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Coronavirus Pandemic

Risk factors for SARS-CoV-2 infection in Jordan: A cross-sectional study in the prevaccination period

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Abstract

Introduction: This study aimed to determine the prevalence and risk factors of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in Jordan during the prevaccination period.

Methodology: Between December 2020 and February 2021, nasopharyngeal and oropharyngeal swabs of 2,460 participants were tested by reverse transcription-polymerase chain reaction (RT-PCR). To assess the risk factors, a questionnaire was applied during sample collection.

Results: Of the participants, 1,463 (59.5%) individuals were found positive for SARS-CoV-2. In multivariate analysis, male gender, younger age, lower educational level, being single, middle and higher socioeconomic status, having symptoms, presence of underlying conditions and smoking were significantly associated with SARS-CoV-2 positivity. On the contrary, washing hands routinely with soap and water, and use of alcohol-based disinfectants significantly reduced possibility of SARS-CoV-2 infection.

Conclusions: The study findings showed that determination of risk factors is of great importance to maintain disease monitoring, prevention and control, particularly in settings with high infection rates.

Key words: COVID-19; epidemiology; Jordan; risk factors; SARS-CoV-2.

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Introduction

Jordan, an Eastern Mediterranean country has a population of about 10.6 million and covers a geographical area of 89,342 square kilometers [1]. In the initial period of the COVID-19 pandemic, strict regulations were applied in Jordan for several months, but despite this, the first wave of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spread was documented between September 2020 and January 2021. During this period nearly 170,000 cases and more than 2,000 deaths were reported [2]. Although SARS-CoV-2 B.1.1.312 and B.1.36.10 lineages were initially widespread during the first wave of COVID-19, the B.1.7.7 (alpha) variant became predominant in December 2020 and January 2021 in Jordan [3]. This variant originated from the United Kingdom in September 2020 and was identified by the World Health Organization (WHO) as a variant of concern (VOC) [4] which was associated with increased transmissibility and more severe disease [5].

SARS-CoV-2 contains single, positive-stranded RNA [6,7], that leads to respiratory disease in people, such as pneumonia [8]. The clinical manifestations observed in COVID-19 patients include cough, fever, shortness of breath, fatigue, myalgia, and chest pain, however abdominal pain, vomiting and diarrhea may also occur [9]. Additionally, COVID-19 patients commonly experience a decrease or loss of smell and taste [10].

Studies have shown that several factors are associated with SARS-CoV-2 infection. These include age, gender, as well as underlying conditions such as cardiovascular disease, diabetes, and malignancy [11]. While SARS-CoV-2 can infect persons of almost any age, it is frequently asymptomatic in younger generations, which can result in high infection rates among young people [12]. Referring to gender, studies documented that males are more likely to contract the virus, as they tend to spend more time outdoors compared to females [11]. Additionally, factors including socioeconomic status [13], educational level

[14] and working at a healthcare setting [15] were also found to affect SARS-CoV-2 positivity.

A previous study from Jordan evaluated the factors related to SARS-CoV-2 infection in healthcare workers [16]. Another Jordanian study particularly focused on demographic factors associated with household transmission of SARS-CoV-2 [17]. The present study that included additional variables was conducted to evaluate the risk factors associated with SARS-CoV-2 infection in the Jordanian population during the prevaccination period.

Methodology

Study design, participants, and ethical approval

The study was conducted between December 2020 and February 2021, which covered the late stage of the first wave and beginning of the second wave of COVID-19 in Jordan. During that time, SARS-CoV-2 B.1.1.7 variant was predominant in the country [2]. A total of 2,460 consecutive individuals were enrolled in this cross-sectional study on a voluntary basis. All study participants were recruited from the individuals who provided nasopharyngeal or oropharyngeal nasal swab samples for SARS-CoV-2 reverse transcription polymerase chain reaction (RT-PCR) test. The inclusion criteria were being residents in Amman (the capital of Jordan) and being aged 18 years and above. Individuals who met these criteria were included in this study.

Ethical approval was obtained from the Near East University Ethics Review Board (Project no: YDU/2020/85-1205). Written informed consent was collected from all participants.

Sample and data collection

Nasopharyngeal and oropharyngeal nasal swab samples were collected from the study participants for RT-PCR test. The volunteers who accepted to participate in the study were also asked to fill out a questionnaire during the sample collection. In the questionnaire, first, information on age, gender, residential place, level of education, socioeconomic status and occupation were collected. Then, the participants were asked about having any symptoms related with COVID-19 during the sample collection. The participants also provided information on previous diagnosis of COVID-19, smoking status, and presence of any chronic underlying condition. In the last part of the questionnaire, the participants were asked about routine application of preventive measures such as wearing mask while working indoors, washing hands routinely with soap and water, and use of alcohol-based disinfectants (Supplementary figure 1).

RT-PCR

Following the sample collection, the swabs were stored in an ice box at 2-8°C until RT-PCR test. All molecular tests were conducted in the Diamond Laboratories, Amman, Jordan. Viral nucleic acid extraction was performed using Zybio kits by EXM3000 Zybio machine that uses the magnetic bead method to separate and purify nucleic acids. After the viral nucleic acid extraction, SARS-CoV-2 was detected by using QuantStudio 1 Real-Time PCR System including one of two kits. The first kit was LiliF COVID-19 Real-time RT-PCR kit (Intron, USA) (sensitivity and specificity were both 100%) [18] that detected the RdRP, E and N genes in the sample by using a fluorescent probe. Zybio SARS-CoV-2 Nucleic Acid Detection Kit (Zybio, China) was the second kit used in this study (sensitivity and specificity were 98.78 % and 100%, respectively) [19] that included certain primers and probes (created using the 34 conserved open reading frame (ORF1ab) and (N gene) sequences for PCR amplification. A positive (SARS-CoV-2 target fragment sequence) and negative control (0.9% NaCl) were included in each run.

Statistical analysis

Descriptive statistics for the study variables were calculated. Frequency and percentage were calculated for qualitative variables whereas arithmetic mean, standard deviation, median, minimum, and maximum values were calculated for quantitative variables. In order to assess the effect of demographic and socioeconomic factors, as well as the health conditions, use of personal protection methods, and impact of certain hygiene practices on the presence of SARS-CoV-2 infection, the Pearson's Chi-square test or Fisher's Exact test was applied, where appropriate. Odds ratios (95% confidence interval) for each factor were calculated. For variables with more than three categories, Univariate Logistic Regression analysis was used to calculate the odds ratio for each category with respect to the selected reference. The same approach was applied to investigate the effect of factors on symptomatic COVID-19 among infected individuals. In the last step, the Multivariate Logistic Regression model was constructed to see the combined effect of identified risk factors on SARS-CoV-2 positivity. The level of statistical significance was set at 0.05. All statistical analyses were performed with SPSS (Demo Version 26.0 for Mac).

Table 1. Univariate analysis of demographic and socioeconomic factors for SARS-CoV-2 positivity, Jordan, December 2020–February 2021.

Risk factor	SARS-CoV-2		χ^2 test		Logistic regression	
	Positive n/N (%)	Negative n/N (%)	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender						
Male	704/1073 (65.6)	369/1073 (34.4)	1.58 (1.34–1.86)	**< 0.001**	–	–
Female	759/1387 (54.7)	628/1387 (45.3)	1 (ref)			
Age (years)						
18–29	684/1121 (61.0)	437/1121 (39.0)			2.15 (1.67–2.76)	**< 0.001**
30–49	642/1014 (63.3)	372/1014 (36.7)	–	**< 0.001**	2.37 (1.84–3.06)	**< 0.001**
50 and above	137/325 (42.2)	188/325 (57.8)			1 (ref)	
Education						
No education	226/274 (82.5)	48/274 (17.5)			4.59 (3.30–6.38)	**< 0.001**
Primary and high school	549/827 (66.4)	278/827 (33.6)	–	**< 0.001**	1.93 (1.61–2.30)	**< 0.001**
University and higher degree	688/1359 (50.6)	671/1359 (49.4)			1 (ref)	
Marital status						
Single	726/1158 (62.7)	432/1158 (37.3)	1.33 (1.13–1.57)	**0.001**	–	–
Married	711/1274 (55.8)	563/1274 (44.2)	1 (ref)			
Socioeconomic status						
Low	230/749 (30.7)	519/749 (69.3)			1 (ref)	
Middle	928/1321 (70.2)	393/1321 (29.8)	–	**< 0.001**	5.33 (4.38–6.48)	**< 0.001**
High	95/137 (69.3)	42/137 (30.7)			5.10 (3.44–7.58)	**< 0.001**
Occupation						
Healthcare worker	63/68 (92.6)	5/68 (7.4)	11.17 (4.45–28.05)	**< 0.001**	–	–
Non-healthcare worker	440/830 (53.0)	390/830 (47.0)	1 (ref)			

OR: odds ratio; CI: confidence interval; ref: reference value.

Results

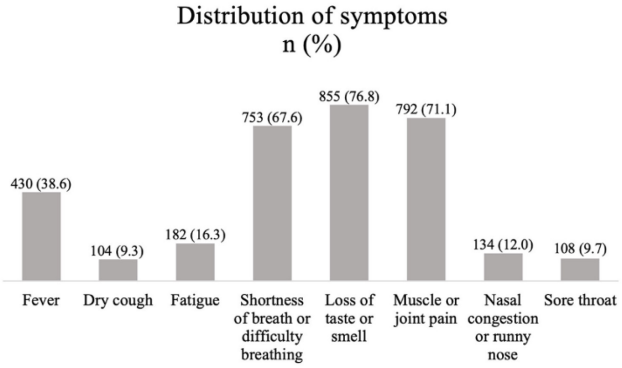
General characteristics of the study participants

A total of 2,460 individuals were enrolled in the study. Of the participants, 1,073 (43.6%) were male, and 1,387 (56.4%) were female. The mean and median age of the study population were 33.93 ± 12.02 and 30.00 (18.00 - 80.00), respectively. Distribution of the study participants according to the age groups was 1,121 (45.6%), 1014 (41.2%) and 325 (13.2%) for the age groups 18–29, 30–49 and ≥ 50 years, respectively. In the study population, 1,359 (55.2%) of the individuals had a university or higher degree diploma. The number of married participants was 1,274 (52.4%) whereas 137 (6.2%) of the study population had a high income. Among the study group, 68 (7.6%) were healthcare workers (Supplementary table 1).

Prevalence of COVID-19, general health condition of the participants, and use of personal protection and hygiene practices among the study population

RT-PCR results of 2460 individuals revealed that 1463 (59.5%) were positive for SARS-CoV-2. Of these individuals who tested positive, 1114 (76.1%) had at least one symptom related with COVID-19 (Supplementary table 2). The most common symptoms were noted as loss of taste or smell (n = 855/1,114; 76.8%), muscle or joint pain (n = 792/1,114; 71.1%), and shortness of breath or difficulty breathing (n = 753/1,114; 67.6%) (Figure 1). Of the 2,460 participants, 27 (1.1%) had a positive test result for SARS-CoV-2 previously and completely cured before participating in the study. None of these individuals tested positive in the current COVID-19 testing. The number of the participants with any underlying chronic disease was 286 (11.6%) among the 2,460 individuals. Of these, hypertension (n = 179/2,460; 7.3%) and diabetes (140/2,460; 5.7%) were the most common diseases. Five hundred and twenty-five (21.5%) individuals stated that they smoked cigarettes or had quit smoking. According to the female participants who gave information on pregnancy (n = 1134), the number of pregnant women was noted to be 97 (8.6%). Among the study participants 26.5% (n = 602/2,272) worked indoors and 89.9% (n = 533/593) of these used masks for protection against COVID-19 during work hours.

Figure 1. Distribution of symptoms among the patients with clinically evident COVID-19 disease (n = 1114), Jordan, December 2020-February 2021.



Moreover, 86.2% (n = 2121/2,460) of the study population declared that they routinely washed their hands with soap and water, and 85.5% (n = 2,104/2,460) used alcohol-based disinfectants as a part of daily personal hygiene practices (Supplementary table 2).

Analysis of demographic and socioeconomic factors for SARS-CoV-2 positivity among the participants

Univariate analysis of demographic factors showed that males (n = 704/1,073; 65.6%) were significantly at higher risk ($p < 0.001$) for SARS-CoV-2 positivity than females (n = 759/1,387; 54.7%). Individuals that belonged to 18–29 (n = 684/1,121; 61.0%) and 30–49 (n = 642/1,014; 63.3%) age groups were more likely to be infected than the participants aged 50 and above (n = 137/325; 42.2%) ($p < 0.001$). A greater percentage for SARS-CoV-2 positivity was observed among the individuals who never went to school (n = 226/274; 82.5%) and those having primary and high school diploma (n = 549/827; 66.4%) compared to the participants with university or higher degree diploma (n = 688/1359; 50.6%) ($p < 0.001$). The infection rate among singles (n = 726/1,158; 62.7%) were significantly more common than in married participants (n = 711/1,274; 55.8%) ($p = 0.001$). Compared to the individuals with low income (n = 230/749; 30.7%), those with middle (n = 928/1,321; 70.2%) and higher (n = 95/137; 69.3%) socioeconomic status were at greater risk for SARS-CoV-2 positivity ($p < 0.001$). Analysis of the participants' occupation showed a significantly increased infection rate among healthcare workers (n = 63/68; 92.6%) (OR 11.17, 95% CI 4.45-28.05, $p < 0.001$) compared to non-healthcare workers (n = 440/830; 53.0%) (Table 1).

Association of general health conditions, and use of personal protection and hygiene practices with SARS-CoV-2 positivity

Individuals showing COVID-19-related symptoms (n = 1,114/1,379; 80.8%) had a significantly greater likelihood (OR 8.82, 95% CI 7.33–10.61, $p < 0.001$) of having a positive SARS-CoV-2 test result than their asymptomatic counterparts (n = 349/1,081; 32.3%). In the current study, none of the individuals with previous SARS-CoV-2 infection tested positive (n = 0/27; 0.0%), however 60.1% (n = 1463/2433) of the participants with no COVID-19 history had a positive test result presently, and the difference was found to be statistically significant ($p < 0.001$). Having a chronic disease (n = 225/286; 78.7%) was significantly associated with SARS-CoV-2 positivity ($p < 0.001$). Univariate analysis of the underlying conditions showed that hypertension (p = 0.006), diabetes ($p < 0.001$), chronic heart disease ($p = 0.023$), chronic lung disease ($p = 0.013$), chronic kidney disease ($p = 0.005$), chronic liver disease ($p = 0.046$) and chronic neurological disease ($p = 0.046$) increased the likelihood of SARS-CoV-2 infection, while cancer ($p = 0.569$) and history of organ or bone marrow transplantation ($p = 0.518$) were not found to be significant factors. The participants who currently smoked or quit smoking had significantly higher (n = 372/525; 70.9%) SARS-CoV-2 rates than those who never smoked (n = 1,070/1,913; 55.9%) ($p < 0.001$). Pregnancy status (n = 69/97; 71.1%) was also found to be a significant factor for SARS-CoV-2 infection ($p = 0.020$). Analysis of the preventive measures showed that use of mask while working indoors (OR 0.02, 95% CI 0.01–0.09; $p < 0.001$), washing hands routinely with soap and water (OR 0.11 95%, CI 0.08–0.17; $p < 0.001$), and use of alcohol-based disinfectants (OR 0.05 95%, CI 0.03–0.09; $p < 0.001$) significantly reduced the possibility of SARS-CoV-2 infection (Table 2).

Analysis of risk factors associated with symptomatic COVID-19 disease

Univariate analysis of the variables showed that age was significantly associated with having COVID-19 symptoms ($p = 0.007$). Individuals aged 18–29 years had a significantly reduced risk (n = 498/684; 72.8%) for developing symptoms (OR 0.51 95%, CI 0.32–0.83; $p = 0.007$) compared to the participants aged 50 and above (n = 115/137; 83.9%). The percentage of symptomatic COVID-19 patients in the age group of 30–49 years (n = 501/642; 78.0%) was lower than in the elderly group, however the difference was not statistically significant ($p = 0.125$). Participants with underlying chronic disease displayed a higher tendency (n = 190/225; 84.4%) to develop symptomatic disease compared to the healthy subjects (n = 924/1,238; 74.6%) ($p < 0.001$). Also, pregnant women were more likely to develop COVID-19 symptoms (n = 63/69; 91.3%) than non-pregnant individuals (n = 464/612; 75.8%) ($p = 0.004$). In contrast with these factors, gender ($p = 0.109$) and smoking ($p = 0.112$) did not have any significant effect on developing symptomatic COVID-19 disease (Supplementary table 3).

Multivariate analysis of risk factors for SARS-CoV-2 positivity

In the multivariate analysis the following variables were included: gender, age, education, marital status, socioeconomic status, presence of symptoms, underlying chronic disease, smoking, washing hands with soap and water, and use of alcohol-based

disinfectants. All these variables remained significant factors for SARS-CoV-2 positivity in the multivariate logistic regression model. Male gender ($p = 0.005$); age groups 18–29 ($p < 0.001$) and 30–49 ($p < 0.001$) compared to the individuals aged 50 and above; no education ($p < 0.001$) and having a primary or high school diploma ($p < 0.001$) compared to having a university or higher degree diploma; being single ($p < 0.001$); middle ($p < 0.001$) and higher socioeconomic status ($p < 0.001$) in comparison to low income; having

Table 2. Univariate analysis of general health conditions, and use of personal protection and hygiene practices for SARS-CoV-2 positivity, Jordan, December 2020–February 2021.

Risk factor	SARS-CoV-2		χ^2 test	
	Positive n/N (%)	Negative n/N (%)	OR (95% CI)	*p* value
Symptoms				
Yes	1114/1379 (80.8)	265/1379 (19.2)	8.82 (7.33-10.61)	< 0.001
No	349/1081 (32.3)	732/1081 (67.7)	1 (ref)	
Previous SARS-CoV-2 infection				
Yes	0/27 (0.0)	27/27 (100.0)	2.51 (2.39–2.63)	< 0.001
No	1463/2433 (60.1)	970/2433 (39.9)	1 (ref)	
Underlying chronic disease				
Yes	225/286 (78.7)	61/286 (21.3)	2.79 (2.08–3.75)	< 0.001
No	1238/2174 (56.9)	936/2174 (43.1)	1 (ref)	
Hypertension				
Yes	124/179 (69.3)	55/179 (30.7)	1.59 (1.14–2.20)	0.006
No	1339/2281 (58.7)	942/2281 (41.3)	1 (ref)	
Diabetes				
Yes	121/140 (86.4)	19/140 (13.6)	4.64 (2.84–7.58)	< 0.001
No	1342/2320 (57.8)	978/2320 (42.2)	1 (ref)	
Chronic heart disease				
Yes	19/23 (82.6)	4/23 (17.4)	3.27 (1.11–9.63)	0.023
No	1444/2437 (59.3)	993/2437 (40.7)	1 (ref)	
Chronic lung disease				
Yes	9/9 (100.0)	0/9 (0.0)	1.69 (1.63–1.74)	0.013
No	1454/2451 (59.3)	997/2451 (40.7)	1 (ref)	
Chronic kidney disease				
Yes	15/16 (93.8)	1/16 (6.3)	10.32 (1.36–78.23)	0.005
No	1448/2444 (59.2)	996/2444 (40.8)	1 (ref)	
Chronic liver disease				
Yes	7/7 (100.0)	0/7 (0.0)	1.69 (1.63–1.74)	0.046
No	1456/2453 (59.4)	997/2453 (40.6)	1 (ref)	
Chronic neurological disease				
Yes	7/7 (100.0)	0/7 (0.0)	1.69 (1.63–1.74)	0.046
No	1456/2453 (59.4)	997/2453 (40.6)	1 (ref)	
Cancer				
Yes	10/15 (66.7)	5/15 (33.3)	1.37 (0.47–4.01)	0.569
No	1453/2445 (59.4)	992/2445 (40.6)	1 (ref)	
Organ or bone marrow transplantation				
Yes	2/2 (100.0)	0/2 (0.0)	1.68 (1.63–1.74)	0.518
No	1461/2458 (59.4)	997/2458 (40.6)	1 (ref)	
Smoking				
Yes (current smoker or quit)	372/525 (70.9)	153/525 (29.1)	1.92 (1.56–2.36)	< 0.001
No (never smoked)	1070/1913 (55.9)	843/1913 (44.1)	1 (ref)	
Pregnancy status				
Yes	69/97 (71.1)	28/97 (28.9)	1.71 (1.08–2.70)	0.020
No	612/1037 (59.0)	425/1037 (41.0)	1 (ref)	
Use of mask while working indoors				
Yes	203/533 (38.1)	330/533 (61.9)	0.02 (0.01–0.09)	< 0.001
No	57/59 (96.6)	2/59 (3.4)	1 (ref)	
Washing hands with soap and water				
Yes	1153/2121 (54.4)	968/2121 (45.6)	0.11 (0.08–0.17)	< 0.001
No	310/339 (91.4)	29/339 (8.6)	1 (ref)	
Use of alcohol-based disinfectants				
Yes	1123/2104 (53.4)	981/2104 (46.6)	0.05 (0.03–0.09)	< 0.001
No	340/356 (95.5)	16/356 (4.5)	1 (ref)	

OR: odds ratio; CI: confidence interval; ref: reference value.

symptoms ($p < 0.001$); presence of underlying disease ($p < 0.001$); and smoking ($p = 0.001$) were significantly associated with an increased risk of SARS-CoV-2 positivity. On the contrary, washing hands routinely with soap and water ($p < 0.001$), and use of alcohol-based disinfectants ($p < 0.001$) were factors that significantly decreased the possibility of SARS-CoV-2 infection (Table 3).

Discussion

COVID-19, although it has not been considered a Public Health Emergency of International Concern (PHEIC) by WHO since May 2023, continues to affect people [20]. SARS-CoV-2 transmission is ongoing globally that result in new infections as well as mortality. Moreover, new variants of the virus can possibly emerge and affect people. Therefore, to maintain disease management globally, monitoring, caution and safety measures should continue for COVID-19 [21]. In line with this, epidemiological studies that search for risk factors are of great importance to maintain disease monitoring, prevention and control [22].

In this cross-sectional study, the results showed that 59.5% of the individuals were positive for SARS-CoV-2. This result was higher than that reported in many other studies. The prevalence of COVID-19 was reported to be 26.5% in Indonesia [23]. The study of Jandaghi et al. [24] showed that the prevalence of COVID-19 was 19.3% in Semnan province North-East of Iran. Other studies in Jordan showed that seroprevalence of COVID-19 was in the range of 0% to 27.4% [25], and up to 34.5% globally [26]. The difference in the prevalence between this study and other studies may be attributed to the period of sample collection and the sensitivity and specificity of the methods used in these studies.

In our study, SARS-CoV-2 infection was detected at higher levels in males ($p < 0.001$) than in females, which is consistent with the literature [11]. Rate of SARS-CoV-2 positivity was found to be significantly

Table 3. Multivariate logistic regression results of risk factors associated with SARS-CoV-2 positivity, Jordan, December 2020–February 2021.

Risk factor	B	SE	OR (95% CI)	*p* value
Gender				
Male	0.391	0.140	1.48 (1.12–1.94) 1 (ref)	**0.005**
Female				
Age (years)				
18–29	1.245	0.250	3.47 (2.13–5.66)	**< 0.001**
30–49	1.112	0.225	3.04 (1.96–4.73)	**< 0.001**
50 and above	–	–	1 (ref)	
Education				
No education	2.286	0.238	9.83 (6.17–15.68)	**< 0.001**
Primary and high school	0.627	0.135	1.87 (1.44–2.44)	**< 0.001**
University and higher degree	–	–	1 (ref)	
Marital status				
Single	0.691	0.154	2.00 (1.48–2.70)	**< 0.001**
Married	–	–	1 (ref)	
Socioeconomic status				
Low	–	–	1 (ref)	
Middle	1.884	0.139	6.58 (5.01–8.64)	**< 0.001**
High	1.851	0.276	6.36 (3.71–10.93)	**< 0.001**
Symptom				
Yes	2.662	0.135	14.32 (11.00–18.65)	**< 0.001**
No	–	–	1 (ref)	
Underlying chronic disease				
Yes	1.164	0.235	3.20 (2.02–5.08)	**< 0.001**
No	–	–	1 (ref)	
Smoking				
Yes (current smoker or quit)	0.576	0.181	1.78 (1.25–2.54)	**0.001**
No (never smoked)	–	–	1 (ref)	
Washing hands with soap and water				
Yes	1.258	0.306	0.28 (0.16–0.52)	**< 0.001**
No	–	–	1 (ref)	
Use of alcohol-based disinfectants				
Yes	2.142	0.334	0.12 (0.06–0.23)	**< 0.001**
No	–	–	1 (ref)	
Constant	−4.872	0.286	–	**< 0.001**

Cox & Snell R2 = 0.452; Nagelkerke R2 = 0.605. B: regression coefficient; SE: standard error; OR: odds ratio; CI: confidence interval; ref: reference value.

more common ($p < 0.001$) in younger age groups compared to the elderly group in our study. On the contrary, the age group 18-29 showed significantly less symptoms ($p = 0.007$). This suggests that, due to the asymptomatic nature of the infection, the virus is more likely to be spread among younger people, which explains the reason for higher prevalence of SARS-CoV-2 in this group [12].

In contrast to the participants with low socioeconomic status, individuals with higher income were significantly at greater risk with SARS-CoV-2 infection ($p < 0.001$). People with higher incomes can be involved in outdoor activities more frequently which increases the possibility of infection. Furthermore, middle- or high-income groups have easier access to health facilities including diagnostic tests, therefore this could also explain the reason for higher rates of SARS-CoV-2 positivity among these individuals [13].

In the study, lower level of education (compared to university or higher degree) was significantly associated with increased risk of SARS-CoV-2 infection ($p < 0.001$), which is in agreement with other reports [14]. This implies that participants with higher educational level had a better understanding of the disease and its related risk factors. In our study, further statistical analysis revealed that individuals with no educational background had the highest income, and this result was statistically significant ($p = 0.008$). The percentages of the individuals with high income in the three educational groups were as follows: 8.4% (n = 21/250; no education), 6.3% (n = 45/716; primary and high school), and 5.7% (n = 71/1241; university and higher degree) (data not shown in the table). Therefore, this can explain the reason why low education and high income were concomitantly associated with higher rates of SARS-CoV-2 positivity in our study. On the other hand, statistical analysis of occupations revealed that participants who were healthcare workers were significantly at greater risk ($p < 0.001$) of having SARS-CoV-2. This result was similar to previous reports where healthcare workers were more likely to be infected with SARS-CoV-2 compared to the general community [15].

The majority (76.1%) of the positive cases showed at least one symptom related with COVID-19, including loss of taste or smell, muscle or joint pain, and difficulty breathing, and this finding was in agreement with other studies [27-29]. Participants previously infected and completely cured tested negative for SARS-CoV-2 in the current study ($p < 0.001$) which can indicate the protective effect of the immune response against further infection with the virus. Participants having underlying chronic diseases (except for those with cancer and transplant patients) were significantly affected with SARS-CoV-2 ($p < 0.05$) compared to the group with no chronic diseases. This may be explained by the fact that presence of chronic diseases can be a predisposing factor facilitating the existence and pathogenesis of COVID-19 [30]. Furthermore, in the statistical analysis pregnant women were found to be at higher risk of SARS-CoV-2 infection ($p = 0.020$). This is also compatible with other reports where pregnancy was considered as a risk factor for COVID-19 [31]. In the current study smoking was found to be another risk factor for SARS-CoV-2 infection ($p < 0.001$), which contradicts other studies [32].

The results showed that there was a high level of knowledge and awareness of protective measures among Jordanian participants. This, in turn, significantly reduced the positivity rate of SARS-CoV-2. Use of mask while working indoors, washing hands routinely with soap and water, and use of alcohol-based disinfectants were associated with lower levels of infection among the study participants ($p < 0.001$). This suggests that people who followed the virus protection guidelines and instructions also published by the media were less likely to contract SARS-CoV-2 [33].

Conclusions

In the present study, a high percentage (59.5%) of SARS-CoV-2 cases was detected in Amman, Jordan. Male gender, younger age, lower educational level, middle and higher socioeconomic status, presence of underlying chronic disease and smoking were among significant factors that increased the possibility of SARS-CoV-2 infection. Although the infection rate was lower among the elderly group, they were more likely to show symptoms in comparison to the younger individuals. Use of protective and hygienic procedures significantly reduced the infection rates. The present study is one of the most comprehensive epidemiological studies that analyzed the factors related to SARS-CoV-2 infection in the Jordanian community. Our study highlights that epidemiological surveys should be continued to evaluate the risk factors for the prevention and control of virus transmission in countries.

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Annex- Supplementary Items

Supplementary table 1. Demographic and socioeconomic characteristics of the study participants, Jordan, December 2020-February 2021.

Factor	Participants n (%)
Gender	
Male	1073 (43.6)
Female	1387 (56.4)
Total	2460 (100.0)
Age	
18-29	1121 (45.6)
30-49	1014 (41.2)
50 and above	325 (13.2)
Total	2460 (100.0)
Education	
No education	274 (11.1)
Primary and high school	827 (33.6)
University and higher degree	1359 (55.2)
Total	2460 (100.0)
Marital status	
Single	1158 (47.6)
Married	1274 (52.4)
Total	2432 (100.0)
Socioeconomic status	
Low	749 (33.9)
Middle	1321 (59.9)
High	137 (6.2)
Total	2207 (100.0)
Occupation	
Healthcare worker	68 (7.6)
Non-healthcare worker	830 (92.4)
Total	898 (100.0)

Supplementary table 2. General health condition of the participants, and use of personal protection and hygiene practices among the study population, Jordan, December 2020-February 2021.

Factor	Participants n (%)
Any symptom among SARS-CoV-2-positive individuals	
Yes	1114 (76.1)
No	349 (23.9)
Total	1463 (100.0)
Previous SARS-CoV-2 infection	
Yes	27 (1.1)
No	2433 (98.9)
Total	2460 (100.0)
Underlying chronic disease	
Yes	286 (11.6)
No	2174 (88.4)
Total	2460 (100.0)
Hypertension	
Yes	179 (7.3)
No	2281 (92.7)
Total	2460 (100.0)
Diabetes	
Yes	140 (5.7)
No	2320 (94.3)
Total	2460 (100.0)
Chronic heart disease	
Yes	23 (0.9)
No	2437 (99.1)
Total	2460 (100.0)
Chronic lung disease	
Yes	9 (0.4)
No	2451 (99.6)
Total	2460 (100.0)
Chronic kidney disease	
Yes	16 (0.7)
No	2444 (99.3)
Total	2460 (100.0)
Chronic liver disease	
Yes	7 (0.3)
No	2453 (99.7)
Total	2460 (100.0)
Chronic neurological disease	
Yes	7 (0.3)
No	2453 (99.7)
Total	2460 (100.0)
Cancer	
Yes	15 (0.6)
No	2445 (99.4)
Total	2460 (100.0)
Organ or bone marrow transplantation	
Yes	2 (0.1)
No	2458 (99.9)
Total	2460 (100.0)
Smoking	
Yes (current smoker or quit)	525 (21.5)
No (never smoked)	1913 (78.5)
Total	2438 (100.0)
Pregnancy status	
Yes	97 (8.6)
No	1037 (91.4)
Total	1134 (100.0)
Use of mask while working indoors	
Yes	533 (89.9)
No	60 (10.1)
Total	593 (100.0)
Washing hands with soap and water	
Yes	2121 (86.2)
No	339 (13.8)
Total	2460 (100.0)
Use of alcohol-based disinfectants	
Yes	2104 (85.5)
No	356 (14.5)
Total	2460 (100.0)

Supplementary table 3. Univariate analysis of risk factors associated with symptomatic COVID-19, Jordan, December 2020-February 2021.

Risk factors	COVID-19		χ^2 test		Logistic regression	
	Symptomatic n/N (%)	Asymptomatic n/N (%)	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Gender						
Male	523/704 (74.3)	181/704 (25.7)	0.82 (0.65-1.05)	0.109	-	-
Female	591/759 (77.9)	168/759 (22.1)	1 (ref)			
Age						
18-29	498/684 (72.8)	186/684 (27.2)			0.51 (0.32-0.83)	**0.007**
30-49	501/642 (78.0)	141/642 (22.0)	-	**0.007**	0.68 (0.42-1.11)	0.125
50 and above	115/137 (83.9)	22/137 (16.1)			1 (ref)	
Underlying chronic disease						
Yes	190/225 (84.4)	35/225 (15.6)	1.85 (1.26-2.71)	**<0.001**	-	-
No	924/1238 (74.6)	314/1238 (25.4)	1 (ref)			
Smoking						
Yes (current smoker or quit)	296/372 (79.6)	76/372 (20.4)	1.26 (0.95-1.68)	0.112	-	-
No (never smoked)	808/1070 (75.5)	262/1070 (24.5)	1 (ref)			
Pregnancy status						
Yes	63/69 (91.3)	6/69 (8.7)	3.35 (1.42-7.90)	**0.004**	-	-
No	464/612 (75.8)	148/612 (24.2)	1 (ref)			

OR: odds ratio; CI: confidence interval; ref: reference value.

Supplementary figure 1. The questionnaire applied in the study, Jordan, December 2020-February 2021.

The purpose of this study is to search for the prevalence of COVID-19 and possible risk factors that are associated with this disease in Jordan. The information that you are going to provide in the questionnaire is important for the success of the study. The information will be kept confidential and only used for this study.

Please answer the following questions and circle the number next to the option that is suitable for you.

Thank you for your interest in our study.

Participant's name-surname: .....

Participant's address: .....

Participant's phone numbers: (Home): ..... (Mobile): .....

Section I.

1	Gender: **1.** Male **2.** Female
2	Age: .....
3	Level of education: **1.** Never been to school **2.** Primary school **3.** Secondary school **4.** High school **5.** University **6.** Postgraduate
4	What is your job? .....
5	Marital status: **1.** Married **2.** Single
6	Socioeconomic status: **1.** Low **2.** Middle **3.** High
7	How long have you been living in Jordan? .....

Section II.

1	Do you have one or more of the following symptoms **at the moment**? **1.** Yes **2.** No If your answer is yes, please circle the suitable choice (you can circle more than one choices). □ Fever □ Dry cough □ Fatigue □ Shortness of breath or difficulty breathing □ Loss of taste or smell □ Muscle or joint pain □ Nasal congestion or runny nose □ Sore throat □ Other (please indicate): .....
2	Previously were you diagnosed positive for COVID-19? **1.** Yes **2.** No
3	Do you smoke cigarettes? **1.** Yes **2.** No, I have never smoked. **3.** I used to smoke, but I quit.
4	Do you have any diagnosed underlying disease? **1.** Yes **2.** No If your answer is yes, please circle the suitable choice (you can circle more than one choices). □ Diabetes □ Hypertension □ Chronic heart disease □ Chronic lung disease □ Chronic kidney disease □ Chronic liver disease □ Chronic neurological disease □ Cancer □ Organ or bone marrow transplantation □ Other (please indicate): .....
5	*To be filled by women participants only:* Are you pregnant? **1.** Yes **2.** No If your answer is yes, what month of pregnancy are you in? .....
6	Do you work indoors? **1.** Yes **2.** No If your answer is yes, do you use mask while working in this place? .....
7	Do you often wash your hands with soap and water during the day? **1.** Yes **2.** No
8	Do you clean your hands using alcohol-based disinfectant during the day? **1.** Yes **2.** No

Our questionnaire has finished. Thank you for your participation and contribution.