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**Predictors of case fatality among individuals who have tested positive for COVID-19**

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## Methods

We identified Ontario residents with a valid health card, aged 20 years or older, who tested positive for COVID-19 between March 1 and December 31, 2020, as recorded in one or more of the four following databases: Ontario Laboratories Information System (OLIS), Public Health Ontario Laboratories Labware database, Distributed Labs database, and iPHIS/CCM. Using information contained in the Ontario Drug Benefit (ODB) database, Ontario Health Insurance Plan (OHIP) physician billings, and the Continuing Care Reporting System (CCRS) to identify long-term care (LTC) residents, we stratified the study population into those residing in LTC and those residing in the community as of March 1, 2020.

The outcome measure was 30-day all-cause mortality following a positive SARS-CoV-2 PCR test. We identified deaths using the Registered Persons Database (RPDB) and iPHIS/CCM.

We used many of the definitions described in Sundaram et al. (pre-print manuscript; https://www.medrxiv.org/content/10.1101/2020.11.09.20223792v1.full.pdf).

We used multivariable logistic regression to generate adjusted odds ratios for the associations between case fatality (death following COVID-19 diagnosis) and individual-level and area-level characteristics. For the community-dwelling group, we examined the following predictors: age, sex, rural residence, comorbidities (asthma, chronic obstructive pulmonary disease [COPD], hypertension, diabetes, congestive heart failure [CHF], dementia and frailty, cancer, chronic kidney disease [CKD], immunosuppression, advanced liver disease, ischemic heart disease, history of stroke), prior healthcare use (number of hospital admissions in the past 3 years, number of outpatient physician office visits in the past year), selected area-level social determinants of health (median household income, proportion of the population who self-report as a visible minority, proportion of the population who are essential workers). For the LTC group, we examined the following predictors: age, sex, rural, the comorbidities listed above. All analyses were adjusted for month of test.

## Results

Descriptive characteristics of the full cohort are presented in Table 1. Among 143,077 community-dwelling individuals who tested positive for COVID-19, there were 2,232 deaths. Increasing age, male sex, prior hospital admissions, COPD, hypertension, CHF, diabetes, dementia or high frailty score, cancer, CKD, and immunosuppression were associated with increased case fatality, with age effect estimates having the largest magnitude for increased risk (Table 2). Residence in high-income neighbourhoods was associated with decreased case fatality.

Among 10,763 LTC residents who tested positive for COVID-19, there were 2,893 deaths. Older age, male sex, COPD, diabetes, dementia and frailty, and CKD were associated with increased case fatality (Table 3).

## Interpretation and Conclusions

These findings, which can be used to inform COVID-19 vaccine prioritization, signal higher case fatality for certain populations. For community-dwelling individuals, increased age, male sex, history of prior hospital admissions in the past 3 years, certain chronic medical conditions, and residing in lower-income neighbourhoods were associated with increased risk of death following COVID-19 infection. Note that these estimates do not account for differences in the risk of COVID-19 acquisition or access to testing across these predictors.

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**Table 1.** Characteristics of Ontario residents over age 20 years, with laboratory-confirmed COVID-19 between March 1 and December 31, 2020.[a]

| Characteristic | Alive N = 148,715 | Died[b] N = 5,125 | Total N = 153,840 | Standardized differences |
|---|---|---|---|---|
| Age: mean ± SD | 47.40 ± 18.65 | 83.20 ± 11.30 | 48.59 ± 19.54 | 2.32 |
| Age: median (IQR) | 46 (32-59) | 86 (77-91) | 47 (32-61) | 2.06 |
| Age group (years): N (%) | | | | |
| 20-34 | 45,347 (30.5%) | 10 (0.2%) | 45,357 (29.5%) | 0.93 |
| 35-49 | 39,183 (26.3%) | 48 (0.9%) | 39,231 (25.5%) | 0.80 |
| 50-64 | 38,113 (25.6%) | 316 (6.2%) | 38,429 (25.0%) | 0.55 |
| 65-74 | 11,734 (7.9%) | 635 (12.4%) | 12,369 (8.0%) | 0.15 |
| 75-84 | 7,204 (4.8%) | 1,333 (26.0%) | 8,537 (5.5%) | 0.61 |
| 85+ | 7,134 (4.8%) | 2,783 (54.3%) | 9,917 (6.4%) | 1.29 |
| Female sex: N (%) | 78,393 (52.7%) | 2,648 (51.7%) | 81,041 (52.7%) | 0.02 |
| Rural residence: N (%)[c] | 5,245 (3.5%) | 144 (2.8%) | 5,389 (3.5%) | 0.04 |
| Long-term care residence | 7,870 (5.3%) | 2,893 (56.4%) | 10,763 (7.0%) | 1.33 |
| High-risk health conditions | | | | |
| Asthma | 22,650 (15.2%) | 862 (16.8%) | 23,512 (15.3%) | 0.04 |
| Chronic obstructive pulmonary disease | 3,401 (2.3%) | 857 (16.7%) | 4,258 (2.8%) | 0.51 |
| Hypertension | 40,507 (27.2%) | 4,310 (84.1%) | 44,817 (29.1%) | 1.40 |
| Diabetes | 23,879 (16.1%) | 2,358 (46.0%) | 26,237 (17.1%) | 0.68 |
| Congestive heart failure | 4,485 (3.0%) | 1,318 (25.7%) | 5,803 (3.8%) | 0.68 |
| Dementia or frailty score >15 | 9,326 (6.3%) | 3,279 (64.0%) | 12,605 (8.2%) | 1.52 |
| Cancer[d] | 2,252 (1.5%) | 272 (5.3%) | 2,524 (1.6%) | 0.21 |
| Chronic kidney disease[d] | 5,037 (3.4%) | 1,223 (23.9%) | 6,260 (4.1%) | 0.63 |
| Immunocompromised[e] | 1,536 (1.0%) | 177 (3.5%) | 1,713 (1.1%) | 0.16 |
| Advanced liver disease | 1,163 (0.8%) | 122 (2.4%) | 1,285 (0.8%) | 0.13 |
| Cardiac ischemic disease | 4,321 (2.9%) | 798 (15.6%) | 5,119 (3.3%) | 0.45 |
| Ischemic stroke or transient ischemic attack[f] | 2,521 (1.7%) | 669 (13.1%) | 3,190 (2.1%) | 0.45 |
| Prior healthcare use | | | | |
| Hospital admissions in the past 3 years: mean ± SD | 0.26 ± 0.91 | 1.26 ± 1.86 | 0.30 ± 0.98 | 0.68 |
| Hospital admissions in the past 3 years: median (IQR) | 0 (0-0) | 1 (0-2) | 0 (0-0) | 0.95 |
| Number of hospital admissions in the past 3 years | | | | |
| 0 | 125,844 (84.6%) | 2,272 (44.3%) | 128,116 (83.3%) | 0.93 |
| 1 | 15,408 (10.4%) | 1,328 (25.9%) | 16,736 (10.9%) | 0.41 |
| 2 | 4,167 (2.8%) | 704 (13.7%) | 4,871 (3.2%) | 0.41 |
| ≥3 | 3,296 (2.2%) | 821 (16.0%) | 4,117 (2.7%) | 0.49 |
| Number of outpatient visits in the past 1 year: mean ± SD | 6.91 ± 7.65 | 13.98 ± 10.97 | 7.15 ± 7.89 | 0.75 |
| Number of outpatient visits in the past 1 year: median (IQR) | 5 (2-10) | 12 (9-16) | 5 (2-10) | 1.07 |

| | | | | |
|---|---|---|---|---|
| Number of outpatient visits in the past 1 year | | | | |
| 0-1 | 32,848 (22.1%) | 200 (3.9%) | 33,048 (21.5%) | 0.56 |
| 2-4 | 38,329 (25.8%) | 369 (7.2%) | 38,698 (25.2%) | 0.52 |
| 5-8 | 33,387 (22.5%) | 680 (13.3%) | 34,067 (22.1%) | 0.24 |
| 9-14 | 26,816 (18.0%) | 2,243 (43.8%) | 29,059 (18.9%) | 0.58 |
| ≥15 | 17,335 (11.7%) | 1,633 (31.9%) | 18,968 (12.3%) | 0.51 |
| Month of testing (2020) | | | | |
| March | 3,582 (2.4%) | 235 (4.6%) | 3,817 (2.5%) | 0.12 |
| April | 12,538 (8.4%) | 1,840 (35.9%) | 14,378 (9.3%) | 0.70 |
| May | 8,617 (5.8%) | 560 (10.9%) | 9,177 (6.0%) | 0.19 |
| June | 4,571 (3.1%) | 98 (1.9%) | 4,669 (3.0%) | 0.07 |
| July | 2,973 (2.0%) | 34 (0.7%) | 3,007 (2.0%) | 0.12 |
| August | 2,306 (1.6%) | 18 (0.4%) | 2,324 (1.5%) | 0.12 |
| September | 9,080 (6.1%) | 105 (2.0%) | 9,185 (6.0%) | 0.21 |
| October | 18,153 (12.2%) | 342 (6.7%) | 18,495 (12.0%) | 0.19 |
| November | 32,694 (22.0%) | 666 (13.0%) | 33,360 (21.7%) | 0.24 |
| December | 54,201 (36.4%) | 1,227 (23.9%) | 55,428 (36.0%) | 0.27 |
| **Social determinants of health**[g] | | | | |
| Neighbourhood income quintile[h] | | | | |
| 1 (lowest income) | 36,722 (24.7%) | 1,493 (29.1%) | 38,215 (24.8%) | 0.10 |
| 2 | 32,929 (22.1%) | 1,306 (25.5%) | 34,235 (22.3%) | 0.08 |
| 3 | 31,951 (21.5%) | 959 (18.7%) | 32,910 (21.4%) | 0.07 |
| 4 | 25,645 (17.2%) | 688 (13.4%) | 26,333 (17.1%) | 0.11 |
| 5 (highest income) | 20,923 (14.1%) | 665 (13.0%) | 21,588 (14.0%) | 0.03 |
| Visible minority quintile (percentage of individuals in the area self-identifying as a visible minority) | | | | |
| 1 (0.0 - 2.2%) | 8,946 (6.0%) | 320 (6.2%) | 9,266 (6.0%) | 0.01 |
| 2 (2.2 - 7.5%) | 12,013 (8.1%) | 458 (8.9%) | 12,471 (8.1%) | 0.03 |
| 3 (7.5 - 18.7%) | 19,264 (13.0%) | 920 (18.0%) | 20,184 (13.1%) | 0.14 |
| 4 (18.7 - 43.5%) | 33,652 (22.6%) | 1,412 (27.6%) | 35,064 (22.8%) | 0.11 |
| 5 (43.5 - 102%)[i] | 73,960 (49.7%) | 1,915 (37.4%) | 75,875 (49.3%) | 0.25 |
| High-risk occupation quintile (percentage of individuals in the area who are essential workers)[j] | | | | |
| 1 (lowest) | 23,681 (15.9%) | 1,045 (20.4%) | 24,726 (16.1%) | 0.12 |
| 2 | 30,313 (20.4%) | 1,026 (20.0%) | 31,339 (20.4%) | 0.01 |
| 3 | 29,293 (19.7%) | 1,029 (20.1%) | 30,322 (19.7%) | 0.01 |
| 4 | 31,465 (21.2%) | 888 (17.3%) | 32,353 (21.0%) | 0.10 |
| 5 (highest) | 33,082 (22.2%) | 1,037 (20.2%) | 34,119 (22.2%) | 0.05 |

[a] Characteristics as of March 1, 2020. Laboratory-confirmed COVID-19 refers to an individual's first positive SARS-CoV-2 PCR test result. Excluding individuals under age 21 years who tested positive for SARS-CoV-2.
[a] Death from all causes within 30 days following or 7 days prior to date of a positive PCR test for SARS-CoV-2
[c] Rural defined as located outside the commuting zone of a city with greater than 10,000 population.
[d] Participants were counted if they had a diagnosis in the last 5 years.
[e] Immunocompromised defined as: diagnosed with HIV, or had an organ or bone marrow transplant, or diagnosed with another immunodeficiency condition.
[f] Includes individuals with ischemic stroke or transient ischemic attack in the last 20 years.
[g] All variables in this category are area-level variables at the level of the Census Dissemination Area (DA), which usually comprises 400-700 individuals.
[h] Income quintile has variable cut-off values in each city or census area to account for cost of living. A DA being in quintile 1 means it is among the lowest 20% DAs in its city by income.
[i] Census counts for individuals are randomly rounded up or down to the nearest number divisible by 5, which may cause minor imprecision.
[j] Employed in one of the following occupational categories: sales and service; trades, transport, and equipment operation; resources, agriculture, and production; and manufacturing and utilities. An individual living in quintile 1 means they are living in a DA that is among the lowest 20% of DAs for percentage of individuals employed in these occupational categories.
Abbreviations: PCR, polymerase chain reaction; SD, standard deviation; IQR, inter-quartile range; DA, census dissemination area

**Table 2**. Predictors of 30-day all-cause mortality following a positive SARS-CoV-2 PCR test for community-dwelling individuals.[a]

| Covariate | Adjusted OR (95% CI) |
|---|---|
| Age category (years) | |
| 30 (ref: 20) | **2.07 (1.29, 3.31)** |
| 40 (ref: 30) | **2.58 (1.96, 3.41)** |
| 50 (ref: 40) | **2.96 (2.56, 3.42)** |
| 60 (ref: 50) | **3.12 (2.87, 3.39)** |
| 70 (ref: 60) | **3.01 (2.80, 3.24)** |
| 80 (ref: 70) | **2.67 (2.52, 2.84)** |
| 90 (ref: 80) | **2.18 (2.03, 2.34)** |
| Sex (ref: female) | **1.98 (1.79, 2.18)** |
| Rural residence [b] | 0.80 (0.60, 1.06) |
| High-risk health conditions | |
| Asthma | 0.97 (0.86, 1.11) |
| Chronic obstructive pulmonary disease | **1.43 (1.24, 1.65)** |
| Hypertension | **1.35 (1.18, 1.54)** |
| Diabetes | **1.33 (1.20, 1.47)** |
| Congestive heart failure | 1.13 (0.99, 1.28) |
| Dementia or frailty score >15 | **1.65 (1.46, 1.86)** |
| Cancer[c] | **1.37 (1.13, 1.66)** |
| Chronic kidney disease[c] | **1.62 (1.43, 1.83)** |
| Immunocompromised[d] | **1.46 (1.12, 1.92)** |
| Advanced liver disease | 1.17 (0.85, 1.60) |
| Cardiac ischemic disease | 0.92 (0.80, 1.06) |
| Ischemic stroke or transient ischemic attack[e] | 1.07 (0.90, 1.28) |
| Hospital admissions in the past 3 years (ref: 0) | |
| 1 | **1.27 (1.12, 1.44)** |
| 2 | **1.65 (1.40, 1.95)** |
| ≥3 | **1.52 (1.27, 1.81)** |
| Outpatient physician visits in the past 1 year (ref: 0-1) | |
| 2-4 | 0.84 (0.69, 1.04) |
| 5-8 | 0.89 (0.73, 1.08) |
| 9-14 | **0.79 (0.65, 0.97)** |
| ≥15 | 0.91 (0.74, 1.11) |
| Neighbourhood income quintile (ref: 1st quintile) | |
| 2 | 0.89 (0.78, 1.02) |
| 3 | **0.84 (0.73, 0.98)** |
| 4 | **0.76 (0.65, 0.90)** |
| 5 (highest income) | **0.65 (0.54, 0.79)** |
| Visible minority quintile (ref: 1st quintile) | |
| 2 | 0.98 (0.77, 1.25) |
| 3 | 1.02 (0.81, 1.28) |
| 4 | 1.11 (0.89, 1.39) |
| 5 (highest percentage) | 0.98 (0.79, 1.22) |
| High-risk occupation (essential workers) quintile (ref: 1) | |
| 2 | 0.96 (0.82, 1.12) |
| 3 | 0.89 (0.75, 1.04) |
| 4 | 1.01 (0.85, 1.19) |
| 5 (highest percentage) | 1.05 (0.88, 1.25) |

[a] All covariates examined in a multivariate logistic regression model and adjusted for month in which individual first tested positive for SARS-CoV-2 by PCR. Individuals less than 20 years of age were excluded.
[b] Rural defined as located outside the commuting zone of a city with greater than 10,000 population.

[c] Participants were counted if they had a diagnosis in the last 5 years.
[d] Immunocompromised defined as: diagnosed with HIV, or had an organ or bone marrow transplant, or diagnosed with another immunodeficiency condition
[e] Includes individuals with ischemic stroke or transient ischemic attack in the last 20 years.
Abbreviations: PCR, polymerase chain reaction; OR, odds ratio; CI, confidence interval

**Table 3**. Predictors of 30-day all-cause mortality following a positive SARS-CoV-2 PCR test for long-term care residents.[a]

| Covariate | Adjusted OR (95% CI) |
|---|---|
| Age (per 10-year increase)[b] | **1.62 (1.54, 1.70)** |
| Sex (ref: female) | **1.92 (1.74, 2.11)** |
| Rural residence[c] | 1.02 (0.76, 1.37) |
| High-risk health conditions | |
| Asthma | 0.92 (0.81, 1.05) |
| Chronic obstructive pulmonary disease | **1.19 (1.04, 1.35)** |
| Hypertension | 0.94 (0.82, 1.07) |
| Diabetes | **1.22 (1.11, 1.34)** |
| Congestive heart failure | 1.11 (0.99, 1.23) |
| Dementia or frailty score >15 | **1.29 (1.13, 1.47)** |
| Cancer[d] | 0.97 (0.76, 1.23) |
| Chronic kidney disease[d] | **1.23 (1.09, 1.38)** |
| Immunocompromised[e] | 1.24 (0.96, 1.60) |
| Advanced liver disease | 0.81 (0.61, 1.08) |
| Cardiac ischemic disease | 1.04 (0.90, 1.19) |
| Ischemic stroke or transient ischemic attack[f] | 0.89 (0.79, 1.01) |

[a] All covariates examined in a multivariate logistic regression model and adjusted for month in which individual first tested positive for SARS-CoV-2 by PCR. Individuals less than 20 years of age were excluded.
[b] 99% of individuals were over age 50 years
[c] Rural defined as located outside the commuting zone of a city with greater than 10,000 population.
[d] Participants were counted if they had a diagnosis in the last 5 years.
[e] Immunocompromised defined as: diagnosed with HIV, or had an organ or bone marrow transplant, or diagnosed with another immunodeficiency condition
[f] Includes individuals with ischemic stroke or transient ischemic attack in the last 20 years.
PCR, Polymerase chain reaction; OR (odds ratio); CI (confidence interval)