Modeling and Visualization of the COVID-19 Outbreak in Ontario

Statistics Canada

June 16, 2020

Sofia Bahmutsky
KT Hobbs
Ngan Lyle (Presenter)
Shreeram Murali

Team

Statistics Canada | Statistique Canada

Sofia

KT

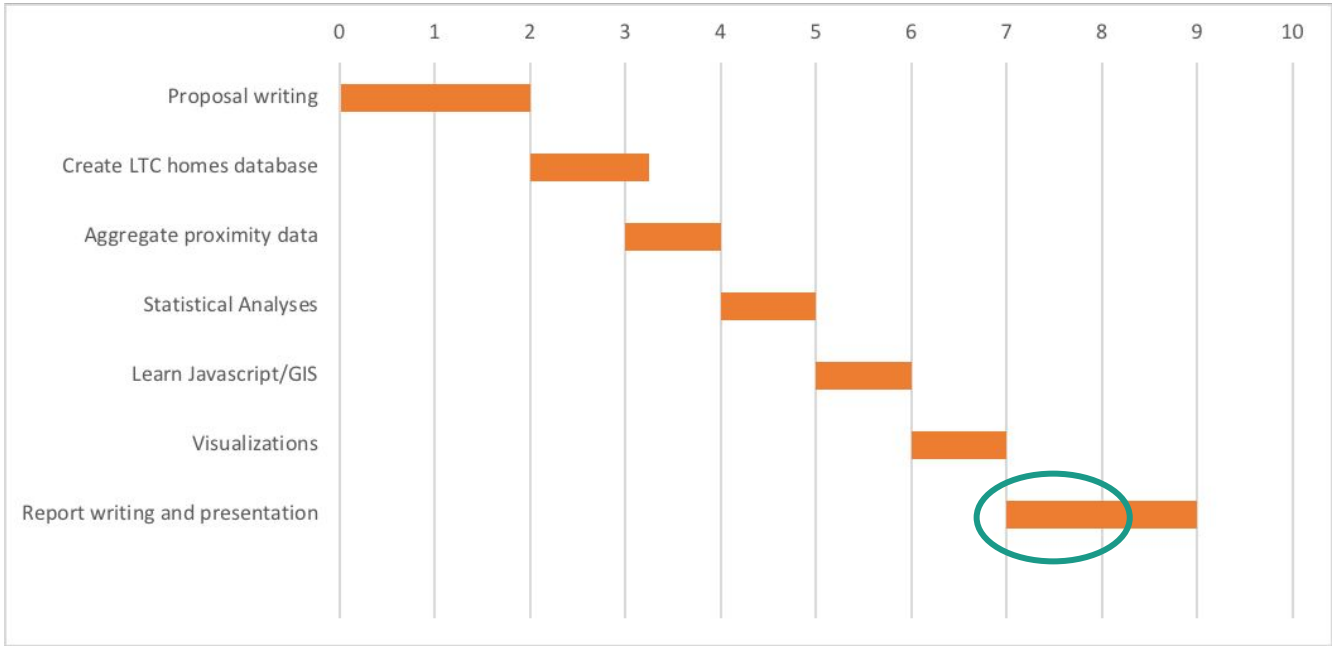
Ngan

Shreeram

Aims

1. Long term care (LTC) homes analysis
    a. Factors associated with a COVID-19 outbreak
2. Public health region analysis
    a. Proximity factors
    b. Comorbidity factors
    c. Socioeconomic factors
3. Visualization

Schedule

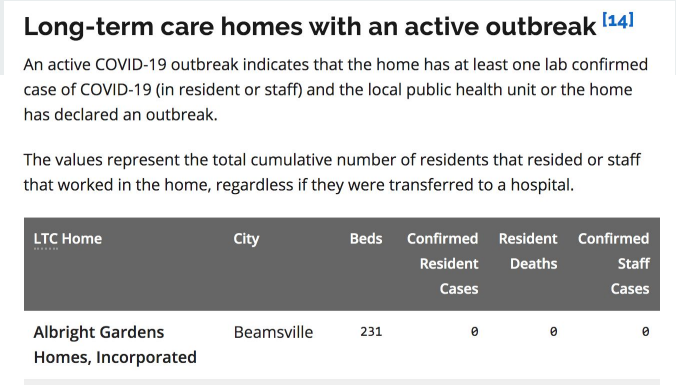

0
1
2
3
4
5
6
7
8
9
10
Proposal writing
Create LTC homes database
Aggregate proximity data
Statistical Analyses
Learn Javascript/GIS
Visualizations
Report writing and presentation

Summary of Week 7

- Refined D3 visualizations
  - Charts for the amenity data
  - Setting up website for hosting
- Update and expand the LTC homes analysis
  - New data about outbreaks in LTCs from new webscrape
  - Added detailed data about inspection report types
  - Added LTC homes quality data
- Expand the PHU regions analysis
  - Added health/comorbidity data
  - Added socioeconomic data
- Final report and documentation

LTC Homes Analysis

- New webscrape from June 5
  - An additional 49 LTC homes with a COVID outbreak
    - 244 to 293
- New webscrape for type of inspection reports
  - Complaints, critical incidents etc.
- New LTC homes quality data

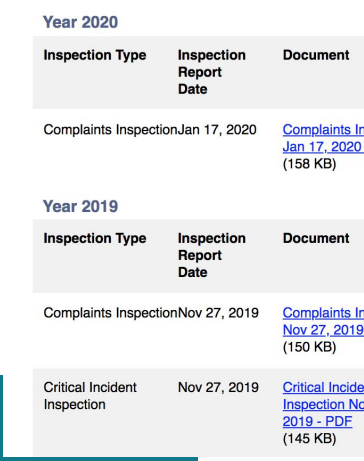


Long-term care homes with an active outbreak [14]

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	0	0	0



Year 2020

Inspection Type	Inspection Report Date	Document
Complaints Inspection	Jan 17, 2020	Complaints In Jan 17, 2020 (158 KB)

Year 2019

Inspection Type	Inspection Report Date	Document
Complaints Inspection	Nov 27, 2019	Complaints In Nov 27, 2019 (150 KB)
Critical Incident Inspection	Nov 27, 2019	Critical Incide Inspection No 2019 - PDF (145 KB)

Health Quality Ontario

Let's make our health system healthier

What is Health Quality | System Performance | Evidence to Improve Care

COVID-19: Get the latest update

SYSTEM PERFORMANCE

Home › System Performance › Long-Term Care Home Performance

Long-Term Care Home Performance in Ontario

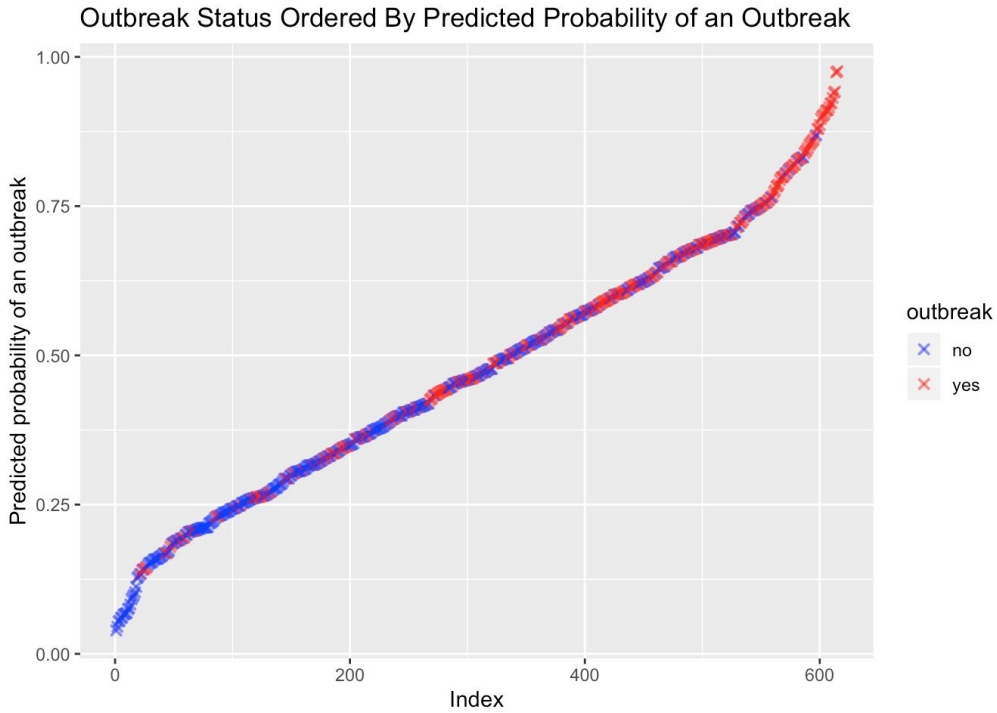
These indicators provide data on wait times for admission to long-term ca
term care home performance in Ontario.

```
##                          Estimate Std. Error z value Pr(>|z|)
## (Intercept)              3.143193   2.840671   1.106   0.2685
## home_typeMunicipal      -0.533617   0.294532
## home_typeNon-Profit      0.048595   0.251397
## number_beds              0.232655   0.050627
## short_stayYes           -0.181057   0.210418
## residents_councilYes    -0.521201   0.953494
## family_councilYes        0.157426   0.267084
## accreditationYes        -0.236254   0.278384
## regionEast              -0.237564   0.324196
## regionNorth             -0.946643   0.427283
## regionToronto            0.689524   0.484719
## regionWest              -0.511712   0.290713
## antipsychotic_percent    0.124144   0.105996
## depression_percent       0.005139   0.010747
## falls_percent           -0.012270   0.021731
## pressure_ulcers_percent -0.012357   0.228484
## pain_percent            -0.128315   0.098233
## total_inspections       -7.622314   4.436957
## X5y_inspections          5.059650   3.793593
## X2y_inspections         -1.082597   1.207296
## total_complaints         0.862600   0.978836
## X5y_complaints           0.087526   0.839495
## X2y_complaints          -0.267613   0.604419
## total_critical          -0.544059   1.194274
## X5y_critical             1.538881   1.340180
## X2y_critical            -1.358774   0.965301
## total_noncomplaints      3.844665   2.718140
## X5y_noncomplaints       -4.774187   2.600318
## X2y_noncomplaints        1.090983   0.776042   1.406   0.1598
## total_withOrders        -0.262043   0.346652  -0.756   0.4497
## X5y_withOrders           0.756159   0.394837   1.915   0.0555 .
## X2y_withOrders           0.135237   0.422691   0.320   0.7490
## total_cc                 0.717939   1.517787   0.473   0.6362
## X5y_cc                  -1.305044   1.571094  -0.831   0.4062
## X2y_cc                   2.055378   1.531700   1.342   0.1796
## total_ccw                1.548906   1.813860   0.854   0.3931
## X5y_ccw                 -0.942757   1.309266  -0.720   0.4715
## X2y_ccw                 -1.033641   1.096100  -0.943   0.3457
##
```

```
##
## Call:
## glm(formula = outbreak ~ home_type + number_beds + total_inspections +
##     total_complaints, family = binomial, data = data_selected)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -2.5854  -0.9661  -0.6290   1.0365   1.9760
##
## Coefficients:
##                          Estimate Std. Error z value Pr(>|z|)
## (Intercept)              -1.60829    0.25716  -6.254 4.00e-10 ***
## home_typeMunicipal       -0.56603    0.26722  -2.118  0.03416 *
## home_typeNon-Profit       0.16650    0.21424   0.777  0.43707
## number_beds               0.01174    0.00183   6.415 1.41e-10 ***
## total_inspections        -0.02500    0.01113  -2.246  0.02468 *
## total_complaints          0.07084    0.02235   3.170  0.00153 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

Binary Logistic Regression

LTC Homes Analysis



R2 = 0.1423571

P-value = 0

Expanded PHU Analysis

Additional health data 4 -> 22 factors
Principal component analysis

	PC1
Arthritis..15.years.and.over.	-0.252734092
Asthma	-0.147632841
Body.mass.index..adjusted.self.reported..adult..18.years.and.over...obese	-0.253449498
Body.mass.index..adjusted.self.reported..adult..18.years.and.over...overweight	0.097920314
Chronic.obstructive.pulmonary.disease..COPD..35.years.and.over.	-0.230483945
Current.smoker..daily	-0.243242458
Current.smoker..daily.or.occasional	-0.248001603
Diabetes	-0.156415295
Has.a.regular.healthcare.provider	0.041701382
Heavy.drinking	-0.215819578
High.blood.pressure	-0.218481334
Influenza.immunization.in.the.past.12.months	0.002864627
Life.satisfaction..satisfied.or.very.satisfied	0.154660547
Mood.disorder	-0.198287286
Perceived.health..fair.or.poor	-0.232404772
Perceived.health..very.good.or.excellent	0.164473036
Perceived.life.stress..most.days.quite.a.bit.or.extremely.stressful	0.083735312
Perceived.mental.health..fair.or.poor	-0.080426792
Perceived.mental.health..very.good.or.excellent	0.127996291
Physical.activity..150.minutes.per.week..adult..18.years.and.over.	0.089902703
Physical.activity..average.60.minutes.per.day..youth..12.to.17.years.old.	-0.061208368
Sense.of.belonging.to.local.community..somewhat.strong.or.very.strong	-0.083423858
prox_idx_emp_med	0.243578450
prox_idx_pharma_med	0.212906708
prox_idx_childcare_med	0.221288366
prox_idx_health_med	0.200838651
prox_idx_grocery_med	0.110041456
prox_idx_educpri_med	0.171584698
prox_idx_educsec_med	-0.071318479

Principal component regression

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

Residuals:
       Min         1Q     Median         3Q        Max
-0.0004644 -0.0002713 -0.0000922  0.0001527  0.0012029

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  8.436e-04  7.015e-05  12.025 8.62e-13 ***
PC1          8.842e-05  2.097e-05   4.217 0.000221 ***
PC2          5.692e-05  3.631e-05   1.568 0.127783
PC3          6.008e-05  4.373e-05   1.374 0.180028
PC4         -1.063e-05  4.634e-05  -0.229 0.820228
PC5          4.551e-05  5.628e-05   0.809 0.425318
PC6         -2.109e-05  6.016e-05  -0.351 0.728445
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.0004209 on 29 degrees of freedom
Multiple R-squared:  0.4419,    Adjusted R-squared:  0.3264
F-statistic: 3.826 on 6 and 29 DF,  p-value: 0.006244
```

Healthy and connected is associated with a higher rate of COVID

Expanded PHU Analysis

Preliminary results from analyses incorporating StatCan socioeconomic data

	PC1
X..of.owner.households.spending.30..or.more.of.its.income.on.shelter.costs	-6.273621e-06
X..of.tenant.households.spending.30..or.more.of.its.income.on.shelter.costs	-2.128570e-06
Apartment.in.a.building.that.has.fewer.than.five.storeys	2.726002e-07
Apartment.in.a.building.that.has.five.or.more.storeys	-5.440228e-06
Average.household.size	-1.886086e-07
Bachelor.s.degree	-1.653548e-01
Bicycle	-2.359152e-07
Car..truck..van...as.a.driver	3.794139e-06
Car..truck..van...as.a.passenger	1.294414e-07
Earned.doctorate	-8.664823e-03
Employment.rate	-2.478146e-06
External.migrants	-4.511173e-02
Interprovincial.migrants	-3.964494e-08
Intraprovincial.migrants	1.828069e-06
Master.s.degree	-5.970900e-02
Median.after.tax.income.of.households.in.2015....	-5.434008e-03
Median.age.of.the.population	3.373874e-06
Movable.dwelling	2.185046e-07
No.certificate..diploma.or.degree	2.097467e-06
Not.in.the.labour.force	-2.694281e-01
Other.attached.dwelling	-1.719063e-06
Other.method	2.557586e-08
Population..2016	-9.457069e-01
Single.detached.house	9.454069e-06
Unemployment.rate	-1.197006e-07
Walked	-2.835082e-08
Arthritis..15.years.and.over.	5.325872e-06
Asthma	1.288864e-06

PC1: higher comorbidities, more detached homes, less amenity dense, higher age of population, less higher education, poorer mental and physical health

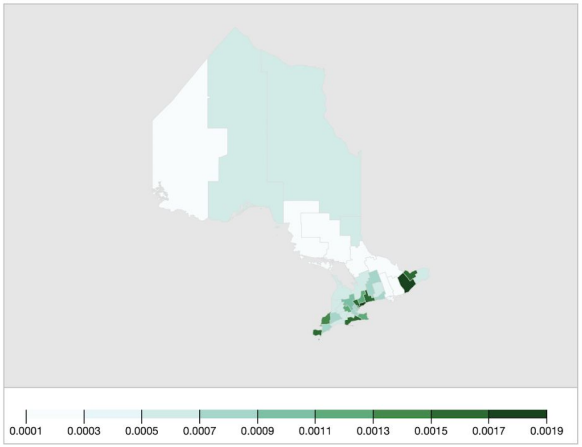
PC2: higher cost of living, high rises, more employment, perceived high stress, more commuting altogether and more vehical transit usage, percieved good health

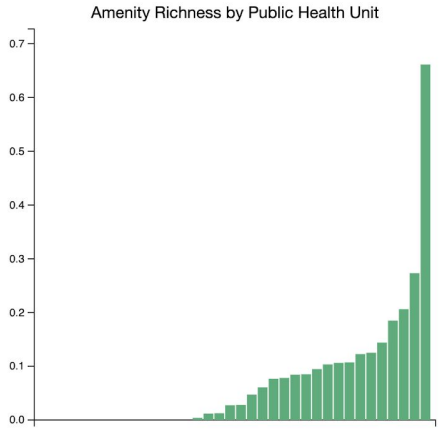
D3 Dashboard - Interactive Map

Ontario COVID-19 Map

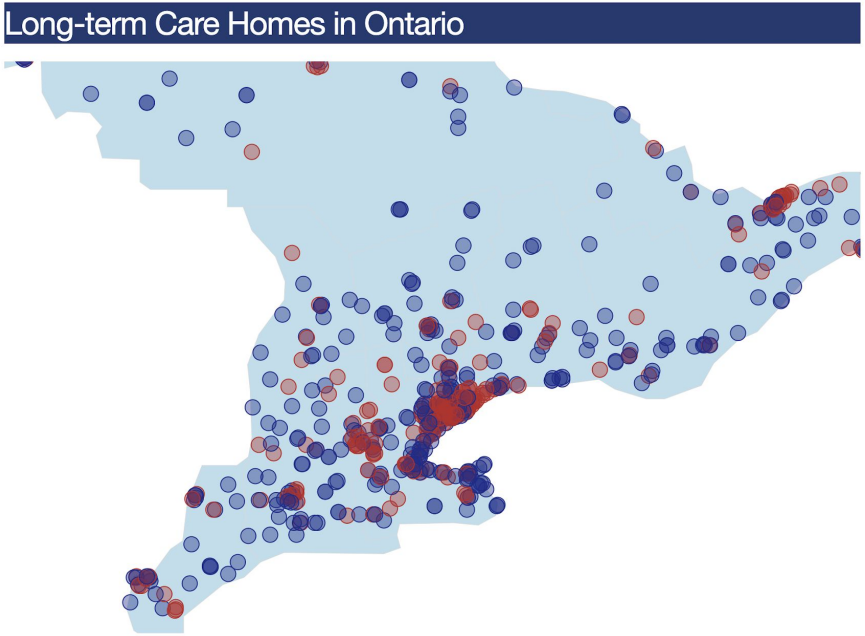
Instructions

- Scroll in the map to zoom in and out.
- Click and drag the map to move.
- Hover over a public health unit or long-term care home (represented as points) to view details.





D3 Dashboard - Interactive Map



Zoom and hover over the map of Ontario Long-Term Care homes to view the home **name**, **type**, **number of beds**, associated **Local Health Integration Network (LHIN)**, and **outbreak status**. In this map, Ontario is subdivided according to LHIN. Red points represent homes that have or have had an outbreak while blue points represent those without.

Week 8 - Agenda

1. Documentation
    a. Explanatory guides
    b. Rerun, clean and consolidate scripts in R and python
    c. Reorganize and folders and files
2. Final report
3. Final presentations
    a. For Data 599 on Tuesday June 23
    b. For StatCan on Friday June 26
4. Loose ends

Limitations

- Limited time
  - Temptation to do more!!!
    - Socioeconomic analysis
    - Further work on the dashboard

Thanks!

Statistics Canada Statistique Canada

Introduction

- Client
  - Statistics Canada
    - Bruno St-Aubin, Team Lead and GIS Developer
    - Marian Radulescu, Unit Head and Analyst
- Requirements
  - Assess the quality and possibly improve upon StatCan open data sources
  - Build a product that shows that StatCan open source data are useable in complex analytical cases

Week 7 - Agenda

1. Produce an inferential statistical model of fact
with the COVID-19 outbreak in long-term care
2. **Produce an inferential statistical model of pro
factors that may be associated with COVID-1
Public Health Units (PHU) regions in Ontario**
3. **Produce an interactive dashboard using QGIS
visualize COVID-19 outbreak in combination
co-morbidity factors in Ontario.**