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Potential risk factors associated with COVID-19 in health care workers

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Background	Health care workers (HCWs) have been recognized as being at higher risk for coronavirus disease 2019 (COVID-19) infection; however, relevant factors and magnitude have not been clearly elucidated.
Aim	This study was aimed to describe COVID-19 infections among hospital employees at a large tertiary care hospital located in Ontario, Canada from March to July 2020, towards better understanding potential risk factors.
Methods	Data on all HCWs with either a positive COVID test or a high-risk exposure from March to July 2020 were analyzed. HCWs with positive COVID test results and high-risk exposures were described. Those who developed COVID-19 following high-risk exposure were compared to those who did not. Data were also analyzed to determine trends over time.
Results	Over the period of observation, 193 staff (2% of total working staff) had a positive COVID-19 test. Incidence of HCW infections closely followed community incidence. Overall, 31% of COVID-19 cases were deemed occupationally acquired. Of these, 41% were acquired from a patient, with the remainder (59%) from fellow staff. Over the same period, 204 staff were identified as having a high-risk exposure. The majority of exposures (55%) were patient-associated, with the remaining (45%) resulting from staff-to-staff contact. Overall, 13% went on to develop COVID-19. Of these cases, 58% were patient-associated and 42% were a result of staff-to-staff transmission.
Conclusions	HCWs are at risk for work-related COVID-19. Given the number of infections attributed to staff–staff transmission, greater attention could be paid to implementing prevention measures in non-clinical areas.
Key words	COVID-19; health care workers; occupational disease; SARS nCoV2.

Introduction

The global pandemic caused by the severe acute respiratory syndrome novel coronavirus 2 (SARS nCoV2) virus has led to millions of coronavirus disease 2019 (COVID-19) cases. Health care workers (HCWs) have been suggested to be at being at higher risk for acquisition of infection due to increased exposure risk [1,2]. However, the nature and magnitude of this risk remain poorly understood.

HCW positivity prevalence has been reported to range widely from 0 to 18% (see Table S1, available as Supplementary data at *Occupational Medicine* Online) [3–8]. Such differences may be affected by several factors, including community prevalence and testing rates [3,4]. In general, where serial repeat testing was performed, incidence of COVID positivity closely followed community rates [8]. HCWs with COVID had low rates of severe/critical disease when compared to the general population [5,6,8].

Though no single risk factor has been identified relevant to elevated HCW COVID-19 infections, several have been proposed. These include community prevalence of disease, testing rates for HCWs, work roles (nursing in particular), personal protective equipment (PPE) availability and use, work with COVID-19 patients and extended work hours [1–15].

Several recent studies provide contrasting data on source of COVID-19 acquisition (e.g. occupational

Key learning points

What is already known about this subject:

- Health care workers are generally considered to be at higher risk for COVID-19 acquisition; however, specific risk factors and the magnitude of the risk remain poorly understood.
- Some studies have observed that health care workers are as likely to acquire COVID-19 from fellow staff as from patients, suggesting that controls in non-clinical areas may be lacking.

What this study adds:

- Our observations support that COVID-19 controls in the health care environment should extend to break areas and other non-clinical areas.
- Additionally, work in a nursing role or work in non-clinical roles may pose an increased risk, either due to the nature of care provided or unfamiliarity with infection prevention and control protocols.

What impact this may have on practice or policy:

- Hazard controls in health care settings could be focused on bolstering hazard protection training for nurses and non-clinical workers, as well as improved controls in non-clinical areas.

versus community) for HCWs (Table S1, available as Supplementary data at *Occupational Medicine* Online). Community or staff-to-staff transmission is often the predominant mode, with work caring for COVID-positive patients often associated with a decreased risk of acquisition [4,5,14].

One of the challenges in controlling COVID-19 exposure in workplaces, including health care, is the nature of the hazard that, unlike other workplace hazards, can 'follow' the worker into their break rooms, communities and homes. HCWs may be exposed anywhere at work and at home, and this poses challenges on many levels, from primary prevention strategies (such as masking and physical distancing, which may not be possible or practical during breaks at work, for example) to tertiary prevention (such as identifying a source of exposure when there are potentially multiple).

The primary aim of this paper was to describe COVID-19 infections among hospital employees (primarily HCWs) during the first wave of the pandemic generally, and among HCWs with high-risk exposures to COVID-19. The secondary aim was to identify characteristics associated with COVID-19 acquisition in the hospital setting to inform a discussion on potential mitigative measures to reduce the burden of infection among this group of workers.

Methods

This observational study is based on 'First Wave' (defined as March–July 2020) data collected at a multisite tertiary care hospital (Trillium Health Partners [THP]), located in Mississauga, Ontario, servicing a large urban area with the highest rate of community transmission in Ontario at the time of writing [16].

An employee health database detailing all staff (including HCWs) identified as having either a positive COVID test or a high-risk exposure to a known or suspected person with COVID-19 over the initial period of the COVID-19 pandemic from March to July 2020 was used for analysis. 'HCW' was defined as any worker who provides direct care to, or works in close proximity to patients (e.g. nurse, doctor, therapist, porter, etc.). 'Staff' includes both HCWs and non-HCWs (e.g. administrative staff, facility support, etc.), of which non-HCWs comprise approximately 7% of all staff. The database contained results from tests conducted:

- as part of asymptomatic staff surveillance (whether positive or negative)—5 June–10 July 2020, or
- following a high-risk exposure, both asymptomatic and symptomatic testing (whether positive or negative)—20 March–20 July 2020, or
- among symptomatic staff (whether positive or negative)—20 March–20 June 2020.

A HCW could also enter the database if they self-reported a positive test from a test completed through the public health care system (community setting).

All results were acquired using RT-PCR via nasopharyngeal swab. COVID testing was performed where a worker had symptoms suggestive of COVID-19, or a high-risk exposure occurred. Testing was performed when a worker was working in an outbreak unit (but no high-risk exposure occurred). Initially, an outbreak was defined as two confirmed COVID-19 cases with an epidemiological link (patient or HCW) identified within a 5-day period; on 12 May 2020, this was expanded to a 14-day period. Additionally, an institution-wide testing campaign (surveillance) was conducted over the period of 5 June–10 July 2020. It was open to all staff, regardless of the presence of symptoms.

We analyzed data from three groups of people: (i) HCWs who volunteered to be tested as part of a surveillance campaign, (ii) HCWs with high-risk exposures and (iii) HCWs with positive COVID test results,

regardless of reason for testing. The rationale for this was to be able to compare testing data to community positivity rates to better characterize if an increased risk was present, and to better characterize exposures that led to infections.

'High-risk exposures' were determined using the US Centers for Disease Control and Prevention (CDC) definition, which includes close (<2 m), unprotected contact (e.g. missing or no appropriate PPE) with a known or suspected COVID-positive individual (either patient or co-worker) for >15 min total (or any duration if in the context of Aerosol-Generating Medical Procedure [AGMP, as per the Public Health Ontario Technical Brief] or a known positive patient) [17,18]. Workers identified with such exposures, if deemed occupational, were put on paid sick leave for a 14-day quarantine period.

Exposure data and demographic information were also collected and compiled by the contact tracing team using telephonic interviews. COVID-19 was considered occupational (regardless of if the source was a patient or staff) if the contact tracing supported acquisition while at work (e.g. there was no known community link, and there was a potential source for acquisition at the hospital, such as contact with COVID-positive patients, COVID-positive staff or work on an outbreak unit). If there was no occupational source identified, and a community link was identified, the case was deemed non-occupational. In all other situations, the case was categorized as 'unclear' as to source of acquisition.

Descriptive statistics (means, frequencies) were performed to determine characteristics common to positive HCWs. Daily test positivity was graphed for the HCWs and the with surrounding community over time to assess any visual correlation (Microsoft Excel; see Figure 1). Data for the community were accessed through public facing databases. Among workers with a high-risk exposure, differences between workers who went on to have a positive COVID-19 test and those who did not were examined using chi-squared tests (or Fisher's exact where cell sizes were <5) and Student's *t*-test (SAS v.9.4). Ethical approval for this study was obtained from both the THP and the University of Toronto Research Ethics Boards.

Results

The first of three datasets we used was derived from an epidemiological campaign to assess burden of asymptomatic disease in all staff, where 2751 total tests were completed of which 5 positives were identified (0.18% positivity). At the time, there were 11 306 total working staff. For comparison, on 28 June 2020, there were 160 positives reported out of approximately 32 000 tests (0.5% test positivity) in the province of Ontario [19].

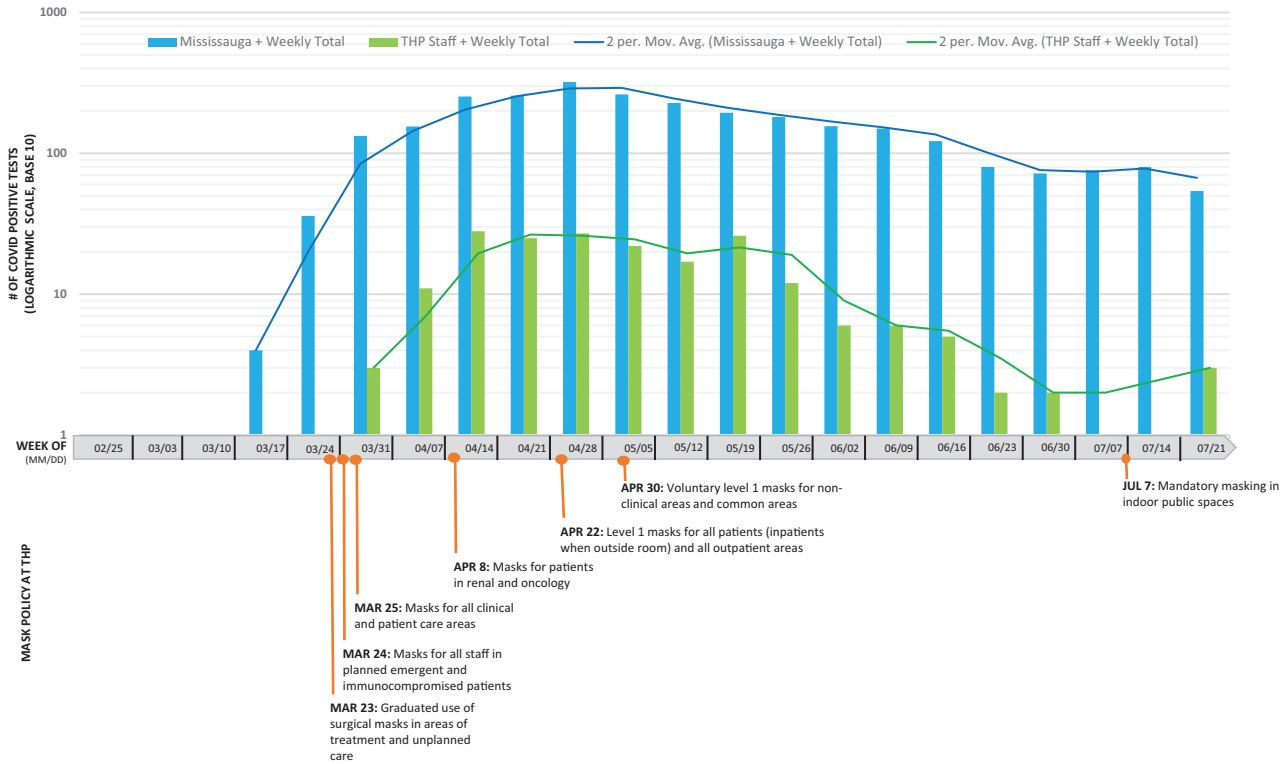

Figure 1. The epidemiological curve of COVID-19 test positivity in Mississauga, Ontario (community, shown in blue) and a multisite tertiary care hospital (THP, shown in green) during the first wave of COVID-19 (25 February–28 July 2020). Figure also shows associated masking policy changes over time [19].

Table 1. Description of hospital staff with a positive COVID-19 test from March to July 2020

	Staff with a positive COVID-19 test	All staff	*P* value
Age, mean (SD)	39.2 (12.1)	–	n.d.
Female sex, *n* (%)	161 (83%)	–	n.d.
Occupational group, *n* (%)			
Nurse	106 (55%)	4559 (40%)	0.001
Allied health	12 (6%)	2011 (18%)	
Physician	14 (7%)	1300 (12%)	
Clinical support staff	36 (19%)	2612 (23%)	
Non-clinical staff	25 (13%)	824 (7%)	
Symptoms, *n* (%)			
Cough	86 (45%)	–	n.d.
Sore throat	64 (33%)	–	n.d.
Fever	54 (28%)	–	n.d.
Headache	52 (27%)	–	n.d.
Dyspnea	17 (9%)	–	n.d.
Anosmia	16 (8%)	–	n.d.
Sinus congestion	10 (5%)	–	n.d.
Asymptomatic	7 (4%)	–	n.d.
Source, *n* (%)			
Occupational	59 (31%)	–	n.d.
Community	63 (33%)	–	n.d.
Undetermined	71 (37%)	–	n.d.

(–), data not available; n.d., statistical test not done.

The second dataset was derived from all employee COVID-19 tests performed at our institution (tests which were included in the other two datasets) from 20 March to 20 June 2020. A total of 193 (1.8%) staff were identified with a positive COVID-19 test out of 11 306 total working staff over the preceding 4 months (Table 1). The mean age was 39.2, and 161 (83%) were female. Overall, nurses comprise 40% of all workers, and 44% of patient-facing workers who acquired COVID-19. Of the 193 cases, 59 (31%) were deemed to be occupational, 63 (33%) non-occupational (community acquired) and 71 (37%) had no identifiable epidemiological link. Of the 193 cases, 7 (4%) workers with COVID-19 were hospitalized, with duration ranging from 3 to 21 days (mean 8.4 days), with no deaths. Symptoms were generally mild (see Table 1).

Among cases deemed occupational, 24 (41%) were considered to be acquired from patients and 35 (59%) from co-workers. Among occupational cases, 3 (5%) worked on a unit that cared for COVID-19 patients and 58 were identified as part of an outbreak (either between staff, or staff and patients). There were 30 occupational cases identified as having had a 'high-risk' exposure (either from other staff or a patient), though only 19 were deemed to have acquired their infection from that exposure (based on timing of exposure and diagnosis).

The third dataset was derived from high-risk exposures among all employees (both HCWs and other staff) over the period between 20 March 2020 and 5 July 2020. A total of 204 individual high-risk exposures were identified. Of these, 83 (41%) were identified as a part of an outbreak investigation. Most cases of high-risk exposure (n = 180, 88%) were female, with a mean age of 39 years (range 19−69). Many high-risk exposures (n = 92, 45%) were associated with contact with a fellow staff member; the remainder (n = 112, 55%) were associated with a patient (Table 2).

With respect to the sources of exposure (e.g. index cases), 3 (1%) were known to be COVID positive at the time of exposure, and 96 (46%) were reported to have been symptomatic at time of exposure (data were not available for the remainder [53%]). Where the source's symptoms were specified (n = 85, 42%), the most common was cough (n = 67, 79%).

Exposure locations were noted to occur in clinical (n = 128, 63%) and non-clinical areas (n = 76, 37%). For non-clinical locations, most (n = 62, 82%) were in a lunchroom/eating area. In clinical locations three exposures (2.3%) occurred on a designated COVID ward, with the remaining 125 (98%) occurring on regular wards. By definition, most high-risk exposures included close proximity (<2 m) and prolonged contact (>15 min) (Table 2).

Of the 204 high-risk exposures, 26 (12.7%) later had a positive COVID test. The positive tests occurred mostly among women (n = 19, 73%) with a mean age of 36 (range 23–65). Just over half of cases resulted from exposure related to a patient (n = 15, 58%); the remainder (n = 11, 42%) were between staff. Eleven (42%) cases followed high-risk exposures in a clinical unit on outbreak, but there was no observed association between the

Table 2. Description of high-risk exposures among hospital staff, March–July 2020

	Staff with a high-risk exposure (N = 204)			Statistical comparison
	Overall	Subsequent positive COVID-19 test (n = 26)	No positive COVID-19 test (n = 178)	P value
Overall	204	26 (13%)	178 (87%)	–
Age, mean (SD)	38 (13.1)	36 (11.6)	40 (11.8)	0.15
Female sex, n (%)	180 (88%)	19 (73%)	161 (90%)	0.01
Occupational group, n (%)[a]				
Nurse	121 (59%)	16 (62%)	105 (59%)	0.001
Allied health	26 (13%)	2 (8%)	24 (13%)	
Physician	2 (1%)	2 (8%)	0 (0%)	
Clinical support staff	45 (22%)	3 (12%)	42 (24%)	
Non-clinical staff	10 (5%)	3 (12%)	7 (4%)	
Exposure source, n (%)				
Fellow staff member	96 (47%)	15 (58%)	81 (46%)	0.24
Patient	108 (53%)	11 (42%)	97 (55%)	
Exposure location, n (%)				
Clinical area	128 (63%)	17 (65%)	111 (62%)	0.75
Non-clinical area	76 (37%)	9 (35%)	67 (38%)	
Within clinical areas[a]				
Unit on outbreak	84 (66%)	11 (65%)	73 (66%)	0.8
COVID unit	3 (2%)	0 (0%)	3 (3%)	
Other	41 (32%)	6 (35%)	35 (32%)	
Within non-clinical areas, n (%)[a]				
Lunchroom/break room	62 (82%)	4 (44%)	58 (87%)	0.008
Other (meeting rooms/ offices)	14 (18%)	5 (56%)	9 (13%)	
PPE worn during exposure, n (%)				
Face shield[a]	4 (2%)	0 (0%)	4 (2%)	1.0
Gloves	85 (42%)	10 (38%)	75 (42%)	0.7
Gown[a]	13 (6%)	2 (8%)	11 (6%)	0.7
Surgical mask	106 (52%)	16 (62%)	90 (51%)	0.3

[a]Comparison P value calculated with Fishers exact test.

clinical location and a subsequent positive COVID-19 test (Table 2). Among high-risk exposures in non-clinical settings, exposures occurring in meeting rooms or (administrative) offices ('other—meeting rooms/offices') were more than five times more likely to result in a subsequent positive COVID-19 test as compared to exposures in lunch/break rooms (5/14 versus 4/62, P = 0.008; Table 2). Of the 11 positive workers who acquired infection from co-workers, based on detailed contact tracing interviews, exposure scenarios included sharing lunch (n = 4, 36%), having a close conversation >15 min (n = 4, 36%) and/or prolonged close contact (n = 6, 54%).

Of the 15 positive workers who acquired infection from patients, all 15 took place on regular, non-COVID wards, in absence of AGMPs or provision of critical care. Overall, 12 (80%) were female, 9 (75%) were nurses, with the remaining 6 in various clinical and non-clinical roles. Exposure scenarios were in the context of prolonged, close contact during the provision of clinical care. Eight (30%) exposures were from a symptomatic source, and two (8%) from a known COVID-positive source. Most were not using full droplet PPE normally required for providing care for COVID-positive patients (which would include surgical masks and face shields), likely due to the fact that only 13% of sources were known to be COVID positive. The most common pieces missing were face shields, gown and gloves. No errors in doffing were noted.

Discussion

Over the period of observation (20 March–5 July 2020), approximately 2% of the workforce had a positive COVID-19 test. This was approximately 3.5 times the community prevalence of 0.5% (Peel Region) though this was not tested statistically [20,21]. The rate of testing was approximately four times the provincial rate (80% at THP versus 20.6% provincially) [22]. Community testing may underestimate prevalence. Provincial data have demonstrated seroprevalence of 1.5% in the nearby Toronto area

[23]. Despite differences in positivity, the pattern in test positivity among staff tracked with community prevalence, supporting that the risk of infection at work was reflective of community prevalence (see Figure 1).

Nurses made up 55% of all cases and 42% of all high-risk exposures, consistent with some studies, but not others [5,11,14]. Of the 24 patient-acquired infections, 18 (75%) were nurses. Nurses make up the largest single group of employees (40% of all workers, 44% of patient-facing workers). Nurses are noted to spend more time at the bedside providing direct patient care than most other HCWs, which may partly explain the increased prevalence among this group [24].

Non-clinical staff were more likely to acquire infection after a high-risk exposure than other occupational groups, which may be due to a number of factors, including unfamiliarity with PPE, improper training, lowered risk perception (from both the employer and employee) and subsequent decreased vigilance. Breakrooms and eating areas have previously been identified as higher-risk areas for occupational acquisition of COVID-19, consistent with our observations here [25–27].

Of those identified with a high-risk exposure, approximately half were associated with patient care. A small proportion (5%) later became positive for COVID-19. Most sources were not COVID positive at the time of exposure (either asymptomatic or pre-symptomatic). The use of various types of PPE (e.g. face shields, gowns, gloves, surgical masks) showed a lack of clear association. In Ontario, N95s (or other respiratory protective equipment) are mandated to be available to all HCWs where deemed appropriate but information on their use was not collected during contact tracing [28]. The practice of wearing a face mask at all times, or 'universal masking', could not be investigated as most cases occurred after this policy was implemented (25 March 2020, with all areas were included by 7 July 2020).

An increased risk of COVID-19 acquisition may exist when public health recommendations are not recommended or enforced. Clear and consistent messaging with respect to public health interventions in non-clinical areas might help in mitigating staff-to-staff transmission. Applying the hierarchy of controls to both clinical and non-clinical areas is prudent (see Figure 2) [29].

COVID-19 screening for all inpatients may be considered to better identify COVID-19-positive patients at admission, regardless of symptom status. Additional infection prevention and control (IPAC) support (including vaccination) for HCW (e.g. nurses) most likely to have prolonged close contact with patients, regardless of patient COVID-19 status, may be warranted. Risk assessment should also be completed for non-clinical staff, with appropriate IPAC support, including training and PPE. Reinforcement of public health measures in offices, meeting rooms, break rooms and eating areas should be undertaken.

Our study was subject to a number of limitations. HCWs with COVID-19-positive tests performed at outside institutions may not have been included in the data. However, this would not be expected to have significantly changed the numbers given the public health reportability of COVID-19 infection in Ontario. A large proportion of COVID-19-positive workers (37%) did not have an identifiable source, which could significantly alter assumptions around occupational acquisition (and risk). Additionally, high-risk exposures that occurred outside of the workplace, or occurred at work but were not reported, were missing from the data.

Future study of COVID-19 risk to HCWs could include analysis of population-level data, which will provide a better estimate of the burden of COVID-19 borne by HCWs. This may be possible in jurisdictions where work information is included in administrative health data, or where data linkages are possible, particularly within large population-based cohort studies, as has been done in the UK [30].

Clinical and non-clinical HCWs are at risk of acquiring COVID-19 at work. The risk of acquiring COVID

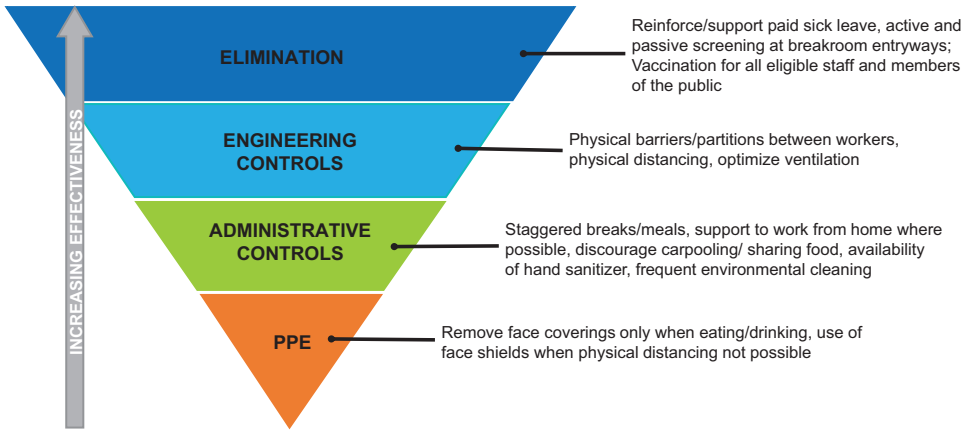

Figure 2. Adapted hierarchy of controls for controlling COVID-19 in non-clinical areas of a health care setting [29].

at work does not just arise from patient care; HCWs are also acquiring COVID-19 from colleagues. Public health recommendations (e.g. physical distancing, PPE, hand hygiene) should be enforced in both clinical and non-clinical areas, and vaccination for all who are eligible strongly encouraged or mandated. COVID-19 risk assessment should include non-clinical staff to ensure support is provided where needed and workers are trained on the appropriate exposure prevention practices.

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Competing interests

None declared.

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