

# Physical, Psychological, and Cognitive Profile of Post-COVID Conditions in Healthcare Workers, Quebec, Canada

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**Background.** The prevalence of post-COVID conditions (PCC) and associated physical, psychological, and cognitive symptoms was assessed among Quebec healthcare workers (HCWs) with coronavirus disease 2019 (COVID-19).

**Methods.** This case-control study compared 6061 symptomatic HCWs with polymerase chain reaction–confirmed COVID-19 between July 2020 and May 2021 with a random sample of 4390 symptomatic HCWs who were test-negative controls. The prevalence of physical symptoms lasting  $\geq 4$  weeks (PCC4w) or  $\geq 12$  weeks (PCC12w) was estimated among hospitalized and nonhospitalized cases. In multivariate models, sociodemographic and clinical characteristics, as well as vaccine history, were evaluated as potential risk factors. Prevalence ratios compared 4 aspects of self-reported cognitive dysfunction among PCC cases to controls, adjusting for psychological distress and fatigue.

**Results.** PCC4w and PCC12w prevalences of 46% (2746/5943) and 40% (653/1746), respectively, were observed among nonhospitalized cases and 76% (90/118) and 68% (27/37), respectively, among hospitalized cases. Hospitalization, female sex, and age were associated with higher PCC risk. A substantial proportion of nonhospitalized PCC4w cases often or very often reported cognitive dysfunction, including concentration (33%) or organizing (23%) difficulties, forgetfulness (20%), and loss of necessary items (10%). All 4 aspects of cognitive dysfunction were associated with PCC4w symptoms, psychological distress, and fatigue.

**Conclusions.** PCC may be a frequent sequela of ambulatory COVID-19 in working-age adults, with important effects on cognition. With so many HCWs infected, the implications for quality healthcare delivery could be profound if cognitive dysfunction and other severe PCC symptoms persist in a professionally disabling way. Further evaluation of PCC prevalence and prognosis is warranted.

**Keywords.** cognitive dysfunction; healthcare workers; post-COVID conditions; SARS-CoV-2.

The coronavirus disease 2019 (COVID-19) pandemic qualifies as the most disruptive global health crisis in recent history. The persistence of symptoms long after the acute phase of the

disease, as reported in a substantial proportion of cases, would add to and extend the already serious burden of this pandemic.

The Centers for Disease Control and Prevention (CDC) has defined post-COVID conditions (PCC) as a wide range of physical and mental health problems persisting  $\geq 4$  weeks after severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection [1]. In October 2021, to improve specificity of this heterogeneous condition and to better represent its potentially prolonged effects, the World Health Organization (WHO) defined PCC as the persistence or relapsing of symptoms at least 12 weeks after the onset of COVID-19 without alternative diagnosis [2].

The prevalence, risk factors, and duration of PCC are still poorly understood. Systematic reviews have reported persistent symptoms among 61% (4–12 weeks), 53% (>12 weeks), or 73%

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(>60 days) of COVID-19 patients [3, 4]. However, hospitalized patients were overrepresented and the reviewed evidence had low certainty due to methodological limits as self-selection bias. Robust and valid estimates of the PCC burden are needed, particularly for nonhospitalized COVID-19 cases who comprise the vast majority of SARS-CoV-2 illness.

While PCC includes a large array of symptoms, neurocognitive symptoms are among the most frequent and debilitating [3, 5]. Large-scale epidemiological quantification of memory, concentration, and executive dysfunction in PCC cases is still lacking. In particular, the contribution of PCC to cognitive dysfunctions needs to take into account the potential separate contributions of fatigue and psychological distress, which are known to have deleterious effects on cognitive abilities [6, 7] and were highly prevalent among healthcare workers (HCWs) in the context of the additional enormous workload caused by the pandemic.

During the second and third waves of the COVID-19 pandemic in Quebec, Canada, a large survey was conducted to evaluate workplace exposure, infection risk, and prevention measures among SARS-CoV-2 infected (cases) and noninfected (controls) HCWs, but data were also collected on the persistence of COVID-19 symptoms at the time of completion of the questionnaire [8]. In the substudy reported here we estimated (1) the prevalence and risk factors for persistent COVID-19 physical symptoms 5–28 weeks after acute illness onset among a cohort of predominantly nonhospitalized HCWs, and (2) the contribution of PCC, fatigue, and psychological distress on persistent neurocognitive symptoms, comparing PCC cases to noninfected controls.

## METHODS

### Study Design and Population

A survey-based retrospective cohort study was conducted. It included HCWs of the province of Quebec tested due to COVID-19-compatible symptoms between 12 July 2020 and 29 May 2021 whose polymerase chain reaction (PCR) test was positive for SARS-CoV-2. Participants needed to be aged  $\geq 18$  years, speak English or French, have worked during the 14 days before their illness, and have completed the survey at least 5 weeks after illness onset or testing. To evaluate cognitive and psychological manifestations, a case-control design was used. Non-COVID-19 controls, recruited only in a second phase of the survey, were a random sample of HCWs tested for COVID-19-compatible symptoms between 14 November 2020 and 29 May 2021, but who were PCR negative and not previously infected.

### Data Collection and Main Variables

Contact information on SARS-CoV-2-infected HCWs and controls was obtained from the provincial COVID-19 and

SARS-CoV-2 laboratory databases, which together contain all confirmed cases reported to public health and all PCR-tested individuals since the beginning of the pandemic.

HCWs were called (85% of all test-positive cases and 95% of all randomly selected controls due to research team logistic constraints) between 3 December 2020 and 31 July 2021. Those reached were invited to participate in a survey aimed to identify workplace prevention and control measures of COVID-19. If eligibility criteria were met, consenting participants were asked to complete a standardized 30-minute online (97%) or phone (3%) questionnaire collecting sociodemographic data, employment characteristics, workplace exposures and prevention measures, clinical data, and COVID-19 vaccination status ([Supplementary Material](#)). HCWs were offered vaccination in Quebec beginning 14 December 2020.

Clinical questions to all SARS-CoV-2-infected HCWs included symptom onset and sick leave dates, hospitalization  $\geq 24$  hours due to COVID-19, and number of weeks until full recovery. Among cases not completely recovered at the time of the survey, information was sought about the presence and severity (mild, moderate, or severe) of 15 physical symptoms at the time of the survey, including fatigue, fever, shortness of breath, cough, wheezing, chest pain, headache, difficulty walking, loss of smell, loss of taste, joint or muscle pain, abdominal pain, diarrhea, sore throat, and runny nose. Persistent physical symptoms were not assessed among test-negative controls.

Self-reported appraisal of 4 aspects of cognitive dysfunction present at the time of the survey were queried in all participants: (1) difficulty concentrating or maintaining attention; (2) difficulty organizing oneself; (3) forgetting things; and (4) losing necessary items. Answers given on a 5-level Likert scale (never, rarely, sometimes, often, or very often), were considered positive if the problem occurred often or very often, due to low numbers of some categories. Psychological distress, which is also associated with cognitive dysfunction and/or PCC, was assessed at the moment of the survey with the validated Kessler Psychological Distress Scale, or K6 (0–24). This scale evaluates the frequency, during the preceding month, of feeling nervous, hopeless, restless, depressed, worthless, and that everything was an effort. A score of 7–12 indicates high psychological distress and of  $>12$  a very high level of psychological distress [9].

### Post-COVID Condition Definition

PCC was defined as the persistence of any of the 15 investigated physical symptoms following an acute COVID-19 disease either  $\geq 4$  weeks (PCC4w) or  $\geq 12$  weeks (PCC12w), similar to the definitions used by the CDC and WHO, respectively [1, 2]. The duration of symptoms was estimated considering the dates of survey completeness and illness onset. For example, the prevalence of PCC4w cases was calculated as the number of HCWs with persistent symptoms at the time of the survey

among those who filled the survey >4 weeks after illness onset. This prevalence was similarly calculated for PCC4w and PCC12w with  $\geq 1$  severe symptom.

To estimate temporal patterns, the prevalence of symptoms was calculated among participants answering the survey at each interval from their illness onset (5–8, 9–12, 13–16, 17–20, 21–24, and 25–28 weeks).

To evaluate the contribution of COVID-19 to the reported persistent physical, cognitive, and psychological symptoms, PCC cases and prevalence were defined based on physical symptoms.

### Statistical Analysis

Prevalence and binomial 95% confidence intervals (CIs) were estimated. The 4-weekly prevalence trend over time for each symptom was assessed using a Cochran-Armitage test. The correlation between symptoms was explored using the Spearman correlation coefficient.

To estimate prevalence ratios (PRs) measuring the total association between PCC, sociodemographic characteristics, vaccination status, and hospitalization with PCC, 3 log-binomial models were built: (1) evaluating only sociodemographic characteristics; (2) evaluating vaccination status adjusted for sociodemographic characteristics; and (3) evaluating hospitalization adjusted for sociodemographic characteristics and vaccination status [10].

The association between cognitive dysfunction and PCC, psychological distress, and fatigue was assessed with PRs using robust Poisson comparing PCC4w cases with SARS-CoV-2 test-negative controls, adjusting for sociodemographic characteristics.

Analysis were performed using SAS version 9.4 software (SAS Institute).

### Patient Consent Statement

All participants gave verbal consent during the phone contact and electronic consent at the beginning of the survey. This study was approved by the research ethics committee of the Centre hospitalier universitaire de Québec–Université Laval.

## RESULTS

### Population

Of the 31 091 HCWs infected with SARS-CoV-2 in Quebec during the study period, 26 548 were called and 17 717 were reached (Figure 1). Inclusion criteria were not met by 549 (3%), 3485 (20%) refused to participate, and 5791 (33%) did not complete the questionnaire (missing data on clinical and/or demographic variables). Among those who answered the questionnaire, 1831 were excluded: 140 answered the survey within 4 weeks from illness onset, 1188 had asymptomatic infection, and 503 reported symptoms lasting  $\geq 4$  weeks but

had recovered at the time of the survey and were not queried about which symptom(s) persisted at least 4 weeks.

SARS-CoV-2-infected participants and nonparticipants were comparable with regard to sex (79.0% vs 77.6% of women), age distribution (48.4% vs 49.4% aged <40 years), and disease severity (1.2% vs 0.9% hospitalized and 0.4% vs 0.4% admitted to intensive care), according to data available in the centralized provincial database (data not shown).

The PCC4w analysis included 6061 HCWs with COVID-19, of whom 118 (2%) had been hospitalized and 5943 (98%) were nonhospitalized cases. The PCC12w analysis included 1783 HCWs (37 [2%] hospitalized and 1746 [98%] nonhospitalized).

For controls, 20 770 were called and 11 498 were reached. Among them, 1243 (11%) did not meet inclusion criteria, 2527 (22%) refused to participate, and 3338 (29%) did not complete the survey, resulting in 4390 controls for the analysis (Figure 1).

Compared to all SARS-CoV-2-infected HCWs reported provincially, case-participants were similar for sex (78% vs 79% women), age distribution (49% vs 48% aged <40 years), and percentage hospitalized (0.9% vs 1.2%).

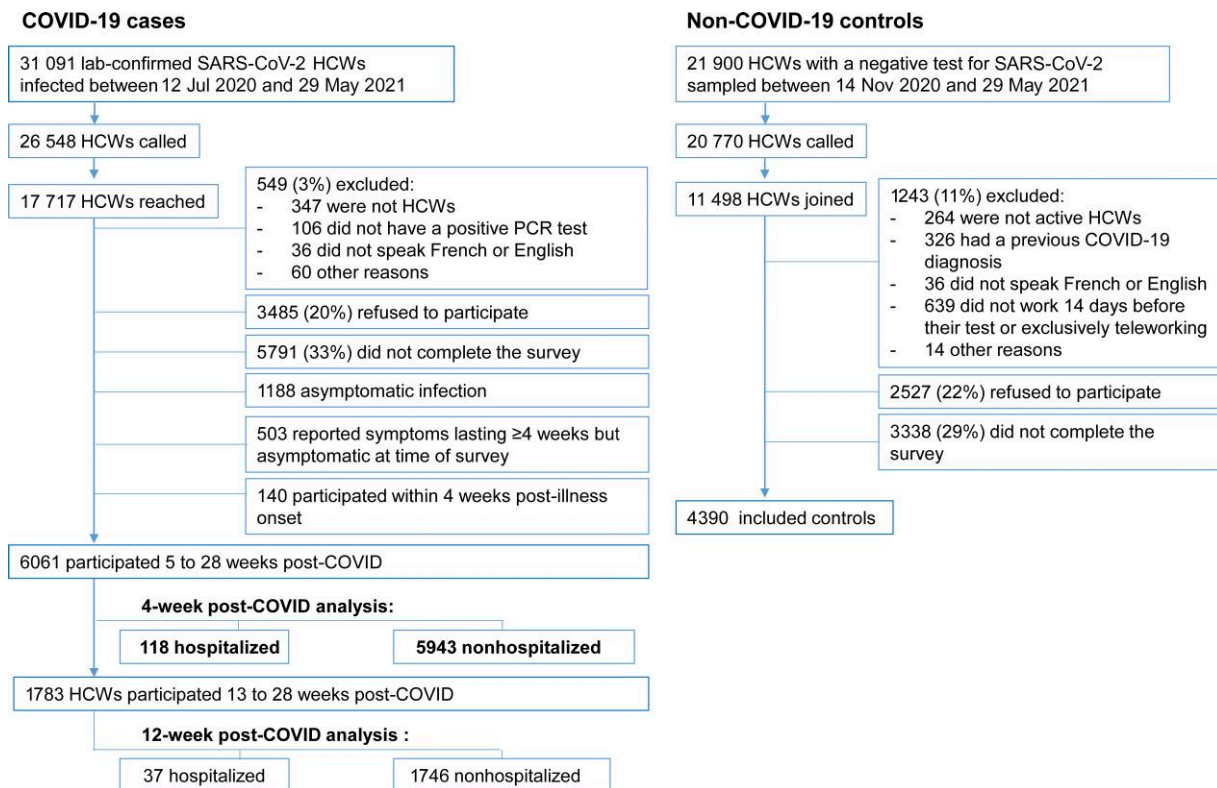
Both hospitalized and nonhospitalized COVID-19 cases completed the questionnaire on average 10 weeks (median, 9 weeks [range, 5–35 weeks]) after illness onset. Compared to SARS-CoV-2-infected participants, controls were younger and more likely to be female, White, and working in occupations without direct patient care (Table 1).

### Prevalence and Symptoms of PCC

Overall, 46.2% (95% CI, 45.0%–47.5%) of the nonhospitalized COVID-19 cases reported symptoms persisting  $\geq 4$  weeks (17.4% with at least 1 severe symptom), and 39.9% (95% CI, 38.3%–41.5%) had symptoms persisting  $\geq 12$  weeks. Among hospitalized COVID-19 cases, 76.3% (95% CI, 67.1%–82.5%) reported symptoms persisting  $\geq 4$  weeks (39.8% with  $\geq 1$  severe symptom) and 67.6% (95% CI, 57.7%–79.1%) had symptoms persisting  $\geq 12$  weeks (35.1% with  $\geq 1$  severe symptom) (Supplementary Table 1).

Persistent post-COVID-19 symptom prevalence among nonhospitalized cases decreased from 49.6% for HCWs reporting symptoms at 4–7 weeks post-COVID-19 onset to 36.6% at 24–27 weeks (trend test:  $P < .001$ ). The proportion with  $\geq 1$  severe symptom (18.7% to 13.6%) showed little decline with time from illness onset (trend tests:  $P = .93$ ) (Figure 2).

Among nonhospitalized and hospitalized cases, the most frequent symptoms lasting  $\geq 4$  weeks were fatigue (30% vs 64%), loss of smell or taste (20% vs 17%), shortness of breath (20% vs 56%), cognitive dysfunction (15% vs 33%), headache (13% vs 23%), and joint and muscular pain (10% vs 22%) (Figure 3). Symptoms more often rated as severe were loss of smell/taste, fatigue, and headache among nonhospitalized, and shortness of breath, headache, and joint and muscular



**Figure 1.** Flowchart of study population. Abbreviations: COVID-19, coronavirus disease 2019; HCW, healthcare worker; PCR, polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

pain among hospitalized cases (Figure 3). Among cases with persistent post-COVID-19 fatigue, 99% also reported pre-COVID-19 fatigue; the level of fatigue, however, was rated as mild by 84% pre-COVID-19 and moderate (63%) or severe (28%) post-COVID-19. The overall prevalence of these symptoms slowly decreased over time, but the prevalence of severe symptoms barely changed (Figure 3 and Supplementary Table 2).

The correlation between symptoms was generally greater for symptoms of the same system (Supplementary Table 3). Loss of smell/taste was the only symptom negatively or not correlated with any other symptom.

#### Self-Reported Cognitive Dysfunctions and Psychological Distress

The prevalence of self-reported difficulty concentrating, difficulty organizing oneself, forgetfulness, and loss of necessary items often or very often was 33%, 23%, 20%, and 10%, respectively, among nonhospitalized PCC4w cases, compared to 39%, 28%, 34% and 15% among hospitalized PCC4w cases (Figure 4). These impairments were no less frequent when considering the 12-week definition.

All 4 aspects of cognitive dysfunction were at least twice as frequent in PCC4w cases as in non-COVID-19 controls or in COVID-19 cases without physical persistent symptoms

(Figure 4). In contrast, psychological distress was similarly reported as high or very high by PCC4w cases than by cases without PCC or by non-COVID-19 controls.

In multivariable models all aspects of cognitive dysfunction were associated with PCC4w, psychological distress, and fatigue (Table 2). They steadily increased with the level of psychological distress and the severity of fatigue (Supplementary Table 4 and Supplementary Figure 1). Difficulty concentrating, difficulty organizing oneself, forgetfulness, and losing necessary items were 2–3 times more common in PCC4w cases compared to non-COVID-19 controls; and 4–5 times more prevalent in individuals with very high psychological distress compared to those without distress. The 4 aspects of cognitive dysfunction were 3–4 times more frequent in those with severe fatigue compared to those without fatigue (Table 2).

#### Risk Factors for PCC

PCC prevalence was higher in hospitalized compared to non-hospitalized acute COVID-19 cases, in those aged  $\geq 40$  years, and in females (Table 3, Supplementary Table 5, and Supplementary Figure 2). Only 4% of cases had been vaccinated with at least 1 dose  $\geq 14$  days before illness onset, and their risk compared to unvaccinated cases was lower for PCC4w (PR, 0.8

**Table 1. Characteristics of Participants and Comparison Groups, Quebec Healthcare Workers**

Characteristics	Type of Participants		
	Symptomatic Hospitalized COVID-19 HCWs	Symptomatic Nonhospitalized COVID-19 HCWs	Non-COVID-19 HCWs (Controls)
Total No.	118	5934	4390
Weeks from illness onset or testing to study participation, mean ± SD	10.3 ± 4.5	10.2 ± 4.3	9.9 ± 3.5
Age, y, mean ± SD	46.7 ± 11.9	40.0 ± 12.1	39.0 ± 10.4
18–29	12 (10.2)	1410 (23.7)	807 (18.4)
30–39	21 (17.8)	1547 (26.0)	1750 (39.9)
40–49	30 (25.4)	1550 (26.1)	1045 (23.8)
50–59	39 (33.1)	1102 (18.5)	608 (13.9)
60–80	16 (13.6)	334 (5.6)	180 (4.1)
Sex, female	83 (70.3)	4704 (79.2)	3819 (87.0)
Race/ethnicity			
White	81 (68.6)	4713 (79.3)	3995 (91.0)
Black	8 (6.8)	482 (8.1)	103 (2.4)
Hispanic	10 (8.5)	163 (2.7)	68 (1.6)
Arab	8 (6.8)	176 (3.0)	78 (1.8)
Asian	2 (1.7)	141 (2.4)	56 (1.3)
Other/no response	9 (7.6)	268 (4.5)	90 (2.1)
Occupation			
Physician	2 (1.7)	241 (4.1)	221 (5.0)
Nurse	20 (17.0)	1118 (18.8)	900 (20.5)
Nurse assistant	15 (12.7)	469 (7.9)	222 (5.1)
Patient healthcare assistant	40 (33.9)	1526 (25.7)	523 (11.9)
Housekeeping	5 (4.2)	197 (3.3)	40 (0.9)
Administration/manager	13 (11.0)	591 (9.9)	618 (14.1)
Psychosocial worker	5 (4.2)	197 (3.3)	397 (9.0)
Other	18 (15.3)	1585 (26.7)	1469 (33.5)
Vaccination status			
Unvaccinated	114 (96.6)	5484 (92.3)	2980 (67.9)
1 dose 0–13 d before illness onset	2 (1.7)	230 (3.9)	280 (6.4)
1 dose ≥14 d before illness onset	2 (1.7)	216 (3.6)	926 (21.1)
2 doses	0 (0.0)	13 (0.2)	204 (4.7)

Data are presented as No. (%) unless otherwise indicated.

Abbreviations: COVID-19, coronavirus disease 2019; HCW, healthcare worker; SD, standard deviation.

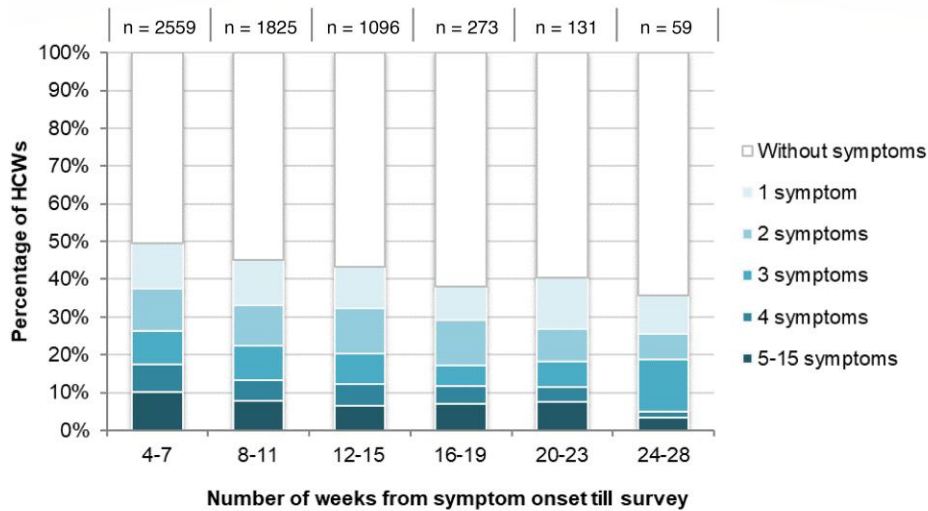
[95% CI, .7–.9]), but not PCC12w (PR, 0.9 [95% CI, .7–1.1]), although sample size was limited (Supplementary Table 5).

## DISCUSSION

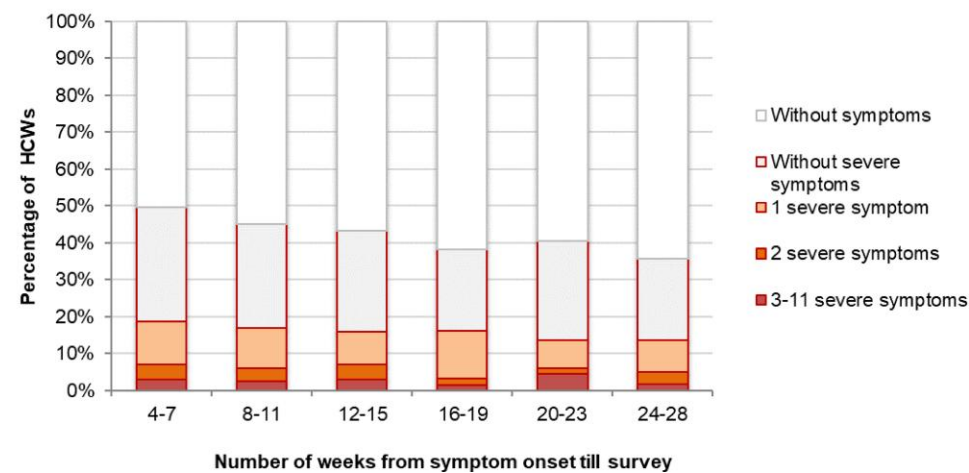
This study included >6000 hospitalized and nonhospitalized COVID-19 cases, representative of all laboratory-confirmed HCWs in Quebec, to estimate the prevalence of PCC using clinical information at the moment of the survey (completed 5–28 weeks after illness onset). COVID-19 symptoms persisting ≥4 weeks were reported by about three-quarters (76%) of hospitalized and nearly half (46%) of nonhospitalized COVID-19 cases with little decline at ≥12 weeks. Self-reported cognitive dysfunctions were highly prevalent and 2–3 times more frequent in PCC4w cases than controls, but were also strongly associated with psychological distress and fatigue.

Similar to our results, a meta-analysis of 63 studies estimated that 61% of laboratory-confirmed COVID-19 cases had symptoms lasting 4–12 weeks and 53% had symptoms lasting >12 weeks [3]. Most included studies were among hospitalized patients, had smaller sample size (between 58 and 1733 participants), and were at moderate or high risk of bias mainly due to participant selection and poor validity of outcome measures, according to the authors. Other studies among nonhospitalized patients have reported highly variable PCC prevalences, ranging from 13% to 44% for symptoms lasting ≥4 weeks [11–13], 5% to 35% for symptoms lasting ≥8 weeks [11, 13, 14], and 14% to 64% for symptoms lasting 5–8 months [15–21]. The estimation of PCC prevalence is limited by the difficulty in obtaining a representative sample of cases with participation and attrition being highly influenced by the persistence of symptoms [17, 22]. Our large cohort is likely representative of all HCWs with laboratory-

**A** Proportion of HCWs reporting 1 to 15 symptoms



**B** Proportion of HCWs reporting 1 to 11 severe symptoms



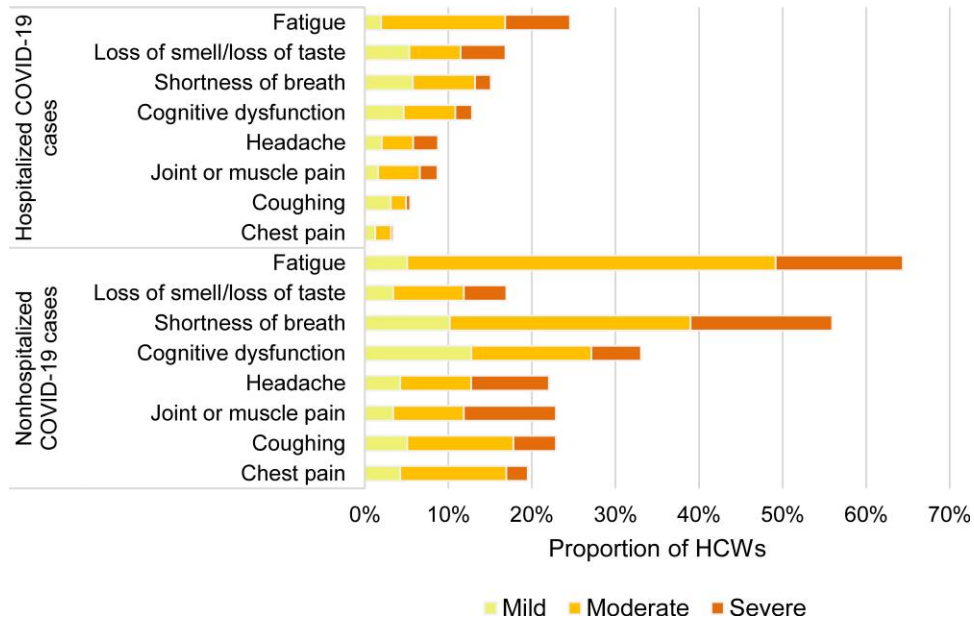
**Figure 2.** Distribution of the number of symptoms (A) and number of severe symptoms (B) reported by nonhospitalized healthcare workers, by time from coronavirus disease 2019 illness onset to survey. Abbreviation: HCW, healthcare worker.

confirmed COVID-19 in the province of Quebec, and self-selection based on symptom persistence may be limited because original recruitment was for a broader study of workplace exposure and prevention, nor PCC.

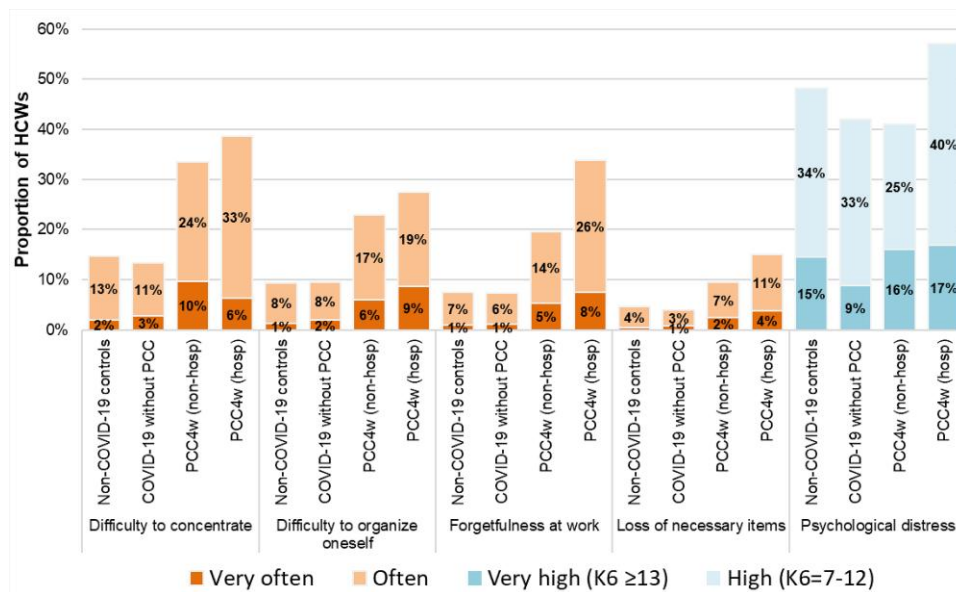
A staggering >100 physical, cognitive, and psychological symptoms have been reported in PCC cases [23]. Similar to our findings, several literature reviews found that fatigue, respiratory symptoms, and cognitive and mental health issues were most frequently reported [3, 22, 24–26]. Memory impairment, brain fog, poor attention, or difficulty thinking have been reported by other authors in 22%–88% of patients with lasting symptoms [5, 25, 27, 28], but these prevalences did not take into consideration the contribution of mood disorders or fatigue, highly associated with cognitive abnormalities and also features of PCC [6, 7]. Objectively measured cognitive deficits

were reported among 46 patients 6 months after severe COVID-19, independent of mental health and fatigue [29]. We similarly observed that the prevalence of cognitive symptoms was 2–3 times higher among patients with PCCs compared to non-COVID-19 HCWs, whose baseline prevalence was as high as 14%.

While some studies found that COVID-19 patients frequently reported anxiety or depression [22, 24, 30], a systematic review including 33 studies found similar rates of anxiety or depression in the general population [31]. In our study, very high psychological distress, which is strongly associated with anxiety and depression [32, 33], was similarly common among PCC cases and controls and likely related to other work-related psychosocial risks and stressors afflicting HCWs during the pandemic [34]. The prognosis of these



**Figure 3.** Prevalence and severity of the main symptoms still present  $\geq 4$  weeks after illness onset reported by nonhospitalized (A) and hospitalized (B) healthcare workers with coronavirus disease 2019. Cognitive dysfunction defined as self-reporting often or very often presenting difficulty to concentrate or maintain attention, difficulty to organize oneself, forgetting things, or losing necessary items among those who did not present with these dysfunctions before being infected with severe acute respiratory syndrome coronavirus 2. Abbreviations: COVID-19, coronavirus disease 2019; HCW, healthcare worker.



**Figure 4.** Prevalence of self-reported cognitive dysfunctions and psychological distress among non-coronavirus disease 2019 (COVID-19) controls, COVID-19 cases without post-COVID conditions (PCC), and nonhospitalized and hospitalized cases with PCC, among Quebec healthcare workers. Abbreviations: COVID-19, coronavirus disease 2019; HCW, healthcare worker; hosp, hospitalized; K6, Kessler Psychological Distress Scale; non-hosp, nonhospitalized; PCC, post-COVID conditions; PCC4w,  $\geq 4$ -week post-COVID conditions; PCC12w,  $\geq 12$ -week post-COVID conditions.

cognitive dysfunctions is unknown, but the lack of decline in prevalence over 4–28 weeks is worrisome. If persisting over the long term, this not infrequent sequela of COVID-19 could

become both personally and professionally impactful on a significant scale among the highly infected population of HCWs. Our study also underscores the significant impact of fatigue

**Table 2. Prevalence of Cognitive Dysfunctions by Clinical Status (Cases with ≥4-Week Post-COVID Conditions and Non-Coronavirus Disease 2019 Controls), Psychological Distress Level, Fatigue Level, and Demographic Characteristics and Adjusted Prevalence Ratios Among Quebec Healthcare Workers (N = 6962)**

Evaluated Expositions	Cognitive Dysfunction											
	Difficulty Concentrating <sup>a</sup>			Difficulty Organizing Oneself <sup>a</sup>			Forgetfulness <sup>a</sup>			Loss of Necessary Items <sup>a</sup>		
	Prevalence, %	aPR <sup>b</sup>	(95% CI)	Prevalence, %	aPR <sup>b</sup>	(95% CI)	Prevalence, %	aPR <sup>b</sup>	(95% CI)	Prevalence, %	aPR <sup>b</sup>	(95% CI)
PCC												
Non-COVID-19 controls	14.6	ref	...	9.3	ref	...	7.6	ref	...	4.7	ref	...
≥4-week PCC cases	33.4	2.6	(2.4-2.8)	23.1	2.8	(2.5-3.1)	20.0	3.0	(2.6-3.4)	9.8	2.2	(1.9-2.7)
Psychological distress												
No (K6 <7)	8.1	ref	...	4.7	ref	...	4.1	ref	...	2.3	ref	...
High (K6 = 7-12)	24.1	2.4	(2.1-2.8)	15.9	2.7	(2.3-3.3)	13.7	2.7	(2.2-3.4)	7.3	<b>2.4</b>	(1.8-3.1)
Very high (K6 ≥13)	53.8	4.6	(4.0-5.3)	38.1	5.6	(4.6-6.7)	31.5	5.2	(4.2-6.4)	17.2	4.3	(3.2-5.8)
Fatigue												
No or mild	10.0	ref	...	6.7	ref	...	5.7	ref	...	2.6	ref	...
Moderate	21.1	1.8	(1.6-2.1)	13.2	1.7	(1.4-2.0)	10.8	1.7	(1.4-2.0)	6.0	2.0	(1.5-2.7)
Severe	47.0	2.8	(2.4-3.2)	33.8	2.9	(2.5-3.5)	29.9	3.1	(2.6-3.8)	16.7	3.8	(2.8-5.1)
Sex												
Male	15.8	ref	...	11.3	ref	...	9.7	ref	...	4.0	ref	...
Female	22.6	1.2	(1.1-1.4)	14.9	1.2	(1.0-1.4)	12.6	1.2	(1.0-1.4)	7.0	1.5	(1.1-2.0)
Age, y												
18-29	22.9	ref	...	15.1	ref	...	11.4	ref	...	8.0	ref	...
30-39	19.5	1.0	(.9-1.1)	13.5	1.1	(.9-1.3)	11.7	1.3	(1.1-1.5)	6.2	0.9	(.7-1.2)
40-49	24.6	1.1	(1.0-1.3)	15.7	1.1	(.9-1.3)	13.7	1.2	(1.0-1.5)	6.5	0.8	(.7-1.1)
50-59	22.2	1.0	(.9-1.2)	15.1	1.1	(.9-1.3)	12.9	1.2	(1.0-1.5)	6.6	0.9	(.7-1.2)
60-80	12.8	0.8	(.4-1.0)	7.7	0.7	(.5-1.0)	6.3	0.8	(.5-1.1)	4.2	0.7	(.4-1.3)

Abbreviations: aPR, adjusted prevalence ratio; CI, confidence interval; COVID-19, coronavirus disease 2019; K6, Kessler Psychological Distress Scale; PCC, post-COVID condition; ref, reference category.

<sup>a</sup>For each manifestation, “yes” corresponds to a reported current frequency of often or very often.

<sup>b</sup>Robust Poisson regression models adjusted for sex, age (5 categories: 18-29, 30-39, 40-49, 50-59, ≥60 years), race/ethnicity (6 categories: White, Black, Hispanic, Arab, Asian, other), occupation (8 categories: physician, nurse, nurse assistant, patient healthcare assistant, housekeeping, administration/management, psychosocial worker, other), fatigue (3 categories: none or mild, moderate, severe), and psychological distress (3 categories: no, <7, high, 7-12, very high, ≥13 in the Kessler scale).



**Table 3. Risk Factors for Post-COVID Conditions Among Coronavirus Disease 2019 Healthcare Workers in Quebec, According to Varying Case Definitions (Multivariable Log-Binomial Regression Model)**

Risk Factor	PCC Definition					
	≥4-Week PCC (Any Symptom)		≥4-Week PCC-S (≥1 Severe Symptom)		≥12-Week PCC (Any Symptom)	
	(n = 6061)		(n = 6061)		(n = 1783)	
	PR	(95% CI)	PR(n = 6061)	(95% CI)	PR	(95% CI)
<b>Model 1: sociodemographic variables</b>						
Age, y (ref = 18–29 y)						
30–39	1.2	(1.1–1.3)	1.1	(.9–1.3)	1.2	(1.0–1.5)
40–49	1.4	(1.3–1.5)	1.4	(1.2–1.7)	1.5	(1.3–1.8)
50–59	1.4	(1.2–1.5)	1.3	(1.1–1.5)	1.3	(1.0–1.5)
60–80	1.3	(1.1–1.5)	1.1	(.8–1.4)	1.2	(.9–1.6)
Sex (ref = male)						
Female	1.2	(1.1–1.3)	1.5	(1.3–1.7)	1.1	(1.0–1.3)
Race/ethnicity (ref = White)						
Black	0.7	(.6–.8)	0.7	(.5–.9)	0.6	(.5–.8)
Hispanic	0.9	(.7–1.0)	1.0	(.8–1.4)	0.8	(.6–1.2)
Arab	0.7	(.6–.9)	0.8	(.5–1.1)	0.8	(.6–1.1)
Asian	0.7	(.6–.9)	0.7	(.4–1.0)	0.9	(.6–1.4)
Other/no response	1.0	(.9–1.1)	1.1	(.9–1.4)	1.0	(.8–1.3)
Occupation (ref = admin)						
Physician	0.7	(.6–.9)	0.6	(.4–.9)	0.8	(.5–1.1)
Nurse	1.0	(.9–1.1)	1.1	(.9–1.3)	0.9	(.7–1.1)
Nurse assistant	1.1	(1.0–1.2)	1.4	(1.1–1.7)	1.0	(.8–1.3)
Patient healthcare assistant	1.0	(.9–1.1)	1.2	(1.0–1.5)	0.9	(.8–1.1)
Housekeeping	1.0	(.8–1.2)	1.1	(.8–1.6)	0.8	(.5–1.2)
Psychosocial worker	1.0	(.8–1.2)	0.8	(.5–1.1)	0.9	(.7–1.2)
Other	0.9	(.8–1.0)	0.8	(.6–1.0)	0.7	(.6–.9)
<b>Model 2: Vaccination adjusted for sociodemographic variables</b>						
Vaccination status <sup>a</sup> (ref = unvaccinated)						
1 dose 0–13 d before illness onset	0.9	(.8–1.1)	1.0	(.7–1.3)	0.9	(.7–1.1)
≥1 dose ≥14 d before illness onset	0.8	(.6–.9)	0.8	(.6–1.1)	0.9	(.7–1.1)
<b>Model 3: Hospitalization adjusted for sociodemographic variables and vaccination status</b>						
Severity of acute disease (ref = nonhospitalized)						
Hospitalized	1.5	(1.4–1.7)	2.1	(1.7–2.6)	1.6	(1.3–2.1)

Abbreviations: admin, administration and management work; CI, confidence interval; PCC, post-COVID condition; PCC-S, post-COVID condition with at least 1 severe symptom; ref, reference; PR, prevalence ratio.

<sup>a</sup>Vaccinated with 1 dose 0–13 days before illness onset or vaccinated with at least 1 dose ≥14 days before illness onset (13, 0, and 5 cases vaccinated with 2 doses for each PCC definition).

and psychological distress during the pandemic on HCW cognitive function independent of PCC status, which also has important implications for quality healthcare delivery.

As reported elsewhere, our hospitalized cases had a higher prevalence and severity of PCC than ambulatory cases [14, 16, 22], with female sex and increasing age also associated with higher PCC risk [11, 14, 17, 18, 27, 35–37]. We could not properly assess the impact of vaccination, as few participants had been vaccinated before their COVID-19 illness.

Our study has several limitations. Using CDC and WHO case definitions for PCC based on 4-week or 12-week duration may have overestimated the prevalence of clinically significant PCC. Clinical significance may be improved by requiring longer duration but remains suboptimal in allowing any symptom

of any intensity. Temporal patterns were identified using a single time survey completed at different intervals since illness onset and querying only about persisting ongoing symptoms and calculating later time from illness onset to survey. This likely limited recall bias and the selective attrition of less symptomatic patients in follow-up studies [3, 17], but may have underestimated the prevalence of symptoms for shorter intervals. Symptom description was based on subjective reporting. This allowed us to capture a large spectrum of the severity of the conditions, including less severe manifestations for which a medical consultation is not sought. A reporting bias is, however, possible considering that most symptoms are not specific and may be due to other conditions, as illustrated by the reported prevalence of fatigue before SARS-CoV-2 infection [38]. We

did not collect information on some potentially relevant risk factors, such as comorbidity or initial COVID-19 symptoms and their severity [16, 17, 27, 35, 37]. Our questionnaire, designed in the fall of 2020, did not collect data on insomnia or postexertional malaise later, also considered to be PCC-qualifying symptoms [23]. Cognitive functions were not objectively assessed with validated tools, and self-reporting might have overestimated their prevalence. Physical symptoms among non-COVID-19 controls were not collected. Comparing the prevalence but also the severity and persistence of symptoms among cases and controls would have allowed better characterization of PCC and PCC-associated cognitive and psychological symptoms. It should be considered in future research. We cannot rule out the possibility of selection bias as half of reached HCWs refused to participate (20%) or did not complete the survey (30%). This may overestimate the PCC prevalence if HCWs with persisting symptoms had participated more. However, self-selection bias may be small as participants were invited to participate to a larger study on workplace prevention practices and not on PCCs. Our participants were mostly unvaccinated working adults infected by the original SARS-CoV-2 virus: findings may not be generalizable to children, elderly adults, vaccinated individuals, or those infected by subsequent variants of concern. Despite these limitations, this study shows the high burden of COVID-19 sequelae among nonhospitalized adults.

In conclusion, PCC may be a frequent sequela of ambulatory COVID-19 in working-age adults, with important effects on cognition. With so many HCWs infected since the beginning of the COVID-19 pandemic, the ongoing implications for quality healthcare delivery could be profound should cognitive dysfunction and other severe PCC symptoms persist in a professionally disabling way over the longer term.

## Supplementary Data

**Supplementary materials** are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

## Notes

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health scientific committee on COVID-19 (Ministry of Health and Social Services, Quebec). All other authors report no potential conflicts.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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