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"Bring the Hoses to Where the Fire Is!": Differential Impacts of Marginalization and Socioeconomic Status on COVID-19 Case Counts and Healthcare Costs

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ABSTRACT

Objectives: Local health leaders and the Director General of the World Health Organization alike have observed that COVID-19 “does not discriminate.” Nevertheless, the disproportionate representation of people of low socioeconomic status among those infected resembles discrimination. This population-based retrospective cohort study examined COVID-19 case counts and publicly funded healthcare costs in Ontario, Canada, with a focus on marginalization.

Methods: Individuals with their first positive severe acute respiratory syndrome coronavirus 2 test from January 1, 2020 to June 30, 2020, were linked to administrative databases and matched to negative/untested controls. Mean net (COVID-19–attributable) costs were estimated for 30 days before and after diagnosis, and differences among strata of age, sex, comorbidity, and measures of marginalization were assessed using analysis of variance tests.

Results: We included 28,893 COVID-19 cases (mean age 54 years, 56% female). Most cases remained in the community (20,545, 71.1%) or in long-term care facilities (4,478, 15.5%), whereas 944 (3.3%) and 2,926 (10.1%) were hospitalized, with and without intensive care unit, respectively. Case counts were skewed across marginalization strata with 2 to 7 times more cases in neighborhoods with low income, high material deprivation, and highest ethnic concentration. Mean net costs after diagnosis were higher for males ($4,752 vs $2,520 for females) and for cases with higher comorbidity ($1,394–$7,751) (both \( P < .001 \)) but were similar across levels of most marginalization dimensions (range $3,232–$7,373, all \( P > .19 \)).

Conclusions: This study suggests that allocating resources unequally to marginalized individuals may improve equality in outcomes. It highlights the importance of reducing risk of COVID-19 infection among marginalized individuals to reduce overall costs and increase system capacity.

Keywords: Canada, costs and costs analyses, COVID-19, marginalization, socioeconomic status, universal healthcare.

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Introduction

Many people, from local health leaders to the Director General of the World Health Organization, have observed that COVID-19 “does not discriminate.” Nevertheless, the disproportionate representation of people of low socioeconomic status (SES) among those infected with the virus resembles discrimination. It is increasingly clear that preexisting inequities have led to unequal distribution of COVID-19. In many countries, individuals with low income or those of ethnoracial minorities have been disproportionately affected by COVID-19.4,44 In Ontario, the most populous province in Canada, the first wave of COVID-19 disproportionately affected individuals of low SES5 and residents of long-term care (LTC) facilities.7

The COVID-19 pandemic has revealed and exacerbated weaknesses in social and healthcare systems,5–11 highlighting the role of social constructs as determinants of health.4,10,12 Among the factors associated with higher risk of acquiring COVID-19 are those that facilitate spread and exposure to the virus, such as having to work outside the home and crowded living conditions.6,13–15 The ability to comply with public health measures such as avoiding nonhousehold contacts, crowds, and public transportation is associated with income, education, and employment status. In addition to inequalities in the risk of acquiring COVID-19,14...
inequalities exist in the ability to manage infection. For example, the inability to isolate because of living or working conditions is more frequently seen among low-income individuals.13,16

Equitable COVID-19 responses are needed to “redress the health and social effects of this pandemic — particularly on the most marginalized groups in society.”14 Equitable responses are also needed to preserve healthcare systems. A reimagined framework for global health that prioritizes equity as a core value offers a necessary path to a more sustainable future after COVID-19.10 One example of an equitable policy is paid sick leave. In the United States, states that provided paid sick leave to subgroups of the population (eg, essential workers in insecure jobs) experienced up to 50% reductions in COVID-19 case volumes across the entire population.17

In Canada, medically necessary healthcare is covered by provincial and territorial healthcare insurance plans, publicly paid under the Canada Health Act.18 For example, the Ontario Health Insurance Plan (OHIP) covers almost all of the approximately 14.7 million residents in the province of Ontario. It is a universal healthcare system that values the principle that healthcare use should be based on need, not ability to pay. Nevertheless, given that the healthcare system is publicly funded (ie, paid by everyone through taxation), keeping healthcare costs for COVID-19 low is advantageous for everyone: to conserve resources to support other necessary medical care during this pandemic and improve health outcomes.

This study examined the relationship among neighborhood-level SES, COVID-19 case counts, and the costs of COVID-19 care during the first wave in Ontario (up to the end of July 2020). In particular, we report on the net attributable per-person costs associated with COVID-19 at the time around diagnosis, and case counts by SES and marginalization strata. This research is part of an interprovincial study describing healthcare costs for individuals with and without COVID-19.19

Methods

We performed a retrospective matched-cohort study examining COVID-19 case counts and healthcare costs, following the Strengthening the Reporting of Observational Studies in Epidemiology/Reporting of Studies Conducted Using Observational Routinely Collected Health Data guidelines (Appendix 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.03.019).20 Costs were estimated from the perspective of the public payers, the Ontario Ministry of Health and the Ontario Ministry of Long-Term Care.

Administrative data sets held at ICES have been well described17,12,15 and are summarized in Appendix 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.03.019. These data sets were linked using unique encoded identifiers and analyzed at ICES. ICES is an independent, nonprofit research institute whose legal status under Ontario’s health information privacy law allows it to collect and analyze healthcare and demographic data, without consent, for health system evaluation and improvement.

This study was approved by the Research Ethics Board at the University Health Network, Toronto, Ontario, Canada.

Study Cohort

Individuals with a positive severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) test result from January 1, 2020, to June 30, 2020, were identified from the Ontario Laboratory Information System COVID-19 database. Their index date was defined as the date of the first positive specimen. Individuals were excluded if they had an invalid or missing OHIP number, non-Ontario residence at index date, or incomplete OHIP coverage for 1 year before the index date.

Cases were matched to individuals who had never had a positive SARS-CoV-2 test result (not tested or with negative or uncertain results) during the same date range. Controls were randomly assigned pseudoindex dates from the distribution of index dates of the cases. Cases and controls were hard matched on sex, place of residence at index date (LTC, homeless, or community), age at index date (≥5 years), calendar week of index/pseudoindex date (±1 week), and the logit of the propensity score (using a caliper of 0.1 SD). Propensity scores for a COVID-19 diagnosis were computed from 3 measures of rurality (Rurality Index of Ontario,24 Statistics Canada,25 and postal code indicator26), health-planning region (identified as Local Health Integration Network), neighborhood income quintile, Ontario Marginalization Index,27 each of the 32 John’s Hopkins’ Adjusted Clinical Groups® System version 10 aggregated diagnosis groups (ADGs),28 and resource utilization band.28 Greedy matching was used to select up to 4 controls per case. The quality of the matching was evaluated using descriptive statistics and weighted standardized differences of all variables between cases and controls.29

For each individual, we also calculated an ADG score, which assigns a positive or negative weight to each ADG that reflects the extent and direction of its association with the probability of 1-year mortality.30

We measured SES using neighborhood-level median household income and the Ontario Marginalization Index.27 They are area-level measures (dissemination areas; small geographic blocks of 400-700 individuals), grouped into quintiles, that may be used as a proxy for individual-level data. The Ontario Marginalization Index was developed using 42 variables from the Canadian Census and has been associated with health outcomes.31 It includes 4 dimensions, measured in quintiles: material deprivation (based on income, parental status, education, and employment), ethnic concentration (proportion of individuals self-identifying as a visible minority and recent immigrants), dependency (proportion of individuals aged 0-14 and 65 years and older or unemployed/unpaid), and residential instability (based on the type and density of dwellings, families, and individuals).

As per the Public Health Ontario definition,32 cases were stratified by the highest level of care received during the first 14 days after index date (community, LTC, hospital, intensive care unit [ICU]) as an indication of illness severity. Cases and controls were censored at the date of the case’s death, end of OHIP eligibility, or July 31, 2020 (end of observation period), whichever occurred first.

Estimating Costs

Costs for cases and controls were estimated using standard person-level costing methods for administrative data33,34 (Appendix 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.03.019). The costs of inpatient hospitalizations, emergency department visits, same-day surgeries, and visits to ambulatory clinics were estimated using the resource intensity weight (RIW) associated with each visit multiplied by the cost of a standard hospital stay for the year of use.35,34 The RIW includes the drugs, procedures, tests, and personnel (excluding physicians) associated with each visit. The cost of a standard hospital stay is the cost of treating an average patient at Ontario hospitals.35 Costs for physician services in inpatient, outpatient, and LTC settings were obtained from the OHIP Claims database. We included the costs of outpatient prescription drugs covered by the Ontario Drug
Benefit program for eligible individuals (aged 65 years and older, on social assistance, in LTC, receiving home care, or whose drug costs are high relative to their income). We also included costs for inpatient mental health, home care, outpatient chemotherapy, LTC, complex continuing care, and diagnostic and laboratory tests. Costs were estimated for cases and controls 30 days before and after index date. The preindex period was included to capture costs associated with investigation and treatment of COVID-19 symptoms before a positive SARS-CoV-2 test result.

We used net costs (mean difference between the cost for a COVID-19 case and those of their controls) to estimate the costs attributable to COVID-19. Mean net costs and 95% confidence intervals were obtained using generalized estimating equations to account for matching. Net attributable costs were stratified by age, sex, sociodemographic variables, rurality, and comorbidity. We used analysis of variance tests to assess the significance of the interaction between the main effects of case (case-control difference in costs) and of the strata of each covariate. A P < .05 for the

Table 1. Demographic and clinical characteristics of COVID-19 cases and matched controls at index date: case counts and percent of the Ontario population.

| Patient characteristics | COVID-19 cases (n = 28 893) | Controls (n = 115 098) | Standardized difference | Ontario population* N = 15 094 199 | COVID-19 cases (% of Ontario population) |
|-------------------------|-----------------------------|------------------------|-------------------------|-------------------------------------|------------------------------------------|
| Age (years) Mean (SD)   | 53.7 (22.7)                 | 53.6 (22.7)            | 0.00                    | n/a                                 | n/a                                      |
| Sex, n (%) Female/male  | 16 219/12 674 (56.4/43.6)  | 64 661/50 437 (56.2/43.8) | 0.00                    | 7 647 925/7 446 274 (50.7/49.3)    | 0.21/0.17                                |
| Rurality, n (%)         |                             |                        |                         |                                     |                                          |
| Urban                   | 27 911 (96.6)               | 109 596 (95.2)         | 0.07                    | 13 533 349 (10.1)                   | 0.21                                     |
| Rural/small town        | 982 (3.4)                  | 5502 (4.8)             | 0.07                    | 1 516 464 (89.9)                    | 0.06                                     |
| Neighborhood income quintile, n (%) |               |                        |                         |                                     |                                          |
| 1 (lowest)              | 8232 (28.5)                | 32 281 (28.0)          | 0.01                    | 2 967 835 (20.0)                    | 0.28                                     |
| 2                       | 6457 (22.3)                | 25 666 (22.3)          | 0.00                    | 2 950 316 (20.0)                    | 0.22                                     |
| 3                       | 5820 (20.1)                | 22 341 (19.4)          | 0.02                    | 3 041 345 (20.1)                    | 0.19                                     |
| 4                       | 4409 (15.3)                | 18 273 (15.9)          | 0.02                    | 3 049 703 (20.2)                    | 0.14                                     |
| 5 (highest)             | 3975 (13.8)                | 16 530 (14.4)          | 0.02                    | 3 040 270 (20.1)                    | 0.13                                     |
| Ontario marginalization index (missing = 0.8%) |               |                        |                         |                                     |                                          |
| Material deprivation, n (%) |                        |                        |                         |                                     |                                          |
| 1 (lowest)              | 4463 (15.4)                | 19 272 (16.7)          | 0.04                    | 3 465 679 (23.0)                    | 0.13                                     |
| 2                       | 4771 (16.5)                | 19 939 (17.3)          | 0.02                    | 3 154 361 (20.9)                    | 0.15                                     |
| 3                       | 5596 (19.4)                | 22 071 (19.2)          | 0.00                    | 2 841 160 (18.8)                    | 0.20                                     |
| 4                       | 5849 (20.2)                | 23 196 (20.2)          | 0.00                    | 2 711 123 (18.0)                    | 0.22                                     |
| 5 (highest)             | 7976 (27.6)                | 29 695 (25.8)          | 0.04                    | 2 789 108 (18.5)                    | 0.29                                     |
| Dependency, n (%)       |                             |                        |                         |                                     |                                          |
| 1 (lowest)              | 8671 (30.0)                | 30 909 (26.9)          | 0.07                    | 4 232 173 (28.0)                    | 0.20                                     |
| 2                       | 5869 (20.3)                | 22 206 (19.3)          | 0.03                    | 3 067 285 (20.3)                    | 0.19                                     |
| 3                       | 5081 (17.6)                | 19 277 (16.7)          | 0.02                    | 2 594 531 (17.2)                    | 0.20                                     |
| 4                       | 3938 (13.6)                | 16 185 (14.1)          | 0.01                    | 2 484 382 (16.5)                    | 0.16                                     |
| 5 (highest)             | 5096 (17.6)                | 25 596 (22.2)          | 0.12                    | 2 583 060 (17.1)                    | 0.20                                     |
| Residential instability, n (%) |                        |                        |                         |                                     |                                          |
| 1 (lowest)              | 5731 (19.8)                | 21 314 (18.5)          | 0.03                    | 3 326 984 (22.0)                    | 0.17                                     |
| 2                       | 4363 (15.1)                | 17 355 (15.1)          | 0.00                    | 2 843 493 (18.8)                    | 0.15                                     |
| 3                       | 4744 (16.4)                | 18 610 (16.2)          | 0.01                    | 2 709 493 (18.0)                    | 0.18                                     |
| 4                       | 5806 (20.1)                | 23 352 (20.3)          | 0.00                    | 2 663 766 (17.6)                    | 0.22                                     |
| 5 (highest)             | 8011 (27.7)                | 33 562 (29.2)          | 0.03                    | 3 417 695 (22.6)                    | 0.23                                     |
| Ethnic concentration, n (%) |                        |                        |                         |                                     |                                          |
| 1 (lowest)              | 1908 (6.6)                 | 10 016 (8.7)           | 0.08                    | 2 248 591 (14.9)                    | 0.08                                     |
| 2                       | 2854 (9.9)                 | 13 750 (11.9)          | 0.07                    | 2 404 271 (15.9)                    | 0.12                                     |
| 3                       | 4296 (14.9)                | 18 017 (15.7)          | 0.02                    | 2 636 333 (17.5)                    | 0.16                                     |
| 4                       | 5858 (20.3)                | 23 474 (20.4)          | 0.00                    | 3 191 637 (21.1)                    | 0.18                                     |
| 5 (highest)             | 13 739 (47.6)              | 48 916 (42.5)          | 0.10                    | 4 440 499 (29.7)                    | 0.31                                     |
| Place of residence, n (%) |                             |                        |                         |                                     |                                          |
| Home (community)        | 23 555 (81.5)              | 94 203 (81.8)          | 0.01                    | n/a                                 | n/a                                      |
| Homeless/shelter        | 186 (0.6)                  | 684 (0.6)              | 0.01                    | n/a                                 | n/a                                      |
| Long-term care          | 5152 (17.8)                | 20 211 (17.6)          | 0.01                    | n/a                                 | n/a                                      |
| Adjusted Diagnostic Group score |                  |                        |                         |                                     |                                          |
| Mean (SD)               | 11.3 (14.1)                | 12.3 (14.9)            | 0.07                    | n/a                                 | n/a                                      |
| Median (IQR)            | 6 (1-18)                   | 7 (1-20)               | 0.06                    | n/a                                 | n/a                                      |

IQR indicates interquartile range; n/a, not applicable.

*Chung H, Fung K, Ferreira-Legere LE, Chen B, Ishiguro L, Kalappa G, et al. COVID-19 Laboratory Testing in Ontario: Patterns of Testing and Characteristics of Individuals Tested, as of April 30, 2020. Toronto, ON: ICES; 2020.
interaction indicated that the net costs differed across strata of a covariate. All costs are reported in 2020 Canadian dollars.

Results

The cohort included 28,893 COVID-19 cases (Appendix Fig. 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.03.019) who were matched to 115,098 controls, with 98.7% of cases matched to 4 controls. Case-control matching based on propensity score was successful, with a median weighted standardized difference of 0.02 (interquartile range 0.008-0.041). The propensity score was successful, with a median weighted standardized difference of 0.02 (interquartile range 0.008-0.041). The mean (± SD) age was 53.7 ± 22.7 years, and 56.1% of cases were female. In contrast, 50.7% of the Ontario population is female. Most individuals (96.6%) lived in urban areas (as does 90% of the Ontario population), 50.8% were in the 2 lowest neighborhood-level income quintiles, and 67.8% lived in areas with high ethnic diversity (Table 1). In Ontario, 39.2% of the population are in the 2 lowest income quintiles and 50.8% live in areas with high ethnic diversity. On the date of their positive test result, 5152 patients (17.8%) lived in LTC, 186 (0.6%) were homeless or living in shelters, and 23,555 (81.6%) were residing in the community. Mean follow-up was 83.1 ± 33.5 days. Within 14 days after their diagnosis, 944 cases (3.3%) received care in the ICU, 2926 (10.1%) received non-ICU hospital care, 4478 (15.5%) remained in LTC, and 20,545 (71.1%) remained in the community.

Healthcare Costs (Total and by Resource)

During the 30-day period before the index date (including care before a positive SARS-CoV-2 test result), mean total costs were highest for cases who received their initial care in hospital (Table 2), potentially because some individuals were admitted at/ before their SARS-CoV-2 test. In the 30 days after their index date, the mean total costs were $381 for cases who received care in the community, $17,050 for hospitalized (non-ICU) cases, and $56,716 for cases hospitalized with ICU stays. Hospitalization represented 88.9% and 82.5% of total costs for hospitalized cases, without and with ICU stays, respectively. Physician services and emergency department visits accounted for 55.8% of total costs for community-managed cases. Costs for LTC comprised 79.4% of total costs for cases who remained in LTC after index date.

Case Counts and Net Per-Person Healthcare Costs

Case counts and mean net healthcare costs by demographic, clinical, and socioeconomic characteristics are summarized in Tables 1 and 3, and Appendix Table 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2022.03.019.

Demographic and Clinical Characteristics

Age, sex, and ADG score were all strongly associated with mean net attributable costs. Mean net costs for the first month after COVID-19 diagnosis generally increased with age, peaking in those aged 70 to 79 years before decreasing (P < .001). For example, in the first month after index date, costs were $2284 for cases aged 19 years and younger, $8914 for 70- to 79-year-olds, and $4784 for cases aged 80 years and older (Fig. 1A), although case counts were higher for those aged 20 to 69 years (by decade, ranging from 3619 to 5053 cases). The mean net cost for males was almost twice that for females ($4752 vs $2520, P < .001) (Fig. 1B), representing 0.21% of the male and female populations of Ontario, respectively (Table 1). Mean net costs attributable to COVID-19 varied greatly with comorbidity, increasing from $1394 for cases with ADG scores of 0-20 to $7751 for those with ADG scores of 20-40 (P < .001) (Fig. 1C). Mean net costs in the first month after index date was $3518 for cases who resided in urban areas and $2973 for rural residents (P = .20).

By SES

Case counts were disproportionately distributed across income and Ontario Marginalization Index dimensions strata (Fig. 2A-E and Table 1). There were twice as many cases residing in the lowest income areas as in the highest income areas (8232 vs 3975

| Resource-specific categories by time period | Community | LTC | Hospital | ICU |
|---------------------------------------------|-----------|-----|----------|-----|
| Day 30 to day 1                             |           |     |          |     |
| No. of cases                                | 20,545    | 4478| 2926     | 944 |
| Mean costs (SD)                             |           |     |          |     |
| Inpatient hospital                          | 39 (653)  | 153 (1517) | 2774 (8377) | 1872 (8548) |
| ED visits                                   | 27 (117)  | 11 (83)  | 238 (380)  | 194 (371) |
| Physician services (GP/FP and specialists)  | 62 (217)  | 156 (260) | 604 (1360) | 411 (1116) |
| LTC and CCC                                 | NR        | 4224 (4395) | 941 (1604) | 359 (880) |
| Total cost†                                 | 260 (1519) | 4836 (2370) | 5391 (10 016) | 3446 (10 007) |
| Mean net cost (95% CI)                      | 34 (11-57) | −748 (−846 to −650) | 3628 (3263-3995) | 2493 (1849-3136) |

Month 1

Mean costs (SD)

| Inpatient hospital                          | 38 (655)  | 169 (1312) | 14 066 (10 074) | 50 446 (34 999) |
| ED visits                                   | 79 (185)  | 28 (129)   | 474 (414)  | 551 (371) |
| Physician services (GP/FP and specialists)  | 134 (297) | 219 (351)  | 1558 (1348) | 4963 (3641) |
| LTC and CCC                                 | NR        | 3281 (1455) | 303 (909)  | 102 (461) |
| Mean total cost†                            | 381 (1393)| 4132 (2695) | 17 050 (11 103) | 56 716 (37 128) |
| Mean net cost (95% CI)                      | 161 (140-183) | −327 (−410 to −244) | 15 750 (15 354-16 147) | 56 088 (53 721-58 455) |

CCC indicates complex continuing care; CI, confidence interval; ED, emergency department; GP/FP, general practitioner/family practice; ICU, intensive care unit; LTC, long-term care; NR, not reportable because of small cell size to comply with ICES privacy rules.

*Minor resources included in the total cost but not listed separately are visits to same-day surgery clinics, cancer clinics, dialysis clinics, other ambulatory clinics, nonphysicians covered by the Ontario Health Insurance Plan, laboratory tests covered by the Ontario Health Insurance Plan, outpatient prescription drugs, home care services, New Drug Funding Program cancer chemotherapy drugs, and mental health inpatient services.
Table 3. Mean net costs during month 1 after diagnosis, stratified by case characteristics at index date.

| Case characteristics | No. of cases | Estimated mean net cost | Standard error | 95% CI (low) | 95% CI (high) | P value* |
|----------------------|--------------|-------------------------|----------------|--------------|---------------|---------|
| **Age (years)**      |              |                         |                |              |               |         |
| 0-19                 | 1337         | 248                     | 49             | 151          | 345           | < .001  |
| 20-29                | 3647         | 547                     | 75             | 401          | 694           |         |
| 30-39                | 3678         | 1064                    | 120            | 829          | 1300          |         |
| 40-49                | 4083         | 2058                    | 163            | 1739         | 2377          |         |
| 50-59                | 5053         | 4097                    | 216            | 3673         | 4520          |         |
| 60-69                | 3619         | 6827                    | 338            | 6175         | 7500          |         |
| 70-79                | 2372         | 8914                    | 418            | 8094         | 9734          |         |
| 80-89                | 3024         | 4784                    | 209            | 4374         | 5193          |         |
| ≥ 90                 | 2080         | 2576                    | 153            | 2277         | 2876          |         |
| **Sex**              |              |                         |                |              |               |         |
| Male                 | 12 674       | 4752                    | 143            | 4472         | 5033          | < .001  |
| Female               | 16 219       | 2520                    | 82             | 2360         | 2680          |         |
| **Rurality of residence (Statistics Canada)** |         |                         |                |              |               |         |
| Urban                | 27 911       | 3518                    | 79             | 3362         | 3673          | .20     |
| Rural                | 982          | 2973                    | 416            | 2158         | 3788          |         |
| **Income quintile**  |              |                         |                |              |               |         |
| 1 (lowest income)    | 8232         | 3535                    | 145            | 3252         | 3818          | .28     |
| 2                    | 6457         | 3637                    | 172            | 3299         | 3975          |         |
| 3                    | 5820         | 3251                    | 161            | 2937         | 3566          |         |
| 4                    | 4409         | 3726                    | 211            | 3313         | 4139          |         |
| 5 (highest income)   | 3975         | 3309                    | 209            | 2900         | 3718          |         |
| **Ontario Marginalization Index quintiles** |         |                         |                |              |               |         |
| Material deprivation |              |                         |                |              |               |         |
| 1 (lowest)           | 4463         | 3513                    | 197            | 3127         | 3900          | .76     |
| 2                    | 4771         | 3368                    | 187            | 3001         | 3735          |         |
| 3                    | 5596         | 3386                    | 168            | 3056         | 3716          |         |
| 4                    | 5849         | 3673                    | 185            | 3312         | 4035          |         |
| 5 (highest)          | 7976         | 3529                    | 149            | 3237         | 3820          |         |
| Dependency           |              |                         |                |              |               |         |
| 1 (lowest)           | 8671         | 3062                    | 137            | 2793         | 3331          | < .001  |
| 2                    | 5869         | 3705                    | 179            | 3354         | 4056          |         |
| 3                    | 5081         | 3227                    | 177            | 2881         | 3573          |         |
| 4                    | 3938         | 4088                    | 227            | 3642         | 4533          |         |
| 5 (highest)          | 5096         | 3828                    | 186            | 3463         | 4192          |         |
| Residential instability |              |                         |                |              |               |         |
| 1 (lowest)           | 5731         | 3622                    | 189            | 3250         | 3993          | .19     |
| 2                    | 4363         | 3361                    | 205            | 2960         | 3763          |         |
| 3                    | 4744         | 3232                    | 188            | 2863         | 3601          |         |
| 4                    | 5806         | 3380                    | 166            | 3054         | 3705          |         |
| 5 (highest)          | 8011         | 3737                    | 144            | 3455         | 4019          |         |
| Ethnic concentration |              |                         |                |              |               |         |
| 1 (lowest)           | 1908         | 3460                    | 291            | 2890         | 4030          | .59     |
| 2                    | 2854         | 3413                    | 223            | 2977         | 3849          |         |
| 3                    | 4296         | 3248                    | 192            | 2872         | 3624          |         |
| 4                    | 5858         | 3660                    | 177            | 3313         | 4006          |         |
| 5 (highest)          | 13 739       | 3538                    | 167            | 3309         | 3766          |         |
| **Place of residence at index date** |         |                         |                |              |               |         |
| Long-term care       | 5152         | 1916                    | 116            | 1688         | 2144          | < .001  |
| Homeless/shelter     | 186          | 7405                    | 1164           | 5124         | 9687          |         |
| Home (community)     | 23 555       | 3802                    | 92             | 3622         | 3981          |         |
| **Adjusted Diagnostic Group score** |         |                         |                |              |               |         |
| −40 to −20           | 55           | 1394                    | 617            | 185          | 2603          | < .001  |
| −19 to 0             | 6363         | 1648                    | 121            | 1411         | 1886          |         |
| 1−20                 | 16 666       | 3129                    | 103            | 2927         | 3332          |         |
| 21−40                | 4228         | 6151                    | 242            | 5677         | 6626          |         |
| 41−76                | 1581         | 7751                    | 399            | 6968         | 8533          |         |

CI indicates confidence interval.

*P values test the significance of the interaction between the main effects of case (case-control difference in costs) and of the strata of each covariate. A P < .05 for the interaction indicates that the net costs differed across strata of a covariate.
and 0.28% and 0.13% of the Ontario population in these areas\textsuperscript{35}. Similarly, there were twice as many cases in areas with the highest levels of material deprivation versus the lowest (7976 vs 4463, or 0.29% and 0.13% of the Ontario population in these areas\textsuperscript{35}). The largest gradient was in the ethnic concentration dimension, with 7 times as many individuals residing in areas with the highest

Figure 1. Mean net costs in the first 30 days after index date among cases: (A) by age at index date, (B) by sex, and (C) by Adjusted Diagnostic Group score at index date.

Figure 2. Mean net costs in the first 30 days after index date among cases by (A) income quintile and Ontario Marginalization Index dimension quintiles: (B) material deprivation, (C) dependency, (D) residential instability, and (E) ethnic concentration.

CAD indicates Canadian dollar.
ethnic concentration as in the lowest (13 739 vs 1908). These case numbers represent 0.35% and 0.09% of the population of Ontario residing in the highest and lowest ethnic concentration quintiles, respectively.\textsuperscript{35} Case numbers were also higher in areas with the greatest residential instability and the lowest dependency, although the distribution of cases was less linear than for other SES measures (Fig. 2C, D and Table 1).

In contrast to the differences across age, sex, and comorbidity, mean net attributable costs for cases in different quintiles of income and marginalization were remarkably similar ($P = 19.76$) (Fig. 2A-E and Table 3), with the only significant range between dependency quintiles (from $3062 to $4088 per person, $P < .001$).

Notably, although only 186 individuals experiencing homelessness were captured by the data set, they had a significantly higher mean net cost ($7405) than individuals residing in LTC or the community at index date ($P < .001$) (Table 3).

**Discussion**

In this study, we report on case numbers and the mean net per-person costs associated with COVID-19, focusing on sociodemographic and other case characteristics at the time around diagnosis. We provide robust and comprehensive population-based estimates of publicly paid healthcare costs in COVID-19 cases in Ontario, Canada, over the first wave.

**Costs and Case Counts by Sociodemographics**

On a per-person level, we observed that the mean net healthcare costs for COVID-19 were very similar across the quintiles of income and the 4 dimensions of the Ontario Marginalization Index. This contrasts with the marked differences in net cost among strata of characteristics such as age and comorbidity score. There was a 16-fold difference between the highest and lowest cost age groups, excluding those younger than 20 years of age, and a fivefold difference in costs between those with the highest and lowest comorbidity scores.

Nevertheless, although per-person costs were relatively comparable, COVID-19 case numbers (and thus total costs) were unevenly distributed across the SES strata. In particular, individuals living in low income, materially deprived, and ethnically diverse areas of Ontario comprised a larger percent of COVID-19 cases than in the general population with a sevenfold increase in areas with the highest ethnic concentration and a doubling of cases among individuals with lower income or higher material deprivation. Although other studies highlighted these observations as areas of concern within Canada and worldwide,\textsuperscript{4,6,13,14,36,37} they did not report on the costs incurred.

Homelessness is an extreme example of marginalization. Nevertheless, only 186 of our 28 893 COVID-19 cases diagnosed from January 2020 to June 30 2020 (0.6%) were identified as experiencing homelessness, thus precluding in-depth examination of the impact of homelessness in this study. This number is comparable with the 274 people with a recent experience of homelessness who had a positive test result for SARS-CoV-2 from January to July 31, 2020, in Ontario in another study.\textsuperscript{17} That study reported higher rates of hospitalization and ICU admission among individuals experiencing homelessness than among community-dwelling people. A study conducted in the pre–COVID-19 era found that the average cost of a hospitalization was approximately $1000 higher among individuals experiencing homelessness than among housed people.\textsuperscript{38} We found that the mean net cost for individuals experiencing homelessness with COVID-19 was approximately $500 higher than among all community-dwelling cases and $1500 higher than among all LTC residents. Our findings are consistent with others that, taken together, highlight the importance of addressing homelessness as one facet of marginalization.

**Marginalization and Structural Risk Factors**

We found that the largest difference in case counts was between the highest and lowest quintiles of neighborhood ethnic concentration, followed by material deprivation and income quintile. In Ontario, neighborhoods with high ethnic concentration have higher percent of low-income residents, recent immigrants (< 5 years), apartment buildings, and average number of persons per household than neighborhoods with low ethnic concentration.\textsuperscript{39} Visible minorities and immigrants to Canada represent a high proportion of the essential workforce, employed in healthcare, food service, and industrial settings, and many have a low income.\textsuperscript{40} The coexistence of these exposure risks within neighborhoods with high ethnic concentration, rather than any one factor, likely contributes to a high rate of infection.

Finally, multimorbidity has been associated with low area-level income among Ontario residents.\textsuperscript{41,42} Although we found that net costs for COVID-19 increased linearly with higher ADG comorbidity score, they were similar across income and marginalization measures.

**Policy Implications**

The unique contribution of our study is a balanced assessment of costs and case counts across sociodemographic characteristics. Based on mean per-person net attributable cost, the overall evidence suggests that healthcare provision is similar for all individuals, independent of SES. This assumes that individuals that required care were able to access care and unmeasured clinical differences outside our matching criteria are balanced between cases and controls. Nevertheless, these results appear to be consistent with Canadian values of ensuring universal healthcare coverage for all within a publicly funded healthcare system.

The uniformity of costs across groups that have substantial differences in risk and incidence of COVID-19 suggests that reducing overall healthcare system cost depends on reducing the number of cases among those groups at higher risk from COVID-19 (ie, equal per-case costs but at unequal case distributions). Therefore, this study highlights the potential role of reducing risk among those with lower SES by addressing social determinants of health\textsuperscript{11} as a strategy to reduce overall healthcare system cost. The idea of allocating resources unequally (ie, interventions specifically supporting those with low SES) to achieve equality in outcomes is the very definition of equity, a core, if elusive, value of the Canadian healthcare system.\textsuperscript{43} Examples of such strategies being considered in Canada include prioritization of vaccination to “hot spots” with high COVID-19 rates\textsuperscript{44} and provision of paid sick leave so that people do not experience financial hardship by staying at home to control spread or progression of COVID-19.\textsuperscript{17,45} These measures will have an outsized effect on the hardest-hit communities, particularly those with the most ethnic diversity, material deprivation, and lowest income, and thus address these marked inequities in case burden.\textsuperscript{17}

**Limitations**

Public Health Ontario reported 4490 more cases of COVID-19 on June 27, 2020,\textsuperscript{46} than we identified (before exclusions), because of differences between the Ontario Laboratory Information System and other data sets not available for research purposes at the time of analysis. We excluded 1248 COVID-19 cases because they did not have one full year of OHIP coverage before their index date (required for calculating ADGs) and 65 cases (0.2%) who could not...
be matched to any controls. Therefore, our sample under-represents recent immigrants and others who may have challenges accessing healthcare and have been shown to be at high risk of COVID-19, such as individuals experiencing homelessness.\textsuperscript{4,47} Additionally, the neighborhood approach to SES can result in the misclassification of individuals in measures of marginalization particularly in rural and northern settings where the geographies of each neighborhood are vast and diverse. Indigenous individuals were included in the databases used in this study but were not identified as such in the analysis. The experience of First Nations people is being addressed in a subsequent phase of study.

In addition, some COVID-19 cases might have been undetected because of restricted access to testing early in the pandemic. Our observation period covered January 2020 to July 31, 2020, which included the initial lockdown in Ontario in mid-March 2020\textsuperscript{48} and the first wave of cases. Therefore, we were unable to compare outcomes across later policy periods and waves or after vaccines were available.\textsuperscript{49}

Limitations of the cost analysis include that the RIW is based on previous years and not specific to COVID-19 diagnoses. Additionally, outpatient prescription drugs are only covered for individuals who are aged 65 years or older, residing in LTC facilities, or receiving social or home care services, or who have high drug costs relative to income, although these costs appeared to play a small role in the overall costs in the time period surrounding COVID-19 diagnosis.

Finally, a limitation of the cost analysis is the potential misclassification of costs attributable to COVID-19 (or not). For example, it may be difficult to determine whether hospitalizations are related to COVID-19. Nevertheless, we believe that we estimated the costs attributable to COVID-19 by calculating net costs of cases compared with well-matched controls. Furthermore, this limitation should be minimal immediately after diagnosis.

**Conclusions**

Our study provides concrete cost data that support the idea that "It's in everyone's best interest, no matter where you live in Ontario, to bring the hoses to where the fire is."\textsuperscript{50} The lack of differences in costs across marginalization strata coupled with the substantial differences in case volumes for these strata contributes relevant and actionable information regarding the need to reduce the risk of COVID-19 for individuals residing in areas of marginalization, to improve everyone's health and sustain the healthcare system for all who depend on it. In addition, our study provides a methodological template and estimates of healthcare costs to assess the value of interventions and policies to reduce the spread and severity of COVID-19 and to support health system planning.

**Supplemental Materials**

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jval.2022.03.019.
this material are based on data and/or information compiled and provided by Canadian Institute for Health Information (CIHI). However, the analyses, conclusions, opinions and statements expressed in the material are those of the author(s), and not necessarily those of CIHI. We thank IQVIA Solutions Canada Inc for use of their Drug Information File. We acknowledge the use of a quotation in the title. Dr Michael Warner, the director of critical care at Michael Gannor Hospital, Toronto, ON, Canada, said, on June 4, 2021, “‘We’ve never seen this before, no matter where you live in Ontario, to bring the hoses to where the fire is.’” (https://www.cp24.com/news/if-ont-wants-to-avoid-a-covid-4th-wave-allocate-more-vaccines-to-hot-spots-doctors-mayors-1-5457474).

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