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MAJOR ARTICLE

Population-level effectiveness of an inactivated whole-virion COVID-19 vaccine: A test negative case-control study in the Dominican Republic

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Background: A continuing nationwide vaccination campaign began in the Dominican Republic on February 16, 2021 to prevent severe consequences of acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. Estimates of vaccine effectiveness under real-world conditions are needed to support policy decision making and inform further vaccine selection.

Methods: We conducted a test-negative case-control study to assess the real-world effectiveness of nationwide coronavirus disease 2019 (COVID-19) vaccination program using an inactivated vaccine (CoronaVac®) on preventing symptomatic SARS-CoV-2 infections and hospitalizations from August to November 2021 in the Dominican Republic. Participants were recruited from 10 hospitals in 5 provinces to estimate the effectiveness of full immunization (≥14 days after receipt of the second dose) and partial immunization (otherwise with at least one dose ≥14 days after receipt of the first dose).

Results: Of 1,078 adult participants seeking health care for COVID-19-related symptoms, 395 (36.6%) had positive polymerase chain reaction (PCR) tests for SARS-CoV-2; 142 (13.2%) were hospitalized during 15 days of follow-up, including 91 (23%) among 395 PCR-positive and 51 (7.5%) among 683 PCR-negative participants. Full vaccination was associated with 31% lower odds of symptomatic infection (odds ratio, 0.69; 95% confidence interval, 0.52-0.93) and partial vaccination was associated with 49% lower odds (0.51; 0.30-0.86). Among 395 PCR-positive participants, full vaccination reduced the odds of COVID-19 related hospitalization by 85% (0.15; 0.08-0.25) and partial vaccination reduced it by 75% (0.25; 0.08-0.80); full vaccination was associated with reduced use of assisted ventilation by 73% (0.27; 0.15-0.49).

Conclusions: Given the ancestral and delta viral variants circulating during this study period, our results suggest that the inactivated COVID-19 vaccine offered moderate protection against symptomatic SARS-CoV-2 infections and high protection against COVID-19 related hospitalizations and assisted ventilation. This is reassuring given that, as of August 2022, an estimated 2.6 billion inactivated CoronaVac® vaccine doses had been administered worldwide. This vaccine will become a basis for developing multivalent vaccine against currently circulating omicron variant.

Key words: COVID-19; SARS-CoV-2; vaccine effectiveness; test-negative case-control study; Dominican Republic

INTRODUCTION

SARS-CoV-2, the virus that causes the novel coronavirus disease 2019 (COVID-19), infected over 640 million individuals and caused over 6.6 million deaths in the period since first recognition in December 2019 through November 2022 [1,2]. The urgency of the global pandemic drove vaccine development and usage at an unprecedented pace through public-private partnerships. By November 2022, twelve vaccines were included in the World Health Organization (WHO) Emergency Use Listing (EUL) — three mRNA, six recombinant, and three inactivated vaccines [3] — and 68% of the world population had received at least one dose and 63% had received two doses of a COVID-19 vaccine [4].

The inactivated whole-virion COVID-19 vaccine (CoronaVac®) was included in the WHO EUL in June 2021. The CoronaVac® vaccine does not requiring freezing and can be transported refrigerated at 2–8 °C (36–46 °F), offering an advantage for field distribution in low- and middle-income countries (LMIC) with limited freezer-dependent cold chain systems. CoronaVac® vaccine has been deployed in 55 countries and over 2.6 billion doses had been administered worldwide by August 2022.

Real-world data on inactivated vaccine effectiveness against symptomatic SARS-CoV-2 infection, hospitalization, and death have been reported from studies in China, Chile, Turkey, Brazil, and Indonesia [5-9]. A prospective national cohort study among 10.2 million Chileans who received CoronaVac® found it 66% effective against symptomatic COVID-19, 88% against hospitalization, 90% against admission to intensive care unit (ICU), and 86% against death [5]. A test-negative case-control study in Indonesia showed the vaccine effectiveness was 67% against laboratory confirmed SARS-CoV-2 sympomatic infection, 71% against hospitalization, and 87% against COVID-19-associated death [6]. As vaccine effectiveness may vary by circulating SARS-CoV-2 variants, population-level immunity, and access to healthcare, it is helpful to have studies with a variety of circumstances and timeframes. We conducted a negative-test case-control study to estimate the real-world effectiveness of the CoronaVac® vaccine in preventing polymerase chain reaction (PCR)-confirmed symptomatic SARS-CoV-2 infection, COVID-19 related hospital admissions, and use of assisted ventilation in the Dominican Republic.

METHODS

Background

The Dominican Republic initiated an aggressive nationwide vaccination program to stem COVID-19 disease beginning in February 2021. By June 2022, 16 million doses had been administered in a population of about 10.8 million persons. National logistics data document that of the total doses applied, 62% were Sinovac Life Sciences Co., Ltd. CoronaVac® inactivate

COVID-19 vaccine (Vero Cell), 33% were Pfizer/BioNTech Comirnaty® COVID-19 mRNA Vaccine (modified nucleoside), 3.8% were AstraZeneca/Serum Institute of India Pvt. Ltd Covishield COVID-19 Vaccine (ChAdOx1-S [recombinant]), and 0.2% were Beijing Institute of Biological Products Co., Ltd./Sinopharm Inactivated COVID-19 Vaccine (Vero Cell). As children have only recently had access to COVID-19 vaccines, 89.2% of vaccines have been administered to persons ≥18 years of age, 9.3% to youth ages 12-17 years, 1.5% to children ages 5-11 years, and none to children under age 5 years.

Since a preponderance of the adult Dominican population has received the CoronaVac® vaccine, documentation its real-world effectiveness could guide further policy planning as to how affordable inactivated vaccines with favorable cold chain storage and shipping characteristics might be used to mitigate the impact of COVID-19 disease. This may be especially relevant in other LMICs with funding limitations and/or logistical constraints for higher cost vaccines that have more restrictive cold chain requirements.

Study setting

The Dominican Republic is a Caribbean nation in a 48,671 sq km area, a population density of 222/sq km. The Dominican Republic has 31 provinces with its capital city, Santo Domingo, designated as a separate Distrito Nacional (National District).

Since the first confirmed COVID-19 cases on March 1, 2020, the Dominican Republic has experienced six epidemic waves. Peaks occurred with dominant emerging variants in July 2020 (ancestral/alpha variant), January 2021 (beta), June (gamma and delta), November (delta), and January 2022 and July 2022 (omicron). By November 6, 2022, over 647,425 cumulative confirmed COVID-19 cases and 4384 cumulative deaths had been reported (case fatality rate of 0.68%).

Study design and study population

In this multisite, test-negative case-control study, we sought to assess the real-world impact of nationwide COVID-19 vaccination program on reducing symptomatic SARS-CoV-2 infections, hospitalizations, and ventilator use. Sample size estimates made clear that death would be underpowered as an outcome. Patient recruitment was completed between August 17 and November 28, 2021 from 10 hospitals in 5 provinces of the Dominican Republic, including Distrito Nacional, La Altagracia, Puerto Plata, Santiago, and Santo Domingo (a province separate from Distrito Nacional). These diverse regions included coastal, inland, plains, and mountainous areas. Two hospitals were selected from each province. The residential area of the population covered by the healthcare services provided by participating hospitals constituted the study catchment areas. Hospitals included six governmental, three private, and one military facilities. The study was completed with final patient follow-up on December 12, 2021.

Patients who visited one of the 10 emergency rooms (ER) who had symptoms/signs compatible with COVID-19 were evaluated by clinicians as "suspected COVID-19 cases", following the national protocol. In 2021, national guidelines identified suspected cases as persons with at least one major COVID-19 symptom (fever documented ≥ 38°C, cough, shortness of breath, and altered sense of smell or taste) or two minor symptoms (fatigue or malaise, sore throat, headache, runny nose, congestion, muscle aches, nausea or vomiting, diarrhea, and abdominal pain). Patients suspected as COVID-19 cases by a clinician according to the national protocol were eligible for study participation if they were ≥18 years of age and met additional inclusion criteria: able and willing to (1) provide informed consent to participate in the study; (2) provide a nasopharyngeal swab for real-time polymerase chain reaction (RT-PCR) testing and a blood sample for future anti-SARS-CoV-2 IgG testing; and (3) complete a questionnaire survey.

Data collection

A trained research nurse or research assistant interviewed enrolled participants. Each participant received a physician exam and completed a questionnaire to collect data on participants' demographics, vital signs, clinical symptoms, medical history, risk of family and social exposures to SARS-CoV-2, and history of COVID-19 vaccination. One nasopharyngeal swab was collected and performed to assess the presence of SARS-CoV-2 RNA using RT-PCR. We collected a blood specimen for anti-SARS-CoV-2 IgG TrimericS antibodies.

If the participant required hospitalization either at recruitment or within the 14 days follow up post-ER visit, a hospital follow up form was completed daily, until the day the patient was released from the hospital. If the patient was released from the hospital before completing the 14-day period, a home follow-up form was filled at 14 days, closing their participation in the study. If the study participant remained hospitalized for >14 days post-recruitment, he/she was followed up until the day of being released from the hospital or the day of death (no home follow-up form was completed in this instance).

Those participants who were not hospitalized were contacted at 14 days post-recruitment and completed a home follow-up form, thereby completing their study participation. No hospital follow-up records were completed for four participants who reported being hospitalized at some point before the follow-up call, but were not hospitalized at the same site of recruitment and the research team could not identify the hospital.

Definitions of cases and controls

Cases were defined as all suspected COVID-19 patients who had a positive RT-PCR test for SARS-CoV-2, whether or not they had a prior history of PCR positive tests. Controls were defined as all suspected COVID-19 patients who were RT-PCR negative and had not had a positive PCR test in the preceding 90-day period.

All participants were followed up daily for a total of 14 days to assess clinical progression of their present disease. The severity of outcomes included hospitalization, use of assisted ventilation and death. Information on death was confirmed through participants' family members.

Statistical analysis

We analyzed the effectiveness of the full two-dose schedule of CoronaVac® against symptomatic SARS-CoV-2 infection and its associated hospitalization, in the period starting 14 days after receipt of the second dose (full vaccination). To estimate possible effectiveness of partial vaccination, we assessed the association between the outcomes and vaccination in the period from 14 or more days after dose 1 to 13 days after dose 2. The reference group for vaccination status was individuals who had not received any COVID-19 vaccine or those who had received one dose for 13 days or less. Participants who received COVID-19 vaccines other than CoronaVac® or who received more than two doses of CoronaVac® vaccine were excluded from the analysis.

We used multivariable logistic regression analyses to estimate the odds ratio (OR) of vaccination among cases (PCR-positive) and controls (PCR-negative). One minus the OR (1-OR) provided an estimate of vaccine effectiveness (VE) under the assumptions of a test-negative design [8]. We estimated VE respectively for the full and the partial vaccination. We included the covariates in the adjusted model: age group, sex, obesity, and having any COVID-19-associated comorbidities (cardiovascular, renal, neurological, haematological, or hepatic comorbidities, diabetes, chronic respiratory disorder, obesity, or immunosuppression).

To assess the effectiveness of full and partial vaccination on COVID-19 disease severity, we calculate VE against hospitalization and mechanical ventilation among PCR-positive participants. All analyses were done in SAS 9.4 (SAS Institute, Cary NC).

RESULTS

Description of study participants

We invited 1,616 patients to participate in the study. Since 148 were ineligible and 26 were not interested in participating in the study, we enrolled 1,442 participants and 1,425 participants (98.8%) completed the study. To evaluate the VE of two-dose (i.e., full) or one-dose (i.e., partial) CoronaVac® vaccination, we excluded 139 participants who received 3 doses of any COVID vaccine and 208 participants who received any doses of other vaccines; therefore, 1,078 participants were included in data analysis (Figure 1).

Of 1,078 participants, 395 (36.6%) were cases, and 683 (63.3%) were controls. Most participants (84%) were 18-59 years old while 16% were aged 60 or above; 669 (62.1%) were female, 268

(24.9%) were obese, and 422 (39.1%) had at least one comorbid disease, including 95 (8.8%) with diabetes and 25 (2.3%) with cardiovascular diseases (Table 1).

Among 1,078 participants, 823 (76.3%) received at least one dose of CoronaVac® vaccine, including 93 (8.6%) with one dose and 730 (67.7%) with two doses (Table 1). Of 142 (13.2%) participants who were hospitalized during 14 days of follow-up, 91 were among 395 PCR-positive (23%) and 51 were among 683 PCR-negative (7.5%) participants (Figure 1). Of 91 (8.4%) admitted to an ICU, 64 were among 395 PCR-positive (16.2%) and 27 were among 683 PCR-negative (3.9%) participants (Figure 1). Of 22 (2.0%) participants who died, 12 were among 395 PCR-positive (3.0%) and 10 were among 683 PCR-negative (1.5%) participants (Figure 1).

Vaccine effectiveness (VE) against symptomatic SARS-cov-2 infection

Three hundred ninety-five (36.6%) participants were PCR positive. Stepwise multivariable logistic regression model showed that older age was independently associated with higher odds and being vaccinated was associated with lower odds of having symptomatic infection. Full vaccination was associated with 31% lower odds of symptomatic infection (OR, 0.69; 95% CI, 0.52-0.93) and partial vaccination was associated with 49% lower odds (OR, 0.51; 95% CI, 0.30-0.86). VE of full and partial vaccination against symptomatic infection were 31% (95% CI, 7%-48%) and 49% (95% CI, 14% - 70%), respectively (Table 2).

Vaccine effectiveness (VE) against COVID-19 hospitalization among PCR-positive participants

Of 395 PCR-positive participants, 91 (23%) were hospitalized on the same date of enrollment or within 14 days of follow-up. Older age and being obese were independently associated with higher odds of hospitalization. Full vaccination with CoronaVac® was associated with 85% lower odds (OR, 0.15; 95% CI, 0.08-0.25) and partial vaccination was associated with 75% lower odds of hospitalization (OR, 0.25; 95% CI, 0.08-0.80). VE of full and partial vaccination against hospitalization were 85% (95% CI, 75% - 92%) and 75% (95% CI, 20% - 92%), respectively (Table 3).

Vaccine effectiveness (VE) against use of assisted ventilation among PCR-positive participants

Of 395 PCR-positive participants, 63 (15.9%) ever used assisted ventilation. Older age and being obese were independently associated with higher odds of assistedventilation. Full vaccination with the CoronaVac® vaccine was associated with 73% lower odds of assisted ventilation (OR, 0.27; 95% CI, 0.15-0.49), and partial vaccination was associated with 56% lower odds (OR, 0.44; 95% CI, 0.12-1.60), but this latter association may have been due to chance (Table 4). VE of full vaccination against assisted ventilation was 73% (95% CI, 51%-

85%). A multivariable assessment of factors associated with COVID-19 mortality faced inadequate statistical power.

DISCUSSION

This test-negative case-control study was conducted in an adult population recruited from 10 (four private and six public) hospitals located in 5 provinces (considering the National District of the Dominican Republic as a province). The study showed that the full (two-dose) CoronaVac® vaccination contributed to a moderate degree of protection against symptomatic SARS-CoV-2 infection by approximately 31% in all participants, but it was highly effective in preventing severe disease outcomes among SARS-CoV-2 infected participants including lowering the risk of hospitalization by 85% and reducing use of assisted ventilation by 73%. Partial vaccination also offered protections against symptomatic infection by 49% and hospitalization by 75%, but these estimates have wider confidence intervals compared to those for full vaccination given the smaller numbers of persons who were only partially vaccinated. The effectiveness of full vaccination against symptomatic infection in this study is slightly lower than those of the CoronaVac® vaccine from other test-negative case-control studies conducted in Brazil and China (VE range: 36%-67%) [6-9], or prospective cohort study in Chile (VE, 66%) [5]. The protection rate against symptomatic infection is also lower than the efficacies of the CoronaVac® vaccine from phase 3 randomized clinical trials conducted in Turkey, Brazil and Indonesia (50%-83%) [10-12].

The effectiveness against hospitalization in this study, in contrast, is higher than those from test-negative case-control studies in Brazil, China and Indonesia (VE, 55%-71%) [6,7,9]. The different results about the VE for the same vaccine between this and previously published studies might be due to the variations in demographics of study populations and the sampling timeframe vis-à-vis SARS-CoV-2 variants. For example, the participants in this study were recruited during August to November 2021, when delta was the predominant SARS-Cov-2 variant in the Dominican Republic; participants in previous studies were recruited before June 2021 when alpha, beta, or gamma were the likely circulating variants. Cohort studies suggest that delta variant was more pathogenic than earlier variants as measured by symptomatology and hospitalization [13-14]. Our study showed that the inactivated vaccine was highly effective in protecting from hospitalization in the setting with circulating delta variant.

Critically ill patients with COVID-19, older particularly patients, often have required use of assisted ventilation. This is the first study demonstrating the effect of the CoronaVac® vaccine on assisted ventilation. This finding of preventing COVID-19 associated assisted ventilation in a resource-constrained environment is consistent with the real-world studies of mRNA COVID-19 vaccine impact in United States and Israel [15-16]. While ventilation is typically provided in ICU settings in high income countries, limited ICU beds in the Dominican Republic mean that ventilation often is provided on general wards, as is the case in many other LMICs.

Given that only 2.2% of participants were admitted to an ICU and only 2.0% died, we could not evaluate VE for these two endpoints. Previous studies demonstrated that the CoronaVac® vaccine offered a high level of protection for ICU admission and COVID-19 related death [5]. Given our findings as to VE in preventing hospitalization and assisted ventilation, we are confident that a larger study would have confirmed vaccine benefits for prevention of ICU admission and death.

Our study has several strengths. First, the study participants were recruited in 10 (four private and six public) hospitals from five diverse provincial regions of the Dominican Republic, representing adults living in rural and urban areas of the north, east, and south of the country. Second, we addressed multiple potential sources of bias in this observational, test-negative case-control study. Cases and controls were ascertained based on PCR laboratory results, thereby minimizing false-positive cases and the possibility of misclassification of cases [17]. In addition, as the cases and controls were enrolled in the same location with the same case definition, they derive from the same source population, reducing potential selection biases due to differential healthcare-seeking behavior [18].

Our study limitations included our study sample size powered for COVID-19 hospitalization, not infrequent outcomes of ICU admission or death. The test-negative design is not appropriate for assessing VE against asymptomatic infection and we did not include asymptomatic infection as an outcome. As the participants were enrolled in the second half of 2021, the VE estimates corresponded with circulating SARS-CoV-2 gamma and delta variants, so we do not know VE for omicron variants. Studies on other COVID-19 vaccines have shown that the omicron variant has higher immunity escapes compared to delta variant [19], but the vaccines, particularly post-booster dose, remain effective for severe outcomes [20-21]. More population-level research will be needed to assess the effectiveness of the CoronaVac® vaccine against the omicron variant, including the value of a third dose booster vaccination, either homologous or heterologous [22]. Our estimates may be subject to unmeasured and residual confounding, as unvaccinated individuals receiving PCR tests may have different risk of SARS-CoV-2 infection than vaccinated individuals for reasons unrelated to vaccination. We addressed this possibility by evaluating the risk associated with being vaccinated 0-13 days before testing, when vaccination is likely to have much reduced effectiveness [13,14].

In conclusion, two doses of the CoronaVac® vaccine offers moderate protection against symptomatic SARS-CoV-2 infection, but high protection against COVID-19 related hospitalization and use of assisted ventilation. As this vaccine can be stored at normal refrigeration temperatures and remains potent up to three years, it offers advantages for distribution to LMIC regions where access to freezers is challenging for storage and shipping. Inactivated vaccines targeting the omicron variant have been developed; further research is needed to test effectiveness of early and new vaccines against emerging SARS-CoV-2 variants. Considering its effectiveness against ancestral SARS-CoV-2 strain and delta variant, this vaccine may constitute a component of multivalent vaccine against currently circulating omicron variant.

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Potential conflicts of interest. Four authors serve on a Sinovac scientific advisory board: YQC, XW, YS, and SHV. HZQ is currently affiliated with GSK plc, and he conducted this study as a faculty member in his former employer Yale University. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical approval.The study was approved and supervised by the National Health Bioethics Committee of the Dominican Republic (CONABIOS, the Spanish acronym) and by the institutional review boards of Yale University and Stanford University. A final report was sent to CONABIOS and many key government officials and community-based organizations upon study completion.

Patient consent. The patients provided written informed consent for participation in this study.

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Key points:

- This test-negative case-control study among 1,078 adult participants seeking health care for COVID-19-related symptoms showed that inactivated whole-virion vaccine offered moderate protection against symptomatic SARS-CoV-2 infection
- The inactivated vaccine offered high protection against COVID-19 related hospitalization and reduced use of assisted ventilation

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Table 1. Characteristics of participants with COVID-19–like illness in the Dominican Republic

Characteristics	Total n (%)	COVID-19 cases	COVID-19 controls	P-value

		(PCR +) n (%)	(PCR -) n (%)	
Total participants	1,078 (100)	395 (36.6)	683 (63.3)	
Age, years (mean ± SD)	42.0 ± 16.8	45.2 ± 18.1	40.2 ± 15.7	<0.001
Age, years				<0.001
18-59	905 (84.0)	308 (78.0)	597 (87.4)	
≥60	173 (16.0)	87 (22.0)	86 (12.6)	
Sex				0.35
Male	409 (37.9)	157 (39.7)	252 (36.9)	
Female	669 (62.1)	238 (60.3)	431 (63.1)	
BMI, kg/m² (mean ± SD)	27.0 ± 5.5	27.3 ± 5.5	26.9 ± 5.4	0.16
Obesity (BMI ≥30 kg/m²)				0.20
No	810 (75.1)	288 (72.9)	522 (76.4)	
Yes	268 (24.9)	107 (27.1)	161 (23.6)	
Province in Dominican Republic				<0.001
Distrito Nacional	222 (20.6)	61 (15.4)	161 (23.6)	
Santo Domingo	274 (25.4)	110 (27.8)	164 (24)	
La Altagracia	158 (14.7)	32 (8.1)	126 (18.4)	
Santiago	207 (19.2)	116 (29.4)	91 (13.3)	
Puerto Plata	217 (20.1)	76 (19.2)	141 (20.6)	
Reported No of comorbidities				0.034
0	656 (60.9)	224 (56.7)	432 (63.3)	
≥ 1	422 (39.1)	171 (43.3)	251 (36.7)	
Cardiovascular disease	25 (2.3)	13 (3.3)	12 (1.8)	0.11
Diabetes	95 (8.8)	43 (10.9)	52 (7.6)	0.068
Vaccination status				0.004
Unvaccinated	255 (23.7)	114 (28.9)	141 (20.6)	
Partially vaccinated	93 (8.6)	26 (6.6)	67 (9.8)	
Fully vaccinated	730 (67.7)	255 (64.6)	475 (69.5)	

Note: PCR, polymerase chain reaction; SD, standard deviation; BMI, body mass index

Table 2. Effectiveness of CoronaVac® inactivated COVID-19 vaccine against symptomatic infection in the Dominican Republic

Variable	n	Symptomatic infection n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)

Total participants	1,078	395 (36.6)		
Age, years				
18-59	905	308 (34.0)	1.0	1.0
≥60	173	87 (50.3)	1.96 (1.41, 2.72)	1.88 (1.35, 2.62)
Sex				
Male	409	157 (38.4)	1.0	
Female	669	238 (35.6)	0.89 (0.69, 1.14)	-
Obesity (BMI ≥30 kg/m²)				
No	810	288 (35.6)	1.0	
Yes	268	107 (39.9)	1.21 (0.91, 1.60)	-
Reported number of comorbidities				
0	656	224 34.1)	1.0	
≥ 1	422	171 (40.5)	1.31 (1.02, 1.69)	-
Vaccination status				
Unvaccinated	255	114 (44.7)	1.0	1.0
Partially vaccinated	93	26 (28.0)	0.48 (0.29, 0.80)	0.51 (0.30, 0.86)
Fully vaccinated	730	255 (34.9)	0.66 (0.50, 0.89)	0.69 (0.52, 0.93)

Note: OR, odds ratio; CI, confidence interval; SD, standard deviation; BMI, body mass index

Table 3. Effectiveness of CoronaVac® inactivated COVID-19 vaccine against hospitalization among PCR positive participants in the Dominican Republic

	n	Hospitalization n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Total PCR+	395	91 (23.0)		
Age, years				
18-59	308	57 (18.5)	1.0	1.0
≥60	87	34 (39.1)	2.83 (1.68, 4.74)	3.19 (1.77, 5.74)
Sex				
Male	157	37(23.6)	1.0	
Female	238	54(22.7)	0.95 (0.59, 1.53)	-
Obesity (BMI ≥30 kg/m²)				
No	288	55 (19.1)	1.0	1.0
Yes	107	36 (33.6)	2.15 (1.31, 3.53)	2.72 (1.54, 4.79)

Reported number of comorbidities				
0	224	41 (18.3)	1.0	
≥ 1	171	50 (29.2)	1.84 (1.1, 2.96)	-
Vaccination status				
				1.0
Unvaccinated	114	55 (48.2)	1.0	
Partially vaccinated	26	4 (15.4)	0.19 (0.06, 0.60)	0.25 (0.08, 0.80)
Fully vaccinated	255	32 (12.5)	0.15 (0.09, 0.26)	0.15 (0.08, 0.25)

Note: OR, odds ratio; CI, confidence interval; SD, standard deviation; BMI, body mass index

Table 4. Effectiveness of CoronaVac® inactivated COVID-19 vaccine against use of assisted ventilation among PCR positive participants in the Dominican Republic

	n	Assisted ventilation n (%)	Crude OR (95% CI)	Adjusted OR (95% CI)
Total PCR+	395	63 (15.9)		
Age, years				
18-59	308	35 (11.4)	1.0	1.0
≥60	87	28 (32.2)	3.70 (2.09, 6.55)	3.99 (2.16, 7.37)
Sex				
Male	157	29 (18.5)	1.0	
Female	238	34 (14.3)	0.74 (0.43, 1.27)	
Obesity (BMI ≥30 kg/m²)				
No	288	39 (13.5)	1.0	1.0
Yes	107	24 (22.4)	1.85 (1.05, 3.25)	2.25 (1.21, 4.16)
Reported number of comorbidities				
0	224	25 (11.2)	1.0	
≥ 1	171	38 (22.2)	2.27 (1.31, 3.94)	
Vaccination status				
Unvaccinated	114	34 (29.8)	1.0	1.0
Partially vaccinated	26	3 (11.5)	0.31 (0.09, 1.09)	0.44 (0.12, 1.6)
Fully vaccinated	255	26 (10.2)	0.27 (0.15, 0.47)	0.27 (0.15, 0.49)

Note: OR, odds ratio; CI, confidence interval; SD, standard deviation; BMI, body mass index

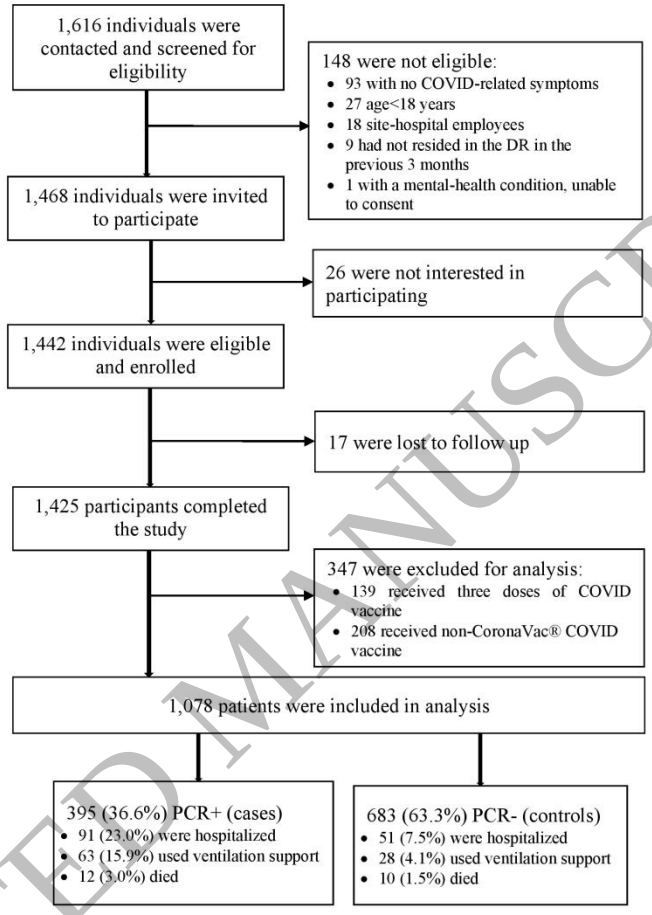

Figure 1. Flowchart of participant selection