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EPIDEMIOLOGY OF COVID-19 AMONG HEALTHCARE WORKERS IN ONTARIO, CANADA DURING THE FIRST PANDEMIC WAVE

Sabrina Chiodo, Emmalin Buajitti, and Laura C. Rosella
Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada
Corresponding author: Sabrina Chiodo, chio2560@mylaurier.ca

Abstract

Aim and Objectives: This study aims to describe and compare COVID-19 cases among healthcare workers, long-term care residents, and the general population in Ontario, Canada, considering baseline characteristics, trends over time, and socioeconomic status.

Methods: This study used test-confirmed COVID-19 case reports between March 13th, 2020 to June 15th, 2020, reported by Ontario’s Public Health Units to the Ontario Ministry of Health Public Health Case and Contact Management Solution (CCM). Cases were stratified into three sub-populations based on risk group characteristics identified in CCM data: healthcare workers, long-term care residents, and the general population. The residential postal codes of the cases reported to CCM were linked to area-level socioeconomic characteristics of material deprivation from the Ontario Marginalization Index (ON-MARG). Demographic characteristics and case outcomes were captured in CCM data for each case.

Results: COVID-19 cases among healthcare workers were more concentrated between working ages of 20–59 and in females, compared to the general population and long-term care cases. Additionally, hospitalization and mortality were low among healthcare workers compared to the other sub-populations. Over time, COVID-19 cases decreased among healthcare workers. For both healthcare workers and the general population, more cases were observed in areas of high material deprivation, and this disparity between high- and low-income areas increased over time.

Conclusion: Healthcare workers are a known high-risk group for COVID-19. For the surveillance of this disease, it is important to understand how they compare to other population groups regarding infection, hospitalization, and mortality. Our analysis shows clear socioeconomic gradients in the distribution of the disease. Thus, focusing our efforts on identifying and testing healthcare workers that work or live in lower socioeconomic areas would benefit the residents and workers in these areas and support the ongoing COVID-19 response.

Introduction

As of June 2020, the novel coronavirus disease 2019 (COVID-19) had spread to 213 countries. In Ontario, Canada, a state of emergency was declared in March 2020. Of particular concern and at high-risk for the disease are those at the first line of defense for the pandemic: healthcare workers.

Previous research concerning the SARS epidemic in 2003 and the H1N1 influenza pandemic in 2009 has suggested the need for increased infectious disease outbreak education among healthcare workers, improved personal protective equipment (PPE) use, and improved safety climates against respiratory pathogens. Despite historical evidence regarding the importance of protection in the healthcare worker population, healthcare workers in Ontario experienced high risk of COVID-19 infection.
early in the pandemic. Exposure to high-risk procedures and contact with unsuspected, asymptomatic patients exacerbated the spread and transmission of this disease among this population. One report from Quebec, Canada found that 40% of a sample of healthcare workers did not always wear PPE during the first weeks of the pandemic, citing a lack of suitable and good quality equipment. This lack of compliance with PPE guidelines among healthcare workers and inadequate PPE supplies at the beginning of the pandemic caused a rapid growth of infection rates. Healthcare workers, especially in departments other than infectious diseases, were unprepared for a sudden outbreak of COVID-19. A general lack of awareness and inadequate training on PPE and infectious disease control caused a surge of cases throughout this population at the beginning of the pandemic.

As the COVID-19 pandemic continues to surge across Ontario, understanding the epidemiology of COVID-19 among healthcare workers is essential to managing risk of exposure, especially among those who live and work in high-risk areas. Given documented socioeconomic and racial inequalities in the COVID-19 pandemic in Ontario, it is particularly important to characterize the socioeconomic distribution of cases among healthcare workers. Within the broad category of healthcare workers, there are numerous occupations with differing socioeconomic profiles. Sociodemographic comparisons of COVID-19 cases among healthcare workers may provide insight on health equity across the province and among specific subpopulations.

This study aims to define 1) COVID-19 trends and 2) socioeconomic characteristics and distributions among healthcare workers’ cases to further contextualize the experience of COVID-19 in Ontario and help inform the ongoing provincial response to COVID-19. Our findings may be useful in informing public health strategies and policies for future infectious outbreaks.

**Methods**

**Data sources**

This study used validated COVID-19 case reports from the Ontario Ministry of Health Public Health Case and Contact Management Solution (CCM), an information system used by Ontario’s Public Health Units for the reporting and surveillance of infectious diseases in Ontario. The data contain test-confirmed case records between March 13th, 2020 to June 15th, 2020, reported to the Ministry of Health and Long-Term Care (MOHLTC) by Public Health Units. This time period was chosen as community transmission had been identified in Ontario prior to March 13th, 2020, and June 15th, 2020 was generally around the end of the first wave of COVID-19 cases in Ontario.

Cases reported to CCM were geographically coded at the forward sortation area (FSA) level. An FSA is a geographic unit defined by the first three characters of a
residential postal code (e.g., A1A). FSAs across Ontario vary in terms of both population size and composition, ranging in size from less than 1000 residents in more rural areas, to more than 100,000 residents in more densely populated areas.

FSAs were linked to socioeconomic characteristics of material deprivation from the Ontario Marginalization Index (ON-MARG). ON-MARG is an area-level summary index, estimated using factor analysis, that categorizes multiple self-reported census variables into socioeconomic domains. Material deprivation scores include variables for education, income, unemployment, and household characteristics. Using ON-MARG data, FSAs were grouped into ranked quintiles (i.e., five equal-sized groups) of material deprivation, which were used as a measure of area-level socioeconomic status.

Demographic characteristics of age and sex were reported and gathered in CCM data for each case. Case outcomes were also ascertained from CCM data, to identify COVID-19 cases that were hospitalized, fatal, recovered, or not yet resolved as of June 15.

**Study population and definitions**

The study population included all test-confirmed COVID-19 cases reported to CCM between March 13 and June 15, 2020. Further, cases were stratified into three sub-populations based on risk group characteristics identified in CCM data: healthcare workers, long-term care residents, and the general population.

In CCM, cases are identified as healthcare workers if they are employed in any of the following occupations: healthcare worker, doctor, nurse, dentist, dental hygienist, midwife, other medical technician, personal support worker, respiratory therapist, or first responder. Cases are identified as long-term care residents if they reside in a public or private long-term care facility. For the purposes of this analysis, all other cases were defined as belonging to the general population.

**Statistical analysis**

To describe baseline characteristics of COVID-19 cases in Ontario, we summarized the study population overall and for each sub-population. Characteristics measured include demographics (age, sex), outcomes for each case (hospitalized, recovered, fatality, or not yet resolved as of June 15th), and area-based material deprivation.

To describe COVID-19 incidence over time, weekly case counts were identified based on CCM accurate onset date for each case. The accurate onset date is a proxy for date of onset, which is calculated as the earliest of several dates surveyed by CCM (including symptom onset date, specimen testing date, and case report date). Based on the weekly case counts, incidence across a total of 13 weeks was compared for all three populations.

The proportion of cases in each quintile of material deprivation was calculated to observe the socioeconomic distributions of COVID-19 cases among healthcare work-
ers and the general population. To determine whether the socioeconomic distribution of cases changed over time, the proportion of COVID-19 cases per week was stratified by material deprivation quintiles for healthcare workers and the general population. The long-term care population was omitted from this analysis, as we are using area-level socioeconomic measures; since the location of long-term care homes is not necessarily related to the socioeconomic status of their residents, we were unable to accurately stratify the long-term care population by socioeconomic status.

**Ethics approval**

This project has been approved by the University of Toronto Health Sciences Research Board (Protocol 39253).

**Results**

**Demographics**

Overall, 31,731 COVID-19 cases were reported to CCM between March 13 and June 15, 2020. Among these cases, 5,265 (16.6%) were among healthcare workers, 5,373 (16.9%) were long-term care residents, 21,093 (66.5%) belonged to the general population.

A higher proportion of COVID-19 cases occurred among healthcare workers aged 20–59, which can be interpreted as working ages, compared to cases among the general population and long-term care residents. For instance, 88% (n=4643) of cases among healthcare workers were between the ages of 20–59, whereas cases among the general population and long-term care residents had 65% (n=13,746) and 3% (n=147) of their cases within the ages of 20–59, respectively (Table 1).

Many more COVID-19 cases among healthcare workers were female than male: the percent of healthcare worker cases among females and males was 81% (n=4266) and 19% (n=985), respectively (Table 1). In comparison, COVID-19 cases among females in the general population and long-term care residents made up 45% (n=9445) and 66% (n=3464) of cases, respectively (Table 1).

Healthcare workers had a lower proportion of hospitalized cases compared to the general population and long-term care residents, with 4% (n=181) of cases resulting in hospitalization (Table 1). Among the general population and long-term care residents, 14% (n=3035) and 12% (n=623) of cases resulted in hospitalization, respectively (Table 1). Mortality was also low among healthcare workers, with only 13 COVID-19 deaths reported. In contrast, among the general population and long-term care residents, 4% (n=869) and 30% (n=1625) of cases resulted in death, respectively (Table 1).

**Cases over time**

For the general population and long-term care resident cases, the peak of cases occurred between April 10th and 16th. During this week, cases among healthcare workers, long-term care residents, and the general population made up 18% (n=734), 35% (n=1444), and 48% (n=1986) of cases, respectively (Figure 1). For
Table 1. Demographic characteristics and case outcomes of COVID-19 cases among healthcare workers, the general population, and long-term care residents from March 13th to June 15th, 2020 in Ontario.

| Variable     | Category | Healthcare Workers | General Population | Long-term Care Residents | Total |
|--------------|----------|--------------------|--------------------|--------------------------|-------|
|              |          | # of Cases         | % Cases            | # of Cases               | % Cases | # of Cases | % Cases | # of Cases | % Cases | # of Cases | % Cases |
| Age          | 0-9      | ≤5<sup>1</sup>     | --                 | 423                      | 2.0    | 0          | 0       | 425        | 1.3     |
|              | 10-19    | 55                 | 1.0                | 910                      | 4.3    | 0          | 0       | 965        | 3.0     |
|              | 20-29    | 903                | 17.2               | 3631                     | 17.2   | ≤5<sup>1</sup> | -- | 4537       | 14.3    |
|              | 30-39    | 1112               | 21.1               | 3190                     | 15.1   | 12         | 0.2     | 4314       | 13.6    |
|              | 40-49    | 1265               | 24.0               | 3227                     | 15.3   | 27         | 0.5     | 4519       | 14.2    |
|              | 50-59    | 1363               | 25.9               | 3698                     | 17.5   | 105        | 2.0     | 5166       | 16.3    |
|              | 60-69    | 516                | 9.8                | 2735                     | 13.0   | 377        | 7.0     | 3628       | 11.4    |
|              | 70-79    | 38                 | 0.7                | 1481                     | 7.0    | 966        | 18.0    | 2485       | 7.8     |
|              | 80+      | 11                 | 0.2                | 1798                     | 8.5    | 3883       | 72.3    | 5692       | 17.9    |
| Sex          | Male     | 985                | 18.8               | 11523                    | 55.0   | 1787       | 34.0    | 14295      | 45.4    |
|              | Female   | 4266               | 81.2               | 9445                     | 45.0   | 3464       | 66.0    | 17175      | 54.6    |
| Outcome      | Fatal    | 13                 | 0.2                | 869                      | 4.1    | 1625       | 30.2    | 2507       | 7.9     |
|              | Recovered| 5071               | 96.3               | 17967                    | 85.2   | 3560       | 66.3    | 26598      | 83.8    |
|              | Not Resolved | 181             | 3.4                | 2257                     | 10.7   | 188        | 3.5     | 2626       | 8.3     |
| Hospitalized | Yes      | 199                | 3.8                | 3035                     | 14.4   | 623        | 11.6    | 3857       | 12.2    |
|              | No       | 2924               | 55.5               | 7487                     | 35.5   | 2230       | 41.5    | 12641      | 39.8    |
|              | Unknown  | 2142               | 40.7               | 10569                    | 50.1   | 2520       | 46.9    | 15231      | 48.0    |

<sup>1</sup> Small cell sizes (≤5) have been suppressed.

healthcare workers, the peak of cases occurred between April 17<sup>th</sup> and 23<sup>rd</sup>. For this week, healthcare workers, long-term care residents, and the general population made up 22% (n=756), 24% (n=855), and 54% (n=1895) of cases, respectively (Figure 1). A second peak of cases occurred in the general population from May 15<sup>th</sup> to 21<sup>st</sup>.
In this week, healthcare workers, long-term care residents, and the general population made up 11% (n=294), 12% (n=302), and 77% (n=1994) of cases, respectively (Figure 1).

![Chart showing new weekly COVID-19 cases among healthcare workers, long-term care residents, and the general population from March 13th to June 15th, 2020 in Ontario, Canada.](chart)

**Figure 1.** New weekly COVID-19 cases among healthcare workers, long-term care residents, and the general population from March 13th to June 15th, 2020 in Ontario, Canada.

After the peak of cases among healthcare workers from April 17th to 23rd, incidence declined steadily over time. A 13% decrease in cases occurred from week April 17th to 23rd to June 5th to 11th. Long-term care resident cases also decreased after the peak; a 15% decrease in cases occurred from week from April 10th to 16th to June 5th to 11th. In contrast, as described above, cases in the general population did not steadily decrease over time, and there was a second peak from May 15th to 21st.

Per-capita case rates over time are given in Supplementary Table 1. Healthcare worker and general population denominators were constructed from 2016 Canadian census data, which captures healthcare workers using National Occupational Classification codes. Long-term care population denominators were based on LTC occupancy data from May 2020 supplied by the Ontario Ministry of Health; because these definitions do not align precisely with the definitions used in CCM reporting, the resultant rates should be interpreted with caution.

**Material deprivation distribution**

Overall distributions for material deprivation were similar in both the healthcare worker and general population groups, where more cases occurred in areas of high material deprivation. For healthcare workers, 17% more cases were in the most deprived regions (quintile 5) compared to the least deprived regions (quintile 1) (30% vs 13%; Figure 2). In the general population, 22% more cases were in the most deprived areas (33% vs. 11%; Figure 2). A gradient effect is evident, where the number of cases increased with each increasing quintile in material deprivation. Our findings are similar to other studies that have also documented higher COVID-19 incidence among neighborhoods with higher material deprivation in Ontario.12

Although overall distributions were similar for material deprivation in both groups, differences were evident in the highest and lowest groups. The percentage of cases in the least deprived group (Q1) was higher among healthcare workers than in the gen-
eral population: 13% and 11% of cases resided in the least deprived areas for healthcare workers and the general population, respectively (Figure 2).

![Material Deprivation Quintiles](https://via.placeholder.com/150)

**Figure 2.** Distribution of COVID-19 cases among healthcare workers and the general population, by neighbourhood socioeconomic status according to ON-MARG material deprivation quintiles from March 13th to June 15th, 2020 in Ontario, Canada.

The proportion of cases in the most deprived group (Q5), in contrast, was lower among healthcare workers compared to the general population: 30% and 33% of cases resided in the most deprived areas for healthcare workers and the general population, respectively (Figure 2). Thus, healthcare workers had a higher number of cases in the least deprived quintile (Q1), and a lower number of cases in the most deprived quintile (Q5), relative to the general population.

The per-capita distribution of COVID-19 cases among healthcare workers and the general population by material deprivation quintiles are given in Supplementary Table 2.

**Material deprivation over time**

Over time, for both healthcare workers and the general population, more new cases of COVID-19 were reported among residents living in neighborhoods with low-socioeconomic status. For the first week of data, from March 13th to 19th, 15% and 16% of new COVID-19 cases resided in the most deprived areas (Q5), for healthcare workers and the general population, respectively (Figure 3). As time went on, this proportion increased; for the week following May 22nd, 38% and 41% of new cases resided in those areas for healthcare workers and the general population, respectively (Figure 3).

Trends in material deprivation were similar among healthcare workers and general population cases until April 24th to 30th. After this date, the percentage of cases in the most deprived group (Q5) was greater for the general population compared to healthcare workers. For example, for the week of March 27th to April 2nd, the percentage of cases in the most deprived group (Q5) among healthcare workers and the general population were equal, at 23% (Figure 3). As time went on, the gap widened. For the week of May 15th to 21st, the percentage of cases in the most deprived group (Q5) among healthcare workers and
the general population was at 38% and 43%, respectively (Figure 3).

After the week of April 17th to 23rd, the percent of cases in the least deprived group (Q1) was less for the general population compared to healthcare workers. For example, for the week of March 27th to April 2nd, the percent of cases in the least deprived group (Q1) among healthcare workers and the general population were equal, at 15% (Figure 3). As time went on, the gap between the two populations widened. For the week of May 15th to 21st, the percentage of cases in the least deprived group (Q1) among healthcare workers and the general population was at 12% and 7%, respectively (Figure 3).

**Discussion**

**Key findings**

This study aimed to characterize and analyze COVID-19 cases among healthcare workers in Ontario by comparing them to cases among long-term care residents and the general population. The results showed demographic differences between healthcare workers and the two other population groups. Healthcare workers had a higher percentage of cases among women compared to the general population and long-term care cases; this is consistent with the demographics of nurses in Ontario, where 92% of nurses are female. Infection among healthcare workers occurred mainly amongst the working ages of 20–59, compared to the general population cases, where cases were distributed more evenly among all age groups. Furthermore, healthcare workers had fewer hospitalizations and a higher survival rate among their
cases compared to long-term care residents and the general population. Likewise, a report in Quebec that sampled about 37% of healthcare workers in the province found a similar hospitalization rate of 2.5%. The less severe outcomes found among healthcare workers in both provinces may be attributed to the healthy worker effect, since workers often experience lower mortality and morbidity rates than the general population. It is important to note that a large proportion of hospitalizations (33%) and fatalities (70%) among the general population was in the 80+ age category; thus, large age trends in hospitalization and fatality rates may explain the lower rates among the healthcare worker population, who are mostly younger.

Over time, weekly case counts of COVID-19 were lower for healthcare workers compared to the general population. Healthcare worker cases continued to decline from the peak on April 17th to 23rd, while the general population experienced a second peak during the week of May 15th to 21st. Although Public Health Ontario released a document for the use of personal protective equipment (PPE) for healthcare workers on March 12th, which is immediately prior to our study period, this document was revised and updated as late as May 3rd, 2020. Thus, as new information was released to healthcare workers on the use of PPE, infection control, and routes of transmission while on duty, healthcare workers, over the course of the pandemic, may have been better prepared to protect themselves from suspected or confirmed COVID-19 patients. Ontario’s efforts to better protect healthcare workers included pledging $2.8 million to local PPE producers, ramping up production of PPE, and creating multiple documents on the routes of transmission and recommendations for the use of PPE during the pandemic. As risk efforts in Ontario were more concentrated for high-risk groups, this may be why the general population experienced a second peak of cases within the study period, whereas the healthcare worker and long-term care resident population did not.

The distribution of cases across material deprivation quintiles was similar among healthcare workers and the general population; cases were more prevalent in areas of high material deprivation for both groups. This demonstrates that there are a higher number of COVID-19 cases among people living in lower socioeconomic areas, regardless of their occupation. However, marked differences occurred between the two subpopulations in the highest and lowest quintiles for material deprivation. Although the socioeconomic gradient of COVID-19 cases was strong in both populations, healthcare workers had a higher number of cases in the least deprived quintile and fewer cases in the most deprived quintile, relative to the general population. This suggests that healthcare workers may represent a modestly higher socioeconomic class compared to the general population.

**Strengths and limitations**

This study is one of the earliest to describe and compare COVID-19 cases among healthcare workers, long-term care residents, and the general population in Canada, considering baseline characteristics,
trends over time, and socioeconomic measures. We are aware of another study in Ontario that examined COVID-19 infections among healthcare workers in Ontario; however, their focus was rather on demographic, exposure, and clinical variables, with no comparison groups or socioeconomic comparison. We used province-wide, validated, and test-confirmed case reports over a period of 13 weeks. As a result, we were able to comprehensively evaluate the distribution of COVID-19 across three different sub-populations in Ontario.

The findings of this study may be limited by a non-specific definition of healthcare workers. Due to limitations in CCM data, we were not able to describe the specific risk of COVID-19 associated with each individual occupation within this category. Moreover, because the use of a broader, non-specific definition of healthcare workers leads to a wider socioeconomic distribution among the population, it is possible that the gradient we found would be different if a narrower definition was used. For example, physicians have been found to have a much lower risk of COVID-19 infection compared to nurses and personal support workers, and the majority of infections from the healthcare workers subpopulation are not physicians. However, we cannot say this definitively, and is an unverifiable assumption about the impact of the definition used. Additionally, incomplete testing across Ontario may have underestimated the incidence of cases among the general population relative to the healthcare worker population.

Our analysis in this study focuses on the high-risk group of healthcare workers who had received a positive COVID-19 test result. Among the general population, especially at the beginning of the pandemic, individuals may have only been tested for COVID-19 when experiencing severe symptoms. In contrast, healthcare workers are more likely to be tested for COVID-19 regardless of symptom severity; thus, cases among healthcare workers may include more mild cases with a lower likelihood of adverse COVID-19 outcomes compared to the general population. This selection bias may have occurred in our study when comparing outcomes between the general population and healthcare workers, and thus, the results of our study related to hospitalizations and fatalities (outcome severity) should be interpreted with caution. Finally, as Ontario health administrative data does not capture individual-level socioeconomic data, this study uses area-level socioeconomic measures to test for socioeconomic disparities among COVID-19 cases. Area-level socioeconomic status measures in Ontario have been found to have poor concordance with individual-level measures and underestimate socioeconomic inequalities in health outcomes. Thus, socioeconomic inequalities among cases described in this study may not accurately reflect the association between individual-level socioeconomic experiences and COVID-19.

Implications

Healthcare workers, who are at the very front line of COVID-19 response, are a known high-risk group for the disease.
Hospital-linked transmission is a significant route of spreading COVID-19, and thus, it is important to characterize cases of this high-risk group for better surveillance of this disease.\(^9\) Going forward, Ontario has released a COVID-19 management strategy, where they outline their ongoing efforts to stop the spread of COVID-19 and continue to protect high-risk and vulnerable groups, such as healthcare workers.\(^{25}\)

Our analysis shows clear socioeconomic gradients in the distribution of this disease in the specific subpopulation of healthcare workers, as well as in the general population. Thus, focusing our efforts on identifying and testing healthcare workers that work or live in lower socioeconomic areas would benefit both the workers themselves and the residents they care for, helping to slow the spread of COVID-19.

Competing interests
None declared.

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