



High seroprevalence of SARS-CoV-2 among high-density communities in Saudi Arabia

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Abstract

Background The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection had been investigated utilizing serology.

Materials and methods This community-based sero-survey was carried out in the neighborhoods of three cities in Saudi Arabia.

Results Of 5629 participants, 2766 (49.1%) were women; and 2148 (38.1%) were 18–34 years of age, and 3645 (64.7%) were from South East Asia. Positive serology was seen in 2825 (50.2% [95% CI: 48.8–51.5%]) for SARS-CoV-2 anti-S1 IgG antibodies by ECLIA. Being in the age category of 18–34 years and being from Eastern Mediterranean Region (country A) were associated with higher COVID-19 seropositivity with estimated odds ratio of 1.3 [95% CI 1.1–1.8] and 2.5 [95% CI 1.1.5–4.2] respectively. Gender, social status, education, nationality, symptoms, presence of comorbidities and activity style were positively associated with increased seropositivity. Factors associated negatively with the rate of seropositivity were higher education and having outdoor activity with estimated OR of 0.92 [95% CI 0.46–0.95] and 0.59 [95% CI 0.47–0.74], respectively.

Conclusion The study showed high seroprevalence of SARS-CoV-2 among high density population. Health education campaigns should target middle-aged, those with low education, those living in lower standards and indoor workers.

Keywords SARS-CoV-2 · Serology · High density · COVID-19

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Introduction

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) results in a wide spectrum of symptoms including: fever, asthenia, myalgia, pneumonia, and acute respiratory distress syndrome as well as asymptomatic infection [1]. In low-income and middle-income countries, structural and institutional inadequacies may result in the rapid spread of the virus with a heightened risk of community transmission [2, 3] and subsequent outcome disparity [3, 4]. There are multiple reasons behind increased transmission of SARS-CoV-2 in slums and include: overcrowding, close contact, and poor sanitation. While tight restrictions on movement may reduce SARS-CoV-2 transmission, there are social and economic consequences of locking down slums with a subsequent impact on access to healthcare [2].

To mitigate the COVID-19 pandemic, emphasis has been laid on hand hygiene using alcohol-based hand rub or soap and water. Physical distancing, keeping at least 2 m away from the nearest person, and applying cough etiquette also had been adopted as a COVID-19 preventive measure. These measures however remain a significant challenge given the inherent nature of slums and overcrowded areas, coupled with inadequate access to safe water and basic sanitation. The recommended home stay is just not an option for urban slum dwellers, as this often means giving up work and necessities [5].

Estimating the prevalence of Coronavirus Virus Disease 2019 (COVID-19) is critical for understanding the overall distribution and the presence of hotspots of SARS-CoV-2. Population-based serological data are essential for understanding the prevalence of subclinical infections and the population's herd immunity against SARS-CoV-2 [6–8]. Seroprevalence of SARS-CoV-2 might also help in risk stratifications based on age, geographic location, or underlying health conditions to develop preventive strategies.

Here, we study the seroprevalence of SARS-CoV-2 in condensed districts in three cities in the Kingdom of Saudi Arabia. The objectives of this study were to determine the magnitude of COVID-19 cases among neighborhoods of high density communities and to identify the epidemiological characteristics and risk factors associated with positive serology. The result of this study would increase our understanding of the prevalence of SARS-CoV-2 infection to implement strategies for prevention, control and vaccination prioritization [9].

Methods

A community-based serosurvey was carried out in three cities in Saudi Arabia. Blood samples were collected through mobile clinics for serology and tested at the Ministry of Health (MOH) regional laboratories. Also, a structured standardized questionnaire [10] was filled to gather information about: demographics, notification information (area/district), clinical information (symptoms, time of onsets, medical history) and epidemiological information (movements history, contact exposure). Data were entered and analyzed using (SPSS) version 21. The study was conducted over 2 weeks in August 2020 before the start of the COVID-19 vaccination in Saudi Arabia which was started in December 2020 [9, 11, 12]. A *P* value < 0.05 indicated statistical significance.

We asked the residents in these neighborhoods to participate voluntarily without any restrictions related to gender, age or nationality. In addition, we included those who had prior positive SARS-CoV-2 PCR result, and had been without symptoms for ≥ 14 days, and also include those who were never tested for SARS-CoV-2 and were asymptomatic. We excluded symptomatic and those who were previously labelled as COVID-19 cases and had not completed 14 days.

Sampling technique

Randomly, we selected participants from the list of the neighborhood. The selected individuals were interviewed by the assigned MOH team members. Each selected participant in area/district gave a verbal consent to participate in the study anonymously. Each participant filled the questionnaire as described previously [6]. One blood sample of 4 ml was obtained for serology testing. Serum samples were transported refrigerated at 2–8 °C. However, if there was a delay then samples were frozen at – 20 to – 80 °C and were shipped on dry ice. Anti-SARS-CoV-2 antibodies were detected by an electrochemiluminescent immunoassay (ECLIA) using the Elecsys[®] test from Roche Diagnostics International Ltd. (Rotkreuz, Switzerland) for the detection of anti-N IgG antibodies, as described previously [6]. The antibody test for SARS-CoV-2 generally detects antibodies using a recombinant protein representing the nucleocapsid (N) or the S proteins of SARS-CoV-2 [13–15]. The study was approved by the Ministry of health Central Institutional Review Board (H-01-R-009).

Results

We enrolled 5792 individuals, including household members of neighborhoods in 3 cities (A, B and C). However, only 5629 had completed the questionnaires, had serology tests and were included in further analysis. Of those who completed the questionnaire, 2766 (49.1%) were women; and 2148 (38.1%) were 18–34 years of age, 1720 (30.5%) were 35–54 years of age; and 3645 (64.7%) were from South East Asia (country 1), and 721 (12.8%) were from Eastern Mediterranean Region (country C) (Table 1).

A total of 2825 [50.2% (95% CI 48.8–51.5%)] tested positive for SARS-CoV-2 anti-N IgG antibodies by ECLIA. The positivity rate per city was as follows: 1633 of 2498 (65.4%) [95% CI 63.4–67.2%] for city A, 504 of 1490 (33.8%) [95% CI 31.4–36.3%] for city B, and 688 of 1642 (41.9%) [95% CI 39.5–44.3%] for City C (Table 1). In univariate analyses, Table 1 reveals that there was statistically significant difference between those having positive and negative serology in relation to age, gender, social status, education, nationality and recruitment city ($P = < 0.0001$). It is interesting to note that females had higher positivity rate than males (50.4% vs. 42.86%;

respectively; $P < 0.0001$). In relation to symptoms, 80 (36.4%) of 220 with symptoms and 2745 (50.7%) without symptoms were seropositive ($P < 0.0001$), and 108 (36%) of 300 with symptoms vs. 2717 (51%) of 5329 without symptoms were seropositive ($P < 0.0001$). In addition, 137 (28.7%) of 337 with frequent outdoor contacts vs. 1055 (39.6%) of 2657 without frequent outdoor contacts were seropositive ($P < 0.0001$).

In addition, there was statistically significant difference between positive and negative groups in relation to history of fever, runny nose, loss of smell/taste and headache (Table 2). Having hypertension or diabetes mellitus, was statistically different between the two groups (Table 3). Contact history to confirmed or recovered cases, attending any gatherings or healthcare facilities showed no significant difference between sero-positive and sero-negative groups (Table 4). Overall seropositivity was significantly ($\chi^2 = 19.78$, P value < 0.0001) higher among those from South East Asia (Country 1) (52.37%) compared to others nationalities (30.7%) (Table 5).

Multivariate analysis revealed that age of 18–34 years was more likely to have COVID-19 seropositivity with estimated odds ratio of 1.3 [95% CI 1.1–1.8]. Moreover, being of Eastern Mediterranean Region (country

Table 1 Socio-demographic factors among the study participants

Item	Category	Total number	Test result		χ^2	P value
			Positive			
			Number	%		
Age in years	≤ 17	239	125	52.3	75.08	< 0.0001*
	> 55	261	124	47.51		
	18–34	2148	1196	55.68		
	35–54	1720	870	50.58		
Gender	Male	161	69	42.86	3.56	< 0.0001*
	Female	5468	2756	50.4		
Social status	Married	3586	1695	47.27	41.3	< 0.0001*
	Single	1955	1094	55.96		
Education	High school	536	221	41.23	383.16	< 0.0001*
	Less than high	2110	765	36.26		
	More than High	371	168	45.28		
WHO Origin	South East Asia (Country 2)	384	255	66.41	140.36	< 0.0001*
	South East Asia (Country 1)	3645	1909	52.37		
	Eastern Mediterranean Region (Country C)	1346	584	43.4		
	Eastern Mediterranean Region (Country A)	202	63	31.19		
	Eastern Mediterranean Region (Country B)					
	Other	254	77	30.31		
City	City A	2498	1633	65.37	434.76	< 0.0001*
	City B	1490	504	33.83		
	City C	1641	688	41.93		

*Statistically significant

Table 2 Seropositivity by symptoms (more than 14 days prior to enrollment in the study) among the study participants

Symptom	Total Number	Positive		χ^2	P value
		Number	%		
Temperature					
No	5511	2786	50.55	10.18	0.001*
Yes	106	37	34.91		
Sore throat					
No	5594	2813	50.29	3.55	0.059
Yes	35	12	34.29		
Runny nose					
No	3972	2133	53.7	5.27	0.022*
Yes	16	4	25		
Cough					
No	3937	2114	53.7	1.49	0.22
Yes	51	23	45.1		
Dyspnea					
No	3969	2130	53.67	2.15	0.14
Yes	19	7	36.84		
Nausea					
No	3984	2136	53.61	1.31	0.25
Yes	4	1	25		
Loss of smell/taste					
No	3974	2135	53.72	8.72	0.003*
Yes	14	2	14.29		
Headache					
No	3956	2126	53.74	4.78	0.029*
Yes	32	11	34.38		
Joint pain					
No	3979	2134	53.63	1.48	0.223
Yes	9	3	33.33		
Muscle ache					
No	3978	2132	53.59	0.052	0.82
Yes	10	5	50		
Diarrhea					
No	3987	2137	53.6	1.15	0.28
Yes	1	0	0		
Other symptoms					
No	1488	503	33.8	0.51	0.47
Yes	1	0	0		

*Statistically significant

A) nationality was a significant positive predictor of seropositivity, with estimated odds ratio of 2.5 [95% CI 1.1–5.2]. On the other hand, significant negative predictors were educational level (being with more than high school) and being employee of outdoor activity were less likely to have seropositive results with estimated OR of 0.92 [95% CI 0.46–0.95] and 0.59 [95% CI 0.47–0.74], respectively (Table 6).

Table 3 Seropositivity by underlying comorbidities among the study participants

Comorbidity	Total Number	Positive		χ^2	P value
		Number	%		
Chronic vascular disease					
No	5611	2818	50.22	0.92	0.33
Yes	18	7	38.89		
Hypertension					
No	5482	2771	50.55	10.92	0.001*
Yes	147	54	36.73		
Diabetes mellitus					
No	5415	2747	50.73	16.79	<0.0001*
Yes	214	78	36.45		
Chronic renal disease					
No	5629	2825	50.19	–	–
Yes	0	0	0		
Chronic liver disease					
No	5628	2825	50.2	1.01	0.31
Yes	1	0	0		
Immuno-compromised					
No	5629	2825	50.19	–	–
Yes	0	0	0		
Other comorbidities					
No	5617	2822	50.24	3.05	0.08

*Statistically significant

Table 4 Seropositivity by contact history (more than 14 days prior to enrollment in the study) with confirmed cases among the study participants

Exposure	Positive		χ^2	P value
	Number	%		
Contact with confirmed case				
No (3122)	1187	37.9	1.17	0.27
Yes (9)	5	55.6		
Contact with recovered case				
No (3101)	1182	38	0.28	0.59
Yes (30)	10	33.3		
Attending gatherings				
No (3122)	1189	38	0.086	0.76
Yes (9)	3	33.3		
Visiting healthcare facility				
No (5556)	2797	48.9	3.8	0.5
Yes (70)	27	38.6		

Discussion

The use of a serological test to detect anti-SARS-CoV-2 antibodies could be a better way to estimate the burden

Table 5 Seropositivity by geographical distribution of the study participants in comparison to South East Asia (Country 1)

Distribution	Positive		χ^2	P value
	Number	%		
City A				
South East Asia (Country 1) (2182)	1418	64.99	3.62	0.057
Other (316)	215	68.04		
City B				
South East Asia (Country 1) (1458)	491	33.68	0.675	0.411
Other (32)	13	40.63		
City C				
South East Asia (Country 1) (5)	0	0	-	-
Other (1636)	688	42.05		
All cities				
South East Asia (Country 1) (3645)	1909	52.37 [95% CI 50.74–54.01%]	19.78	<0.0001
Other (1984)	916	46.17		

Table 6 logistic regression analysis of socio-demographic and predictors of having COVID-19 sero-positivity

Predictor	β	Exp.(B)/adjusted odds ratio (95% CI)	P value
Age category			
≤ 17*			
18–34	0.305	1.357 (1.015–1.812)	0.039*
35–54	0.177	1.194 (0.908–1.570)	0.204
> 55	0.226	1.254 (0.774–2.031)	0.357
WHO Origin			
South East Asia (Country 1)*			
Eastern Mediterranean Region (country A)	0.425		0.015*
Eastern Mediterranean Region (Country B)	0.923	1.017 (0.46–2.21)	0.965
Eastern Mediterranean Region (Country C)	0.001	1.547 (1.07–2.22)	0.923
South East Asia (Country 2)	0.008	0.992 (0.64–1.53)	0.973
Educational level			
Less than high school*			
More than high school	– 0.158	0.854 (0.63–1.14)	0.295
High school	– 0.346	0.921 (0.464–0.954)	0.013*
Outdoor activity			
No			
Yes	– 0.525	1(r) 0.59 (0.47–0.74)	<0.0001*

*Reference category

of SARS-CoV-2 infection, and improve the understanding of the associated epidemiology [16]. The overall seroprevalence of the SARS-CoV-2 antibody in this study was 50.2% with differences between the included cities (33.8–65.4%). In a study from a neighboring country, Kuwait, the seroprevalence of anti-SARS-CoV-2 antibodies was 38.1% (95% CI 34.0–42.3) among migrant workers [17]. In a review study, the seroprevalence of SARS-CoV-2 antibodies among people in slums was 41.7% (40.0–43.4%) [18]. These results are much higher than what was reported in other studies from the general

population during the pandemic in Europe [16]. In Spain, a nationwide, population-based sero-epidemiological study from April 27 to May 11, 2020 included 35,883 households and the seroprevalence was 4.6% (95% CI 4.3–5.0%) [19]. A study from Switzerland between April 6 and May 9, 2020 reported a seroprevalence of 4.8% (95% CI 2.4–8.0%; $n = 341$) in the first week, and 10.8% (95% CI 8.2–13.9%; $n = 775$) in the fifth week among 2766 participants [20]. In USA, a large study in March 23–May 12, 2020 showed a seroprevalence of 1% among 16,025 tested persons in the San Francisco Bay Area, 6.9% in New York

City [21] and 22.7% in Blaine County [8]. The highest seroprevalence was found to be 31.5% among 200 asymptomatic residents in Chelsea, Massachusetts [22]. Thus, the prevalence of anti-SARS-CoV-2 antibodies is variable depending on the country and the time of the study. The current study showed the possible vulnerability of migrant workers and those living in crowded areas in relation to SARS-CoV-2 infection. The disparity of SARS-CoV-2 infection and outcomes had been described in previous studies [3, 4, 23]. This disparity is important as a large percentage of the population in many developing countries are low-skilled migrant workers [17].

It is interesting to note that females had higher positivity rate than males (50.4% vs. 42.86%; respectively; $P < 0.0001$). In a review article of 129 studies the sero-prevalence among females was 1.03 (0.98–1.08) compared to males [18]. The differences may be related to the sociodemographic interactions or the difference in the underlying immune response between males and females [24]. A recent study from Saudi Arabia showed a higher seroprevalence among non-citizens compared to citizens (OR 13.6, $P = 0.001$) [6]. The variation in seroprevalence was also noted across multiple zip codes and ethnicity in a study from Blaine County, Idaho, USA with a range from 28.4 to 34.8% [8]. The difference in seropositivity among slum and non-slum communities was significant with rates of 54.1% and 16.1%, respectively [25]. These findings may be due to the fact that anti-SARS-CoV-2 antibody seroprevalence varies according to the different study countries/ regions, study populations, timing during the period of the COVID19 pandemic, and methods used for serology testing [16].

Significant symptoms such as fever (> 38.5 °C), runny nose, loss of smell and headache were associated risks with COVID-19 infection, as reported previously [26]. Nationality and race appeared to be important predictors of SARS-CoV-2 infection risk. These findings are consistent with another study from USA where minorities might be more likely to live in communities with higher population density, poor air quality, work in jobs frequently contact with community, and lack access to healthcare which may increase the risk of infection [4]. For these reasons, high density population and underserved communities of colors may have additional barriers to social distancing measures and are more vulnerable to severe illness [27]. As with other infectious diseases, additional predictors of SARS-CoV-2 infection include age, nationality, education level and outdoor activity (frequent contact with the community). These factors may also influence the ability to seek care, adhere to treatment, and practice physical distancing measures [27].

In conclusion, risk of SARS-CoV-2 infection was higher among groups already affected by health disparities across age, nationality, educational level and employment status. Health promotion and disease prevention strategies should

prioritize groups most vulnerable to infection and address structural inequities that contribute to risk through social and economic policy. Furthermore, effective strategies for predicting risk factors for community transmission should include both clinical and social factors. Culturally and linguistically appropriate interventions are essential, including communication materials of different formats and reading levels, as well as the use of community health workers that can engage with underserved groups. Regional differences in infection risk are evident as the seroprevalence varies according to different populations. Therefore, further continued surveillance of seroprevalence is warranted to estimate and monitor the growing burden of COVID-19.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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