

## Controlled Randomized Clinical Trial on Using Ivermectin with Doxycycline for Treating COVID-19 Patients in Baghdad, Iraq

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### Abstract

COVID-19 patients suffer from the lack of curative therapy. Hence, there is an urgent need to try repurposed old drugs on COVID-19. Randomized controlled study on 70 COVID-19 patients (48 mild-moderate, 11 severe, and 11 critical patients) treated with 200 µg/kg PO of Ivermectin per day for 2-3 days along with 100 mg PO doxycycline twice per day for 5-10 days plus standard therapy; the second arm is 70 COVID-19 patients (48 mild-moderate and 22 severe and zero critical patients) on standard therapy, which is (vitamin C, D, and zinc, azithromycin, dexamethasone and oxygen supply if needed). The time to recovery, the progression of the disease, and the mortality rate were the outcome-assessing parameters. Among all patients and among severe patients, 3/70 (4.28%) and 1/11 (9%), respectively progressed to a more advanced stage of the disease in the Ivermectin-Doxycycline group versus 7/70 (10%) and 7/22 (31.81%), respectively in the control group ( $P>0.05$ ). The mortality rate was 0/48 (0%), 0/11 (0%), and 2/11 (18.2%) in mild-moderate, severe, and critical COVID-19 patients, respectively in Ivermectin-Doxycycline group versus 0/48 (0%), and 6/22 (27.27%) in mild-moderate and severe COVID-19 patients, respectively in standard therapy group ( $p=0.052$ ). Moreover, the mean time to recovery was 6.34, 20.27, and 24.13 days in mild-moderate, severe, and critical COVID-19 patients, respectively in Ivermectin-Doxycycline group versus 13.66 and 24.25 days in mild-moderate and severe COVID-19 patients, respectively in standard therapy group ( $P<0.01$ ). It is concluded that Ivermectin with doxycycline reduced the time to recovery, the percentage of patients progress to more advanced stage of disease, and reduced mortality rate in severe patients from 22.72% to 0%.

**Keywords** Ivermectin, Doxycycline, COVID-19, Coronavirus, SARS-CoV-2

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**List of abbreviations:** COVID-19 = Coronavirus disease-19, CT = Computerized tomography, FDA = United States Food and drug administration, PCR = Polymerase chain reaction, SARS-CoV-2 = severe acute respiratory syndrome-coronavirus-2, WHO = World Health Organization

### Introduction

Since December 2019, the world has been facing unprecedented health caused by global spread of a novel coronavirus, SARS-CoV-2, which causes respiratory, and multi-organ viral infection, called COVID-19. The pandemic of COVID-19 resulted in 35

million infections and more than one million deaths till the date of writing this article <sup>(1)</sup>. Almost all patients start as mild-moderate disease; however, about 15% of them progress within 5-14 days post infection to a more advanced stage of the disease, being severe and critical patients <sup>(2)</sup>. The highest risk patients have been shown to be elderly, obese, diabetic, immunosuppressed, or those with cardiovascular diseases <sup>(3,4)</sup>. The main problem of COVID-19, there is no curative therapy till now; and the vaccine

development takes time. Even after developing a successful vaccine, SARS-CoV-2 seems to induce a short-lasting humeral immunity, 3-12 months only. Therefore, in the coming years when COVID-19 will be converted to seasonal endemic viral infection, a reliable therapy is still needed along with working vaccines <sup>(5)</sup>.

From December 2019 till September 2020, no single drug was found to be a silver bullet for COVID-19. COVID-19 starts as respiratory viral infection but, in some patients, progress to severe viral pneumonia and very dangerous immune deregulation condition called cytokine storm, which if it is not promptly treated, it might result in acute respiratory distress syndrome (ARDS), multi-organ failure, lethal coagulopathies and death <sup>(2,4,6)</sup>. Therefore, potent antiviral therapy and immunomodulatory therapy for COVID-19 patients are desperately needed.

Ivermectin reduced viral load of SARS-CoV-2 in vitro by 5000 folds within 48 h <sup>(7)</sup>. Moreover, several previous reports revealed antiviral activity of Ivermectin on Dengue HIV, Yellow fever, West Nile, Hendra, Newcastle, and Zika viruses <sup>(8-10)</sup>. Furthermore, several observational studies and real-world clinical practice showed that Ivermectin is effective in treating COVID-19 patients at both mild-moderate and severe phases of the disease <sup>(11-14)</sup>; accordingly, it is thought that Ivermectin might possess antiviral as well as immunomodulatory activity <sup>(12-14)</sup>. Ivermectin is most probably a host-specific antiviral drug and it acts as a specific inhibitor of importin  $\alpha/\beta$ -mediated nuclear import inhibiting replication of several viruses such as HIV-1, Zika and dengue viruses <sup>(10)</sup>. It is thought that Ivermectin might inhibit SARS-CoV-2 using the same mechanism <sup>(7)</sup>. In addition, there have been several reports revealed that Ivermectin acts as anti-inflammatory and immunomodulatory agent and it can curb over-reacting innate and cellular immune responses <sup>(8,15)</sup>. This explains how Ivermectin could alleviate symptoms of COVID-19 patients at viral replication phase

(the first 7-10 days of infection) as well as the later hyperinflammatory phase <sup>(7-10)</sup>.

Doxycycline is a broad-spectrum antibiotic with reported antiviral activities on several viruses including SARS-CoV-2 <sup>(16-18)</sup>. The mechanism of the antiviral effects of tetracycline derivatives might be due to transcriptional upregulation of intracellular zinc finger antiviral protein, which serves for encoding genes in host cells <sup>(19)</sup>. Doxycycline acts as an ionophore for zinc facilitating zinc entry into human cells and increasing cytoplasmic zinc concentration; high intracellular zinc levels are inhibitory to the replication of RNA viruses in cytoplasm of the cells by inhibiting RNA-dependent RNA polymerase enzyme <sup>(20)</sup>. Moreover, doxycycline has immune dampening effect making it useful to ease over-reacting immune systems <sup>(21)</sup>.

In an attempt to find an effective therapy to COVID-19 patients, the current clinical trial was set up to test the combinational therapy of Ivermectin and Doxycycline in treating COVID-19 patients at different stages of the disease.

## Methods

### Patients

One hundred forty (140) COVID-19 patients at different stages of the disease were included in this study. Half of them (70 patients) received Ivermectin with Doxycycline and standard care while the other half (70 patients) received the standard care only. The patients were recruited in Alkarkh and Alforat hospitals in Baghdad city in the duration from July 1<sup>st</sup> to September 30<sup>th</sup>. The recruited patients were either outpatients or inpatients, according to the severity of the disease. Mild-moderate patients were outpatients while severe and critical patients were all inpatients. All of the recruited COVID-19 patients were diagnosed by clinical, radiological and laboratory polymerase chain reaction (PCR) testing. Alike, recovery of COVID-19 patients was based on the disappearance of symptoms, clearance of radiological chest x-ray or Computerized tomography (CT) scans, and getting negative PCR results.

The classification of COVID-19 patients to mild-moderate, severe, and critical was carried out according to the World Health Organization (WHO) guidelines. Ivermectin-Doxycycline group consisted of 48 mild-moderate, 11 severe and 11 critical patients while the control group consisted of 48 mild-moderate and 22 severe patients. For ethical basis, no critical patient recruited in this study was allocated to the control group; all of critical patients were allocated to the Ivermectin-Doxycycline group. The classification of the recruited patients was based on the stage of the disease at the 1<sup>st</sup> day of recruitment; the designated therapy of the current study was initiated at the 1<sup>st</sup> day of recruitment. Inclusion criteria of the patients enrolled in the clinical trial were those who were symptomatic for no more than three days for mild-moderate cases, no more than two days after being severe cases, and no more than one day after being critical cases. The purpose behind this was to assess Ivermectin-Doxycycline therapy versus standard care therapy at the beginning of each stage of the disease. The recruited patients were monitored till recovery or death.

The present study was approved by the Ethical and Scientific Committee in Baghdad-Alkarkh General Directorate of under the approval number BKH-CT-016.

### Randomization of patients

COVID-19 patients were randomly allocated to one of the study groups depending on a simple method. Patients recruited at dates with odd number were allocated to Ivermectin-Doxycycline group while other patients were allocated to the control group. Inside each group, maximal limit of 48 mild-moderate patients and 22 severe and/or critical patients were allowed. The randomization process as well as the patients records for disease progression, recovery, and clinical or laboratory testing were supervised by the health authority of Alkarkh Health General Directorate in Baghdad city.

### Protocols of therapy

#### *Ivermectin-Doxycycline group*

Ivermectin 200 µg/kg PO per day for two days, and in some patients who needed more time to recover, a third dose 200 µg/kg PO per day was given 7 days after the first dose. Doxycycline 100 mg capsule PO every 12 h per day was given for 5-10 days, based on the clinical improvement of patients. In addition, standard care was given to the patients of Ivermectin-Doxycycline group based on the clinical condition of each patient.

#### *Control group*

The patients in this group received only standard care which included all or some of the following, according to the clinical condition of each patient.

#### *Standard care*

- Acetaminophen 500 mg on need
- Vitamin C 1000 mg twice/ day
- Zinc 75-125 mg/day
- Vitamin D3 5000 IU/day
- Azithromycin 250 mg/day for 5 days
- Oxygen therapy/ C-Pap if needed
- Dexamethasone 6 mg/day or methylprednisolone 40 mg twice per day, if needed
- Mechanical ventilation, if needed

### Outcome-assessing parameters of the disease progression or recovery

Three parameters used in the present study were to assess the disease progression or recovery in COVID-19 patients who received standard care only compared to patients who received standard care with Ivermectin and Doxycycline therapy. These three parameters are:

1. Time to recovery, if any. It is the time between taking therapy till recovery.
2. Percentage of patients who progress to a more advanced stage of the disease after at least 3 days of giving therapy. For example, a patient was recruited as mild-moderate; after 3 days from starting therapy, the patient progressed to severe stage; such patient is considered a progressing patient

even though she or he was under treatment.

3. Mortality rate among mild-moderate, severe, or critical patients in Ivermectin-Doxycycline group versus those in control group.

### Statistical analysis

Data was processed according to the normality tests results; parametric data were represented with mean values and non-parametric data were represented with median values. Percentage of mortality rate was calculated for each group of the study. Odds ratio and chi-square were used to test the strength and significance of association. P values less than 0.05 was considered significant.

## Results

### Patients' characteristics

Mean age of the recruited patients was  $48.7 \pm 8.6$  year with range 16 to 86 year; patients in Ivermectin-Doxycycline and control groups were age- and sex- matched. Mean age of Ivermectin-Doxycycline group was  $50.1 \pm 9.3$  year with 53% males and 47% females while mean age of control group patients was  $47.2 \pm 7.8$  year with 51% male and 49% females ( $P > 0.05$ ). In both groups, the median post-infection day for starting therapy was 3 days in mild-moderate, 7 days in severe, and 8.5 days in critical cases. The mean weight of Ivermectin-Doxycycline and control patients was  $79.6 \pm 13.2$  kg and  $71.5 \pm 11.9$  Kg, respectively ( $P > 0.05$ ).

### Time to recovery

The time to recovery was shown to be significantly reduced in the Ivermectin-Doxycycline compared to the control group; mean recovery time in Ivermectin-Doxycycline group was  $10.61 \pm 5.3$  days versus mean recovery time in control group,  $17.9 \pm 6.8$  days ( $P < 0.05$ ). Hence, using Ivermectin along with Doxycycline reduced mean time to recovery up to 7 days. By analyzing the mean time to recovery in mild-moderate, severe, or critical patients in each group, it was shown that the

mean time to recovery in Ivermectin-Doxycycline group was  $6.34 \pm 2.4$ ,  $20.27 \pm 7.8$ ,  $19.77 \pm 9.2$  days, respectively versus  $13.66 \pm 6.4$ ,  $24.25 \pm 9.5$  days, in control group, respectively ( $P < 0.01$ ). Accordingly, Ivermectin-Doxycycline reduced recovery time about 7.32 days in mild-moderate, and 3.98 or roughly 4 days in severe patients (Table 1, Figure 1).

### Progression of the disease

The rate of progression of the disease, or the deterioration of the clinical condition of the patients, despite of taking standard care with/without Ivermectin-doxycycline therapy, was shown to be varied between the two groups studied. At beginning, no single mild-moderate patient in both groups progressed to a more advanced stage of the disease. For severe COVID-19 patients, 1/11 (9%) in Ivermectin-Doxycycline group versus 7/22 (31.81%) in control group progressed to more advanced stage of the disease, namely being classified as critical cases ( $P > 0.05$ ). Thus, Ivermectin-Doxycycline protocol was shown to lower progression of the disease in severe patients if given within the first two days of the severe stage of the disease. For critical patients, ethically, critical patients were not included in the control group as critical patients need to receive all possible medications for saving their lives; hence, it was not possible to compare the rate of progression of the disease in critical patients between the two studied groups (Table 1, Figure 2).

### Mortality rate

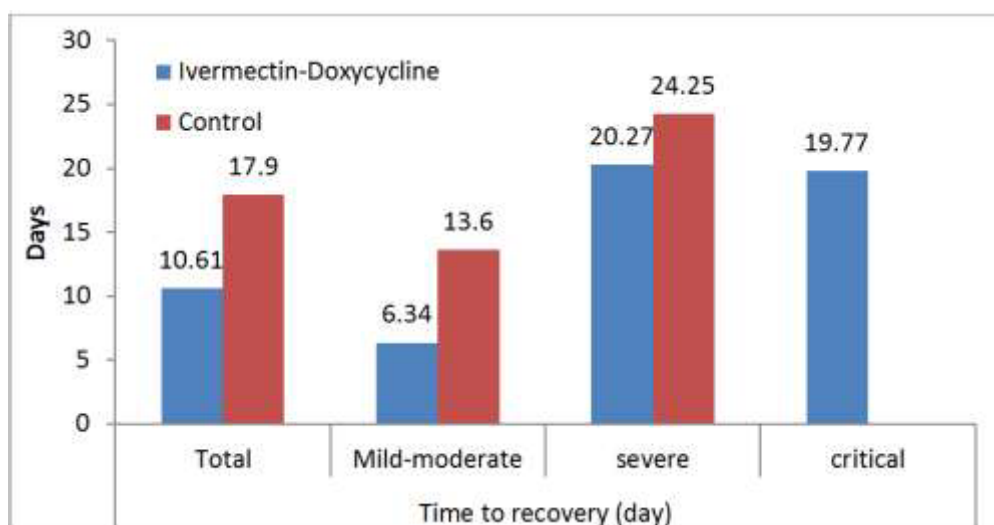
The mortality rate was shown to be 0/48 (0%) in mild-moderate patients in both groups. Nevertheless, the mortality rate was diminished to 0/11 (0%) in Ivermectin-Doxycycline group compared to 6/22 (27.27%) ( $P = 0.052$ ). For critical patients, Ivermectin-Doxycycline did not prevent death in those patients as mortality rate was shown to be 2/11 (18.2%), (Table 1, Figure 3). No critical patients were included in the control group to compare with; however, it is obvious that 18.2% of death in critical COVID-19 patients

received Ivermectin-Doxycycline is much lower than the death rate in critical cases of COVID-19 in Iraq that might reach above 50% (based on real-world data not official published data).

**Table 1. Parameters of the study outcomes between Ivermectin-Doxycycline and control groups**

Outcome parameter	Subgroup of patients	Ivermectin-Doxycycline	Control	P value
Time to recovery (day)	Total	10.61± 5.3	17.9±6.8	<0.0001
	Mild-moderate	6.34±2.4	13.66±6.4	<0.0001
	Severe	20.27±7.8	24.25±9.5	0.29
	Critical	19.77±9.2	/	
Rate of progression of disease number/total (%)	Total	3/70 (4.28%)	7/70 (10%)	0.19 (OR*=0.4, P=0.2)
	Mild-moderate	0/48 (0%)	0/48 (0%)	1
	Severe	1/11 (9%)	7/22 (31.81%)	0.15 (OR=0.21, P=0.17)
	Critical	2/11 (18.2%)	/	
Mortality rate	Total	2/70 (2.85%)	6/70 (7.14)	0.14 (OR=0.31, P=0.16)
	Mild-moderate	0/48 (0%)	0/48 (0%)	1
	Severe	0/11 (0%)	6/22 (27.27%)	0.052 (OR=0.11, P=0.14)
	Critical	2/11 (18.2%)	/	

OR\*: Odds ratio



**Figure 1. Time to recovery in days between Ivermectin-Doxycycline and control groups**

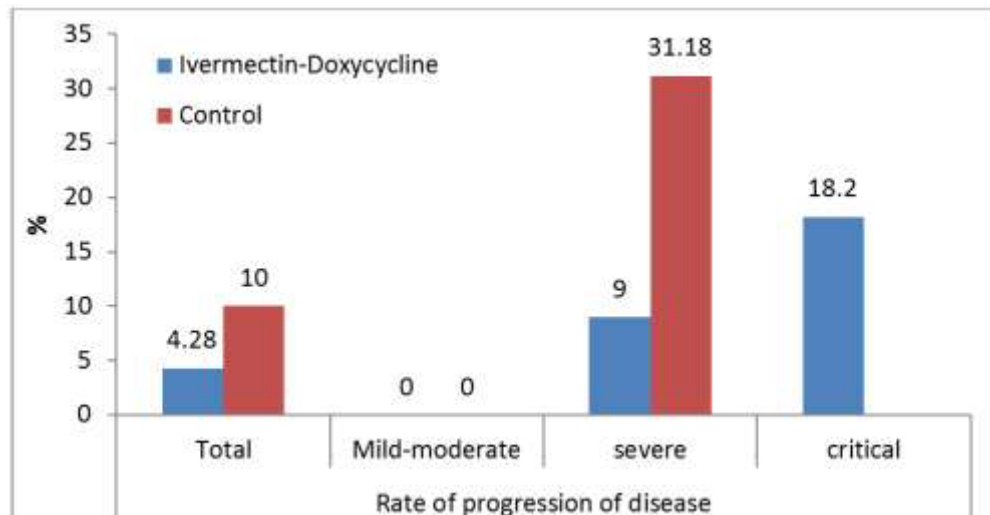


Figure 2. Percentage of patients who showed progression of COVID-19 disease between Ivermectin-Doxycycline and control groups

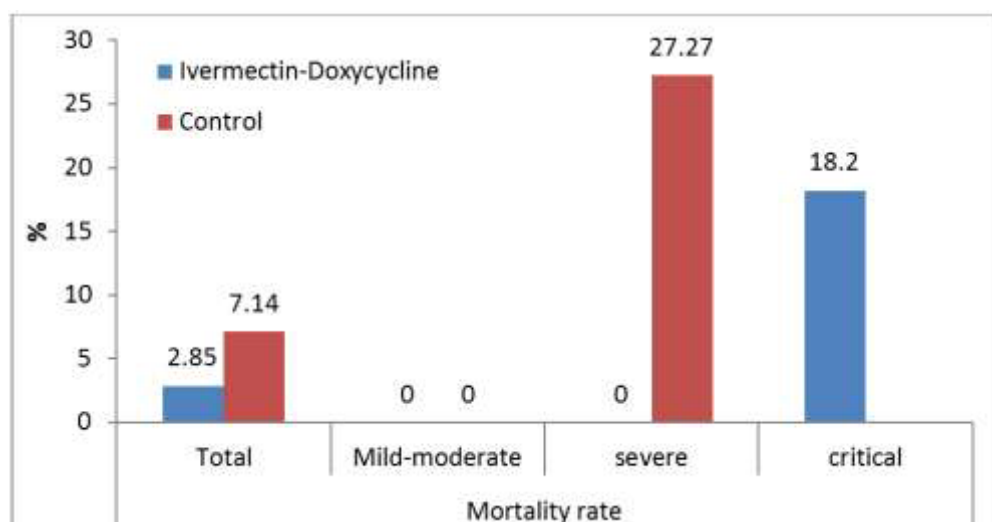


Figure 3. Percentage of patients died in Ivermectin-Doxycycline group versus control group

## Discussion

Finding an effective therapy for COVID-19 is an ultimate goal for health bodies all over the world. The problem of the standard care for COVID-19 patient is not curative; however, the current situation is much better than the first months of the pandemic, after introducing steroid therapy for severe/critical patients and high doses of vitamin D3, vitamin C and Zinc for mild-moderate cases <sup>(22)</sup>. COVID-19 is a multiphasic disease starting with virus replicative phase lasting for 7-10 days then, in

some patients, is followed with hyperinflammatory phase and cytokine storm where the most fatalities occur <sup>(2,4)</sup>. If the viral and hyperinflammatory phases of the disease were not addressed early and properly, the patient might progress to ARDS, which is almost fatal <sup>(2,6)</sup>. Hence, antiviral, anti-inflammatory, and immunomodulatory medications are necessary to stop the vicious progression of COVID-19 from mild-moderate to severe and to stop the clinical deterioration of the already severe patients.

Accordingly, Ivermectin and Doxycycline were used in this study because both drugs have shown antiviral and immunomodulatory activities <sup>(8-15)</sup>. Moreover, Doxycycline is a broad-spectrum antibiotic, which tackles the problem of secondary bacterial infection in COVID-19 patients <sup>(16-20)</sup>. Both drugs are United States Food and Drug Administration (FDA) approved and have a high historical safety record <sup>(8,10,16,19)</sup>; moreover, no interaction is known between Ivermectin and Doxycycline or between Ivermectin-Doxycycline and any of the medications given in the standard care. By contrary, for example, Azithromycin with Hydroxychloroquine are known to interact adversely for prolonging QT interval of cardiogram which might lead to serious complications <sup>(23)</sup>.

Using FDA approved and safe antiviral and immunomodulatory medications for COVID-19 is scientifically justified for untreatable disease like COVID-19. It has been found that most of COVID-19 patients who progress to severe/critical disease have high viral load of SARS-CoV-2 and over-reacting immune response <sup>(24)</sup>. Therefore, reducing the viral load and dampening the immune response and inflammatory cytokines are necessary to save patients' lives.

The findings of the current trial showed that Ivermectin-Doxycycline reduced the mean time to recovery from 17.9 to 10.61 days in the recruited COVID-19 patients. Alike, for mild moderate patients, Ivermectin-Doxycycline reduced mean time to recovery from 13.66 to just 6.34 days with reduction in time up to 7.32 days. Nevertheless, Ivermectin-Doxycycline reduced the mean time to recovery in severe patients only 4 days, from 24 to 20 days. Based on these findings, Ivermectin and Doxycycline protocol proves to be effective in speeding up recovery in both mild-moderate outpatients and severe inpatients. This has a tremendous effect on lowering the burden of the disease, minimizing chances of developing immune deregulation, and freeing as quickly as possible hospital beds to other patients. This adds further evidence that Ivermectin-Doxycycline could exert both antiviral and immunomodulatory actives. Several

observational studies showed that Ivermectin with/without Doxycycline shortens the time needed to recover COVID-19 patients and Ivermectin is beneficial for mild-moderate as well as severe patients <sup>(8-15)</sup>.

In the current study, Ivermectin-Doxycycline arm lowered the rate of progression of the severe patients from 31.81% to as low as 9%. More interestingly Ivermectin-Doxycycline abolished death in severe patients, 0% mortality rate, compared to control arm, 27.27%. It is noteworthy to mention that the non-progression of the disease and the zero mortality in mild-moderate patients in both arms of the study might be attributed to the early diagnosis and therapy; moreover, the current standard care has become more effective than that used in the early months of the pandemic. However, larger study population is required to trace differences in the disease progression or the mortality rate of mild-moderate patients of COVID-19 taking Ivermectin-Doxycycline compared to patients taking standard care.

The present study reveals that Ivermectin-Doxycycline might stop disease progression and reduce death rate in severe patients of COVID-19. An observational preprint study conducted in Florida showed that Ivermectin cuts mortality rate of severe COVID-19 patients from 80.7% to 38.8% <sup>(25)</sup>. Interestingly, both Ivermectin and Doxycycline concentrations in the tissue of the lung have been estimated 2 times more than that in plasma <sup>(26,27)</sup>. Therefore, their antiviral and anti-inflammatory effect on pulmonary tissues is expected to be prominent. These findings provide evidence that Ivermectin might be a potent immunomodulatory in addition to being antiviral agent. Nevertheless, these observational findings still need confirmation by a large randomized controlled study.

This clinical trial concluded that Ivermectin with Doxycycline reduced the time to recovery, the percentage of patients progress to more advanced stage of disease, and reduced mortality rate in severe patients from 22.72% to 0%. Taken together, the earlier administered Ivermectin with doxycycline, the higher rate of successful therapy. Moreover, the observed

benefits of Ivermectin-Doxycycline on the enrolled COVID-19 patients cannot be separated from the effect of the standard care, including Vitamin D and C, Zinc, and steroids, which was given concomitantly. Therefore, giving Ivermectin-Doxycycline along with Zinc, Vitamins D and C, and steroids at the viral and/or the hyperinflammatory phase of the disease seems clinically of benefit. This might shape the future most-fit combinational therapy of COVID-19 patients to minimize as could as possible the death rate and to decrease the duration and the progression of the disease.

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### Author contribution

Dr. Hashim and Dr. Maulood applied the intervention on patients and collected data. Dr. Abdulmir, Dr. Ali, Rasheed, Fatak, and Kabah designed the clinical trial and the study. Dr. Ahmed S. Abdulmir wrote the manuscript.

### Conflict of interest

Authors confirm that there is no conflict of interest concerning this research and the written manuscript.

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