Modeling and Visualization of the COVID-19 Outbreak in Ontario

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Capstone Midterm Status Presentation
June 2, 2020

Team

Sofia

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Introduction

Statistics Canada **Statistique Canada**

Clients

- Bruno St-Aubin, Team Lead and GIS Developer
- Marian Radulescu, Unit Head and Analyst

Purpose

- Analyze the COVID-19 Outbreak in Ontario
  - Spread in LTC homes
  - Disease activity in different (Public Health Unit) PHU regions

Background

British Columbia · Analysis

Why B.C. is flattening the COVID-19 curve while numbers in central Canada surge

Luck and timing are part of the equation — but leadership at the top could also play a role

82% of Canada's COVID-19 deaths have been in long-term care, new data reveals
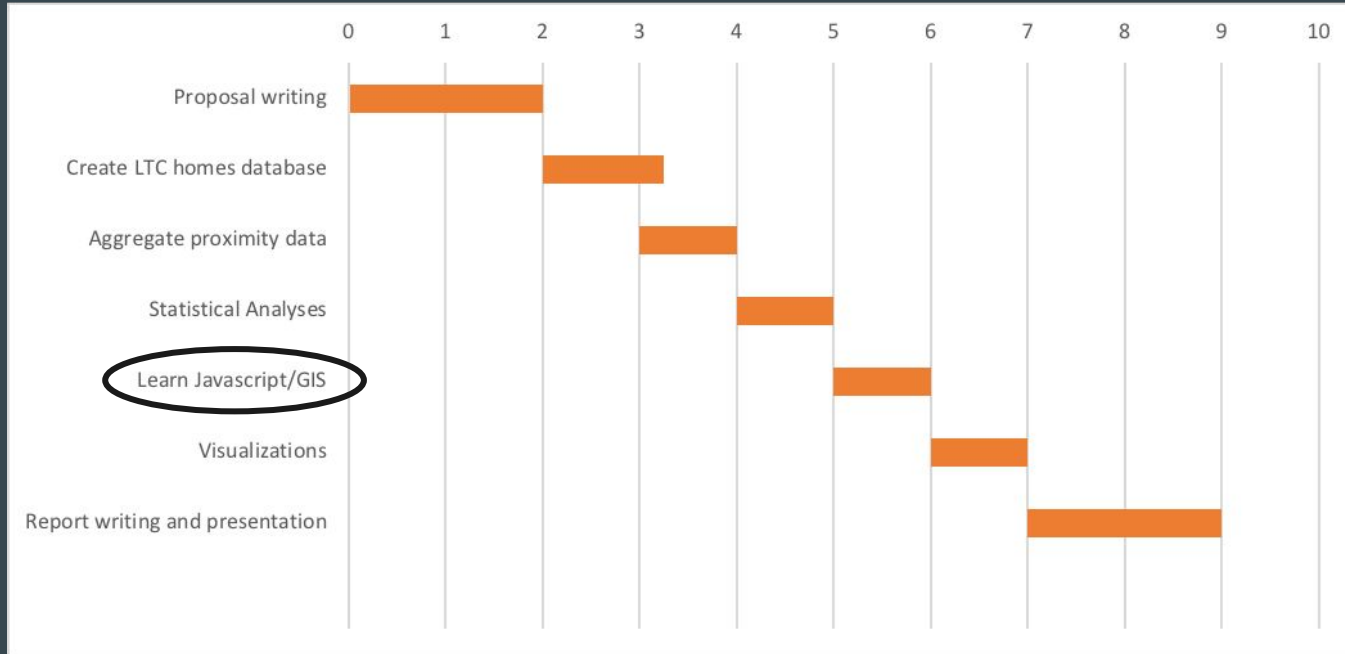
By **Tonda MacCharles** Ottawa Bureau
Thu., May 7, 2020 | ⏱ 5 min. read

Objectives

1. Produce an inferential statistical model of factors that may be associated with the COVID-19 outbreak in long-term care (LTC) homes in Ontario

2. Produce an inferential statistical model of proximity and comorbidity factors that may be associated with COVID-19 outbreaks at the level of Public Health Units (PHU) regions in Ontario

3. Produce an interactive dashboard using qGIS and D3 (Javascript) to visualize COVID-19 outbreak in combination with proximity and co-morbidity factors in Ontario.

Timeline

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Objective 1: LTC Home Data

Long-term care homes with an active outbreak[14]

An active COVID-19 outbreak indicates that the home has at least one lab confirmed case of COVID-19 (in resident or staff) and the local public health unit or the home has declared an outbreak.

The values represent the total cumulative number of residents that resided or staff that worked in the home, regardless if they were transferred to a hospital.

LTC Home	City	Beds	Confirmed Resident Cases	Resident Deaths	Confirmed Staff Cases
Albright Gardens Homes, Incorporated	Beamsville	231	<5	0	0

Long-term care homes no longer in an outbreak[14]

All active cases of COVID-19 have been resolved in a home that previously had an active outbreak.

The values represent the total cumulative number of residents that resided or staff that worked in the home, regardless if they were transferred to a hospital.

LTC Home	City	Beds	Resident Deaths
Allendale	Milton	200	0
Arbour Creek Long-Term Care Centre	Hamilton	129	0

Home Report

The LTC home listed on this screen is the result of your search. To view details on this home:

- Click on the corresponding tabs to view the Home Profile or Inspections for a LTC home.

BETHANY LODGE
23 Second Street
Markham, L3R2C2
Tel : (905) 477-3838
Fax : (905) 477-2888
Click here to visit this LTC home's website

HOME PROFILE | INSPECTION(S)

Local Health Integration Network (LHIN)	Central
Home, Community and Residential Care	Central
Home Administrator	MR BASIL TAMBAKIS
Licensee	Bethany Lodge
Management Firm	
Home Type	Non-Profit
Licensed Beds	Home with approximately 128 beds
Approved Short Stay Beds	No
Residents' Council	Yes
Family Council	Yes
Accreditation	No
Home Designated Under French Language Services Act	No
Additional Information	

January 10, 2020

Long-Term Care Publicly Reported Quality Indicators: LTC Home Results
www.hqontario.ca/System-Performance/Long-Term-Care-Sector-Performance

Legend
Data Sources:
◊Modernized Client Profile Database (CPRO), provided by the Ministry of Health and Long-Term Care (MOHLTC).
‡Continuing Care Reporting System (CCRS), provided by the Canadian Institute for Health Information (CIHI). Parts of this material are based on da are those of the author, and not necessarily those of the Canadian Institute for Health Information.

*Risk-adjusted results

Reporting Period:
◊2018/19 (Data cut prepared in August 2019)
♦2018/19 (Data cut prepared in November 2019)
NR: Facility is not required to report
ST: Data point is not precise
LV: Number is too small to report

Visit HQO's Indicator Library for technical descriptions of the indicators: indicatorlibrary.hqontario.ca

Home Name	Placements for referrals from all prior locations (days)◊	Placement comm
Ontario Provincial Average	**147**	
1230839 Ontario Ltd. - Brouillette Manor	48	
2109577 Ontario Ltd. - Of Arbour Heights	166	
412506 Ontario Ltd - St. Jacques Nursing Home	46	
458422 Ontario Ltd. - Sandfield Place	334	
601091 Ontario Ltd. - Cedarvale Terrace	153.5	
601092 Ontario Limited - Vermont Square	77	
848357 Ontario Inc. - The O'Neill Centre	146	
913096 Ontario Limited - Nipissing Manor Nursing Care Centre	192	
Advent Health Care Corporation - Valley View Residence	317	
Albright Gardens Homes Inc.	342	
Algonquin Nursing Home of Mattawa Limited - Algonquin Nursing Home of Mattawa Ltd.	148	
Almonte General Hospital - Fairview Manor	828.5	

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https://www.ontario.ca/page/how-ontario-is-responding-covid-19#section-1

http://publicreporting.ltchomes.net/en-ca/homeprofile.aspx?Home=c507&tab=0

www.hqontario.ca/System-Performance/Long-Term-Care-Sector-Performance

Objective 1: Model of Factors Associated with Outbreaks in LTC Homes

Binary logistic regression

- Explanatory variables
  - Binary: Accreditation (yes or no)
  - Nominal: Home type (For-profit, non-profit, municipal)
  - Continuous: Number of inspection reports
- Response variable
  - Binary: Outbreak or not

Results

- Municipal home type is protective
- Increased number of beds increases risk

```
Call:
glm(formula = outbreak ~ ., family = binomial, data = logtrans)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-2.2547  -0.9220  -0.6293   1.0998   2.1211

Coefficients:
                        Estimate Std. Error z value Pr(>|z|)
(Intercept)             -3.32916    0.97837  -3.403 0.000667 ***
home.typeMunicipal      -0.58475    0.27292  -2.143 0.032149 *
home.typeNon-Profit      0.22367    0.22648   0.988 0.323340
short.stayYes           -0.31095    0.19703  -1.578 0.114527
residents.councilYes    -0.97843    0.78062  -1.253 0.210060
family.councilYes       -0.10029    0.25447  -0.394 0.693497
accreditationYes        -0.11189    0.26660  -0.420 0.674705
total_inspections        0.29208    0.36757   0.795 0.426831
X5y_inspections          0.27034    0.44828   0.603 0.546479
X2y_inspections         -0.36956    0.30072  -1.229 0.219097
number_beds              0.28530    0.04073   7.005 2.46e-12 ***
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
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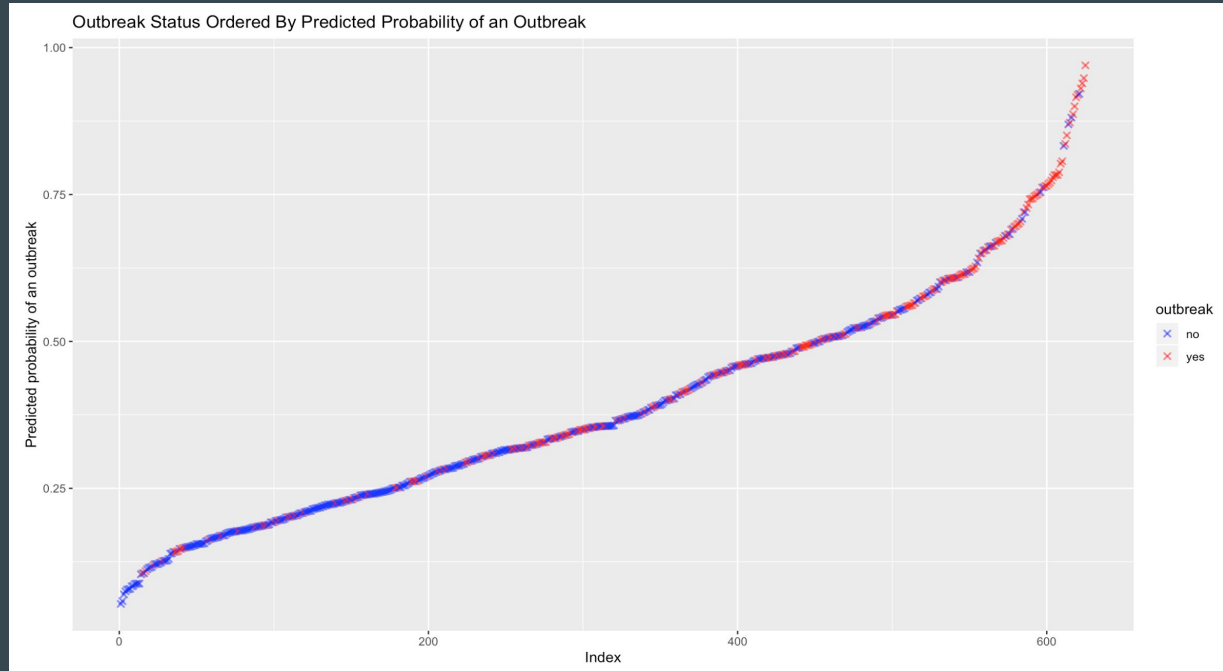
Objective 1: Model of Factors Associated with Outbreaks in LTC Homes

Outbreak Status Ordered By Predicted Probability of an Outbreak
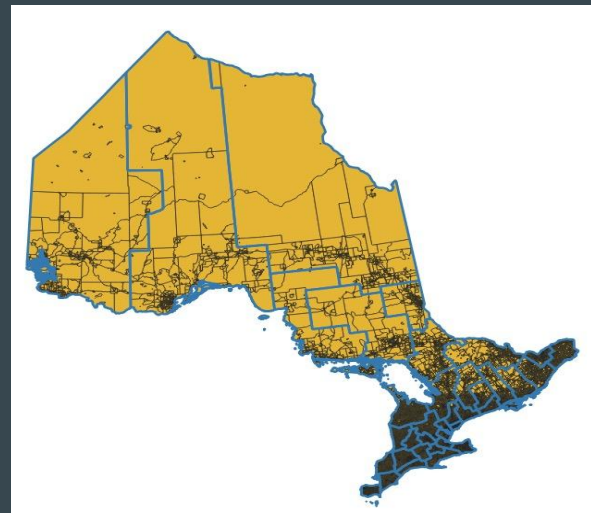
Objectives

1. Produce an inferential statistical model of factors that may be associated with the COVID-19 outbreak in long-term care (LTC) homes in Ontario

2. **Produce an inferential statistical model of proximity and comorbidity factors that may be associated with COVID-19 outbreaks at the level of Public Health Units (PHU) regions in Ontario**

3. Produce an interactive dashboard using qGIS and D3 (Javascript) to visualize COVID-19 outbreak in combination with proximity and co-morbidity factors in Ontario.

Objective 2: Data

(1) PHU

Proximity Measures: transit, primary education, secondary education, parks, libraries, pharmacies, grocery stores, health facilities, childcare, employment, amenity denseness
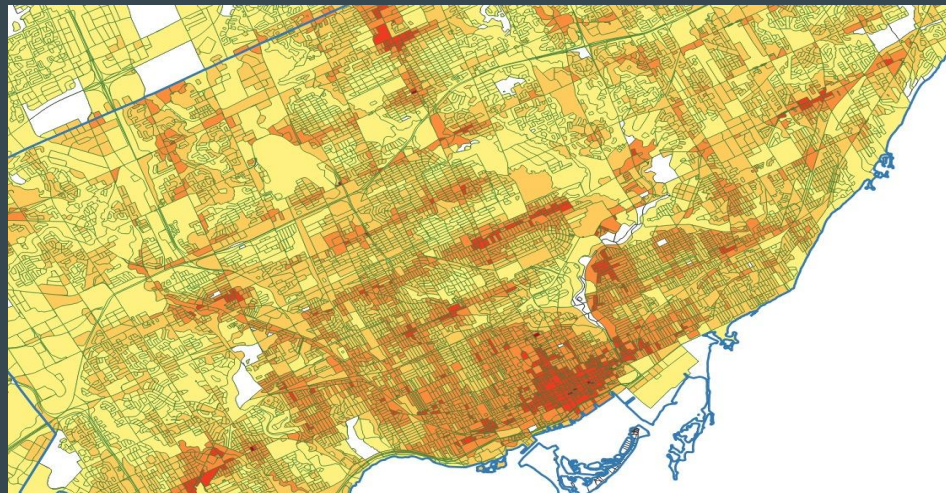
Comorbidities: high blood pressure, asthma, smokers, chronic obstructive pulmonary disease

(2) COVID-19 cases in Ontario (auto-updating)

Location: reporting PHU, complete PHU address, latitude and longitude of PHU

Case Information: date reported, age group, gender, case acquisition, outcome

Objective 2: Model of Factors Associated with Outbreaks in PHUs

- Factor analysis
  - Factor1: Connectedness
  - Factor2: Health compromise

```
Loadings:
                    Factor1 Factor2
asthma.percent               0.582
copd.percent        -0.402   0.748
hbp.percent         -0.434   0.473
smokers.percent     -0.361   0.758
prox_idx_emp         0.839  -0.434
prox_idx_pharma      0.721  -0.333
prox_idx_childcare   0.659  -0.290
prox_idx_health      0.826  -0.248
prox_idx_grocery     0.650
prox_idx_educpri     0.901
prox_idx_educsec     0.228   0.614
prox_idx_lib        -0.127   0.358
prox_idx_parks       0.667  -0.519
prox_idx_transit     0.868  -0.116

                    Factor1 Factor2
SS loadings          5.324   2.935
Proportion Var       0.380   0.210
Cumulative Var       0.380   0.590

Test of the hypothesis that 2 factors are sufficient.
The chi square statistic is 68.54 on 64 degrees of freedom.
The p-value is 0.326
```

- Linear model using factors

```
Call:
lm(formula = V1 ~ ., data = total_fa)

Residuals:
       Min         1Q     Median         3Q        Max
-5.254e-04 -2.685e-04 -7.527e-05  1.620e-04  1.198e-03

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.436e-04  6.922e-05  12.186 9.21e-14 ***
Factor1      2.311e-04  7.266e-05   3.181  0.00319 **
Factor2     -2.284e-04  7.618e-05  -2.998  0.00514 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.0004153 on 33 degrees of freedom
Multiple R-squared:  0.3816,    Adjusted R-squared:  0.3441
F-statistic: 10.18 on 2 and 33 DF,  p-value: 0.0003598
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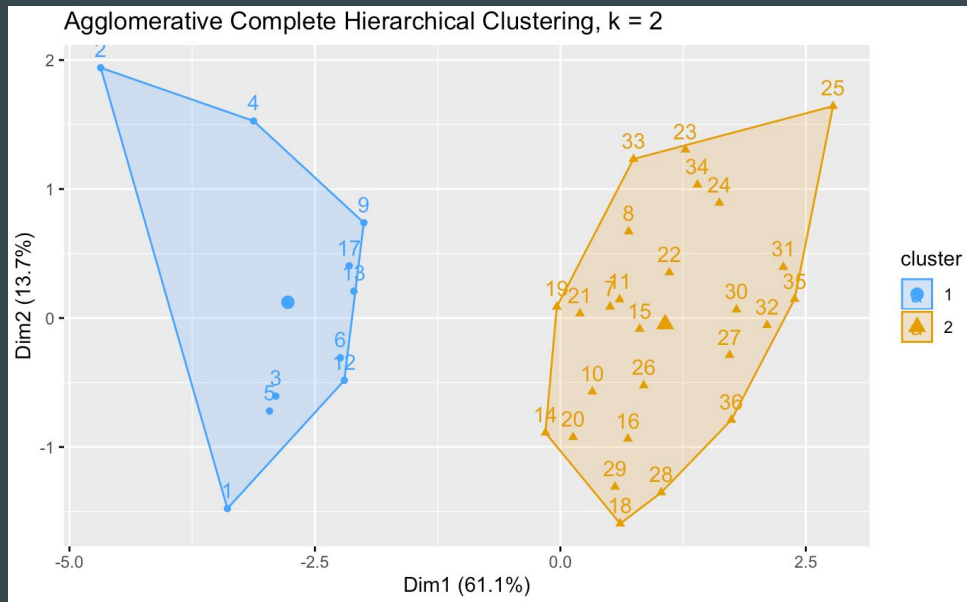
Proportion COVID cases = 0.0002*Factor1 - 0.0002*Factor2 + 0.0008

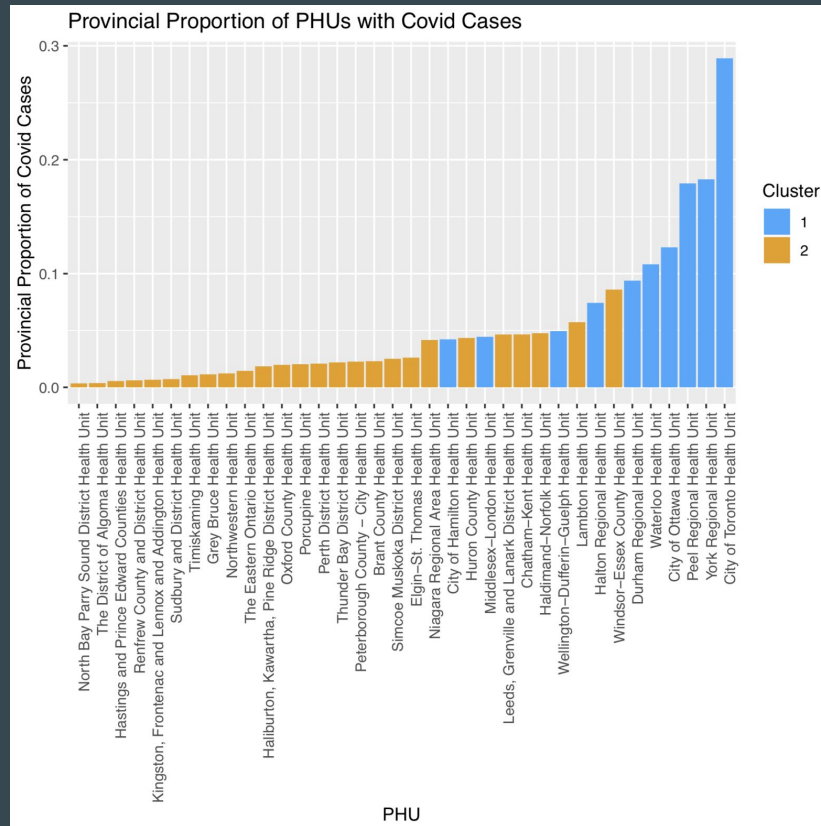# Objective 2: Model of Factors Associated with Outbreaks in PHUs

- **Unsupervised, agglomerative hierarchical clustering** was performed on comorbidities and amenity-dense predictors

Objective 2: Model of Factors Associated with Outbreaks in PHUs

- PHUs cluster by urban region and suggest relation between comorbidities and amenity-dense locations

- COVID-19 proportions for each PHU were calculated and clusters were visualized

COVID-19 proportion = $\dfrac{\text{PHU Case Count}}{\text{Ontario Population}}$

Provincial Proportion of PHUs with Covid Cases

Objective 2: Model of Factors Associated with Outbreaks in PHUs

LASSO showed that 3 of 5 predictor variables are influential: proportion of COPD, amenity richness, and proportion of smokers in the PHU..

Beta Regression: Useful for continuous response variables which are bound between 0, 1. This is suitable for our scenario.

Beta regression on the 3 predictors showed that the proportion of COVID-19 cases is associated with the proportion of COPD in PHU as well.
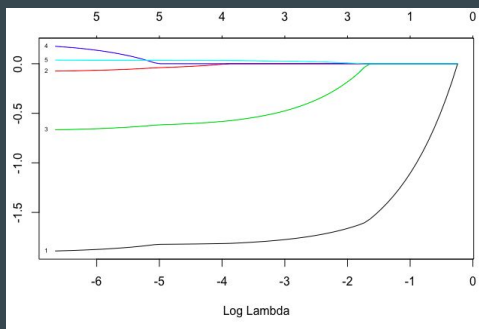


```
betareg(formula = TotalStratified ~ copd.prop + amenity + smokers.prop, data = final,
    link = "logit")

Standardized weighted residuals 2:
    Min      1Q  Median      3Q     Max
-2.4571 -0.6721 -0.1271  0.8179  1.8858

Coefficients (mean model with logit link):
              Estimate Std. Error z value Pr(>|z|)
(Intercept)    -1.2335     0.3859  -3.196  0.00139 **
copd.prop     -31.4649     7.2556  -4.337 1.45e-05 ***
amenity         1.1270     0.4259   2.646  0.00814 **
smokers.prop   -4.1898     3.3944  -1.234  0.21708

Phi coefficients (precision model with identity link):
     Estimate Std. Error z value Pr(>|z|)
(phi)  175.21     42.29   4.144 3.42e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Type of estimator: ML (maximum likelihood)
Log-likelihood: 112.8 on 5 Df
Pseudo R-squared: 0.6903
Number of iterations: 309 (BFGS) + 6 (Fisher scoring)
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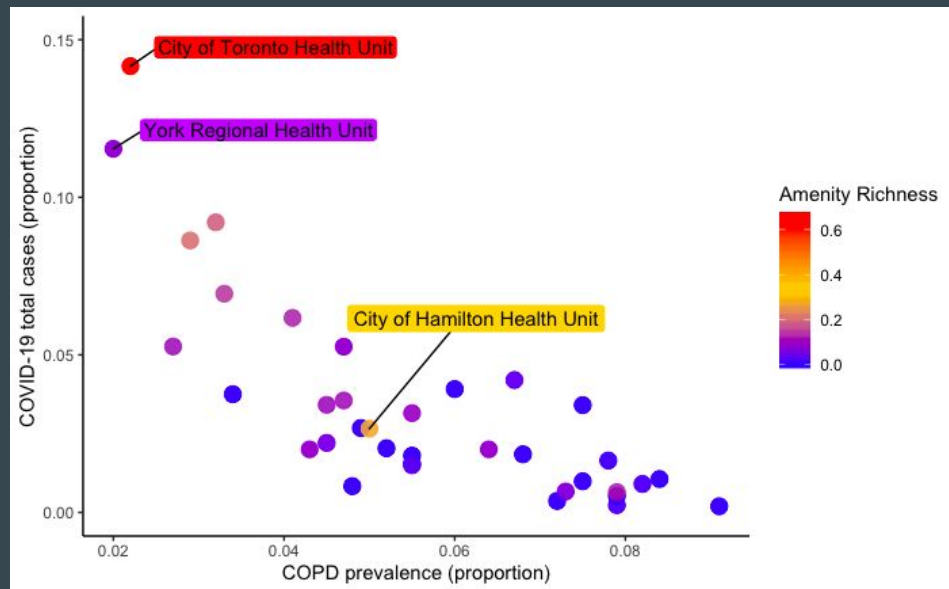
Upcoming...

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Objective 3: Interactive Dashboard of COVID-19 Data

- PHU borders layer

- LTC locations layer

- On-click metadata for statistical analysis

Limitations

- Learning JavaScript/D3

- Understanding some statistical concepts such as representing COVID-19 case proportions accurately

Thank you!