Original Article

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TANAFFOS

Household Secondary Attack Rate of COVID-19 among Healthcare Workers and Related Factors

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Background: The risk for transmission of COVID-19 to people in close contact with infected people, especially healthcare workers, has not been well estimated. Therefore the present study was conducted to assess the household secondary attack rate (SAR) of COVID-19 among healthcare workers and related factors.

Materials and Methods: The present prospective case-ascertained study was conducted on 202 healthcare workers with confirmed COVID-19 in Hamadan , diagnosed from March 1, 2020, to August 20, 2020. For households with close contact with the index case, RT-PCR was performed regardless of symptoms. We defined SAR as the proportion of secondary cases from the total contacts that live in the index case household. SAR was reported as a percentage and 95% confidence interval (CI). Multiple logistic regression was performed to explore the predictors of COVID-19 transmission of index cases to their households.

Results: We found 36 secondary cases out of 391 household contacts with laboratory confirmation (RT-PCR), representing a household SAR of 9.2% (95% CI: 6.3, 12.1). Among factors related to the family member, female gender (OR: 2.9, 95% CI: 1.2, 6.9), being the patient's spouse (OR: 2.2, 95% CI: 1.0, 4.6), and living in the apartment (OR: 2.78, 95% CI: 1.24, 6.23), and among factors related to index cases, hospitalization (OR: 5.9, 95% CI: 1.3, 26.9) and caught (OR: 2.4, 95% CI: 1.1, 5.2) were the significant predictors of disease transmission to other family members ($P<0.05$).

Conclusion: The findings of this study suggest that the SAR is remarkable in household contacts of infected healthcare workers. Some characteristics of family members of the index case, including female gender, being the patient's spouse, and living in the apartment, and some characteristics of the index case, including hospitalization and caught, were associated with the increased SAR.

Key words: Secondary attack rate; COVID-19; Healthcare worker

INTRODUCTION

The coronavirus disease 2019 (COVID-19) is an acute respiratory infection caused by SARS-Cov2. The disease was first reported in December 2019 in Wuhan, China, and has gradually spread worldwide (1). The elderly and people with underlying diseases, such as cardiovascular disease, chronic pulmonary disease, high blood pressure,

diabetes, and cancer, are at greater risk of developing the disease and its related complications (2).

Epidemiological studies on the COVID-19 epidemic can play a valuable role in controlling the epidemic and providing robust evidence to health policymakers for timely and effective planning to control the epidemic (3). COVID-19 is an emerging infectious disease with many unknown epidemiological aspects, and epidemiological studies are needed to address the ambiguities associated with the disease (4).

Although our knowledge regarding the epidemiologic and clinical characteristics of the disease has increased significantly compared to the beginning of the epidemic (2, 5), there are essential ambiguities regarding the control of the epidemic (6), including the transmissibility rate, patient characteristics associated with increased infectivity, susceptibility to increased risk of infection, and the proportion of asymptomatic infected cases. Many COVID-19 patients have mild symptoms or are asymptomatic and remain at home without hospitalization; therefore, close contact management is an essential factor in controlling the disease (7).

The possibility of contracting COVID-19 at home is higher due to continuous and direct contact with family members, less use of personal protective equipment, living environment, and common food and toilet (8, 9). The risk for transmission of COVID-19 to people with close contact with infected people, especially healthcare workers, has not been well estimated. Therefore the present study was conducted to assess the household secondary attack rate (SAR) of COVID-19 among healthcare workers and its related factors.

MATERIALS AND METHODS

The present prospective case-ascertained study was conducted on 202 healthcare workers affiliated with the Hamadan University of Medical Sciences diagnosed with COVID-19 from March 1, 2020, to August 20, 2020. Patients with positive real-time reverse transcriptase polymerase chain reaction (RT-PCR) results for samples obtained from upper respiratory nasopharyngeal swabs were enrolled in the study.

For households with close contact with the index case, RT-PCR was performed regardless of symptoms, and their serum IgG and IgM were checked. Family members with a previous infection with COVID-19 and no close contact with the index case during incubation or the disease period were considered exclusion criteria.

The study protocol was approved by the Ethics Committee of Hamadan University of Medical Sciences. The data regarding the gender, marital status, age, BMI, education, location, type of accommodation, coughing, underlying disease, treatment type, treatment result, family member, and living area of index cases and also data regarding the gender, marital status, age, BMI category according to WHO classification (below 18.5: underweight, 18.5-24.9: average weight, 25-29.9: overweight, and >30: obese), education, living area, type of accommodation, smoking status, underlying disease, daily contact with the index case and family relationship with the index case of their family members were collected.

We defined SAR as the proportion of secondary cases from the total contacts living in the index case household (7). For estimating the SAR, we put the number of exposed contacts in the denominator, and the number of family members who were infected with SARS-CoV-2 or developed COVID-19 (through RT-PCR) during the infectious period of the case patient (from the disease onset until two weeks later) in the numerator. We considered household contacts as individuals who were either family members or close relatives living in the same household and having close contact with the confirmed case.

To determine the serum levels of IgG and IgM antibodies of COVID-19, about 5 cc of blood were taken from participants. For serological tests, serum samples were collected and stored at -30 ° C and then serum levels of IgG and IgM antibodies were assessed using Pishtaz Teb ELISA kits (Iran).

Descriptive statistics were reported as number and percentage for categorical variables and mean and

standard deviation for continuous variables. SAR was reported as a percentage and 95% confidence interval (CI). Multiple logistic regression was performed to explore the association between demographic and clinical characteristics of index cases and their family members and the risk for COVID-19 transmission to their households. We used Hosmer and Lemeshow approach for model building. This approach describes a purposeful selection of covariates for multiple model building, and those with a p-value less than 0.2 in the crude model were entered into the multiple model. Statistical analyses were done using Stata version 14 software (Stata Corp LP, College Station, TX, USA). A significant level was considered less than 0.05.

RESULTS

In the present study, 202 COVID-19-positive healthcare workers participated, of whom 118 cases (54.2%) were male, and most were married (80.7%). Also, 97.5% were successfully treated, and 135 cases (66.8%) did not report any underlying disease. The baseline characteristics of COVID-19-positive index cases are shown in Table 1.

We found 36 secondary cases with laboratory confirmation (RT-PCR) among 391 household contacts representing a household SAR of 9.2% (95% CI: 6.3, 12.1).

The median (IQR) of IgG and IgM of family members with close contact with the index case was 0.3 (0.9) mg/ml and 0.1 (0.4) mg/ml, respectively. In 11 cases (2.8%), the IgM was positive (>1.1 mg/ml), and two of them had negative PCR. The baseline characteristics of the investigated family members of COVID-19-positive cases are presented in Table 2. Out of 391 cases, 197 subjects (50.4%) were male, 231 subjects (59.1%) were married, and 377 subjects (96.4) were living in the city. Nearly 15% were 60 years old, and 133 cases (34.0%) had academic education. Also, 308 cases (78.8%) did not report any underlying disease. The mean (SD) of their contact with the case was 4.9 (4.1) hours.

In the multiple logistic regression analysis (Table 3), we assessed the risk factors of secondary cases. Among factors related to the family member, female gender (OR: 2.9, 95% CI: 1.2, 6.9), being the patient's spouse (OR: 2.2, 95% CI: 1.0, 4.6), and living in the apartment (OR: 2.8, 95% CI: 1.2, 6.2), and among factors related to index cases, hospitalization (OR: 5.9, 95% CI: 1.3, 26.9) and coughing (OR: 2.4, 95% CI: 1.1, 5.2) were the significant predictors of disease transmission to other family members (P<0.05).

Table 1. Characteristics of COVID-19 positive index cases

Variable	Levels	Frequency (%)
Gender	Male	118 (58.4)
	Female	84 (41.6)
Marital status	Single	29 (14.4)
	Married	163 (80.7)
	Widow	10 (5.0)
Age group (year)	<30	17 (8.4)
	30-44	71 (35.2)
	>45	114 (56.4)
BMI (Kg/m^2)	Underweight	1 (0.5)
	Normal	65 (32.2)
	Overweight	105 (52.0)
	Obese	31 (15.4)
Education	Less than diploma	24 (11.9)
	Diploma	83 (41.1)
	Academic	95 (47.0)
Location	Urban	197 (97.5)
	Rural	5 (2.5)
Type of accommodation	Apartment	106 (52.5)
	House courtyard	96 (47.5)
Cough symptom	Yes	126 (62.4)
	No	76 (37.6)
Underlying disease	No	135 (66.8)
	Pulmonary disease	16 (7.9)
	Cardio-vascular disease	11 (5.5)
	Diabetes	16 (7.9)
	Cancer	3 (1.5)
	Co-morbidity*	3 (1.5)
	Other**	18 (8.9)
Treatment type	Outpatient treatment	44 (21.8)
	Hospitalized	158 (78.2)
Treatment result	Remission	197 (97.5)
	Death	5 (2.5)
Family member, Mean (SD)		3.7 (1.9)
Home area (m^2), Mean (SD)		135 (62.0)

* Simultaneous infection with two or more Pulmonary, Cardio-vascular, diabetes or cancer diseases, **Liver disease or immune system dysfunction or renal failure

Table 2. Characteristics of investigated family members with close contact to index cases

Variable	Levels	Frequency (%)
Gender	Male	197 (50.4)
	Female	194 (49.6)
Marital status	Single	152 (38.9)
	Married	231 (59.1)
	Widow	8 (2.1)
Age group (year)	<15	62 (15.9)
	15-29	71 (18.2)
	30-44	118 (30.2)
	45-59	85 (21.7)
	60+	55 (14.1)
BMI (Kg/m^2)	Underweight	65 (16.6)
	Normal	156 (39.9)
	Overweight	117 (39.9)
	Obese	53 (13.6)
Education	Illiterate	43 (11.0)
	Less than diploma	123 (31.5)
	Diploma	92 (23.5)
	Academic	133 (34.0)
Location	Urban	377 (96.4)
	Rural	14 (3.6)
Smoking status	Yes	13 (3.3)
	No	378 (96.7)
Underlying disease	No	308 (78.8)
	Pulmonary disease	6 (1.5)
	Cardio-vascular disease	25 (6.4)
	Diabetes	15 (3.8)
	Cancer	5 (1.3)
	Co-morbidity*	10 (2.6)
	Other**	22 (5.6)
Family relationship with the index case	Child	124 (31.7)
	Grandchild	9 (2.3)
	Parents	58 (14.8)
	Grandparents	14 (3.6)
	Spouse	163 (41.7)
	Brother/sister	16 (4.1)
	Other	7 (1.8)
Daily contact with the index case (hour), Mean (SD)		4.9 (4.1)

* Simultaneous infection with two or more Pulmonary, Cardio-vascular, diabetes or cancer diseases, **Liver disease or immune system dysfunction or renal failure

Table 3. Predictors of confirmed secondary COVID-19 cases

Variable	Adjusted Odds ratio*	95% CI	P.Value
Factors related to the family member			
Gender			
Male	Reference		
Female	2.9	1.2, 6.9	**0.02**
Education			
Academic	Reference		
Illiterate	3.4	0.9, 13.0	0.07
Less than diploma	1.4	0.5, 4.0	0.58
Diploma	1.8	0.6, 5.3	0.28
Relationship with the patient			
Other	Reference		
Spouse	2.2	1.0, 4.6	**0.04**
Smoking			
Underlying disease			
No	Reference		
Yes	2.2	0.7, 6.4	0.17
House type			
House courtyard	Reference		
Apartment	2.8	1.2, 6.2	**0.01**
Factors related to the index case			
Treatment type			
Outpatient treatment	Reference		
Hospitalized	5.9	1.3, 26.9	**0.02**
Having caught symptom			
No	Reference		
Yes	2.4	1.1, 5.2	**0.03**

*Adjusted for other variables in the model

DISCUSSION

In this study, we investigated the household SAR of COVID-19 and associated factors among healthcare workers. Household SAR in this study was 9.2%, and among the factors related to the family members, female gender, being the patient's spouse, and living in the apartment, and among the factors related to index cases, hospitalization and coughing were the significant predictors of disease transmission from the index case to other family members.

A meta-analysis showed that the household SAR varied from 4.6% in Taiwan, with the lowest incidence, to 49.6% in China, with the highest incidence. In this study, the majority of included studies reported household SAR of less than 20% (10). In a recent meta-analysis of Madewell et

al., the SAR ranged from 3.9% in Australia to 44.6% in Italy (the overall SAR was 19%) (11).

The time of study and consequently, changes in the level of public awareness about the disease can justify these varieties. On the other hand, our study was conducted on healthcare workers, and the relatively low rate of SAR in our study could be due to their high level of awareness about the disease and more compliance with health standards. Jing et al. reported that the household SAR varied from 13.8% if household contacts are defined as all close relatives to 19.3% if household contacts only include those at the same residential address as the case (12). Therefore, some disagreements can be due to different definitions of SAR in different studies. In our study, women were vulnerable to SAR. While in this study, there was no gender difference in the risk of infection (12). However, Shah et al. (10) reported that spouses were the most vulnerable individuals in the household to COVID-19, which was in line with our findings. The higher vulnerability of these groups can be due to their involvement in the care of patients, which may result in constant close contact with the patients and, consequently, more prolonged exposure to the virus (13, 14). Staying longer at home due to household responsibilities can be another justification for women's higher chance of SAR. Moreover, Li et al. showed the presence of SARS-CoV-2 in semen (15). Although more studies are required to investigate the role of sexual contact on COVID-19 transmission.

We found that patients with cough were more likely to transmit the disease to other family members with close contacts. This finding is in line with the results of the meta-analysis by Shah et al., in which the SAR for symptomatic cases was 3.2 fold higher (10). Moreover, Madewell et al. reached similar findings (11). However, asymptomatic index cases are also important drivers of COVID-19 (16, 17).

The limitations of this study were as follows: First, in this study, the index cases were restricted to the economically productive age of society, and we could not assess the SAR for the child's index case. Second, given the presence of family members outside, it is difficult to distinguish whether they became ill due to exposure to the case index or other cases in the community. Third, some other unknown factors of transmission as a confounder can be present in the household contacts of this new disease, and finally, we did not examine the use of personal protective equipment, such as masks by family members in contact with the index case, which can be an essential factor in the transmission of the disease.

CONCLUSION

The findings of this study suggest that the SAR in household contacts of infected healthcare workers is remarkable. SAR in household contacts is elevated in females, the patient's spouse, and those living in the apartment regarding family members, and in index cases, hospitalization and having a caught are important factors.

REFERENCES

1. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. ***N Engl J Med*** 2020;382(8):727-33.
2. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. ***Lancet*** 2020;395(10229):1054-62.
3. Lipsitch M, Swerdlow DL, Finelli L. Defining the Epidemiology of Covid-19 - Studies Needed. ***N Engl J Med*** 2020;382(13):1194-6.
4. Hui DS, I Azhar E, Madani TA, Ntoumi F, Kock R, Dar O, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health - The latest 2019 novel coronavirus outbreak in Wuhan, China. ***Int J Infect Dis*** 2020;91:264-6.
5. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. ***N Engl J Med*** 2020;382(18):1708-20.
6. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19)

Outbreak in China: Summary of a Report of 72 314 Cases From the Chinese Center for Disease Control and Prevention. ***JAMA*** 2020;323(13):1239-42.

7. Arnedo-Pena A, Sabater-Vidal S, Meseguer-Ferrer N, Pac-Sa MR, Mañes-Flor P, Gascó-Laborda JC, et al. COVID-19 secondary attack rate and risk factors in household contacts in Castellon (Spain): Preliminary report. ***Enfermedades Emergentes*** 2020;19(2):64-70.
8. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. ***J Hosp Infect*** 2020;104(3):246-51.
9. Parasa S, Desai M, Thoguluva Chandrasekar V, Patel HK, Kennedy KF, Roesch T, et al. Prevalence of Gastrointestinal Symptoms and Fecal Viral Shedding in Patients With Coronavirus Disease 2019: A Systematic Review and Meta-analysis. ***JAMA Netw Open*** 2020;3(6):e2011335.
10. Shah K, Saxena D, Mavalankar D. Secondary attack rate of COVID-19 in household contacts: a systematic review. ***QJM*** 2020;113(12):841-50.
11. Madewell ZJ, Yang Y, Longini IM Jr, Halloran ME, Dean NE. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. ***JAMA Netw Open*** 2020;3(12):e2031756.
12. Jing QL, Liu MJ, Zhang ZB, Fang LQ, Yuan J, Zhang AR, et al. Household secondary attack rate of COVID-19 and associated determinants in Guangzhou, China: a retrospective cohort study. ***Lancet Infect Dis*** 2020;20(10):1141-50.
13. Liu T, Liang W, Zhong H, He J, Chen Z, He G, et al. Risk factors associated with COVID-19 infection: a retrospective cohort study based on contacts tracing. ***Emerg Microbes Infect*** 2020;9(1):1546-53.
14. James A, Eagle L, Phillips C, Hedges DS, Bodenhamer C, Brown R, et al. High COVID-19 Attack Rate Among Attendees at Events at a Church - Arkansas, March 2020. ***MMWR Morb Mortal Wkly Rep*** 2020;69(20):632-5.
15. Li D, Jin M, Bao P, Zhao W, Zhang S. Clinical Characteristics and Results of Semen Tests Among Men With Coronavirus Disease 2019. ***JAMA Netw Open*** 2020;3(5):e208292.
16. Liu Y; Centre for Mathematical Modelling of Infectious Diseases nCoV Working Group, Funk S, Flasche S. The contribution of pre-symptomatic infection to the transmission dynamics of COVID-2019. ***Wellcome Open Res*** 2020;5:58.
17. Aguilar JB, Faust JS, Westafer LM, Gutierrez JB. Investigating the impact of asymptomatic carriers on COVID-19 transmission. ***MedRxiv*** 2020.