

Advanced age is an important risk factor of SARS-CoV-2 infection among persons who live with COVID-19 patients

Podeszły wiek jest istotnym czynnikiem ryzyka zakażenia SARS-CoV-2 osób mieszkających w jednym gospodarstwie domowym z chorym na COVID-19

Agnieszka Bednarska^{1,2}, Dominik Bursa^{1,2}, Natalia Bluszcz², Iwona Sosińska-Bryła², Marcin Paciorek^{1,2}, Małgorzata Hackiewicz², Michał Makowiecki^{1,2}, Andrzej Horban^{1,2}

¹ Department of Adults' Infectious Diseases, Medical University of Warsaw, 02-091 Warsaw, Żwirki i Wigury 61, Poland

² Hospital for Infectious Diseases in Warsaw, 01-301 Warsaw, Wolska 37, Poland

Abstract

Background. SARS-CoV-2 is the cause of an acute respiratory disease, named 'coronavirus disease 2019' (COVID-19). Airborne transmission in the indoor environment is an important factor, especially if vulnerable persons stay in the same enclosed spaces and are exposed to prolonged exposure to respiratory particles. **Methods.** We analysed the records of 490 consecutive persons, the researched group consisted of patients who were diagnosed in the Hospital for Infectious Diseases, Warsaw, Poland with the SARS-CoV-2 infection between 07.04.2020 and 11.06.2020 and the persons, not originally infected who lived with the patients in the same household. **The aim** of this study was to estimate the rate and risk of SARS-CoV-2 infection among studied population. **Results.** The study covered 490 persons, 231 women and 259 men, aged from less than one year to 85 years. Out of 251 individuals who were considered as not infected with SARS-CoV-2 but were living with COVID-19 patients 78 tested positive during follow-up. Thus secondary attack was estimated at 31 %. The age was an important risk factor of infection increasing the chance of it by 1.9% with each subsequent year of life. **Conclusions.** Age is an important risk factor of SARS-CoV-2 infection among persons living with a COVID-19 patient. Every subsequent year of life increases the risk of infection by 1.9% . *Geriatrics* 2022;16:75-81. doi: 10.53139/G.20221615

Keywords: COVID-19, age, risk of infection, household contact

Streszczenie

Wstęp. COVID-19 („choroba koronawirusowa 2019”) jest ostrą infekcją dróg oddechowych wywołaną zakażeniem SARS-CoV-2. Transmisja wirusa odbywa się drogą kropelkową. Może być szczególnie intensywna jeśli osoby wrażliwe przebywają w tych samych zamkniętych przestrzeniach, a tym samym są narażone na długotrwały kontakt z aerozolem pochodzącym z dróg oddechowych osoby z COVID-19. **Metody.** Analizowano retrospektywnie dokumentację 490 osób w wieku od poniżej roku do 85 lat. Grupa badana składała się z 239 (49%) pacjentów, u których w okresie od 07.04.2020 do 11.06.2020 zdiagnozowano w ramach porady w Izbie Przyjęć Wojewódzkiego Szpitala Zakaźnego w Warszawie zakażenie SARS-CoV-2 oraz ich współdomowników w liczbie 251 (51%). **Celem** tego badania było oszacowanie częstości i ryzyka zakażenia SARS-CoV-2 wśród współdomowników chorych na COVID-19. **Wyniki.** Badaniem objęto 490 osoby, 231 kobiety i 259 mężczyzn w wieku od poniżej roku do 85 lat. Spośród 251 współdomowników pacjentów z COVID-19 u 78 (31%) stwierdzono dodatni wynik badania PCR-RNA-SARS-CoV-2 wykonanego w czasie obserwacji. Wiek okazał się istotnym statystycznie czynnikiem ryzyka zakażenia zwiększając je o 1.9% z każdym kolejnym rokiem życia. **Wnioski.** Wiek jest istotnym czynnikiem ryzyka zakażenia SARS-CoV-2 wśród współdomowników osób z COVID-19. Każdy kolejny rok życia zwiększał ryzyko zakażenia o 1,9%. *Geriatrics* 2022;16:75-81. doi: 10.53139/G.20221615

Słowa kluczowe: COVID-19, wiek, ryzyko zakażenia u współdomowników

Introduction

In December, 2019, a novel coronavirus causing severe acute respiratory syndrome (SARS) emerged in Wuhan, China [1].

SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) is related to beta coronaviruses and to SARS-CoV-1 [2].

This highly transmissible and pathogenic coronavirus is the cause of an acute respiratory disease, named 'coronavirus disease 2019' (COVID-19) [3].

The vast majority of patients suffer from a mild course of COVID-19 [4]. The disease in persons with the infection has thus been documented both in hospitals and in family settings [5]. Airborne transmission in the indoor environment is an important factor, especially if vulnerable persons stay in the same enclosed spaces and are exposed to prolonged exposure to respiratory particles [6,7]. It is only right that secondary rate attack among household contacts is higher than in other environments. However the reported in published studies rate of SARS-CoV-2 transmission vary meaningfully [8].

Aim of the study

We studied the rate and risk of SARS-CoV-2 infection among persons who lived with COVID-19 patients in the same household, as well as the dependence of the risk of infection on age and the number of people in one cluster.

Methods

Study population

We analysed retrospectively the records of 490 consecutive persons aged from less than one year to 85 years. The studied group consisted of patients who were diagnosed in the Hospital for Infectious Diseases, Warsaw, Poland with the SARS-CoV-2 infection between 07.04.2020 and 11.06.2020 and the persons who lived with the patients in the same household. The basic demographic data as age, sex, number of persons leaving in one cluster; the frequency of reported symptoms as well as the risk of infection with SARS-CoV-2 were evaluated.

Diagnosis of SARS-CoV-2 and assessment visits

Persons with symptoms that could suggest COVID-19 were consulted in the Hospital for Infectious Diseases Emergency Room. A swab from the nasopharynx was obtained. Those patients whose

PCR test for the diagnosis of SARS-CoV-2 was positive were included for further observation.

The first assessment visit was arranged two weeks after the infection had been detected. Then subsequent assessments were held every seven days. During every visit a swab was obtained from the nasopharynx for the detection of SARS-CoV-2 using the PCR method. Additionally patients completed a questionnaire which concerned the following symptoms: fever ≥ 38 degrees Celsius, cough, dyspnoea or breathing difficulties, muscle pain, weakness, conjunctivitis, sneezing, runny nose, sore throat, diarrhoea, vomiting, dizziness, loss of taste or smell.

The people living in the same household with the patients diagnosed in the Emergency Room were also invited for an assessment.

Statistical analysis

Statistical calculations were made for the entire study group and for groups of infected and not infected with SARS-CoV-2 persons. The distribution of variables was analyzed with the Shapiro-Wilk test. The Mann-Whitney U test was used to compare the groups. The dependence of the time to recovery on age was identified in linear regression analysis. Variables associated with an increased probability of infection were identified in the logistic regression analysis.

Results

Study population

The study covered 490 persons, 231 women and 259 men, aged from less than one year to 85 years (average 36, median 36 years). The largest group were people aged 18-65 (336 persons, out of them 208 originally infected and 54 secondary infected) (table I and II, figure 1).

These people lived in 178 households (clusters), the number of persons living in one household vary from 1 to 10 (average 3 people, median 2 people).

Out of 490 studied persons 239 (49%) were originally diagnosed in the Hospital for Infectious Diseases Emergency Room with SARS-CoV-2 infection. Out of 251 (51% of whole population) individuals who were living with COVID-19 patients and were considered as not infected with SARS-CoV-2 seventy eight (31%) tested positive during follow-up (table I).

Risk of infection with SARS-CoV-2

The risk of infection was positively dependent on age and the number of people in the cluster in

Table I. Demographic data of study population

Tabela I. Dane demograficzne badanej populacji

total	490 persons	
age	< 1 year to 85 years (average 36, median 36 years).	
sex	women 231 (47%)	men 259 (53%)
	no of patients originally diagnosed with COVID-19 (% of whole population)	239 (49%) age <1-83 (average 39, median 36) 109 women, 131 men
	no of persons living with COVID-19 patients and remained not infected with SARS-CoV-2 (% of whole population)	173 (35%) age <1-84 (average 39, median 35) 83 women, 90 men
	no of persons who appeared to be infected with SARS-CoV-2 during follow-up (% of whole population)	78 (16%) age <1-85 (average 39, median 36) 40 women, 38 men
no of households (clusters)	178	
no of persons living in one household	1 to 10 (average 3 people, median 2 people).	

Table II. Stratification of the study population according to age groups

Tabela II. Podział badanej populacji według grup wiekowych

age	secondary infected	originally infected	whole population	women	men
0-18 years	20	17	145	93	52
18-65 years	54	208	336	172	194
≥65 years	5	16	35	20	15
≥80 years	2	2	9	4	5

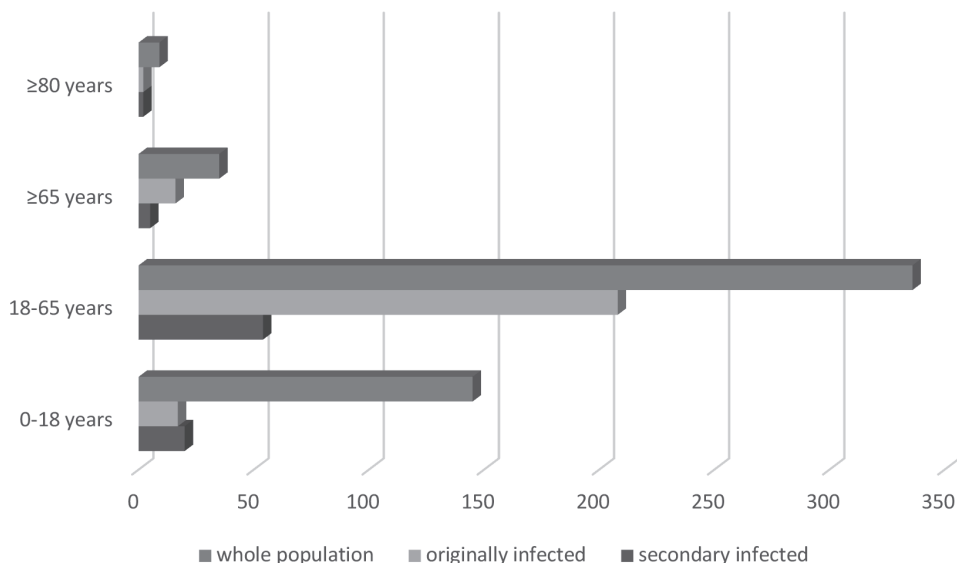


Figure 1. Stratification of the study population according to age groups

Rycina 1. Podział badanej populacji według grup wiekowych

the Mann-Whitney U test and in univariate logistic regression, however in multivariate logistic regression analysis age was the only risk factor increasing the chance of infection by 1.9% with each subsequent year of life (table III and IV, figure 2).

Reported symptoms

Weakness was the most common symptom reported at the beginning of the infection, followed

by coughing, muscle pain, loss of taste or smell, fever, runny nose, sore throat, sneezing, dyspnoea, dizziness, diarrhea, conjunctivitis and vomiting. Sixty two persons denied any symptom – in this group there were 12 patients, 10 persons secondary infected with SARS-CoV-2 and 40 roommates who did not become ill. The frequency of the reported symptoms is presented in table V.

Table III. The dependence of the risk of infection on age and the number of people in the cluster in the Mann-Whitney U

Tabela III. Wpływ wieku i liczby osób zamieszkujących jedno gospodarstwo domowe na ryzyko zakażenia SARS-CoV-2 (test U Whitney-Mann)

persons without infection vs infected	persons without infection		infected		p value
	median	IQR	median	IQR	
age	28,0	32,0	39,0	25,0	0,000029
number of people in a cluster	4,0	2,0	3,0	3,0	0,000136

Table IV. The dependence of the risk of infection on the age and number of people in the cluster in the multivariate logistic regression ($p < 0.1$)

Tabela IV. Wpływ wieku i liczby osób zamieszkujących jedno gospodarstwo domowe na ryzyko zakażenia SARS-CoV-2 (regresja wieloczynnikowa, $p < 0.1$)

variable	OR	CI 95%	p value
age	1.019	1.009-1.030	<0.0001
number of people in a cluster	0.959	0.916-1.003	0.070

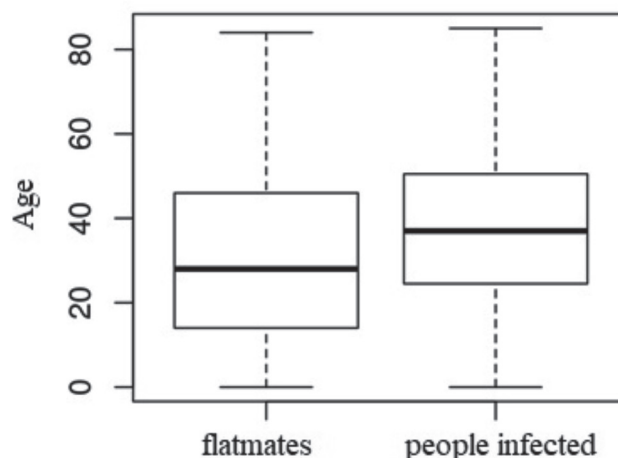


Figure 2. The influence of age on the risk of SARS-CoV-2 infection in the study group

Rycina 2. Wpływ wieku na ryzyko zakażenia SARS-CoV-2

Table V. Frequency of reported by infected with SARS-CoV-2 persons symptoms

Tabela V. Częstość zgłaszanych przez zakażone SARS-CoV-2 osoby objawów

symptom	no of persons reported selected symptom (% of whole population)	symptom	no of persons reported selected symptom (% of whole populationa)
weakness	total: 111 (23%) originally infected:80 (16%) secondary infected:22 (4%)	sneezing	total: 39 (8%) originally infected:27 (6%) secondary infected:8 (2%)
cough	total: 99 (27%) originally infected:70 (14%) secondary infected:21 (4%)	dyspnea	total: 38 (8%) originally infected:28 (6%) secondary infected:5 (1%)
muscles pain	total: 78 (16%) originally infected:51 (10%) secondary infected:19 (4%)	dizziness	total: 34 (7%) originally infected:26 (5%) secondary infected:7 (1%)
loss of taste or smell	total: 75 (15%) originally infected:59 (12%) secondary infected:12 (2%)	diarrhea	total: 31 (6%) originally infected:21 (4%) secondary infected:8 (2%)
fever $\geq 38^{\circ}\text{C}$	total: 61 (12%) originally infected:40 (8%) secondary infected:16 (3%)	conjunctivitis	total: 11 (2%) originally infected:9 (2%) secondary infected:1 (0.2%)
running nose	total: 45 (9%) originally infected:27 (6%) secondary infected:10 (2%)	vomiting	total: 2 (0.4%) originally infected:1 (0.2%) secondary infected:1 (0.2%)
sore throat	total: 40 (8%) originally infected:19 (4%) secondary infected:13 (3%)		

Lack of data: 257 (52%) out of 490 studied persons did not completed the questionnaire.

Whole population: 490 persons (239 originally infected, 78 secondary infected)

Discussion

The main mode of transmission of COVID-19 is through droplets and contact transmission [9]. The isolation of persons with COVID-19 is implemented to prevent the spread of SARS-CoV-2 [10,11]. It has to be assumed that staying in the same household with someone with COVID-19 increases the risk of infection with the novel coronavirus [12,13].

Age is a well-known risk factor for the severe course of COVID-19 [14] but has also been indicated as an infection-enabling variable [15]. The older individuals are the most susceptible to household transmission of SARS-CoV-2 as well [16-18]. Age-associated immune dysfunction, mainly T cell-dependent adaptive responses manifested as a decreased ability to eliminate infection, seems to be the most obvious reason [19].

In our study of 251 individuals who were considered as originally not infected with SARS-CoV-2 but were living with COVID-19 patients, 78 (31%) tested positive during the first or subsequent examination. As in other researches age was found to be a risk factor of SARS-CoV-2 infection among household of COVID-19 patients. We also made an attempt to assess the severity of the risk and found that it increases by 1.9% with each subsequent year of life.

The secondary attack rate among household contacts vary from 6 to 40% depending on the methods of contact tracing and the quarantine rules applied [17,20-23]. In the retrospective observation of Ng OT et al symptomatic contacts were transferred to hospital, those who as a result of testing appeared to be infected with SARS-CoV-2 were admitted to hospital and remained until the discharge as convalescents [23]. A low, from five to nine percentage of secondary infected persons most likely resulted from the very strict rules relevant to infected patients isolation. In the study of Li W et al there was no secondary attack rate to household contacts if the infected persons quarantine themselves since the symptoms onset and 27.8% to the spouses of index cases who was not isolated [20]. Margarita L et al found even higher (42%) rate of positive tests results among close contacts who were traced retrospectively using index patients' epidemiological records [22]. Similar to our study another then index patient source of infection cannot be surely rule out.

Whereas in the study of Letizia AG et al approximately 2% of U.S. Marine Corps recruits who underwent quarantine at a closed college campus and had negative results for SARS-CoV-2 infection on the entry tested positive by day 14 [24]. In our group 25%

of negative flatmates turned out to be already infected after two weeks of observation.

Common symptoms reported by outpatients include sore throat, fatigue, fever, loss of smell or taste, headache, musculoskeletal pain, dry cough. Among them fever, myalgia or arthralgia, fatigue, and headache could be considered red flags for COVID-19 [25,26].

In our study regarding individuals with a mild course of COVID 19, weakness was the most common symptom reported at the beginning of the infection and was followed by coughing, muscle pain, loss of taste or smell, fever, runny nose, sore throat, sneezing, dyspnoea, dizziness, diarrhea, conjunctivitis and vomiting. Viral infection is associated with abnormal psychological and somatic sensations such as fatigue. A recent study on an animal model demonstrated that this suppression of locomotive activity is caused by neuroinflammation of brain tissue including production of interleukin (IL)-1 β by activated microglia [27].

Conclusions

The study is not free from limitations, among them lack of information regarding the flatmates of the infected patients during the first two weeks of observation and the presence of comorbidities possibly enabling

the infection. Still, we can conclude that the sensation of fatigue is the most common symptom reported by patients with mild and moderate COVID 19, age is an important risk factor of SARS-CoV-2 infection among persons living with a COVID-19 patient, and every subsequent year of life increases the risk of infection by 1.9% .

Funding

The study was supported by Fundacja Rozwoju Nauki w Wojewódzkim Szpitalu Zakaźnym (Foundation for the Development of Infectious Diseases at the Voivodship Infectious Diseases Hospital) and Agencja Badań Medycznych (Medical Research Agency)

Conflict of interest

None

Correspondence address

✉ Agnieszka Bednarska
Hospital for Infectious Diseases
Wolska St. 37, 01-301 Warsaw
☎ (+48 22) 335 53 72
✉ abednarska@zakazny.pl

References

1. Poland GA, Ovsyannikova IG, Kennedy RB. SARS-CoV-2 immunity: review and applications to phase 3 vaccine candidates; Clinical Characteristics of Coronavirus Disease 2019 in China. *Lancet*.2020;396:1595-606.
2. Paules CI, Marston HD, Fauci AS. Coronavirus infections — more than just the common cold. *JAMA* 2020; 323: 707-8.
3. Zhu N, Zhang D, Wang W, et al. Characteristics of SARS-CoV-2 and COVID-19) A novel coronavirus from patients with pneumonia in China, 2019. *N Engl J Med* 2020;382:727-33.
4. Wu Z, McGoogan J. M. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in china: summary of a report of 72314 cases from the Chinese Center for Disease Control and Prevention. *JAMA* 2020;323, 1239–42.
5. Guan W, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med* 2020;382:1708-20.
6. Lelieveld J, et al. Model Calculations of Aerosol Transmission and Infection Risk of COVID-19 in Indoor Environments. *Public Health* 2020;17(21),8114.
7. <https://www.cdc.gov/coronavirus/2019-ncov/more/scientific-brief-sars-cov-2.html>. Accessed 16 December 2021.
8. Zhao X, Shen Z, Sun L et al. A network meta-analysis of secondary attack rates of COVID-19 in different contact environments. *Epidemiology and Infection* 149, e219, 1–9.
9. Gao Z, et al. A systematic review of asymptomatic infections with COVID-19. *J Microbiol Immunol Infect*. 2021;54:12-6.
10. <https://www.cdc.gov/coronavirus/2019-ncov/hcp/duration-isolation.html>. Accessed 08 February 2022.
11. <https://www.ecdc.europa.eu/en/publications-data/covid-19-guidance-discharge-and-ending-isolation>. Accessed 08 February 2022.
12. Du N, et al. A case series describing the epidemiology and clinical characteristics of COVID-19 infection in Jilin Province. *Virulence* 2020;11:482-5.
13. Jasper JF, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. 220;395:514-23.
14. <https://www.cdc.gov/media/releases/2020/p0625-update-expands-covid-19.html>. Accessed 17 December 2021.

15. Chen N, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan. *Lancet*. 2020;395:507-13.
16. Jing QL, Liu MJ, Zhang ZB et al. Household secondary attack rate of COVID-19 and associated determinants in Guangzhou, China: a retrospective cohort study. *Lancet Infect Dis*. 2020;20:1141-50.
17. Bi Q, et al. Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: a retrospective cohort study. *Lancet Infect Dis* 2020;20:911–19.
18. Pung R, Park M, Cook AR et al. Age-related risk of household transmission of COVID-19 in Singapore. *Influenza Other Respir Viruses*. 2021;15:206-8.
19. Sadighi Akha AA. Aging and the immune system: an overview. *J Immunol Methods*. 2018;463:21-26.
20. Li W, Zhang B, Lu J et al. The characteristics of household transmission of COVID-19. *Clin Infect Dis*. 2020;71:1943-6.
21. Jing QL, Liu MJ, Zhang ZB et al. Household secondary attack rate of COVID-19 and associated determinants in Guangzhou, China: a retrospective cohort study. *Lancet Infect Dis*. 2020;20:1141-50.
22. Martinez-Fierro ML, Rios-Jasso J, Garza-Veloz I et al. The role of close contacts of COVID-19 patients in the SARS-CoV-2 transmission: an emphasis on the percentage of nonevaluated positivity in Mexico. *Am J Infect Control*. 2021;49:15-20.
23. Ng OT, Marimuthu K, Koh V et al. SARS-CoV-2 seroprevalence and transmission risk factors among high-risk close contacts: a retrospective cohort study. *Lancet Infect Dis*. 2021;21:333-43.
24. Letizia AG, Ramos I, Obla A et al. SARS-CoV-2 Transmission among Marine Recruits during Quarantine. *N Engl J Med*. 2020;383,2407-2416.
25. Weinbergerova B, Mayer J, Hrabovsky S et al. COVID-19's natural course among ambulatory monitored outpatients. *Sci Rep*. 2021;11:10124.
26. Struyf T, Deeks JJ, Dinnes J et al. Signs and symptoms to determine if a patient presenting in primary care or hospital outpatient settings has COVID-19 disease. *Cochrane Database Syst Rev*. 2020;7:CD013665.
27. Yamoto M, Kataoka Y. Fatigue sensation following peripheral viral infection is triggered by neuroinflammation: who will answer these questions? *Neural Regen Res*. 2015;10:203-4.