Input Feature Class:*	Hospitals_in_HealthRegions
Expected Index:	-0.007937	*Conceptualization:*	INVERSE_DISTANCE
Variance:	0.000867	*Distance Method:*	EUCLIDEAN
z-score:	9.462168	*Row Standardization:*	False
p-value:	0.000000	*Distance Threshold:*	1227290.7397 Meters
		Weights Matrix File:	None
		Selection Set:	False
		Input Field:	HOSPITALS_IN_HEALTHREGIONS.HOSP_10K_P

Figure 5 – Spatial Autocorrection Report for Saskatchewan
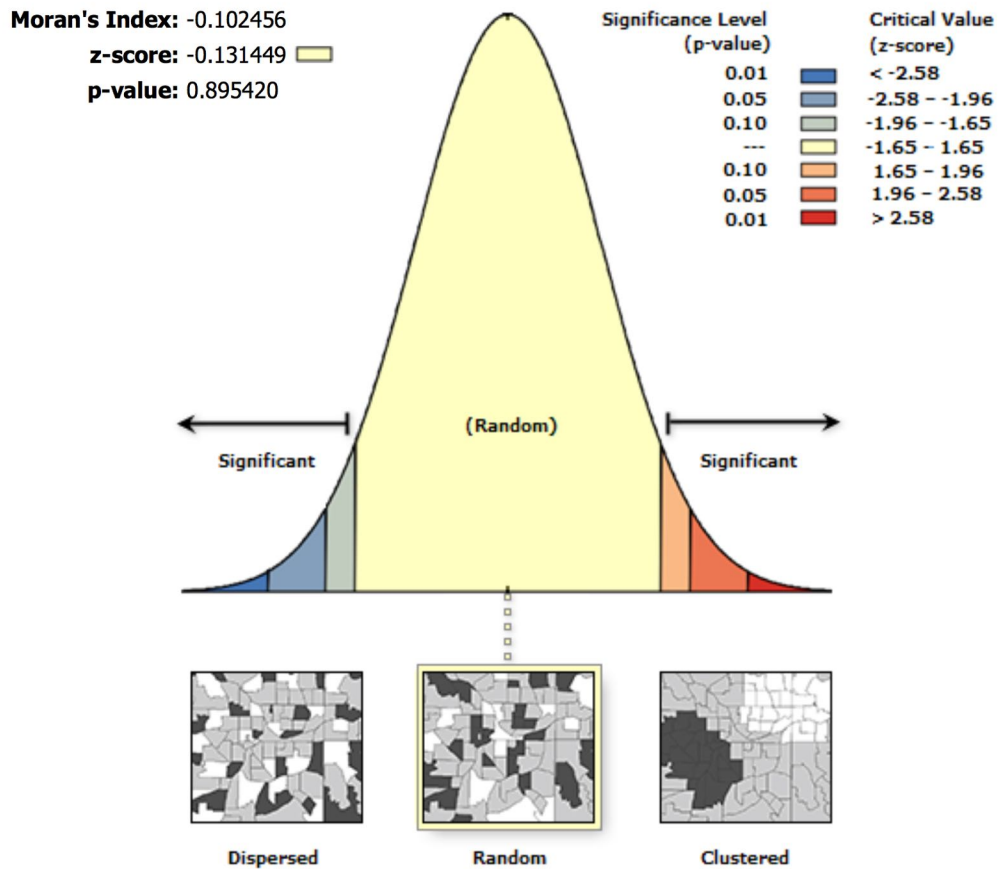
Moran's Index: -0.102456
z-score: -0.131449
p-value: 0.895420

Significance Level (p-value)	Critical Value (z-score)
0.01	< -2.58
0.05	-2.58 – -1.96
0.10	-1.96 – -1.65
---	-1.65 – 1.65
0.10	1.65 – 1.96
0.05	1.96 – 2.58
0.01	> 2.58

(Random)

Significant   Significant

Dispersed   Random   Clustered

Given the z-score of 9.46216793531, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary		Dataset Information	
Moran's Index:	-0.102456	Input Feature Class:	Hospitals_in_SK_HealthRegions
Expected Index:	-0.083333	Conceptualization:	INVERSE_DISTANCE
Variance:	0.021163	Distance Method:	EUCLIDEAN
z-score:	-0.131449	Row Standardization:	False
p-value:	0.895420	Distance Threshold:	340572.3688 Meters
		Weights Matrix File:	None
		Selection Set:	False
		Input Field:	HOSP_10K_P

Figure 6 – Average Nearest Neighbour Summary for Canada
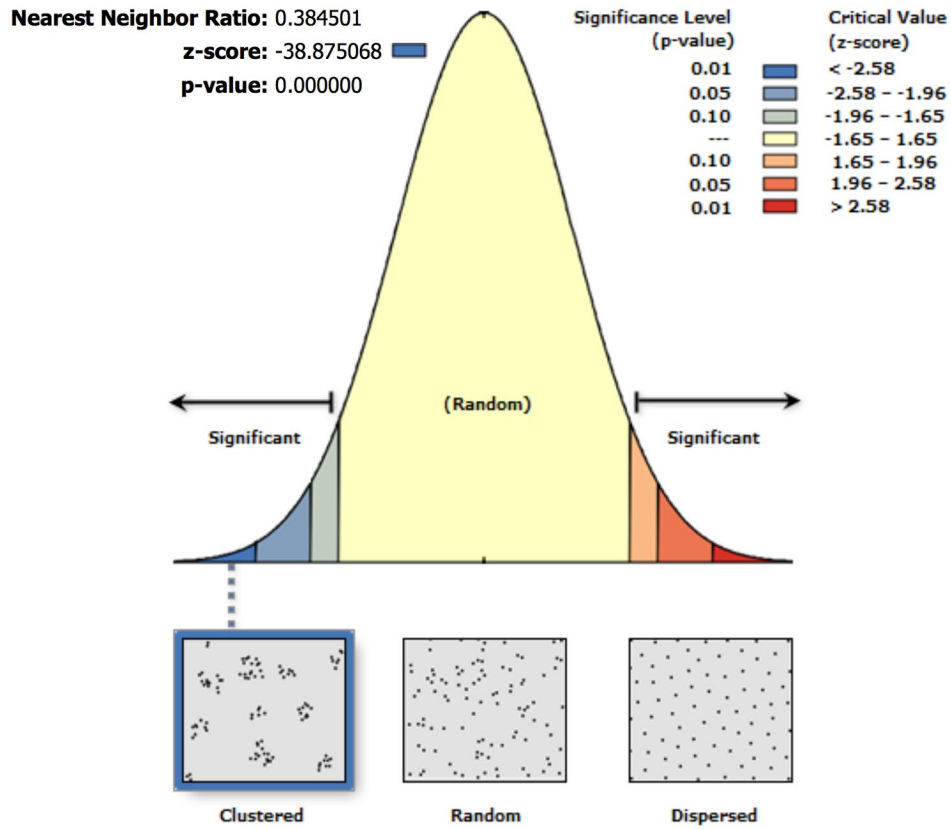
Given the z-score of -38.8750675487, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Average Nearest Neighbour Summary

Observed Mean Distance: 20981.3755 Meters

Expected Mean Distance: 54567.7391 Meters

Nearest Neighbor Ratio: 0.384501

z-score: -38.875068
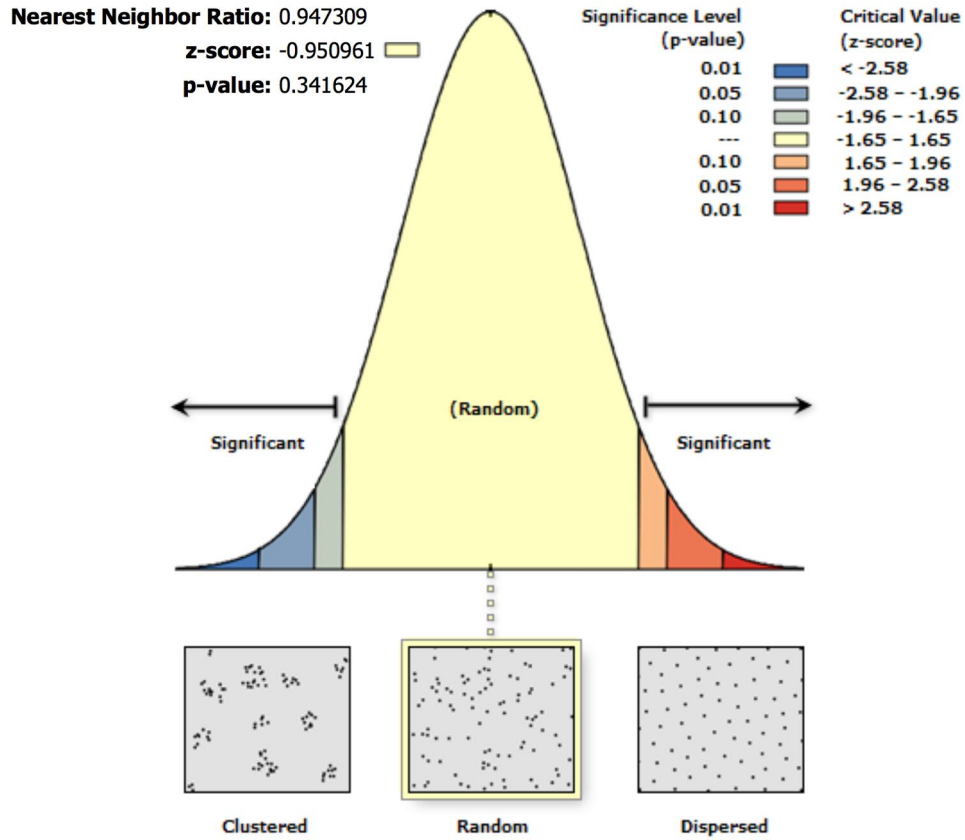
p-value: 0.000000

Dataset Information

Input Feature Class: Hospitals

Distance Method: EUCLIDEAN

Study Area: 12982502348412.447266

Selection Set: False

Figure 7 – Average Nearest Neighbour Summary for Saskatchewan

Given the z-score of -0.950960942779, the pattern does not appear to be significantly different than random.

Average Nearest Neighbour Summary

Observed Mean Distance: 29731.1009 Meters

Expected Mean Distance: 31384.7987 Meters

Nearest Neighbor Ratio: 0.947309

z-score: -0.950961

p-value: 0.341624

Dataset Information

Input Feature Class: SK_Hospitals

Distance Method: EUCLIDEAN

Study Area: 350661989711.329956

Selection Set: False

Table 2 – Hospitals per 10,000 persons statistics

STUDY_AREA_NAME	COUNT	MIN	MAX	SUM	MEAN	STD_DEV
Canada	127	0.00	3.04	81.97	0.65	0.57
Canada w/o Saskatchewan	114	0.00	3.04	68.10	0.60	0.53
subset_Saskatchewan	13	0.00	2.16	13.86	1.07	0.73

Table 3 – Population Characteristics of High Hospital Densities Statistics

H10K_P_VALUE	COUNT	MIN	MAX	SUM	MEAN	STD_DEV
All Health Regions	127	955.00	2,456,805.00	29,639,030.00	233,378.19	330,377.63
Values of 0	6	955.00	21,160.00	56,300.00	9,383.33	6,744.43
Values less than 1.0 and greater than 0	96	18,835.00	2,456,805.00	27,932,815.00	290,966.82	361,101.27
Values 1.0 or greater	25	14,125.00	165,130.00	1,649,915.00	65,996.60	31,000.49

Bar Graphs Representing Frequency Distribution of Hospitals per 10,000 persons
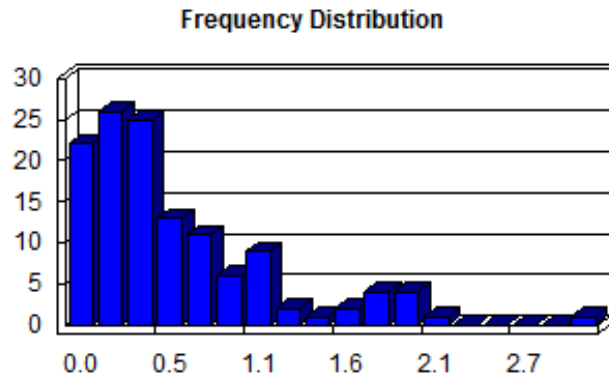
Figure 8 – Frequency distribution of hospitals per 10,000
persons in all of Canada
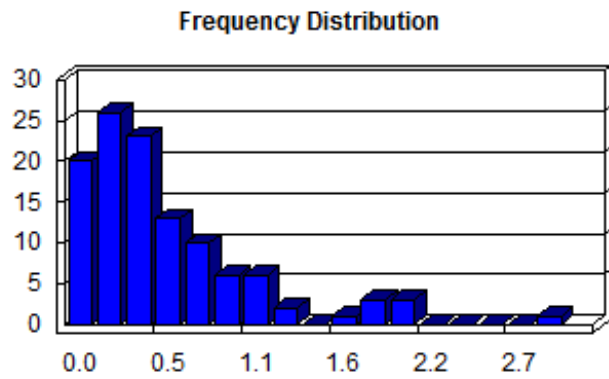
Figure 9 – Frequency distribution of hospitals per 10,000
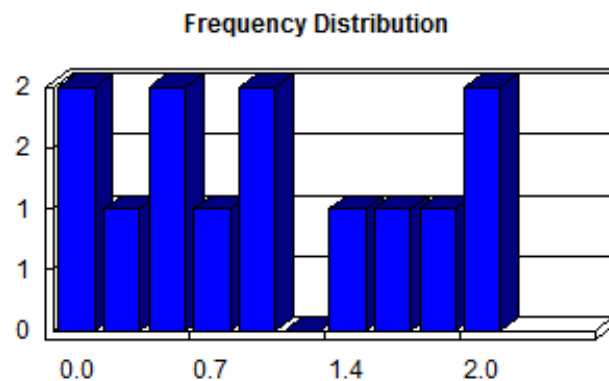persons in Canada not including Saskatchewan

Figure 10 – Frequency distribution of hospitals per 10,000
persons in Saskatchewan

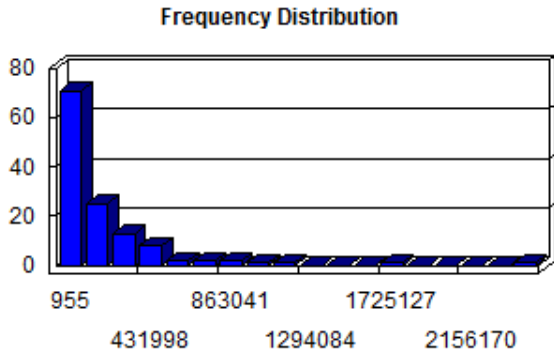## Bar Graphs Representing Frequency Distribution of Hospitals in Health Regions Based on Population (2006 Canadian Census)

Figure 11 – Frequency distribution of hospitals in health regions based on population data for all of Canada
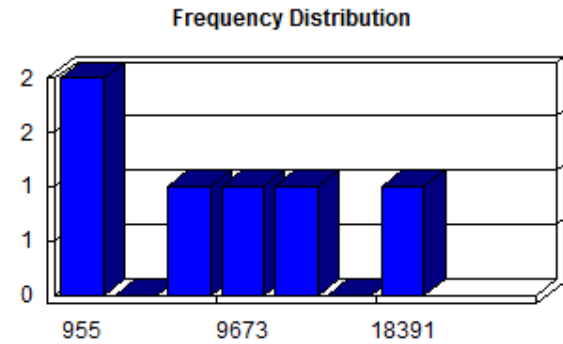
Figure 12 – Frequency distribution of hospitals in health regions based on population data for hospitals per 10,000 persons that equal 0
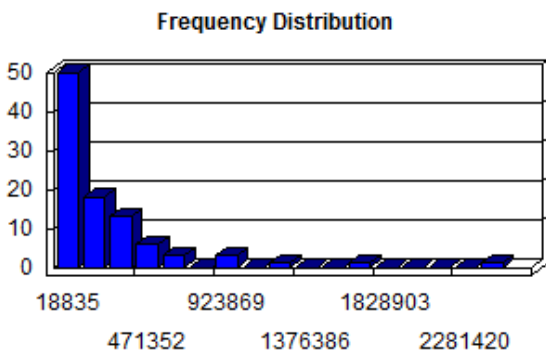

Figure 13 – Frequency distribution of hospitals in health regions based on population data for hospitals per 10,000 persons are greater than 0 but less than 1.0
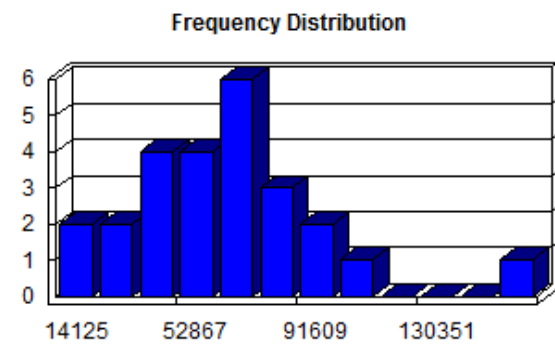

Figure 14 – Frequency distribution of hospitals in health regions based on population data for hospitals per 10,000 persons greater than or equal to 1.0
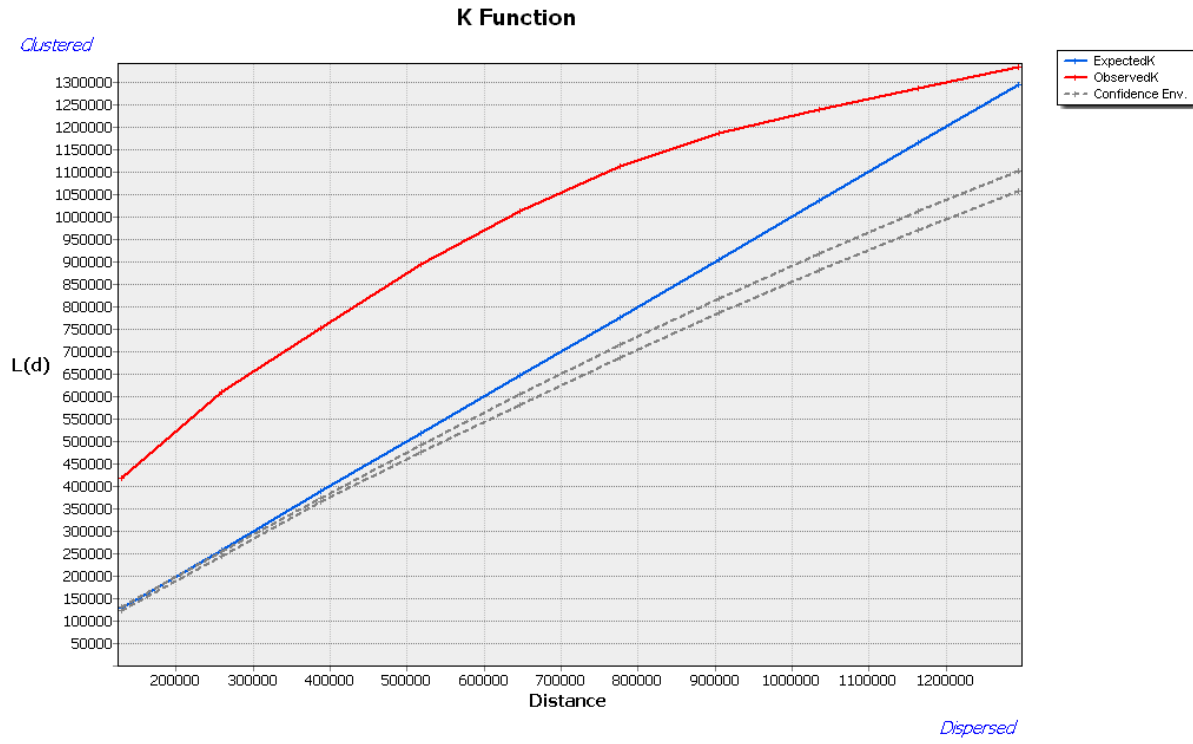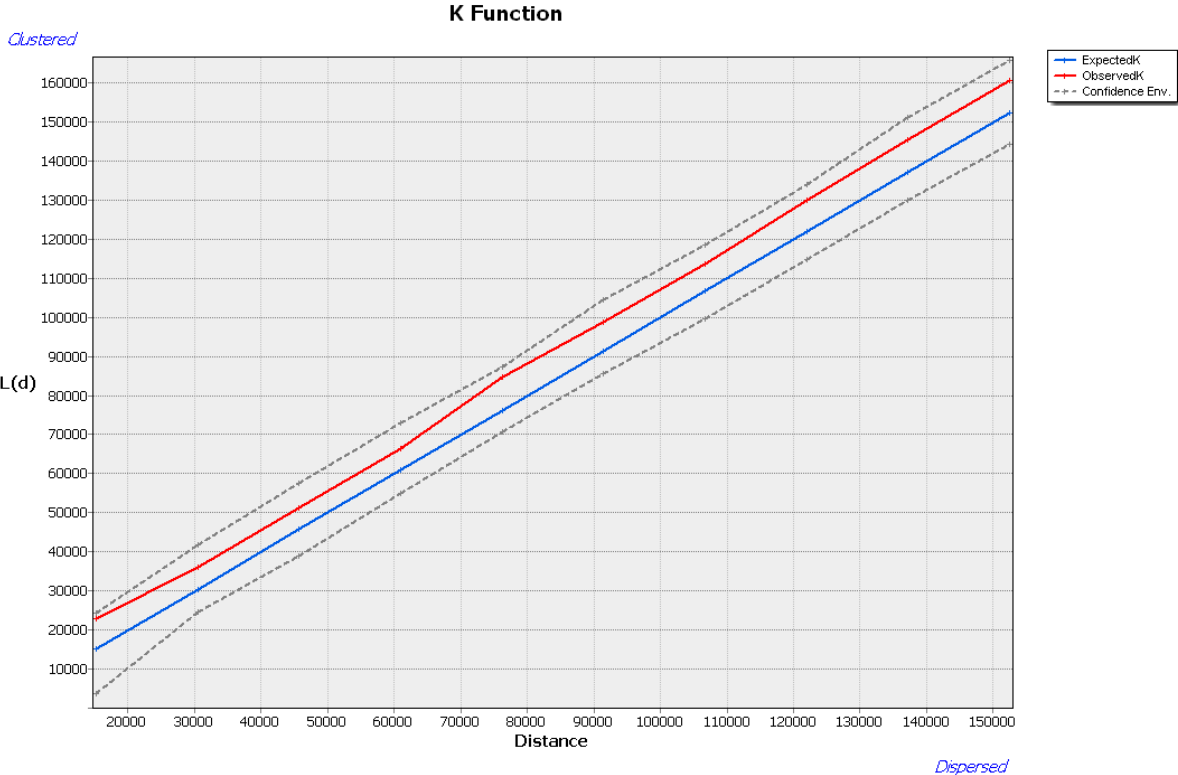
17

Figure 15 – Ripley K Graph for Canada

K Function

Figure 16 – Ripley K Graph for Saskatchewan

Part C: References

       To complete this project, several ArcMap files were provided that included information related to hospitals, health regions, and population data in Canada. The information for the hospital locations come from DMTI (`http://dmtispatial.com`). All other data is from Statistics Canada (`http://statcan.gc.ca`).