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COVID-19 seroconversion in the aircrew from Turkey

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ABSTRACT

Background: Pneumonia due to Severe Acute Respiratory Syndrome 2 (SARS-CoV-2) is spreading rapidly all over the world and air travel is the leading transmission route of the virus among countries. The aim of the study is to determine the frequency of SARS-CoV-2 Immunoglobulin G (IgG) antibodies in aircrew, to determine occupational exposure, and to understand the spread of immunity in social groups.

Method: The study was designed as a cross-sectional retrospective study. SARS-CoV-2 IgG levels were measured in patients who applied to between December 1, 2020 and January 13, 2021. Coronavirus disease-2019 (COVID-19) Reverse transcription polymerase chain reaction (RT-PCR) positivity was investigated before December 1, 2020.

Results: The patients were divided into three groups according to their jobs such as 313 aircrew; 451 healthcare workers; 4258 other patients. The PCR positivity rate was found to be 39% in the aircrew group, 32% in the healthcare workers and %20 other patient group ($p < 0.001$). The IgG antibody positivity rate was 46% in the aircrew, 41% in healthcare workers, and 35.3% in the other patient group ($p < 0.001$).The group with the highest IgG antibody titer is in the aircrew; there was a significant difference between the groups ($p < 0.001$).

Conclusions: In our study, it was observed that aircrew, similar to healthcare workers, are at serious risk against SARS-CoV-2. In this process, it is suggested that the vaccination processes included repeated doses of aircrew should be accelerated and protective measures and equipment should be increased in terms of reinfection.

1. Introduction

In recent years, air transportation has been increasing all over the world [1]. Large numbers of people traveling increase the contagiousness of airborne pathogens, and the better connection between remote regions poses an increased risk for the rapid spread of infectious diseases globally, leading to pandemics [2–4]. It has been reported that air transport is important in the spread of many epidemics such as tuberculosis, severe acute respiratory syndrome (SARS-CoV), influenza, smallpox and measles [5]. In the H1N1 flu epidemic in 2009, the rapidly increasing cases associated with travelers from North America to Europe and Asia indicate the central role of international air travel in the spread of viruses [6]. Coronavirus disease 2019 (COVID-19) started on December 19th, 2019 in Wuhan, China, as pneumonia cases of unknown origin, spread throughout the world, and became a pandemic in March 2020. Preventing the transmission of COVID-19, which could be mortal in the elderly and people with comorbid diseases, is important for public health and ending the pandemic [7]. COVID-19 has affected all areas of our lives and has had a heavy impact on the aviation industry [8]. Measures such as personal protective equipment and social distance are taken into an account in air travel to reduce the risk of COVID-19 exposure and spread [9]. Infection contamination during flights may be caused by direct contact with blood, skin or other body fluids. As with indirect contact, droplet infection can occur with contaminated surface

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and object contact (as in methicillin-resistant *Staphylococcus aureus*) [10]. Air travel increases the size and spreading rate of the pandemic with the movement of infected people [11]. Spread of the disease through international travelers has been documented [12], with insufficient evidence transmission of on-board and between passengers. Unfortunately, there are not enough studies showing COVID-19 seroprevalence in airline workers. The aim of our study is to show the immunity variability within social groups by determining the COVID-19 seroprevalence in flight personnel, which is a risky group like healthcare workers, and to emphasize the importance of preventing viral transmission in airline travel, as in other viral infections, in the spread of the epidemics.

2. Methods

2.1. Study design and participants

The study was designed as a cross-sectional retrospective study. The recorded data of 5032 patients attending the outpatient clinics at Biruni University Medical Faculty Hospital between December 1, 2020 and January 13, 2021 were examined from the patients' files. The patients were divided into three groups according to their jobs due to the risk of infectious diseases. The first group consisted of 313 aircrews (female: male 179: 134, mean age 31.6 ± 18 years). The second group consisted of 451 healthcare workers (female: male 284: 167, mean age 30.6 ± 9.8 years) working at Biruni University Faculty of Medicine. The third group consisted of 4258 other patients who were non-aircrews and non-healthcare workers (female: male 1696: 2562, mean age 40.4 ± 13.4 years). In the groups pilots, co-pilots, and flight attendants are defined as aircrew, while doctors, nurses, allied health personnels are defined as healthcare workers.

Serum Immunoglobulin G (IgG) levels against to SARS-CoV-2 of all patients in the study had been measured during their admission to the hospital. All participants in the research had their data examined from six months prior to testing for IgG antibody levels. It was determined how many times the individuals with COVID-19 clinical symptoms underwent a Reverse Transcription Polymerase Chain Reaction (RT-PCR) nucleic acid test and were PCR positive. The demographic characteristics and comorbidities of all patients were taken from the hospital records. At the beginning of the study, the patients with pregnancy; below eighteen years; chronic heart failure; chronic kidney and liver diseases; alcoholism; malignancy; connective tissue diseases; neurologic and psychiatric problems (Parkinson's disease, bipolar disorder, depression); using steroids or immunosuppressives drugs; immunosuppressive illness were not included to the study.

The study protocol was permitted by Biruni University Faculty of Medicine Ethics Committee and the Ministry of Health. Number was given 2021/47-42 by Ethics Committee. The study was completed according to the mandates of the Helsinki Declaration. All patients were given full information about the study procedures before providing written consent.

2.2. Procedure

SARS-CoV-2 RT-PCR results were taken patient hospital record. All patients included in the study had oropharyngeal and nasal swab samples taken for COVID-19 RT-PCR nucleic acid test. Both mouth and nose swab samples were placed in VNAB (viral nucleic acid buffer) fluid. VNAB fluid provides viral nucleic acid extraction. VNAB liquid was added to the prepared PCR mix and it was worked on Biorad CFX96 Realtime PCR device. As a result of RT-PCR device operation, 200 relative fluorescence unit value was taken as threshold value in each channel. N gene channel (HEX) was studied as an internal control. And in this channel, sigmoidal curves with cycle threshold (Ct) value≤32 were accepted. Sigmoidal curves with a Ct value of≤38 in the ORF1ab gene (FAM) channel were accepted as positive. Samples with ct values > 38 in the FAM channel or with no peaks were considered negative provided that internal controls were run.

In this serological assay was collected 2 mililiter (ml) of venous blood from each participant between December 1, 2020 and January 13, 2021 (before the beginning of public vaccination in Turkey). Blood sample tested within 4 h after blood collection in room temperature. We used an immunofluorescence assay (IFA), using COVID-19 IgG antibody IFA fast test kits (IF2084 for Getein 1600, Getein Biotech, Inc. Nanjing, China), to evaluate the presence of serum IgG antibody against SARS-CoV-2, in accordance with the manufacturer's instructions. The test uses mixed recombinant SARS-CoV-2 nucleocapsid protein (N protein) and spike protein (S protein). Briefly, each cartridge for Getein 1600 contains a specific radio-frequency identification card which can calibrate automatically. Put the sample diluent at the correct position in Getein 1600, place samples in the designed area of the sample holder, insert the holder and select the right test item, Getein 1600 will do the testing and print the result automatically. The test result is displayed numerically in terms of cut-off index (COI) value. Test result is negative if COI is < 1.0 and positive if COI is ≥ 1.0.

2.3. Statistical analysis

A sample size of $n = 311$ per group is required to provide 80% power to detect a difference in the anticipated seroprevelance with a significance of 0.001 (2-sided α). The fit to a normal distribution of all data was analyzed using the Kolmogorov-Smirnov test. Categorical variables are presented as percentages, while continuous variables are presented as mean ± standard deviation. Categorical variables were analyzed using the chi-square test. An analysis of variance was utilized to compare multiple group means. The following post hoc evaluation was made by Bonferroni method. All data were tested using the SPSS 20.0 (SPSS, Chicago, IL, USA) software, and values of $p < 0.05$ were considered statisticallysignificant.

3. Results

The demographic characteristics and comorbidities in the studied groups are shown in Table 1. Age did not differ between healthcare workers and aircrew groups. However, the average age of aircrew and healthcare workers were lower than the other patient group ($p < 0.001$). The female sex ratio was significantly higher in the healthcare worker and aircrew compared to the other group ($p < 0.001$). The smoking habits did not differ among the groups. The frequency of comorbidities (hypertension, diabetes mellitus, COPD/Asthma, coronary artery disease and hyperlipidemia) was significantly higher in other groups then aircrew and healthcare workers (each all $p < 0.001$). Frequency of PCR monitoring was higher in healthcare workers compared to other groups ($p < 0.001$). The PCR positivity rate was 39% in the flight personnel, 32.6% in healthcare workers, 20.6% in the other patients, and it was significantly higher in the flight personnel group ($p < 0.001$). Antibody positivity rate was 46% in the aircrew, 41% in healthcare workers, and 35.3% in other patients ($p < 0.001$). Antibody titer was 41.8 ± 19.2 in aircrew; 36.5 ± 21.2 in health workers and 33.2 ± 21.9 in other patients. Among the groups antibody titer was significantly higher in aircrew ($p < 0.001$). According to antibody or PCR positivity, people who had COVID-19 were found to be 46% in the flight crew, 46.1% in healthcare workers and 35.5% in other patients. While the number of people with COVID-19 was the lowest in the other patient group, the rate in aircrew and healthcare workers was similar ($p < 0.001$).

4. Discussion

In our study, the positivity rates of COVID-19 RT-PCR and IgG antibody against to SARS-CoV-2 and the IgG antibody titers were found to be significantly higher in the aircrew group compared to healthcare workers and other patients groups who were in the high risk group to all

Table 1
The demographic characteristics, comorbidities and the positivity of SARS-CoV-2 RT-PCR tests and the IgG antibody in the studied groups.

	Aircrews Group (n = 313)	Healthcare workersGroup (n = 451)	Other Patients Group (n = 4258)	p
Age (years)	31.6 ± 7.6	30.6 ± 9.8	40.4 ± 13.4	< **0.001**
Gender (female)	179 (57.2)	284 (63)	1696 (39.8)	< **0.001**
Smoking	90 (28.8)	136 (30.2)	1322 (31.1)	0.532
Comorbidities				
Hypertension	11 (3.5)	21 (4.7)	778 (18.3)	< **0.001**
Diabetes mellitus	4 (1.3)	8 (1.8)	341 [8]	< **0.001**
COPD/Asthma	3 (0.9)	6 (1.3)	254 (5.9)	< **0.001**
Coronary artery disease	2 (0.6)	3 (0.7)	312 (7.3)	< **0.001**
Hyperlipidemia	3 (0.9)	3 (0.7)	308 (7.2)	< **0.001**
Count of RT-PCR screening for symptoms resembling COVID-19 until positivity	0.7 ± 1.1	2.2 ± 3.3	0.8 ± 1.9	< **0.001**
PCR positivity	122 (39)	147 (32.6)	876 (20.6)	< **0.001**
The positivity of IgG antibody to SARS-CoV-2	144 (46)	185 (41)	1503 (35.3)	< **0.001**
The titers of IgG antibody to SARS-CoV-2	41.8 ± 19.2	36.5 ± 21.2	33.2 ± 21.9	< **0.001**
COVID-19 positivity (RT-PCR or antibody)	144 (46)	208 (46.1)	1510 (35.5)	< **0.001**

COPD, chronic obstructive pulmonary disease; COVID-19, Coronavirus disease-2019; RT-PCR, Reverse Transcription Polymerase Chain Reaction, IgG, immunoglobulin; SARS-CoV-2, severe acute respiratory syndrome-2. P value < 0.05; statistically significant.

infectios diseases.

The COVID-19 pandemic has caused over 100 million cases and nearly 2.5 million deaths worldwide since the beginning of the epidemic [13]. SARS-CoV-2 transmitted by respiratory droplets from person to person and close contact has an incubation period of 1–14 days before the onset of symptoms, and asymptomatic carriers can be a source of infection [14]. This feature indicates the urgency and importance of preventing social transmission. The COVID-19 pandemic has touched every aspect of human life, affecting the global economy and many sectors, including the aviation industry [9]. Every year, 4.1 billion people use airlines in the worldwide and only 140 thousand pilots and 120 thousand flight attendants work in the United States [15,16]. Flight cancellations, travel restrictions, border closures and measures taken in response to the pandemic have seriously strained the travel industry. Although many countries oblige passengers traveling from abroad to screen with RT- PCR within 48–72 h before, transmission between countries and aircrew continues to be a major problem due to the RT-PCR test not capturing all patients such as asymptomatic patients and incubation period. Studies suggest that the number of passengers, the risk of on-board transmission of the infection in passengers and the duration of the flight should be taken into an account [17]. There is still a little evidence evaluating protective measures for air travel or daily life [18].

During the flight, the aircrew is exposed to environmental factors that may cause cancer and other diseases by damaging deoxyribonucleic acid (DNA). Exposures such as air pressure change, vibration, prolonged immobility, circadian rhythm disturbances and cosmic ionizing radiation are the leading environmental factors [9,19]. DNA repair plays a central role in immunity, and DNA repair capacity affects severe COVID-19 development. Failure to provide social distance in airplanes or time to flight increase the risk of COVID-19 exposure for the aircrew [9]. It is known that 50% of COVID-19 cases are asymptomatic who increase transmission of viruses. Also United States Centers for Disease Control and Prevention (CDC) recommends asymptomatic screening with antigen test 1–3 days before the flight and 3–5 days after the flight [20,21]. Incompatible results can be detected in the SARS-CoV-2 RT-PCR tests in oropharyngeal and nasopharyngeal sampling, and similar results can be detected with the noninvasive saliva test, which can give rapid results [22]. In most cases, IgM cannot be detected or is detected negatively in the early period of the disease. Additionaly the IgG antibody response shows immune response rather than infection [23]. Antibody tests can be used in the diagnosis of cases with negative RT-PCR tests in the late stage of the disease; in the diagnosis of asymptomatic infection; in monitoring the progress towards herd immunity; in determining seroprevalence in a particular population; in contact monitoring with molecular testing [24]. Seroprevelance in the community varies between 0.1% and 20%, and in healthcare workers between 1% and 31.6%. Seroprevelance varies from region to region, and among social groups, and depends on the timing during the pandemic and the test used. Regular monitoring of seroprevalence is recommended in each region to establish the epidemiology of COVID-19 [25].

Public service workers employed in the health, food and public security sector and other groups who cannot work from home are at high risk in terms of exposure to COVID-19 [26]. Studies conducted in these high-risk groups are summarized in Table 2. Studies conducted by Lachassinne et al. [27] found seroprevalence to be 7.7% in 197 daytime childcare personnel, while Murhekar et al. were found the seroprevalence was to be 14,7% in employees with high virus exposure, such as healthcare workers, police, security guards, grocery stores, bus and taxi drivers [28]. In the study conducted by Johson et al. [29] with 247 pharmacists, seroprevalence was 14.6%, while seroprevalence was 11.5% in the study of 157 dentists by Sarapultseva et al. [30]. The seroprevalence in 203 firefighter paramedics was found to be 8.9% in the study performed by Martinez et al. [31] Although studies reported on SARS-CoV-2 seroprevalence in healthcare workers from many countries, there is no reported data in Turkey. In our study, seroprevelance was 46.1% in healthcare workers and 46% in aircrew who are the leading high-risk groups to COVID-19. The seroprevelance was observed that 35.5% of the other patients group. Healthcare workers and aircrew were at higher risk than the average population. Highly exposed groups, including aircrew, are acutely affected by the pandemic, are frequently exposed to infection and work closely with people. Employees who are at the forefront of this crisis environment, and thus vulnerable to illnesses, should be protected in case of illness, including paid sick leave and compensation allowances, as well as personal protective equipment

Table 2
The COVID-19 seroconversion related studies in the public service workers.

Study	Population	n	Seroprevelance
Lachassinne et al.[27] (2021)	Childcare personnel	197	%7,7
Johson et al.[29] (2021)	Pharmacists	247	%14,6
Sarapultseva et al.[30] (2021)	Dentists	157	%11,5
Martinez et al.[31] (2020)	Firefighter paramedics	203	%8,9
Murhekar et al.[28] (2020)	Occupations with a high risk of exposure to virus	4263	%14,7

[32].

The current study has some limitations. First, it cannot be generalized to the whole population because it is a cross-sectional study conducted at a single center and only patients older than 18 years of age who are not pregnant and do not have many chronic diseases are included. Second, since healthcare workers and aircrew included in the study could not be screened periodically, RT-PCR is negative and the time between exposure and antibody detection in antibody positive individuals is unknown. Third, it fails to provide sufficient evidence for the elderly and people with comorbidities due to the young study sample and low comorbid conditions.

In conclusion our study observed that SARS-CoV-2 RT-PCR and IgG antibody positivity among high risk groups were higher in aircrew than healthcare workers and other patients groups. Also the IgG antibody titers in flight crew were higher than healthcare workers and the other patient group. Our study suggests that, similar to healthcare workers, the vaccination processes included repeated doses for aircrew should be accelerated and protective measures and equipment should be increased in terms of reinfection. To our knowledge this study is first study to report COVID-19 seroprevalence in aircrew from Turkey.

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Ethical approval

The study protocol was approved by the Biruni University Faculty of Medicine ethics committee and the Republic of *Turkey's* Ministry of Health (approval No. 2021/47–42)

Declaration of competing interest

The authors have no competing of interests to declare.

CRediT authorship contribution statement

Mehmet Sami Islamoglu: Conceptualization, Data curation, Writing – original draft. **Mahir Cengiz:** Investigation, Methodology, Writing – review &amp editing. **Betul Borku Uysal:** Writing – original draft. **Hande Ikitimur:** Writing – review & editing, Investigation. **Mahmut Demirbilek:** Software. **Mehmet Dokur:** Data curation, Methodology. **Serhat Seyhan:** Conceptualization, Methodology. **Suna Koc:** Methodology, Validation. **Serap Yavuzer:** Project administration, Data curation.

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