

Brief Communication  
Infectious Diseases,  
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# Seroprevalence of Anti-SARS-CoV-2 Antibodies among Outpatients in Southwestern Seoul, Korea

Ji Yun Noh ,<sup>1\*</sup> Yu Bin Seo ,<sup>2\*</sup> Jin Gu Yoon ,<sup>1</sup> Hye Seong ,<sup>1</sup> Hakjun Hyun ,<sup>1</sup> Jacob Lee ,<sup>2</sup> Nuri Lee ,<sup>3</sup> Seri Jung ,<sup>3</sup> Min-Jeong Park ,<sup>3</sup> Wonkeun Song ,<sup>3</sup> Jung Yoon ,<sup>4</sup> Chae Seung Lim ,<sup>4</sup> Jungsang Ryou ,<sup>5</sup> Joo-Yeon Lee ,<sup>5</sup> Sung-Soon Kim ,<sup>5</sup> Hee Jin Cheong ,<sup>1</sup> Woo Joo Kim ,<sup>1</sup> Soo-Young Yoon ,<sup>4</sup> and Joon Young Song <sup>1</sup>

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Address for Correspondence:

Joon Young Song, MD, PhD

Division of Infectious Diseases, Department of Internal Medicine, Korea University Guro Hospital, Korea University College of Medicine, 148 Gurodong-ro, Guro-gu, Seoul 08308, Korea.

E-mail: infection@korea.ac.kr

Soo-Young Yoon, MD, PhD

Department of Laboratory Medicine, Korea University Guro Hospital, Korea University College of Medicine, 148 Gurodong-ro, Guro-gu, Seoul 08308, Korea.

E-mail: labmd@korea.ac.kr

\*Ji Yun Noh and Yu Bin Seo contributed equally to this work.

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ORCID iDs

Ji Yun Noh

<https://orcid.org/0000-0001-8541-5704>

Yu Bin Seo

<https://orcid.org/0000-0001-5183-1996>

Jin Gu Yoon

<https://orcid.org/0000-0003-3283-1880>

Hye Seong

<https://orcid.org/0000-0002-5633-7214>

<sup>1</sup>Division of Infectious Diseases, Department of Internal Medicine, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Korea

<sup>2</sup>Division of Infectious Diseases, Department of Internal Medicine, Hallym University College of Medicine, Chuncheon, Korea

<sup>3</sup>Department of Laboratory Medicine, Hallym University College of Medicine, Chuncheon, Korea

<sup>4</sup>Department of Laboratory Medicine, Korea University Guro Hospital, Korea University College of Medicine, Seoul, Korea

<sup>5</sup>Korea National Institute of Health, Korea Centers for Disease Control and Prevention, Cheongju, Korea

## ABSTRACT

Serosurveillance studies reveal the actual disease burden and herd immunity level in the population. In Seoul, Korea, a cross-sectional investigation showed 0.07% anti-severe acute respiratory syndrome coronavirus-2 antibody seropositivity among 1,500 outpatients of the university hospitals. Low seroprevalence reflects well-implemented social distancing. Serosurveillance should be repeated as the pandemic progresses.

**Keywords:** Seroprevalence; Seroepidemiology; SARS-CoV-2; COVID-19

In Korea, the first case of coronavirus disease 2019 (COVID-19) was confirmed on January 20, 2020. The distinguishing characteristic of COVID-19, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is the substantial transmission potential of asymptomatic or subclinical patients. In a previous study, the viral load of SARS-CoV-2 in the upper respiratory tract of asymptomatic patients was similar to that of symptomatic patients.<sup>1</sup> However, the proportion of asymptomatic patients among the total number of patients with COVID-19 varied between studies. Among patients with mild COVID-19 in community treatment centers, asymptomatic cases accounted for 26.6% (53/199) to 58.7% (371/632).<sup>2,3</sup>

A seroepidemiological investigation can reveal the proportion of asymptomatic or subclinical infections in the general population. In addition, since SARS-CoV-2 is a novel coronavirus, surveillance of antibody seropositivity can provide useful information on the extent of infection and the cumulative herd immunity in the general population.<sup>4</sup> This cross-sectional study on the seroprevalence of antibodies to SARS-CoV-2 included outpatients of university hospitals in Seoul, Korea.

Hakjun Hyun   
<https://orcid.org/0000-0002-1193-8948>  
 Jacob Lee   
<https://orcid.org/0000-0002-7041-065X>  
 Nuri Lee   
<https://orcid.org/0000-0001-7727-8279>  
 Seri Jung   
<https://orcid.org/0000-0002-4199-7033>  
 Min-Jeong Park   
<https://orcid.org/0000-0002-2775-2128>  
 Wonkeun Song   
<https://orcid.org/0000-0001-5056-9033>  
 Jung Yoon   
<https://orcid.org/0000-0001-9296-5085>  
 Chae Seung Lim   
<https://orcid.org/0000-0002-7765-0840>  
 Jungsang Ryou   
<https://orcid.org/0000-0001-5337-7504>  
 Joo-Yeon Lee   
<https://orcid.org/0000-0002-0993-9626>  
 Sung-Soon Kim   
<https://orcid.org/0000-0003-2774-6710>  
 Hee Jin Cheong   
<https://orcid.org/0000-0002-2532-1463>  
 Woo Joo Kim   
<https://orcid.org/0000-0002-4546-3880>  
 Soo-Young Yoon   
<https://orcid.org/0000-0002-2302-3825>  
 Joon Young Song   
<https://orcid.org/0000-0002-0148-7194>

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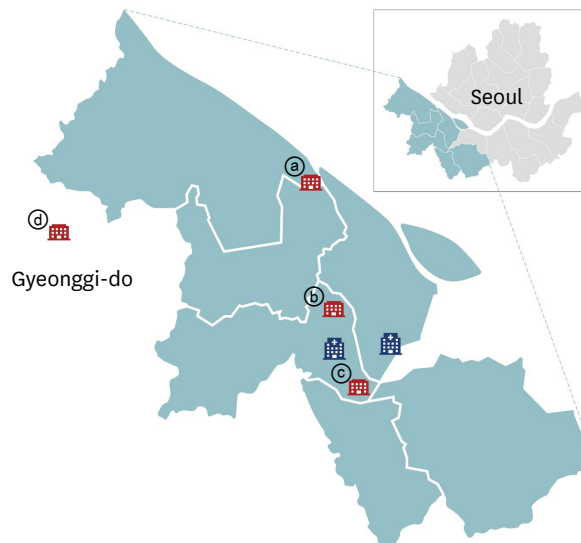
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#### Disclosure

The authors have no potential conflicts of interest to disclose.

#### Author Contributions

Conceptualization: Noh JY, Seo YB, Yoon SY, Song JY; Data curation: Noh JY, Seo YB, Cheong HJ, Kim WJ, Song JY; Formal analysis: Noh JY, Yoon J, Lim CS, Yoon SY, Song JY; Investigation: Noh JY, Seo YB, Yoon JG, Seong H, Hyun H, Lee J, Lee N, Jung S, Park MJ, Yoon J, Lim CS, Song W, Ryu J, Lee JY, Kim SS, Cheong HJ, Kim WJ, Yoon SY, Song JY; Methodology: Noh JY, Seo YB, Yoon SY, Song JY; Validation: Noh JY, Seo YB, Yoon SY, Song JY; Writing - original draft: Noh JY, Song JY; Writing - review & editing: Noh JY, Seo YB, Yoon JG, Seong H, Hyun H, Lee J, Lee N, Jung S, Park MJ, Song W, Yoon J, Lim CS, Ryou J, Lee JY, Kim SS, Cheong HJ, Kim WJ, Yoon SY, Song JY.



**Fig. 1.** Map of study site with study hospitals marked in blue. Sites of clusters of coronavirus disease outbreaks near the study hospitals are shown in red: (a) sports club; (b) call center; (c) church; (d) distribution center. The COVID-19 outbreak in a sport club (a) was detected on Jun 5, 2020, and visitors at the sport club from May 28 to June 2, 2020 were investigated. A call center (b) outbreak was first detected on March 9, 2020. Outbreak in a church (c) was detected on March 26, 2020 and outbreak at the distribution center (d) was detected on May 25, 2020.

A total of 1,500 serum samples were collected at two hospitals in southwestern Seoul—Korea University Guro Hospital and Hallym University Kangnam Sacred Heart Hospital. In southwestern Seoul, several clusters of COVID-19 outbreaks occurred at churches, sports clubs, and a call center (Fig. 1).<sup>5</sup> Moreover, a COVID-19 outbreak occurred at a large distribution center in Bucheon City, Gyeonggi-do Province, which is close to southwestern Seoul.<sup>5</sup>

Convenience samples of residual serum samples of outpatients who had visited the hospitals between May 25 and May 29, 2020 were used (Fig. 2). These patients lived in six administrative districts in southwestern Seoul: Guro-gu, Yeongdeungpo-gu, Gangseo-gu, Yangcheon-gu, Gwanak-gu, and Geumcheon-gu. The serum samples were used anonymously except for the information about sex and age. Serum samples from patients of different ages were collected to investigate the age-stratified seroprevalence of SARS-CoV-2. Samples from patients with laboratory-confirmed COVID-19 were excluded from this study.

The electrochemiluminescence immunoassay (ECLIA) was performed to detect antibodies including immunoglobulin G (IgG) against SARS-CoV-2 using Elecsys® Anti-SARS-CoV-2 (Roche, Solna, Switzerland) according to the manufacturer's protocol. Elecsys® Anti-SARS-CoV-2 used a recombinant protein representing the nucleocapsid antigen of SARS-CoV-2 with a double-antigen sandwich assay.<sup>6</sup> Clinical sensitivity of this assay was reported as 99.5% in polymerase chain reaction (PCR)-confirmed SARS-CoV-2 cases when tested at  $\geq 14$  days post-PCR confirmation and specificity of Elecsys® Anti-SARS-CoV-2 was reported as 99.8%.<sup>6</sup> A cutoff index (COI, signal sample/cutoff) of  $\geq 1.0$  was considered positive for anti-SARS-CoV-2 antibodies. Additionally, a plaque reduction neutralization test (PRNT) was performed for samples that tested positive by ECLIA. Wild-type SARS-CoV-2 (BetaCoV/Korea/KCDC03/2020) was used for PRNT, and the median neutralizing titer (ND50) was measured.

The study population comprised 48.7% men (730/1,500), and the patient age range was 0–92 years. The patients were divided into the following age groups: 0–19 years, 226 (15.1%); 20–29

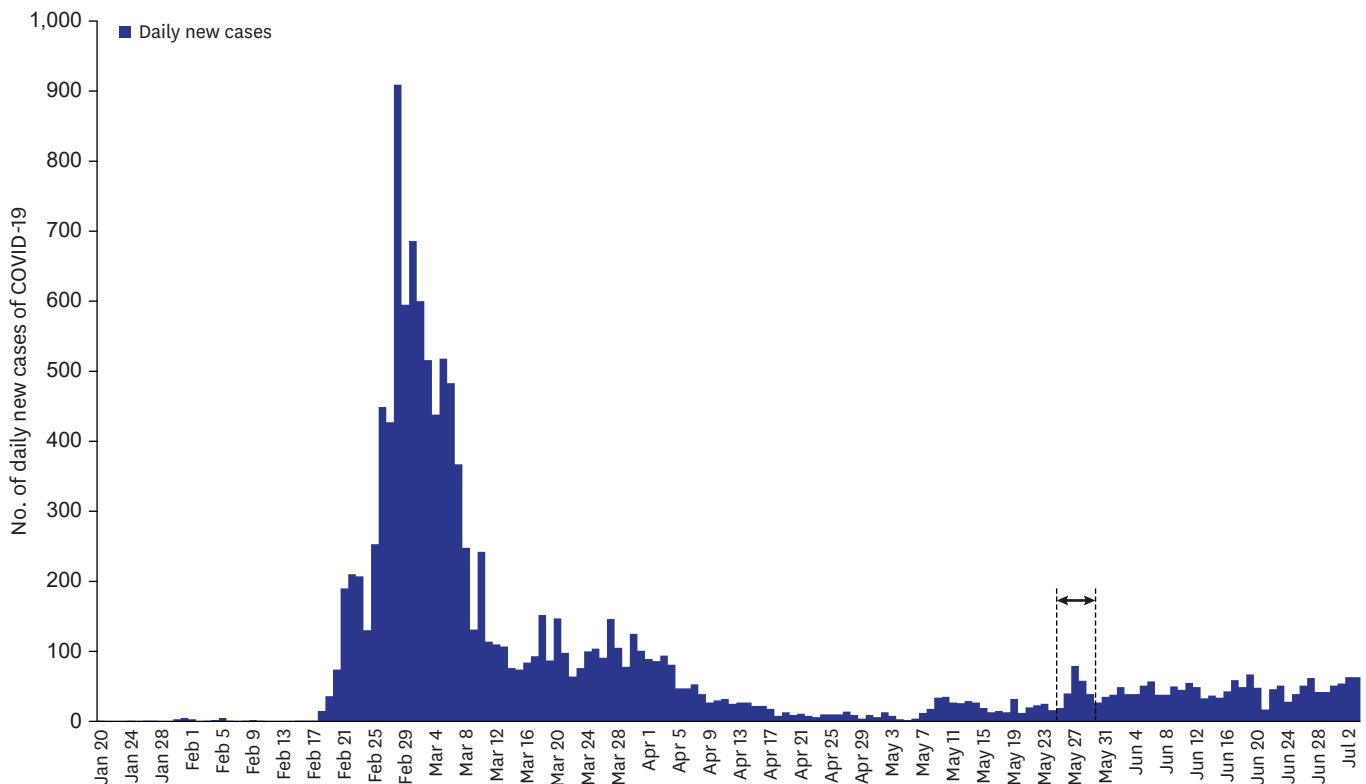


Fig. 2. Number of cases of coronavirus disease as of July 3, 2020 in Korea. Study samples were collected from May 25 to May 29, 2020 (indicated with an arrow).

years, 258 (17.2%); 30–39 years, 261 (17.4%); 40–49 years, 254 (16.9%); 50–59 years, 255 (17.0%);  $\geq 60$  years, 246 (16.4%). The rate of antibody positivity to SARS-CoV-2 was 0.07% (1 of 1,500; 95% confidence interval [CI], 0–0.44). The COI of a positive sample was 63.82 by ECLIA. ND50 was determined to be 1:764.48 using PRNT. Since the person who showed seropositivity was a 32-year-old man, seroprevalence of antibodies to SARS-CoV-2 was 0.38% (1 of 261; 95% CI, 0.02–2.45) in the 30–39-year age group.

The study hospitals were located at Guro-gu and Yeongdeungpo-gu, Seoul. Among the 25 administrative districts of Seoul, 34% of Chinese immigrants live in these two districts.<sup>7</sup> Since COVID-19 pandemic was first originated from Wuhan, China, concerns about outbreak of SARS-CoV-2 infections had been raised in these areas. However, this study indicated low-level seroprevalence of antibodies to SARS-CoV-2 in southwestern Seoul, Korea. As of May 29, 2020, the incidence of COVID-19 cases among the residents in study sites were as follows: Guro-gu, 0.009% (41/438,308); Yeongdeungpo-gu, 0.008% (34/404,766); Gangseo-gu, 0.007% (44/595,703); Yangcheon-gu, 0.006% (27/460,532); Gwanak-gu, 0.011% (59/516,662); Geumcheon-gu, 0.006% (15/251,370).<sup>8</sup>

Seroprevalence of antibodies to SARS-CoV-2 varies with country, study population, time of sampling, and laboratory testing method (Table 1). In cross-sectional studies conducted in outpatients in China and Japan, the seropositivity rate of antibodies to SARS-CoV-2 was 3.8% and 3.3%, respectively.<sup>9,10</sup> In another study, seropositivity against SARS-CoV-2 was evaluated in Hong Kong residents who were evacuated from Hubei Province, China, on March 4–5, 2020; the analysis of serum samples obtained within 13 days after evacuation revealed that 17 of 452 (3.8%) individuals were seropositive.<sup>11</sup> In a community survey in

**Table 1.** Studies on the seroprevalence of coronavirus disease 2019

Countries	Source of samples	No. of samples	Time of sampling	Laboratory method	Seropositivity, %	Reference
China	Outpatients	993	March 9 to April 10, 2020	Magnetic chemiluminescence enzyme immunoassay	3.8	9
Hong Kong	Asymptomatic Hubei returnees	452	March 2020	Microneutralization assay or enzyme immunoassay	3.8	11
Italy	Blood donors	390	March 18 to April 6, 2020	Microneutralization assay	23.3	13
Japan	Residual serum samples from outpatients	1,000	March 31 to April 7, 2020	Immunochemical test	3.3	10
Netherlands	Blood donors	7,361	April 1 to April 15, 2020	Enzyme-linked immunosorbent assay	2.7	15
Sweden	General population	1,104	Late April, 2020	Not available	7.3 (Stockholm), 4.2 (Skåne), 3.7 (Västra Götaland)	17
Switzerland	General population	2,766	April 6 to May 9, 2020	Enzyme-linked immunosorbent assay	7.9	14
United States	General population	863	April 10 to April 14, 2020	Lateral flow immunoassay	4.06	12
Korea	Outpatients and guardians	198	May 25 to June 5, 2020	Immunochemical test	7.6	18
Korea (present study)	Residual serum samples from outpatients	1,500	May 25 to May 29, 2020	Electrochemiluminescence immunoassay to detect antibodies including immunoglobulin G, plaque reduction neutralization test	0.07	

California, the United States, the seroprevalence of antibodies to SARS-CoV-2 was 4.06%.<sup>12</sup> In Lombardy, Italy, where the first COVID-19 case was identified on February 20, 2020, the seropositivity rate of neutralizing antibody against SARS-CoV-2 in blood donors was 23.3% (91/390). A seroepidemiological investigation revealed that 1.7% (5/300) of the blood donors collected before identification of the first case tested seropositive against SARS-CoV-2.<sup>13</sup> In a population-based serosurveillance study in Switzerland, 7.9% of the population showed anti-SARS-CoV-2 IgG antibodies.<sup>14</sup> In particular, the seropositivity rate was highest in the 20–49 year age group (9.9%). In the Netherlands, the seroprevalence of antibodies to SARS-CoV-2 was 2.7% among 7,361 blood donors, and seropositivity in donors aged 18–30 years was significantly higher (4.2%) than that in other age groups.<sup>15</sup> The Swedish response to the COVID-19 pandemic aimed to promote herd immunity by allowing a proportion of the population to be infected rather than containing the virus.<sup>16</sup> Nevertheless, the seroprevalence of SARS-CoV-2 antibodies was just 7.3% in Stockholm, Sweden.<sup>17</sup> The seropositive rate of SARS-CoV-2 was higher in young adults than in the elderly in Sweden—4.7%, 6.7%, and 2.7% in the age group of 0–19 years, 20–64 years; and 65–95 years, respectively.<sup>17</sup>

In Korea, seroprevalence of antibodies to SARS-CoV-2 among 198 outpatients and their guardians was 7.6% in Daegu in which more than half (56.9%, 6,881/12,088) of domestic cases with COVID-19 occurred as of August 11, 2020.<sup>18</sup> However, because of the heterogeneous and inconsistent results, the clinical performance of SARS-CoV-2 rapid lateral flow assay is still under evaluation, requiring confirmatory testing such as neutralization assay.<sup>19</sup> Considering the possible cross-reactivity from the pre-existing common cold coronaviruses (NL63, 229E, OC43 or HKU1) antibodies, it is necessary to be careful in interpreting the results.

This study has some limitations. First, a selection bias could have existed; hence, the study result might not represent the seroprevalence of antibodies to SARS-CoV-2 in the general population of southwestern Seoul, Korea. Second, epidemiological information of one person who was seropositive was not available. Third, this study was a one-time cross-sectional investigation, and seroprevalence may change as the pandemic progresses. Thus, a cross-sectional investigation should be repeated to estimate the herd immunity level.

However, this study revealed low seroprevalence of antibodies to SARS-CoV-2 in healthcare facility users in Seoul, Korea. A low seroprevalence (0.07%) reflects that the COVID-19 pandemic is relatively under control by implementation of social distancing and rigorous epidemiological investigations, including contact tracing, active testing, and patient isolation. However, low seroprevalence of SARS-CoV-2 suggests that most people are still vulnerable to SARS-CoV-2 infection. Considering the basic reproduction number of COVID-19, > 60% of the population should be immune against SARS-CoV-2 to suppress the pandemic. Therefore, we are still at the beginning of the pandemic, and we should follow social distancing norms to prevent the explosive spread of COVID-19 until effective vaccines are available. Serosurveillance should be repeated to estimate the level of herd immunity in each country as the pandemic progress.

### Ethics Statement

The study protocol was exempted from review by the Public Institutional Review Board designated by the Ministry of Health and Welfare (approval No. P01-202005-31-006).

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