INTRODUCTION

Coronavirus disease 2019 (COVID-19) is caused by a virus belonging to the Coronavirus family (HCoV-229E, HCoV-OC43, HCoV-NL63, HKU1-CoV), a family that often causes epidemics in the winter months and is responsible for one-third of common cold cases.\(^1\)

Vaccines play a crucial role in increasing herd immunity, preventing severe diseases, and controlling ongoing health crises. CoronaVac (Sinovac Life Sciences, Beijing, China) is an inactivated vaccine against COVID-19 that shows good immunogenicity in animal trials and can neutralize severe acute respiratory syndrome (SARS-CoV-2) with vaccine-derived neutralizing antibodies.\(^2\) The first vaccine used within the scope of the COVID-19 immunization program in Türkiye was CoronaVac. Phase III studies were completed in Türkiye, Brazil, Chile, and Indonesia. The positive neutralizing antibody rate was reported to be higher than 90%.\(^3\) In addition, the results of phase III clinical trials conducted in Brazil showed that two doses of the Sinovac vaccine protected 50.7% of symptomatic COVID-19 patients and all moderate-to-severe cases.\(^4\)
vaccine was approved for emergency use by World Health Organization (WHO) on 01.06.2021. Both pre-clinical and clinical studies have revealed that the vaccine provides adequate protection for a certain period and prevents hospital admissions to a great extent.\textsuperscript{15,6} The Turkish Ministry of Health approved the use of CoronaVac (Sinovac) on 13.01.2021, after which the vaccine was first administered to healthcare workers (HCW).\textsuperscript{7} CoronaVac has been demonstrated to be well tolerated in healthy adults aged 60 years and above and is immunogenic with neutralizing antibody responses against live SARS-CoV-2 having been shown to not decrease in said healthy adults over 60 years. Further studies are needed on the efficacy of this vaccine in preventing COVID-19 in older adults.\textsuperscript{8} HCWs, older adults, and those with underlying health problems are especially at higher risk.\textsuperscript{9,10} HCWs have continued to work on the front line to care for their patients throughout the COVID-19 pandemic, and despite changes in routine practices, community pharmacists have delivered uninterrupted services to their patients. Moreover, the vaccine has been administered to community pharmacists and pharmacy staff in Türkiye, and they have, to a large degree, taken part in vaccination campaigns. Although there are studies in the literature on the changes in antibody levels in society and, more specifically, health workers created by COVID-19 vaccines and the factors affecting these changes, for these changes to be better understood, more studies need to be conducted with pharmacists and pharmacy staff. The aim of the present study was to measure the presence of antibodies produced following vaccination in pharmacists and pharmacy staff. The study was based on the results of COVID-19 spike antibody tests performed at the following centers contracted by the Istanbul Chamber of Pharmacists: Biruni Laboratories, Datalab Laboratory, Gelişim Tıp Laboratories, Türk Kızılay Sağlık A.Ş. (Turkish Red Crescent Health Co.), and Yaşar Hospital. IgG measurements taken from 15 days up to 120 days after the two vaccine doses were included in the study.

Participants were asked whether they smoked, had any chronic diseases (hypertension, chronic obstructive pulmonary disease, asthma, diabetes, etc.), or took any medications. Subgroup analyses were performed for each method used to measure antibody levels. In accordance with the central limit theorem, parametric tests were used without testing for normality. For data analysis, the mean and standard deviation along with minimum and maximum values of characteristics were used for statistics of the continuous variables, while frequency and percentage values were used to describe the categorical variables. Student’s t-test was used to compare the means of two independent groups, and the chi-square test was used to evaluate the categorical variables. Statistical significance was set at \( p < 0.05 \). For data analysis, the www.e-picos.com New York software and MedCalc statistical package program were used.\textsuperscript{32} The study received ethical approval from the Institute of Health Sciences Ethical Committee of Marmara University (approval number: 17.05.2021–82). Permission for the study was obtained from the Ministry of Health of the Republic of Türkiye. Online informed consent was obtained from all participants.

RESULTS

Three hundred and seventy-four pharmacists/pharmacy staff participated in the study; however, 45 of them were excluded due to COVID-19 diagnoses, and analyses continued with 329 participants (298 pharmacists and 31 pharmacy staff). Of these, 312 had positive antibody levels, while 17 were measured negative. In the evaluation of the relationship between antibody levels and sociodemographic parameters, only positive patients were considered, the results of laboratories with small sample numbers were not included, and the antibody levels of 222 individuals were evaluated in the two laboratories, where most of the tests were performed (Figure 1).

The antibody results of 62 individuals under the other category were not further evaluated for descriptive characteristics.
because they were obtained from different institutions' laboratories.

The mean age of the 329 participants was 49.7 ± 13.7 years; 71.4% were female, and 94.9% had positive antibody levels following two doses of the CoronaVac. The rate of positivity was 95.4% in participants aged < 65 years and 91.8% in those aged ≥ 65 years. Fifty percent of the participants were tested within 45 days following the second dose of Sinovac to determine antibody response. The participants with negative and positive antibody test results had no statistically significant differences in the descriptive parameters listed in Table 1 (p > 0.05).

Comparison of antibody levels according to sociodemographic characteristics of individuals with a positive antibody response after vaccination is provided in Table 2. These results were analyzed only internally without comparing the two laboratories. Although antibody levels were lower in smokers, older people, and the ones with chronic diseases, this difference was not statistically significant.

**DISCUSSION**

Following the vaccination during the COVID-19 pandemic, many studies have assessed the antibody levels of HCWs worldwide including Türkiye. Most of these studies included doctors and healthcare staff working in hospitals and clinics. The present study is the first to investigate community pharmacists and pharmacy staff's post-vaccine antibody levels and their association with age, smoking status, and chronic diseases.

We found antibody positivity to be approximately 95% after two doses of the CoronaVac. In other studies conducted with healthcare professionals in Türkiye, seropositivity rates of 99.6%, 99.4%, and 97%, respectively, were observed after four weeks in individuals vaccinated with two doses of the CoronaVac. The slightly lower positivity rate in our study may be related to antibody level measurements being made over a wider time interval after two doses of the vaccine.

A subject we investigated was the possible factors affecting the vaccine antibody response. Although it is well known in other vaccines that the antibody response is affected by decreasing T-cell-derived antibody production and B lymphocyte production with age, more data are needed on the COVID-19 vaccine. In this study, the antibody level in older participants was lower than that in younger individuals; however, the difference was not statistically significant. In a study conducted with HCWs vaccinated with the CoronaVac in Türkiye, the antibody level was found to be highest in the group aged 30-39 years, but this finding was not statistically significant. In Xia et al.'s study, neutralizing antibody titers were lower in the group aged ≥ 60 years compared with the group aged 18-59 years. Similarly, in a study performed in Türkiye by Şenol Akar et al., the antibody response was significantly higher in participants aged 18-64 years.

The association with age was shown not only in studies of the CoronaVac-SinoVac but also in studies of other COVID-19 vaccines produced using different methods. To compare the antibody responses against the first and second doses of Biontech/Pfizer BNT162b2, a cohort study was conducted with two age groups: < 60 years and > 80 years. Although most participants produced titers of specific IgG antibodies in response to the SARS-CoV-2 spike protein, titers were found to be significantly lower in older individuals. It was observed that antibody levels measured three months after the second dose of the Biontech/Pfizer BNT162b2 vaccine in HCWs in Japan were higher in individuals aged 20-29 years than in those aged 60-79 years.

<table>
<thead>
<tr>
<th>Table 1. Comparison of antibody test results by descriptive characteristics (n: 329)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Descriptive characteristics</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Sex, n (%)</strong></td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td><strong>Disease status, n: 212, n (%)</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td><strong>Medication use, n: 104, n (%)</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td><strong>Smoking status, n: 208, n (%)</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
<tr>
<td><strong>Age, n: 311, n (%)</strong></td>
</tr>
<tr>
<td>&lt; 65 years</td>
</tr>
<tr>
<td>≥ 65 years</td>
</tr>
<tr>
<td><strong>Time from the second vaccine to antibody, mean ± SD (days)</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
| SD: Standard deviation
In this study, it was observed that comorbid disease and chronic medication use had no effect on antibody response. A study on HCWs vaccinated with the Biontech/Pfizer BNT162b2 vaccine in Japan found that other diseases, such as diabetes and allergic diseases, were not associated with low antibody levels.8 However, a study by Güzel et al.17 found that the presence of comorbidities (diabetes mellitus and cardiovascular disease) decreased COVID-19 IgG antibody levels.

Watanabe et al.18 conducted an observational study with 86 HCWs who received Pfizer-BioNTech COVID-19 vaccines and showed that higher waist circumference, smoking, and the presence of hypertension were associated with lower antibody titers. Two studies conducted in Indonesia on HCWs vaccinated with the CoronaVac concluded that the presence of hypertension negatively affects antibody levels.19

In this study, lower antibody levels were observed in smokers; however, this was not statistically significant. A study conducted by Uysal et al.13 in Türkiye found that antibody levels were lower in smokers than in non-smokers (p = 0.032) among HCWs vaccinated with the CoronaVac vaccine. In another study conducted with healthcare professionals in Türkiye, antibody levels following CoronaVac vaccination were found to be significantly higher in non-smokers.15 Nomura et al.6 reported that age and smoking habits were the most important factors associated with low antibody titers. They highlighted that being a smoker was associated with lower antibody titers and that quitting smoking before vaccination may improve the individual efficacy of the vaccine.6

A study including a group of HCWs in Italy examined the effects of smoking on the humoral response produced by the BioNTech-Pfizer COVID-19 vaccine. In the study, antibody levels were lower in smokers than in non-smokers 60 days after vaccination (p = 0.002). According to the authors, although the pathophysiological basis of the effect of smoking on the dynamics of vaccine-induced anti-SARS-CoV-2 antibodies is not yet clear, previous studies reported that antibody response decreases more rapidly in smokers who receive other vaccines, such as vaccines for hepatitis B and influenza. Exposure to smoking impairs the immune system’s ability to form memory cells, which are critical for maintaining the protective immune response induced by vaccines.8

### Study limitations

This study has several limitations. The foremost limitation was the lower-than-expected number of participants, as the participants did their antibody testing voluntarily and at their own expense. Individuals with positive and negative antibody results were not compared because this was not a purpose of this study. Because the study evaluated post-vaccination antibody levels, it is likely that some individuals with negative results did not participate. Another limitation was conducting the study on a specific occupational group. Because of this specificity, the data cannot be generalized. In this study, only the COVID-19 spike antibody (IgG) response to the vaccine was assessed, and no information on cellular immunity was provided. Therefore, it cannot be assumed that our results provide adequate evidence regarding the level of protection from the disease that this vaccine offers individuals. Age, smoking, and the presence of diseases that may affect antibody response were examined; however, due to difficulties in collecting data from patients, parameters such as obesity and distribution of existing diseases and drugs could not be evaluated.

### CONCLUSION

CoronaVac, an inactive SARS-CoV-2 vaccine administered to community pharmacists and pharmacy staff, produced seropositivity within two months in approximately 95% of the participants. The antibody response was higher in participants younger than 65 years, non-smokers, and those without a chronic disease; however, the differences were not statistically significant. Further studies are needed to determine how much the vaccine protects individuals from the disease. Although the effects of smoking, old age, and the presence of chronic diseases on the immunological response to the COVID-19 vaccine have been clinically proven by other studies, there is still a need for trials with a higher number of individuals and longer follow-ups.
Acknowledgements
The authors thank all the pharmacists and pharmacy staff who agreed to answer the questionnaire. Moreover, we must acknowledge the support of the Istanbul Chamber of Pharmacists. The authors would also like to thank biostatistics specialist Elif Ertas of Medicres Türkiye for statistical analysis of the data.

Ethics

Ethics Committee Approval: The study received ethical approval from the Institute of Health Sciences Ethical Committee of Marmara University (approval number: 17.05.2021-82). Permission for the study was obtained from the Ministry of Health of the Republic of Türkiye.

Informed Consent: Online informed consent was obtained from all participants.

Peer-review: Externally peer reviewed.

Authorship Contributions


Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES