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Original article

The effects of COVID-19 severity on health status in Kazakhstan: A prospective cohort study

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ABSTRACT

On May 5, 2023, the World Health Organization announced the end of the coronavirus pandemic. Nonetheless, there are growing reports indicating that individuals who have contracted COVID-19, especially in its more severe manifestations, may endure medium-to long-term impacts of the condition.

The purpose of this study was to investigate the impact of the severity of COVID-19 on the subsequent health outcomes.

Methods: The prospective cohort study ran from March to October of 2021.482 study participants were divided into two cohorts: the first cohort encompassed 118 individuals who received hospital care, while the second cohort included 364 individuals receiving outpatient care. Propensity Score Analysis was used as the probability of being hospitalized for COVID-19 in logistic regression as a covariate, to account for the influence of intervening factors that were associated with the probability of being hospitalized for COVID-19. The odds ratio (OR) was the association metric that was applied.

Results: Patients with more severe COVID-19 are more prone to infectious and parasitic diseases ORadj 6.61 (with 95 % CI 1.84–23.75), $p = 0.004$, more likely to show complications from the respiratory system ORadj 2.37 (with 95 % CI 1.35–4.16), $p = 0.003$, more frequently diagnosed eye pathologies ORadj 5.60 (with 95 % CI 1.96–15.98), $p = 0.001$, susceptible to hospitalization, ORadj 3.49 (1.78–6.84), $p < 0.001$.

Conclusion: Our study's findings indicate that patient with more severe COVID-19 have a higher requirement for medical attention regardless of other factors that influence the need for medical care.

1. Introduction

The declaration by the World Health Organization on May 5, 2023, signaling the conclusion of the coronavirus pandemic, did not signify the cessation of concerns related to COVID-19. Despite this announcement, the disease continues to pose significant public health challenges, persistently affecting global populations. The cumulative count of over 696 million documented COVID-19 cases worldwide as of October 18, 2023 [1], highlights the ongoing uncertainty regarding the extent and lasting impact of this illness. As time passes since the onset of the SARS-CoV-2 outbreak, it becomes increasingly evident that a subset of individuals afflicted may face enduring consequences. Emerging evidence strongly suggests that survivors of COVID-19, particularly those affected severely, may grapple with medium-to long-term health implications necessitating adjustments in their medical care.

Longitudinal investigations reveal that 74–88 % of COVID-19 patients hospitalized due to the virus experience persisting symptoms extending beyond 50–80 days, with fatigue and dyspnea (difficulty breathing) ranking among the most prevalent complaints.[2,3] Notably, lung complications in hospitalized COVID-19 patients exhibit sustained growth and persistence for up to 24 days following their initial manifestation.[4] Furthermore, evidence suggests the development of cardiovascular-related conditions in patients within 1–3 months post-coronavirus infection, with reports also surfacing on fresh,

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irreversible loss of renal function among COVID-19 individuals.[5,6] Extensive data on the acute phase of the SARS-CoV-2 pandemic have been amassed. However, comprehensive studies probing the long-term ramifications of COVID-19 on broader public health remain limited,[7] as well as information regarding the effects of the severity of COVID-19 on health of the population.

An extensive literature review examining the enduring effects of other viral infectious diseases—such as acute respiratory infections, the 2002 SARS-CoV-1 outbreak, the 2009 H1N1 pandemic, and the 2012 Middle East respiratory syndrome-CoV (MERS)—has unveiled a spectrum of complications across various bodily systems. These include respiratory system complications like lung fibrosis,[8,9] diminished lung capacity,[10] pulmonary opacities characterized by "frosted glass" appearance with pleural thickening,[8] bronchiectasis[11]; musculoskeletal complications such as avascular necrosis in the hip and knee[12]; neurological manifestations encompassing encephalitis, headache, seizures, and Guillain-Barré syndrome[13]; as well as mental health conditions including post-traumatic stress disorder, anxiety, depression,[14] and chronic fatigue syndrome.[15] Authors emphasize the heightened susceptibility of individuals with severe illnesses necessitating hospitalization to these complications,[16] further compounded by pre-existing systemic pathologies, accentuating the risk of coronavirus-related complications and exacerbating chronic conditions.[17]

It is challenging to investigate how COVID-19 affected the need for health care later on because the severity of the disease's course was closely linked to the patient's pre-pandemic condition and other factors as gender, age, and the presence of comorbidities. In other words, even in the absence of a pandemic, individuals with severe COVID-19 were still more likely to require medical attention. In light of this, we conducted a prospective cohort study to gain deeper insights into the lasting effects of COVID-19, comparing healthcare utilization over an 8-month period following COVID-19 infection among hospitalized COVID-19 patients, outpatients treated for COVID-19, and close contacts of COVID-19 patients who did not seek medical care.

1.1. Goal of the research

This study aimed to investigate the impact of the severity of COVID-19 on the subsequent health outcomes.

Hypothesis: our hypothesis suggests that the severity of a COVID-19 infection correlates positively with an increased requirement for post-disease medical care for both hospitalized and ambulatory patients. Depending on the illness group, some diseases may require more medical attention. Specifically, a more severe manifestation of coronavirus infection is anticipated to amplify the demand for ongoing medical attention following the acute phase of the illness.

2. Materials and methods of research

2.1. Data sources

Our study was an extension of the prospective cohort study which was conducted within the framework of the global initiative titled "Study of confirmed and probable COVID-19 cases along with their close contacts in Kazakhstan", spanning from November 2020 to February 2021. Consequently, the study's sources were the Republic of Kazakhstan's Ministry of Health's official data from health information databases (database of confirmed cases of the Republic of Kazakhstan for the initial phase; the ERHP or electronic registry of hospitalized patients, and the "Unified Payment System" electronic system for outpatients to gather information on post-COVID-19 effects).

2.2. Base-line

According to Fig. 1, the study encompassed 487 participants, among whom 172 were diagnosed with COVID-19. Within this cohort, 118 (24 %) received inpatient care, 54 (11 %) were treated as outpatients, and 315 (65 %) were identified as close contacts sharing a domicile with individuals exhibiting both mild and severe forms of COVID-19. Throughout of investigation, 310 contacts (98 %) had tested positive for COVID-19 via PCR, ELISA, or a combination of both methods.[18] Only five contacts were excluded from the subsequent follow-up due to the absence of any signs indicative of COVID-19 infection. All 172 cases that were discovered and nearly all contacts (310 people) with minor COVID-19 symptoms—including those who continued to show no symptoms—were included in our analysis.

The cohort with severe COVID-19 comprised hospitalized patients displaying positive results for coronavirus infection via PCR and/or ELISA assays, alongside confirmed evidence of COVID-19 lesions identified through radiographic and CT examinations. On the contrary, the mild COVID-19 group encapsulated all COVID-19 cases received inpatient care and all close contacts with laboratory-confirmed COVID-19, either managed as outpatients within their residences or those who remained asymptomatic. These participants constituted the remaining segment of the study cohort.

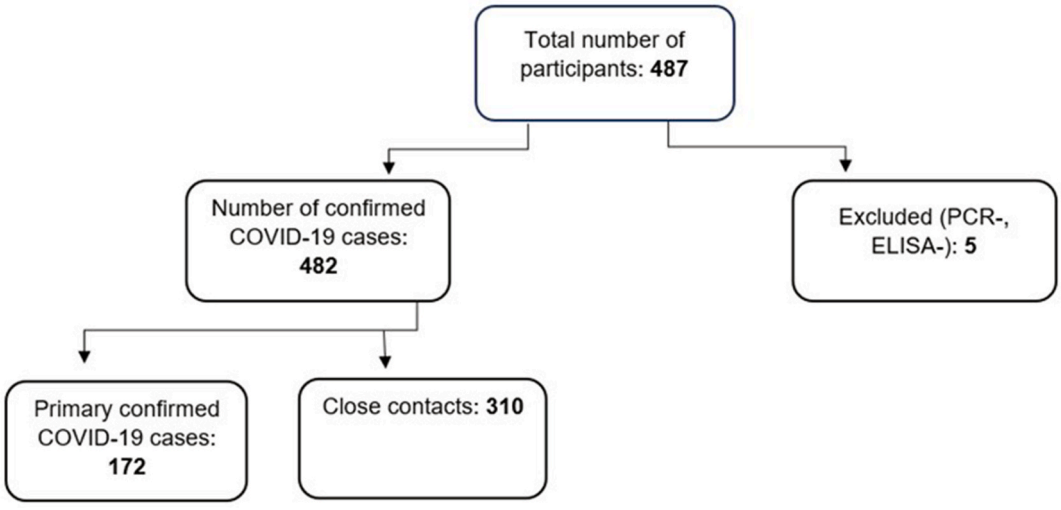

Fig. 1. The total study sample box. Flow chart of cases of COVID-19 and household contacts.

2.3. Follow-up

Our study was conducted from March to October 2021, segregated the participants into two cohorts: the first cohort – hospital cohort, encompassed 118 individuals who received hospital care for severe COVID-19 cases, while the second cohort – outpatient cohort, included 364 individuals receiving outpatient care or displaying asymptomatic or mild COVID-19 (i.e., individuals with mild symptoms or close contacts) (Fig. 2). To assess the health outcomes of COVID-19, data on health conditions were taken from the electronic registry of hospitalized patients, and the "Unified Payment System" electronic platform for outpatients in Kazakhstan. This included all newly diagnosed conditions within the 8 months following the conclusion of the initial study period. Comprehensive health information systems provided detailed data encompassing medical care received, including diagnostic profiles, treatment duration, and hospitalization records.

2.4. Diagnosis classification and outcome variables

The diagnoses obtained, encompassing initial diagnoses and exacerbations of chronic diseases, were systematically classified into 17 groups using the ICD-10 classes. Subsequently, 13 out of the initial 17 disease groups were retained, while four were excluded due to minimal reporting during the follow-up period. The study's dependent variable was the occurrence of hospitalization, excluding instances related to childbirth or trauma.

Consequently, the study comprised 14 dependent binary variables, including hospitalizations recorded throughout the observation period and the presence or absence of 13 distinct illness groups.

1) Urogenital diseases (N10 - N97.9)
2) Digestive diseases (K00 - K87)
3) Diseases of the skin (L00 - L99)
4) Diseases of the nervous system (G20 - G99)
5) Musculoskeletal diseases (M05 - M99)
6) Communicable and parasitic diseases (A00 - B99)
7) Respiratory diseases (J00 - J99)
8) Oncology (C50 - D48)
9) Diseases of the endocrine system and metabolic disorders (E00 - E90)
10) Diseases of the eye and appendage apparatus (H00 - H52)
11) Diseases of the circulatory system (I10 - I89)
12) Psychiatric disorders (F00 - F29)
13) Diseases of the ear and mastoid process (H65 - H95)
14) Hospitalization for any cause other than trauma or childbirth

2.5. Statistical analysis

Data evaluation was conducted using IBMSPSS® statistical software version № 23 (https://www.ibm.com/support/pages/downloading-ibm-spss-statistics-23) subsequent to entry into Microsoft Excel. The association between variables was quantified using odds ratios (ORs), each accompanied by a p-value and a 95 % confidence interval.

The assessment aimed to delineate correlations between risk factors for coronavirus infection, the type of medical care received, and the occurrence of complications contingent upon the severity of the disease course. Categorical data were presented as frequencies or percentages and analyzed utilizing the Chi-square test and logistic regression. Associations were deemed significant at a 95 % confidence interval with a 5 % error rate.

A comprehensive model encompassing variables potentially impacting the severity of COVID-19 course necessitating hospitalization — such as gender, age, and comorbidities like obesity, diabetes mellitus, cardiovascular disease, chronic lung disease, and other chronic illnesses — was developed to calculate the probability of hospitalization, termed the Propensity Score.

Propensity Score Analysis was deployed using logistic regression with Propensity Score (PS) as a covariate to adjust for intervening factors associated with COVID-19 hospitalization likelihood while concurrently impacting the emergence of medically necessary conditions. Essentially, it standardized the likelihood of hospitalization among patients with equivalent estimated PS values.

We use dependent and independent variables in all of our models. Hospitalizations and 13 groups of diseases found in the electronic system (urogenital diseases, digestive diseases, diseases of the skin, diseases of the nervous system, musculoskeletal diseases, communicable and parasitic diseases, respiratory diseases, oncology, disease of endocrine system, diseases of the eye and appendage apparatus, diseases of the circulatory system, psychiatric disorders, diseases of the ear and mastoid process) are the dependent variables. We identified the severity of the coronavirus infection course (a mild form that was treated as an outpatient and a more severe form that necessitated the patient's

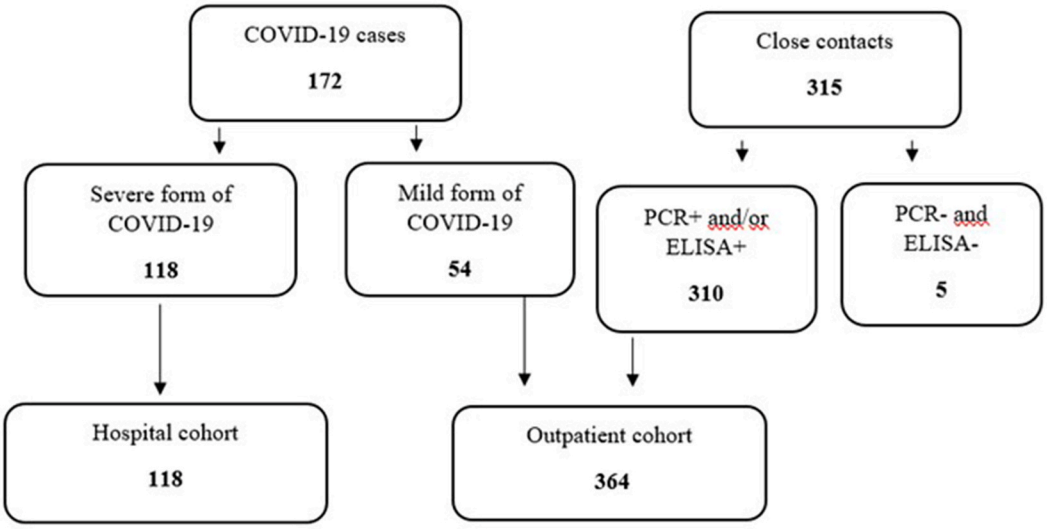

Fig. 2. Participation trends in the study. Note: PCR-polymerase chain reaction test for COVID-19 is a molecular test that analyzes your upper respiratory specimen, looking for genetic material (ribonucleic acid or RNA) of SARS-COV-2, the virus that causes COVID-19. ELISA-enzyme-linked immunosorbent assay also referred to as the serology test. The antibody test can assist with precision diagnoses as well as characterization of the spread and prevalence of the disease.

hospitalization) and the propensity score to have severe form of the COVID-19 as an independent variable. We used Propensity Score to make an adjustment because we knew that health issues affected how severe the COVID-19 course was.

The literature states that comorbidities, age, and gender all affect how severe an infection is. All of these elements have also been considered in the Propensity Score. Logistic regression was used to determine the Propensity score, with COVID-19 severity serving as the dependent variable and gender, age, and comorbidities like obesity, diabetes mellitus, cardiovascular disease, chronic lung disease, and other chronic illnesses serving as the independent factors. To account for multiple comparisons, the critical p-value (p-value with Bonferroni adjustment: 0.05/14 = 0.004) was determined using the Bonferroni correction.

The odds ratio (OR) of specific diagnoses among hospitalized patients compared to those without a severe disease course was utilized to evaluate the influence of COVID-19 severity on care receipt across distinct disease categories. Hospitalization due to COVID-19 constituted the primary independent variable, while the Propensity Score for COVID-19 hospitalization served as a covariate. The refined odds ratio was computed using logistic regression analysis.

3. Results

The mean age among hospitalized patients stood at 54.2 years (SD 16.8), contrasting with outpatients averaging 37.8 years (SD 17.9). Males constituted 44.4 % (214/482) of the study cohort, while females comprised 55.6 % (268/482). In the initial trial phase, 47.5 % (56) of females and 52.5 % (62) of males were hospitalized due to COVID-19 (Table 1).

The study encompassed two cohorts: the hospital cohort which included 118 (24 %) patients with severe form of COVID-19 and the outpatient cohort with 364 (76 %) patients receiving care at the outpatient level or with asymptomatic or mild COVID-19.

Utilizing logistic regression to derive the Propensity Score (PS) for hospitalization owing to COVID-19, sex, age, and comorbidities were employed as covariates (Table 2). The generated PSs ranged between [Min 0.00790-Max 0.99365].

In this study, during the acute phase of COVID-19, the likelihood of hospitalization was higher in men compared to women (OR 0.44 (CI 0.26–0.74), p = 0.002), increased with older age (p = 0.001), and was associated with a history of obesity (OR 40.60 (CI 13.27–124.19), p < 0.001), cardiovascular disease (OR 2.78 (CI 1.16–6.67), p = 0.021), and chronic respiratory diseases (OR 0.18 (CI 0.03–1.03), p = 0.054). The mean PS for severe COVID-19 hospitalizations was 0.497839 (SD 0.319295), whereas for mild cases, it was 0.162788 (SD 0.148290). Notably, despite accounting for significant variables influencing COVID-19 hospitalizations, unmeasured factors could potentially influence PS values if not considered.

Analysis of medical care received within 8 months post-COVID-19 infection revealed correlations between severe COVID-19 and subsequent medical treatment across 13 illness groups and hospitalizations (Table 3). Individuals with severe COVID-19 were at higher odds (adjusted odds ratio [AOR]) of developing infectious and parasitic diseases (AOR 6.61 with 95 % CI 1.84–23.75, p = 0.004), respiratory diseases (AOR 2.37 with 95 % CI 1.35–4.16, p = 0.003), eye pathology (AOR 5.60 with 95 % CI 1.96–15.98, p = 0.001), and facing subsequent hospitalization (AOR 3.49 with 95 % CI 1.78–6.84, p < 0.001).

Table 1
Characteristics of the inpatient and outpatient participants of the study.

Sample characteristic	% (N = 482)	Hospital cohort	Outpatient cohort
female	268 (55.6 %)	56 (47.5 %)	212 (58.2 %)
male	214 (44.4 %)	62 (52.5 %)	152 (41.8 %)
Age groups			
0–17 years	52 (10.8 %)	4 (3.4 %)	48 (13.2 %)
18–44 years	220 (45.6 %)	28 (23.7 %)	192 (55.5 %)
45–59 years	106 (22.0 %)	31 (26.3 %)	75 (20.6 %)
60–90 years	104 (21.6 %)	55 (46.6 %)	49 (13.5 %)
Obesity	43 (8.9 %)	38 (32.2 %)	5 (1.4 %)
Diabetis	9 (1.9 %)	8 (6.8 %)	1 (0.3 %)
Heart diseases	60 (12.4 %)	23 (19.5 %)	37 (10.2 %)
Chronic lung diseases	12 (2.5 %)	3 (2.5 %)	9 (2.5 %)
Other chronic conditions	26 (5.4 %)	8 (6.8 %)	18 (4.9 %)

4. Discussion

Our prospective cohort study revealed a higher likelihood of post-infection medical attention needs among hospitalized COVID-19 patients, even after adjusting for gender, age, and comorbidities influencing severe COVID-19 necessitating hospitalization. It was found that men exhibited a greater likelihood of hospitalization during the acute phase of COVID-19 compared to women (p = 0.002). Hospitalization rates increased with advancing age (p = 0.001), and were correlated with obesity (p < 0.001), cardiovascular disease (p = 0.021), and chronic respiratory diseases (p = 0.054). Hospitalized patients exhibited elevated risks for subsequent respiratory diseases (p = 0.003), infectious and parasitic diseases (p = 0.004), eye diseases (p = 0.001), and necessitated hospitalization within eight months post-COVID-19 contraction (p < 0.001).

Age emerged as a significant risk factor for post-coronavirus sequelae, consistent with similar investigations where comorbidities were more prevalent among older individuals.[19,20] Regarding gender disparities, studies suggest that hospitalized males with severe radiographic or CT alterations are prone to respiratory issues, such as post-COVID-19 pulmonary fibrosis.[21] Another study revealed a notable risk of developing post-COVID-19 diabetes among patients with severe form of COVID-19 (RR = 1.67, 95 % CI [1.25–2.23]) regardless of sex and age. Particularly, the risk peaked within the initial 3 months following COVID-19 infection.[22]

Patients with severe virus manifestations showed marked impairments in functional capacity, particularly pulmonary function, in the initial months post-illness.[23] In our study, within eight months of acute COVID-19, individuals who were in the hospital cohort had diagnoses including acute bronchitis (8 %), bacterial pneumonia, bronchopneumonia, and unclassified pneumonia (14 %), initial identification of asthma (11 %), and respiratory failure in one patient. Numerous studies substantiate the emergence of cardiovascular complications post-COVID-19, particularly in individuals with pre-existing cardiac conditions during the acute phase.[24–26] However, our study did not identify an association between the incidence of cardiovascular complications and the severity of COVID-19 course (p < 0.05). This could be due to the absence of significant cardiovascular diagnoses among the study participants, who were under the care of their primary care physicians throughout the study.

The intriguing effects of COVID-19 on the eye are also noteworthy. Some studies highlight retinal artery changes and retinal diseases.[27,28] In our study, 1.2 % had vascular and retinal disorders, 1.7 % had lens diseases like cataracts, 0.6 % had glaucoma, 0.6 % had vitreous and ocular diseases, and one patient was diagnosed with optic atrophy. Notably, 67 % of patients presenting ocular issues during acute hospitalization had severe COVID-19.

While there wasn't an observed rise in morbidity or hospitalizations for these conditions in Kazakhstan in 2020–2021, the significant excess mortality related to COVID-19, particularly among the elderly and those with chronic illnesses, likely contributed to subsequent increased demand for medical attention. According to the country's Bureau of National Statistics the COVID-19 outbreak correlated with a 24 % rise in Kazakhstan's death rate between 2016 and 2020, and WHO reports indicate a 1.7-fold increase in COVID-19 excess mortality in Kazakhstan between 2020 and 2021.[29] In general, Kazakhstan's yearly death toll has been roughly 130,000, but in 2020, 162,000 people passed away. A comparable trend of escalating COVID-19 excess mortality rates has

Table 2
Association between health factors and severity of COVID-19 (hospitalization).

Variables	Two cohorts of the study		Odds ratio	*p*	Odds ratio adj	*p*
	hospital	outpatient				
female	56 (47.5 %)	212 (58.2 %)	0.65 (0.43–0.98)	0.043	0.44 (0.26–0.74)	0.002
male	62 (52.5 %)	152 (41.8 %)	1		1	
Age groups						
0–17 years	4 (3.4 %)	48 (13.2 %)	0.07 (0.02–0.22)	<0.001	0.08 (0.03–0.25)	<0.001
18–44 years	28 (23.7 %)	192 (55.5 %)	0.13 (0.07–0.23)	<0.001	0.11 (0.06–0.21)	<0.001
45–59 years	31 (26.3 %)	75 (20.6 %)	0.37 (0.21–0.65)	0.001	0.31 (0.16–0.61)	0.001
60–90 years	55 (46.6 %)	49 (13.5 %)	1		1	
Obesity						
yes	38 (32.2 %)	5 (1.4 %)	34.1 (13.02–89.37)	<0.001	40.60 (13.27–124.19)	<0.001
no	80 (67.8 %)	359 (98.6 %)	1		1	
Diabetis						
yes	8 (6.8 %)	1 (0.3 %)	26.40 (3.26–213.40)	<0.001	5.93 (0.53–66.60)	0.149
no	110 (93.2 %)	363 (99.7 %)	1		1	
Heart diseases						
yes	23 (19.5 %)	37 (10.2 %)	2.14 (1.21–3.78)	0.008	2.78 (1.16–6,67)	0.021
no	95 (80.5 %)	327 (89.8 %)	1		1	
Chronic lung diseases						
yes	3 (2.5 %)	9 (2.5 %)	1.03 (0.27–3.87)	0.595	0.18 (0.03–1.03)	0.054
no	115 (97.5 %)	355 (97.5 %)	1		1	
Other chronic conditions						
yes	8 (6.8 %)	18 (4.9 %)	1.40 (0.59–3.30)	0.289	1.70 (0.55–5.28)	0.358

Table 3
The impact of the severity of COVID-19 on the onset of late sequelae of COVID -19 infection.

Variables	% (N = 482)	Hospital cohort	Outpatient cohort	Odds ratio	*p*	Odds ratio adj	*p*
Urogenital diseases (N10-N98)							
yes	37 (7.7 %)	10 (8.5 %)	27 (7.4 %)	1.16 (0.54–2.46)	0.419	1.67 (0.68–4.07)	0.262
no	445 (92.3 %)	108 (91.5 %)	337 (92.6 %)	1		1	
Digestive diseases (K00-K87)							
yes	42 (8.7 %)	13 (11 %)	29 (8.0 %)	1.43 (0.72–2.85)	0.200	1.18 (0.50–2.81)	0.710
no	440 (91.3 %)	105 (89 %)	335 (92.0 %)	1		1	
Diseases of the skin (L00-99)							
yes	15 (3.1 %)	5 (4.2 %)	10 (2.7 %)	1.57 (0.52–4.68)	0.295	0.83 (0.19–3.55)	0.800
no	467 (96.9 %)	113 (95.8 %)	354 (97.3 %)	1		1	
Diseases of the nervous system (G20-99)							
yes	26 (5.4 %)	10 (8.5 %)	16 (4.4 %)	2.01 (0.89–4.57)	0.075	1.84 (0.67–5.10)	0.239
no	456 (94.6 %)	108 (91.5 %)	348 (95.6 %)	1		1	
Musculoskeletal diseases (M05-99)							
yes	42 (8.7 %)	16 (13.6 %)	26 (7.1 %)	2.04 (1.05–3.95)	0.029	1.36 (0.58–3.18)	0.482
no	440 (91.3 %)	102 (86.4 %)	338 (92.9 %)	1		1	
Communicable and parasitic diseases (A00-B99)							
yes	12 (2.5 %)	5 (4.2 %)	7 (1.9 %)	2.26 (0.70–7.25)	0.144	6.61 (1.84–23.75)	0.004
no	470 (97.5 %)	113 (95.7 %)	357 (98.1 %)	1		1	
Respiratory diseases (J00-99)							
yes	113 (23.4 %)	42 (35.6 %)	71 (19.5 %)	2.28 (1.44–3.60)	<0.001	2.37 (1.35–4.16)	0.003
no	369 (76.6 %)	76 (64.4 %)	293 (80.5 %)	1		1	
Oncology (C50-D48)							
yes	15 (3.1 %)	7 (5.9 %)	8 (2.2 %)	2.81 (1.00–7.91)	0.048	0.92 (0.22–3.85)	0.909
no	467 (96.9 %)	111 (94.1 %)	356 (97.8 %)	1		1	
Diseases of the endocrine system and metabolic disorders (E00-90)							
yes	33 (6.8 %)	16 (13.6 %)	17 (4.7 %)	3.202 (1.56–6.56)	0.002	1.74 (0.68–4.41)	0.247
no	449 (93.2 %)	102 (86.4 %)	347 (95.3 %)	1		1	
Diseases of the eye and appendage apparatus (H00-52)							
yes	20 (4.1 %)	11 (9.3 %)	9 (2.5 %)	4.06 (1.64–10.04)	0.003	5.60 (1.96–15.98)	0.001
no	462 (95.9 %)	107 (90.7 %)	355 (97.5 %)	1		1	
Diseases of the circulatory system (I10-89)							
yes	54 (11.2 %)	31 (26.3 %)	23 (6.3 %)	5.28 (2.93–9.52)	<0.001	2.07 (0.97–4.42)	0.061
no	428 (88.8 %)	87 (73.7 %)	341 (93.7 %)	1		1	
Psychiatric disorders (F00-F29)							
yes	3 (0.6 %)	2 (1.7 %)	1 (0.3 %)	6.26 (0.56–69.64)	0.150	6.49 (0.41–103.82)	0.186
no	479 (99.4 %)	116 (98.3 %)	363 (99.7 %)	1		1	
Diseases of the ear and mastoid process (H65-95)							
yes	4 (0.8 %)	3 (2.5 %)	1 (0.3 %)	9.47 (0.98–91.91)	0.047	18.01 (1.62–200.36)	0.019
no	478 (99.2 %)	115 (97.5 %)	363 (99.7 %)	1		1	
Hospitalization after COVID-19							
yes	62 (18.9 %)	30 (25.4 %)	32 (8.8 %)	3.54 (2.04–6.14)	<0.001	3.49 (1.78–6.84)	<0.001
no	420 (87.1 %)	88 (74.6 %)	332 (91.2 %)	1		1	

been noted across numerous countries. Nonetheless, the comparability of published data on COVID-19 mortality between countries is hindered by variations in reporting methodologies, public health interventions implemented to curb the pandemic, and the influence of other factors impacting mortality within each country.[30]

Our study's objective was to determine whether severe COVID-19 has an impact on Kazakhstani health. This would enable us to determine whether additional medical care arrangements for patients with severe COVID-19 are necessary. Statistical data from the Ministry of Health of Kazakhstan validated our hypothesis suggesting that severe manifestations of coronavirus infection are expected to increase the need for continued medical care beyond the acute phase of the illness. Thorough post-hospitalization follow-ups for COVID-19 patients are crucial given the substantial numbers released from hospitals and emergency rooms—approximately 600,000 sought inpatient care in Kazakhstan from 2020 to 2022.

Limitations include potential unmeasured factors influencing hospitalization likelihood not accounted for by the Propensity Score model and reliance on self-reported morbidity, potentially not reflecting the true morbidity pattern. Additionally, factors like healthcare accessibility, patient willingness for examinations, and the brief post-acute phase duration after COVID-19 require consideration. We could only apply these findings to individuals who have survived COVID-19 because we did not include individuals who did not have the virus in our study. Since only a small subset of individuals tested negative for COVID-19, our findings and interpretations apply to all individuals who have not had severe COVID-19. It should be mentioned that the majority of people with COVID-19 experienced moderate or no symptoms. We are unable to expand our data to include all countries due to the possibility that different hospitalization standards and hospitalization availability were used in other nations.

5. Conclusion

Patients experiencing severe COVID-19 exhibited an elevated likelihood of developing subsequent respiratory, ocular, and infectious diseases compared to those with milder manifestations of the virus. To effectively address the health consequences of COVID-19, there's a vital need for comprehensive rehabilitation planning, particularly focusing on individuals impacted by the severe form of the illness. Incorporating early disease detection methods, such as screening tests, could prove pivotal in both prevention and treatment strategies concerning COVID-19-related health complications. This approach holds the potential to mitigate the strain of COVID-19 on economic, clinical health, and healthcare system resources.

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Ethical considerations

Prior to their inclusion in the trial and publication of study results, all participants provided written informed consent via an informed consent form (ICF). Approval for the project was granted by the Astana Medical University Local Bioethics Committee under Protocol No. 9, dated September 09, 2020. This ensured compliance with ethical guidelines and standards for research involving human participants.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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