

## Coronavirus Pandemic

# Exposure to COVID-19 among unvaccinated healthcare personnel and risk for infection: a single-center retrospective study

Aslıhan Candevir<sup>1</sup>, Damla Ertürk<sup>2</sup>, Ferit Kuşcu<sup>1</sup>, Süheyla Kömür<sup>1</sup>, Yasemin Saygıdeğer<sup>3</sup>, A Seza Inal<sup>1</sup>, Ezgi Özyılmaz<sup>3</sup>, Behice Kurtaran<sup>1</sup>, Yeşim Taşova<sup>1</sup>

<sup>1</sup> Cukurova University Medical School, Department of Infectious Diseases and Clinical Microbiology, Adana, Turkey

<sup>2</sup> Tepecik Training and Research Hospital, Department of Infectious Diseases and Clinical Microbiology, Izmir, Turkey

<sup>3</sup> Cukurova University Medical School, Department of Pulmonology, Adana, Turkey

### Abstract

**Introduction:** Characteristics of exposure and infection risk, are important in strategy development for infection control among healthcare workers (HCWs). Our objective was to investigate the characteristics of exposure of HCWs to SARS-CoV-2 and determine the risk of COVID-19 development.

**Methodology:** This is a retrospective single-center cohort study, conducted between March and December 2020. Unvaccinated and exposed HCWs were asked to complete a standard form, including demographic data and characteristics of exposure(s). Exposures were stratified according to national guidelines. STROBE checklist was used.

**Results:** Among a total of 4,385 healthcare workers, 1,483 HCWs (33.8%) with a total of 1,903 exposures to SARS-CoV-2 were identified. Median age was 31 (IQR: 26–40) years and 45.4% were male (N = 673). Following exposure, 78 HCWs became SARS-CoV-2-positive (attack rate: 3.9%) and secondary attack rate was 4/16. In terms of infection, exposure to SARS-CoV-2-positive HCWs posed a greater risk compared to contact with patients (8.9%, [n = 66] vs. 3.8% [n = 12], respectively,  $p = 0.003$ ). PCR positivity rates were 11.5%, 6.3%, and 8.4% for low, medium, and high-risk contacts ( $p = 0.152$ ). Median time to infection post-exposure was 7 (IQR: 4–13) days.

**Conclusions:** Given the attack rates, there was no correlation between risk levels and PCR test positivity rates. There was no difference between HCWs with or without work restrictions, in terms of PCR positivity. Due to feasibility issues, prioritizing universally applied symptom screening and resource control strategies and suspending contact tracing and work restrictions, appear to be safe during high prevalence period.

**Key words:** COVID-19 exposure; healthcare personnel; risk of infection; contact tracing; unvaccinated.

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### Introduction

Coronaviruses are important human and animal pathogens, causing common cold and sometimes serious epidemics, such as SARS and MERS-CoV. At the end of 2019, a novel coronavirus was identified as the cause of a cluster of pneumonia cases in Wuhan, a city in the Hubei Province of China [1]. It rapidly spread, resulting in an epidemic throughout the world [2]. The pandemic reached Turkey in March 2020, with the first case being officially confirmed on March 11, 2020, and by April 1<sup>st</sup>, it was confirmed that COVID-19 had spread all over Turkey.

Healthcare workers (HCWs) have been shown to be at the greatest risk for COVID-19. In a study from the United States, it has been shown that the prevalence of COVID-19 was more than ten times greater among the front-line HCWs compared to the general population [3]. Infection control practices, respiratory and/or

surgical masks and other personal protective equipment (PPE) supplies, work restrictions, and contact tracing are important in order to prevent transmission between HCWs and from HCWs to patients. Although work restrictions may be challenging for HCWs and administrations, particularly at times of high prevalence, measures for exposure must be different from those for general public. Turkish Ministry of Health recommendations for the assessment of and response to HCWs' exposure to SARS-CoV-2-infected patients have evolved since the beginning of the pandemic as more data becomes available and are coherent with CDC and ECDC guidelines, which have also evolved in time [4–6]. However, there is little data supporting these recommendations [7].

Characteristics of exposure and risk of infection after particular exposure are important factors to be considered in the development of a strategy for

infection control among HCWs and hospitals. Our objective in this study is to investigate the characteristics of HCWs, who had been exposed to SARS-CoV-2 and to determine the risk of developing COVID-19 after exposure and whether the work restrictions are feasible for the exposed and unvaccinated HCWs.

## Methodology

This is a retrospective, single-center cohort study, investigating the characteristics of the exposed personnel and the risk of developing COVID-19 following exposure. Çukurova University Hospital is a 1,200-bed teaching hospital in the southern region of Turkey. After COVID-19 outbreak, the number of beds has been reduced to 850 for the purposes of patient safety with one room allocated to one person. The total number of personnel, employed in the hospital was 4,385. Training programs on COVID-19 and prevention of infection have been offered to employees before the initial outbreak and these have been repeated regularly. Also, infection control practices were implemented and rigorously monitored during the outbreak and there were no PPE shortages.

Exposed HCWs were referred to the infectious diseases outpatient clinic between March and April 2020, at the beginning of the outbreak, and then to the infection control committee of the hospital. At the time of the collection of data, no HCWs had been vaccinated. They were asked to complete a standard form, including the demographic data of the exposed HCWs and the characteristics of the exposure, such as date, nature, duration of exposure, distance, whether the HCW and/or the patient were wearing mask(s), and person of contact. Only in-hospital contacts were recorded. HCW exposure was stratified according to the most recently updated version of the assessment guidelines for

HCWs' Contact Status with COVID-19 Patients, prepared by the Scientific Board of Turkey for COVID-19 [4]. In accordance with these guidelines, low-risk and medium-risk personnel were asked to wear a mask and work in accordance with social distance rules. Medium-risk personnel were asked to provide a nasal/oral combined swab for SARS-CoV-2 PCR test on days 5-7. In contrast, high-risk personnel were restricted to work for 7 days and were also asked to give nasal/oral combined swabs for SARS-CoV-2 PCR tests on days 5-7 before starting to work.

Assessment of HCW's contact status with COVID-19 patients is demonstrated in Table 1 (nosocomial contacts). Intense contact with a COVID-19 patient was defined as a contact during any of the following actions: taking respiratory tract samples, intubation, aspiration of respiratory secretions, non-invasive ventilation, high flow oxygen therapy, cardiopulmonary resuscitation, using nebulizer, endoscopic procedures, bronchoscopy, video laryngoscopy, dentistry applications, mouth-throat-nose examination, ophthalmological examinations, insertion of central catheter. As for social contacts, ECDC definitions were used. A COVID-19 contact has been described as any person, who had contact with a COVID-19 patient within a time period ranging from 48 hours before the onset of symptoms of the patient until 14 days after the onset of symptoms. A high-risk contact has been described as a person, who had face-to-face contact with a COVID-19 patient within a 2-meter distance for more than 15 minutes, who had physical contact with a COVID-19 patient or had unprotected direct contact with infectious secretions of a COVID-19 patient (e.g., being coughed on). Face-to-face contact with a COVID-19 patient within a 2-meter distance for less than 15 minutes has been deemed as a low-risk contact.

The data concerning positive SARS-CoV-2 PCR test results were gathered from the Public Health Management System of the Ministry of Health and the number of the HCWs was obtained from administration. HCWs, who had become positive for SARS-CoV-2 in PCR test within a month after exposure to a COVID-19 patient, were included in the study.

Statistical analyses were performed using SPSS v.20.0 statistics program. For continuous and normally distributed variables, a 2-sample t-test was used. Mann-Whitney U test was used for non-normally distributed continuous variables in order to compare mean median and values respectively. The chi-square test or Fisher's exact test was chosen for categorical variables, when appropriate. Mean values are reported in  $\pm 1$  standard

**Table 1.** Breakdown of HCWs' exposure to COVID-19 patients.

Use of PPE by HCWs	Contact Risk
<b>Intense contact with COVID-19 patients wearing a medical (surgical) mask</b>	
Did not use a medical mask or N95 mask, or used a medical mask despite N95 indication	Medium
Did not use eye protection	Low
Did not use gloves and aprons	Low
Used all PPE properly	No Risk
<b>Intense contact with COVID-19 patients without wearing a medical (surgical) mask</b>	
Did not use a medical mask or N95	High
Use of medical mask despite N 95 indication	Medium
Did not use eye protection	Medium
Did not use gloves and aprons	Low
Used all PPE properly	No Risk

deviation while median values were reported with interquartile range. Two-tailed significance under 0.05 was accepted as significant in all tests. The association of independent variables was shown as an odds ratio (OR) with 95% confidence intervals (CI).

The investigation authorization was obtained from the Republic of Turkey Ministry of Health and ethics approval was obtained from Local Ethics Committee for non-interventional studies (2020/06-33).

The manuscript was prepared according to STROBE checklist for observational studies [8].

**Results**

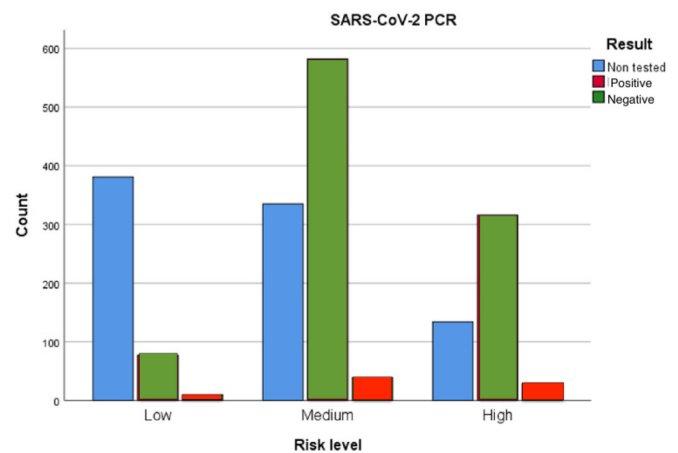
Among a total of 4,385 HCWs, 1,483 (33.8%) HCWs had been exposed to SARS-CoV-2, with a total of 1,903 SARS-CoV-2 exposures between March 1, 2020 and December 15, 2020. Mean age was 33.6 ± 9.2 years and median age was 31 (IQR: 26-40) years. Of these 1,483 HCWs, 45.4% were males (N = 673).

Among these exposures, 1,236 (65%) consisted of exposure to other HCWs in a social environment and 667 exposures consisted of exposure to patients (35%). Risk levels of the exposures are shown in Table 2. In total, 78 HCWs (attack rate: 3.9%) became SARS-CoV-2-positive following exposure, and four of these were secondary infections (secondary attack rate: 4/16) and there were no tertiary cases. It was found that exposure to SARS-CoV-2-positive HCWs posed a greater risk compared to exposure to patients (8.9%, [n = 66] vs. 3.8% [n = 12] respectively, *p* = 0.003). Total number of SARS-CoV-2-positive HCWs was 460 (10.5%) and only 16.9% of infected personnel had exposure. None of the HCWs died.

Most of the exposed personnel consisted of nurses (28.4%, n = 540) and doctors (22.8%, n = 433). Other exposed HCWs included auxiliary health personnel by 10.5% (n = 200) and intern students 6.9% (n = 132). Among these, 598 individuals (31.4%) were miscellaneous personnel such as cleaning staff, office staff or technical staff.

Among these exposures, 468 exposures (24.6%) were classified as low-risk, 956 as medium-risk (50.2%) and 479 as high-risk (25.2%). For low-risk exposures, some personnel provided swabs for SARS-CoV-2 PCR test due to having symptoms or other reasons (18.6%, n = 87) and some of the medium- (35%, n = 335) and high-risk (28%, n = 134) exposures

**Figure 1.** SARS-CoV-2 PCR test results according to risk levels.



didn't provide PCR test samples, even though they were required to do so. No swabs for SARS-CoV-2 PCR test were provided for 850 (44.7%) exposures, while 975 out of 1,053 exposures tested negative (51.2%) and 78 tested positive (4.1%) (Figure 1). PCR positivity rate was 10/87 (11.5%) for low-risk exposures, 39/621 (6.3%) for medium-risk exposures and 29/345 (8.4%) for high-risk exposures. There was no difference between risk levels in terms of PCR positivity (*p* = 0.152).

Contact tracing was performed and maximum number of the contacts for a single infected person was 24 and none of these persons tested positive on PCR test. Maximum number of persons, infected by a single person, was two. Total secondary contact number was 100. Among the 78 HCWs, who tested positive for SARS-CoV-2 in PCR test, 49 had low- to medium-risk exposures and worked until becoming positive and 29 had high-risk exposures and had work restrictions until their recovery from COVID-19 infection. Mean numbers of exposed contacts were 1.37 ± 3.6 and 1.14 ± 3.0 for HCWs, removed from work (*p* > 0.774). For working HCWs, mean number of exposed contacts, who tested positive after contact was 0.16 ± 0.32 and for personnel, removed from work this number was 0.03 ± 0.19 (*p* > 0.680). Six out of ten low risk contacts had practiced social distancing, yet had had prolonged exposure in a closed room to SARS-CoV-2-positive people.

Most of the samples from HCWs were taken in November 2020 (n = 416) and the highest positivity rates were observed in November (13%) and December

**Table 2.** Contacts, classified according to risk levels.

	Low risk, n (%)	Medium risk, n (%)	High risk, n (%)	<i>p</i> value
Contact with HCWs	279 (22.6)	529 (42.8)	428 (34.6)	< 0.0001
Contact with Patients	189 (28.3)	427 (64)	51 (7.6)	

(11.9%) at the peak of outbreak (Figure 2). These rates were compatible with the number of patients, tested positive for SARS-CoV-2 in PCR test in Çukurova University Hospital (Figure 3).

7.7% of men (n = 36) and 7.2% of women (n = 42) tested positive and there was no difference between genders in terms of SARS-CoV-2 PCR test positivity (OR = 1.082, CI: 0.681-1.718, p = 0.813). Median age for SARS-CoV-2-positive HCWs was 33.5 (range: 17-59, IQR: 28-42) years and 31 (range: 17-60, IQR: 26-39) years for -negative HCWs. Mean age of HCWs, who tested positive on PCR test, was significantly higher than those, who tested negative (p = 0.053). PCR positivity rates according to positions, were as follows: intern students (2/76, 2.6%), doctors (10/233, 4.1%), nurses (20/287, 6.5%), auxiliary healthcare personnel (9/96, 8.6%), and other personnel (37/283, 11.6%) (p = 0.004).

Mean and median incubation periods after exposure were 9.18 ± 6.84 days and 7 (IQR: 4-13) days, respectively. There was no difference between risk levels or work restriction statuses of exposed HCWs. (p = 0.124 and p = 0.290, respectively). Median incubation periods were 6 (IQR: 2-8), 10 (IQR: 4-16), 7 (IQR: 4-10) days for low-, medium- and high-risk exposures, respectively. Median incubation periods for HCWs, who continued to work and who were restricted after exposure, were 7 (IQR: 4-16) and 7 (IQR: 4-10) days, respectively.

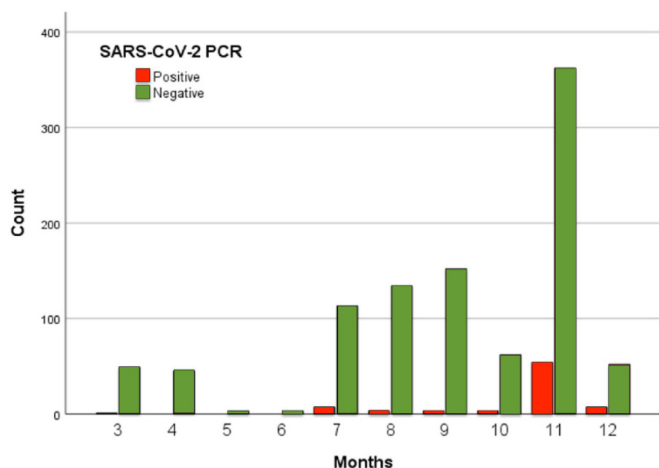
**Discussion**

Due HCWs’ frequent, extensive, and close contact with vulnerable individuals, a conservative approach to HCW monitoring and implementation of work restriction practices, is recommended to prevent

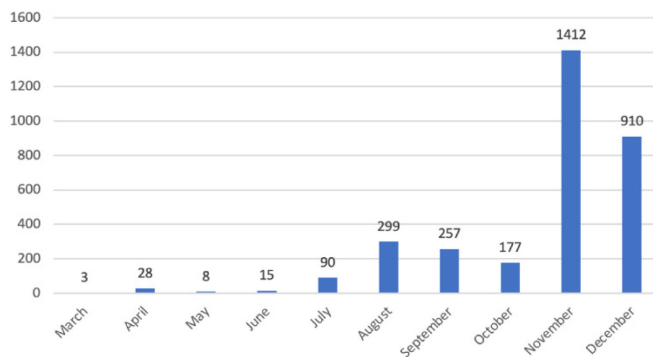
transmission from potentially contagious HCWs to others. In our country, work restrictions were implemented only for cases of high-risk exposures. Also, in our cohort we observed that there was no difference between different exposure risk groups in terms of PCR test positivity. Unexpectedly, it was found that HCWs with low-risk exposures had the highest positivity rate. This condition was thought to be the consequence of the low hospitalization rate and low testing rates of personnel with low-risk exposures. Also, there was no difference between medium- and high-risk exposures in terms of infection. In addition, there was no difference between personnel with or without work restrictions in terms of mean number of exposed persons and exposed persons, who tested positive. Data from our study showed that medium-risk contacts could also be accepted as high-risk contacts in accordance with CDC guidelines, which has modified the classification and eliminated the medium-risk exposure status in the course of pandemic [5]. On the other hand, we saw a positive correlation between the rate of HCW positivity and the level of community transmission. The feasibility and utility of performing contact tracing of exposed HCWs and application of work restrictions should depend on the level of community transmission of SARS-CoV-2 and the resources, available for contact tracing. Instead of work restrictions, more strict infection control practices can be employed in times of high prevalence.

In our study, the total number of SARS-CoV-2 positive healthcare workers was 460 (10.5%) and infected personnel constituted only 16.9 % of exposed HCWs. None of the infected HCWs died. A study, aiming to determine the number of laboratory-confirmed symptomatic cases and associated contacts, which has actively monitored a cohort of HCWs between March and December 2020, has found an infection rate of 13.9% (95% CI: 13.8-14%). In a cross-

**Figure 2.** SARS-CoV-2 Positivity Rates by Months of 2020 (p < 0.001).



**Figure 3.** Number of SARS-CoV-2-Positive Patients Diagnosed by PCR Test at Çukurova University Hospital in 2020 by Months.



sectional survey for SARS-CoV-2 antibodies among National Health Service (NHS) staff, aiming to compare with community seroconversion, the seroconversion rate has been found as 16.3% (95% CI: 16.2% to 16.4%) for NHS staff, compared to the national community seroconversion rate of 5.9% (95% CI 5.3% to 6.6%). Also, there was a significant geographical regional variation, showing the importance of community prevalence rates. Infection rates among NHS staff was higher compared to the general population (OR: 3.1, 95% CI: 2.8 to 3.5) [9]. In a study, conducted in Mexico, the mortality rate has been found as 11.0 (95% CI: 10.9-12.0) per 10,000 HCWs and the case fatality rate has been found as 0.8 (95% CI: 0.7-0.9) per 100 infected HCWs [10]. These rates are similar to the values, obtained from other studies, conducted in China (0.3%–0.7%), the United States (0.4%), Germany (0.2%–0.5%), and Italy (1.2%) [3,11-13]. In another study, conducted in the United States, aiming to organize deaths by demographic features, such as age, gender, and occupation, it has been found that the number of reported deaths among physicians, primary care physicians, males, and HCWs were higher compared to opposing groups [14]. The secondary attack rate (SAR) in our study was 4% and Tian, *et al.*, in a meta-analysis, have found that the pooled SAR of COVID-19 was 0.07 (95% CI: 0.03-0.12) in diverse contact settings. The SAR differed significantly among contact settings and peaked in households (0.20, 95% CI: 0.15-0.28), followed by in social gatherings (0.06, 95% CI: 0.03-0.10) and was lower in healthcare facilities, transports and work/study settings [15]. In our study, 65% of the exposures were with other HCWs in a social environment and 35% were with patients in medical procedures. Therefore, the risk of transmission in medical procedures was found to be low. HCWs must be aware of this situation and be more careful in social gatherings inside and outside of the hospital, particularly at times of high prevalence.

As for risk factors, the mean age of HCWs, who tested positive in PCR test, was significantly higher compared to those, who tested negative, but the difference was not clinically significant (mean ages 33.5 vs. 31 years, respectively). Also, there was no difference between genders in our study. A study, conducted in Cairo, Egypt, has shown that males had higher positivity rates in PCR test in contrast to females, who had higher seroprevalence rates of anti-SARS-CoV-2 antibodies [16]. However, these findings are not supported by previous research. For example, studies from China, India, and Iran have shown that fewer females were infected by SARS-CoV-2 [17-21].

According to these findings, females may be less vulnerable to SARS-CoV-2 infection and/or less likely to develop signs of COVID-19. However, more recent studies, conducted with the rapid spread of SARS-CoV-2 worldwide and increasing epidemiological research, have found no significant differences between men and women in terms of COVID-19 prevalence [22]. On the contrary, in several publications, it has been reported that female patients had better outcomes compared to male patients [9,23-25]. Several studies have shown differences between different job categories in terms of the risk of infection. It has been reported that healthcare workers, who had more contact with patients, such as nurses and auxiliary personnel, were at higher risk for infection. This is consistent with our results, where most of the exposed HCWs were nurses and physicians, yet rates of positivity in PCR tests were higher among auxiliary healthcare personnel (9/96, 8.6%) and other personnel (37/283, 11.6%). Other than close contact with patients, differences between different occupations in terms of infection risk, could be explained not only by heterogeneous precautions taken during occupational activities but also by more rigorous measures taken by physicians and nurses, probably arising from greater awareness of infection risks and a higher level of knowledge.

The median incubation period for COVID-19 is thought to be 4-5 days after exposure, which, according to some early studies, could extend to 14 days. One study has reported that most of the people with SARS-CoV-2 had demonstrated symptoms of COVID-19 infection within 11.5 days [17,26,27]. Also, in a recent study, the incubation period has been found to be shorter in HCWs compared to the general population [28]. Longer incubation periods up to 24 days have also been reported. However, World Health Organization (WHO) has commented that these could reflect double exposures and has not considered modifying the recommendations concerning the incubation period [17,29]. A recent meta-analysis of 42 studies on incubation periods, mainly from China, has found the pooled mean incubation period as 6.2 (95% CI: 5.4, 7.0) days. In various parametric models, the 95th percentiles were in the range of 10.3–16 days [30]. In our study, the median incubation period after exposure was 7 (IQR: 4-13) days and it did not differ according to risk levels or whether the exposed personnel worked or was restricted after exposure. Longer median incubation time could also be due to double exposures or later PCR swabs at days 5-7 post-exposure for asymptomatic personnel. This data does not dismiss the possibility of incubation periods up to 14 days or longer.

## Conclusions

In conclusion, there were no differences between risk levels of exposure and work restriction statuses in terms of infection risk. Instead of making greater efforts for contact tracing and work restrictions, prioritizing universally applied symptom screening and source control strategies, together with educating HCWs concerning the risks of social gatherings and benefits of PPE use may be deemed safe during the high prevalence conditions.

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## Authors' Contributions

Aslihan CANDEVİR, Concept/design, Data analysis/interpretation, Drafting article, Critical revision of article, Approval of article, Statistics, Data collection; Damla ERTÜRK, Data analysis/interpretation, Critical revision of article, Approval of article; Ferit KUŞÇU, Data analysis/interpretation, Drafting article, Critical revision of article, Approval of article, Statistics; Süheyla KÖMÜR, Data analysis/interpretation, Drafting article, Critical revision of article, Approval of article; Yasemin SAYGIDEĞER, Data analysis/interpretation, Critical revision of article, Approval of article; A. Seza İNAL, Data analysis/interpretation, Critical revision of article, Approval of article; Ezgi ÖZYILMAZ, Data analysis/interpretation, Critical revision of article, Approval of article; Behice KURTARAN, Data analysis/interpretation, Critical revision of article, Approval of article; Yeşim TAŞOVA, Data analysis/interpretation, Critical revision of article, Approval of article.

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### Corresponding author

Aslıhan Candevir, MD  
Associate Professor,  
Infectious Diseases and Clinical Microbiology  
01330, Sarıçam  
Adana, Turkey  
Tel: +90 533 5775954  
Email: acandevir@gmail.com

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