

## RESEARCH

# Examination of the effects of long-term COVID-19 impacts on patients with neurological disabilities using a neuromachine learning model

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Currently, studies have shown that one in three people infected with coronavirus disease-19 (COVID-19) is likely to have had long-term exposure to COVID-19, known as long-term COVID-19. Clinical studies indicate that many people infected with the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) COVID-19 pandemic have long-term COVID-19 exposure. According to the study, it has been said that people with diabetes and obesity, and people who have received organ transplants, are more likely to suffer from this long-term effect of COVID-19. In this article, the effects of long-term COVID-19 exposure on neurological disability patients are analyzed with the help of a neuromachine learning model. The proposed model also shows that this long-term COVID problem does not depend on the factors such as race, age, gender, and socioeconomic status of those people. According to the proposed model, people suffering from long-term COVID problems continue to suffer from physical fatigue and shortness of breath and are regularly monitored and classified as per the proposed instructions. Even after they recover from the disease, various side effects are seen.

**Keywords:** COVID-19, long-term COVID-19, SARS-CoV-2, diabetes, obesity, organ transplants, neurological disability, neuromachine learning

## Introduction

It has been affecting us for some time now. The virus is an acute illness that usually lasts more than three weeks (1). However, some patients with neurological disabilities experience various lingering symptoms even months after the infection (2). According to the World Health Organization (WHO), it has been mentioned that some long-term health disorders may occur in people who have been exposed to the coronavirus for a long time (3, 4). This means that these effects can occur if there is a corona infection for more than 12 weeks (5) and it can affect many organs. It can also develop a variety of long-term symptoms.

Researchers are investigating what causes this strange vulnerability, and now a new study reports on people who have been infected during the corona virus pandemic (6, 7). Along with people experiencing hair loss, headaches, and sore throats during this corona infection, some other side effects also occur (8). And the findings suggest that people who are obese are more likely to have prolonged COVID-19 symptoms (9).

The new research comes from a two-week study of corona virus neurological disability patients between March 2020 and March 2021. The study is published in the *Journal of Scientific Reports*. The final sample of the study consisted of 308 infected, non-hospitalized individuals. However, 23%

of these patients with neurological disabilities reported new-onset symptoms more than 12 weeks after infection.

This can be considered a long-term effect of corona infection (10–12). It is known that some of the health effects persist for these people who have had long-term COVID-19.

According to the study, the researchers found that headaches (22%), colds or stuffy noses (19%), stomach problems (18%), and fatigue (17%) continued to be the most common symptoms. And the primary long-term symptoms in children are fatigue, headaches, difficulty with schoolwork, mood disorders, and shortness of breath (13–15).

Similarly, those with Omicron disease, which is now dominant in most countries, also have long-term infectious effects (16). Researchers warn that many health disorders are likely to persist in people infected with the Omicron type of corona even longer than the previous corona infection (17).

Physical and mental rest are essential for people with long COVID-19. Everyone needs different amounts of rest (18). Therefore, proper rest for the body and mind is required until the symptoms subside (19). If proper rest is not taken between daily activities, long-term COVID-19 will additionally worsen or persist (20).

Avoid or reduce cell phone and television use to get a good night's rest. Avoid spending time on social media (21). Meditate if possible. Don't neglect the rest. Although systematic exercise and physical activity (walking, running, swimming, and bicycling) have physical and mental benefits, guidelines for people with long-term COVID-19 have not yet been developed (22, 23).

In cases of fatigue, low blood oxygen levels, fatigue, etc. anyone with chronic COVID-19 should not do chiropractic activities/exercises on their own without proper medical advice/monitoring/recommendation (24). Neurological disability patients who had previously suffered from the COVID-19 infection believed that once they recovered from it, they would get rid of all the symptoms they experienced. However, over time, long-term COVID-19 has become a common problem among those who have recovered from the coronavirus (25, 26).

These lingering symptoms not only take a toll on people's physical health. One in five survivors of the corona virus was reported to have symptoms after 5 weeks and at 12 weeks (27, 28). Additionally, a team of British researchers studying long-term symptoms in COVID-19 neurological disability patients found that long-term COVID-19 affects women twice as often as men (29).

## Related works

Most people recover within a few weeks of contracting the virus. However, some people may have symptoms for 4 to 12 weeks or even longer. They are called "Long COVID-19." In this case, the question has arisen for many people

whether the Omicron infection with mild symptoms will have long-term effects (1).

Experts commented that it is too early to decide whether Omicron can cause long-term COVID-19. But they suggest that long-term effects from omicron variation are possible. According to the WHO, long-term COVID-19 is diagnosed several days after the infection is confirmed. It said long-term COVID-19 effects can be seen for at least 90 days after the initial symptoms clear up (4).

According to the study, more than one-third of people who have recovered from the common corona infection suffer from chronic COVID-19. They will have problems like fatigue, brain damage, breathing disorders, and anxiety (7). Those who are admitted to the hospital after the infection worsens are more likely to develop long-term COVID-19. At the same time, studies suggest that people with mild symptoms may develop chronic COVID-19. Omicron began rolling out globally at the end of last year. This strain caused less damage than Delta.

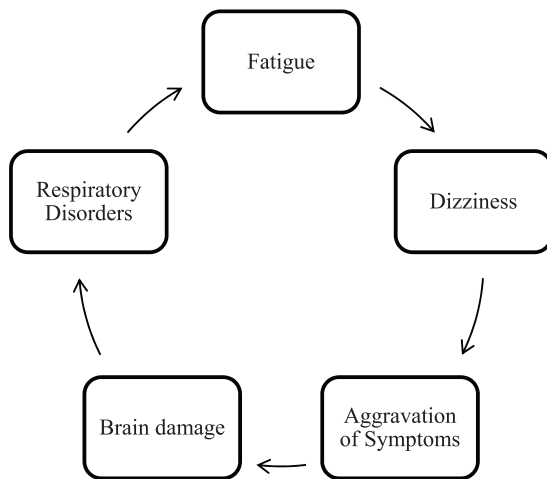
However, hospitals were overwhelmed by the rapid spread (8). Meanwhile, scientists are actively working to find out why the long-standing COVID-19 problem is occurring. It is thought to be an autoimmune disorder (12). It is thought that small microclots can cause disabling symptoms or reactivate latent viruses in the body. In two laboratory results, vaccination before exposure to the corona virus reduced the likelihood of contracting long-term COVID-19. At least it keeps the disease from getting worse (18).

Long-term, COVID-19 has become a growing concern among people. Although it is already known that severe COVID-19 neurological disability patients have symptoms of a long-term COVID-19 problem, studies show that 50% of COVID-19 neurological disability patients who experience mild-to-moderate symptoms experience clinical complications 6 months after infection (30).

Long-term COVID-19 is the condition of experiencing the problems caused by the COVID-19 infection for a long period of time. This means that people infected with COVID-19 may experience some permanent damage to areas such as the lungs, heart, kidneys, or brain, or may continue to experience lasting symptoms despite no damage to these organs (31).

## Proposed model

Since COVID-19 is a respiratory disease, it is likely to cause long-term damage to the lungs. SARS-CoV-2 has the ability to cause inflammatory changes in the lungs. It negatively affects lung tissue and air sacs, leading to long-term effects. While it is important to understand the length of time it takes for COVID-19 to develop into a long COVID-19, it is also important to recognize the early signs of a long COVID-19. Most people recover within a few weeks of being infected with the corona virus.



**FIGURE 1** | Long-term COVID-19 symptoms' dataset.

But in some people, symptoms may persist for 4 to 12 weeks or even longer. These prolonged COVID-19 related symptoms are called “long COVID-19.” Long-term COVID-19 infection, according to current medical research, can affect anyone who has been infected with COVID-19. In particular, people with mild-to-moderate symptoms have been shown to be more susceptible to long-term disease. The symptoms' dataset was shown in [Figure 1](#).

- **Fatigue:** Suffers from excessive fatigue. This fatigue, unlike normal fatigue, can be very severe. It is not reduced by sleeping and resting. This fatigue can be unpredictable, both when it comes on and when it gets worse. Even doing normal daily tasks may become difficult.
- **Aggravation of symptoms:** Severe fatigue can affect thinking ability, exercise tolerance, etc., if you do strenuous physical work, emotional stress, or high-stepping work. It can also cause physical pain. This is known as fatigue after strenuous physical or mental work. Treating it is a major challenge.
- **Dizziness:** The autonomic nervous system is the part of our body that controls automatic functions like blood pressure, digestion, breathing, body temperature, etc. When this zone is not functioning properly, there can be problems controlling body temperature, blood pressure, etc. When such difficulties occur, symptoms such as dizziness, difficulty breathing, and stuttering may appear. These symptoms can be triggered by viral infections like COVID-19. When sitting or standing up due to COVID-19, the heart rate may increase and dizziness or lightheadedness may occur.
- **Brain damage:** Clinical studies are confirming that many people with long-term COVID-19 develop brain damage. This is called “brain fog.” Problems with concentration at work, memory, thinking, and controlling emotions seem to occur.

- **Respiratory disorders:** Changes in breathing patterns that occurred early in the course of the COVID-19 infection may not reverse in some people and persist into the long COVID-19 period. Such disorders differ from the normal breathing pattern and indicate excessive breathing. This problem can be caused by things like breathing through the mouth or upper chest and using the wrong breathing muscles.

While recovering from a COVID-19 infection, body fatigue is common. You may feel so weak that you can't even do normal daily tasks (sitting, bathing, reading a book, etc.). Three strategies are recommended to deal with this problem: moderation, planning, and prioritization. This was shown in [Figure 2](#).

- **Moderation:** Do not do too much work at once, to the point of exhaustion. Work can be broken down into smaller parts, or you can continue after resting for a few minutes in between.
- **Planning:** Divide the daily/weekly tasks according to physical strength and plan in advance which tasks can be done on which days.
- **Prioritization:** List and categorize tasks according to which work needs to be done immediately or must be done, which can be done later, and who can help get a job done. Complete tasks according to their importance.

These three strategies should be followed even when going about daily work, from home to office. Medical experts recommend not going back to full-time work at once but gradually increasing the hours or dividing the work according to your body.

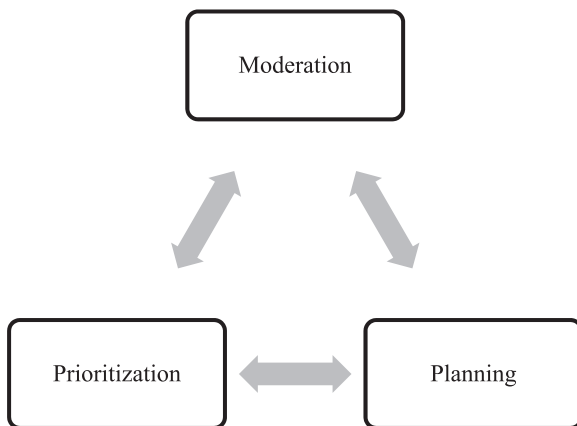
As soon as the novel corona virus began to spread strongly, many symptoms appeared among the population. While the list of corona virus symptoms continues to grow, there are some symptoms that are more common and prevalent among those infected. Common symptoms of COVID-19 include the following:

- Fever
- Runny nose and stuffy nose
- Fatigue
- Gastrointestinal infection
- Loss of smell and taste

Experts say that those recovering from the corona virus should be prepared to face the physical side effects of the illness in the months that follow, while also following disease prevention and healthy lifestyle measures after recovery.

After recovery, it is said that some disease-related and new symptoms are revealed after a few months. Symptoms include shortness of breath, fatigue, muscle spasms, cough, irregular heartbeat, depression, and kidney problems.

The study revealed that about one and a half months after recovery from the disease, excessive hair loss, inflammation



**FIGURE 2** | Proposed strategies to resolve the problem.

of the heart, chest pain, diarrhea, excessive forgetfulness, an inability to recognize taste, and suffering from not being able to smell had occurred to some of the people. Doctors refer to those who suffer from chronic effects after recovering from Corona as long-term sufferers (long haulers). This type of infection is known as long COVID-19.

The effects that occur even after recovery are similar to those previously experienced by those infected with SARS, swine flu, and Ebola. It is said that even though the long-term effects of this corona will not be life-threatening, it will be very challenging for them to lead a healthy life.

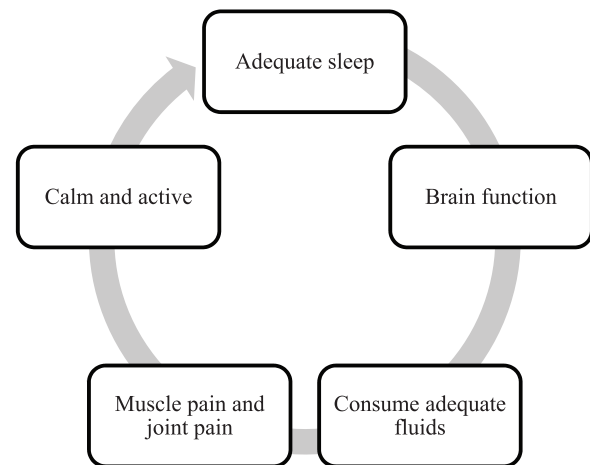
To avoid danger, people recovering from Corona are being advised not to ignore any symptoms in the coming years. They are also advised to lead as healthy a lifestyle as possible. A healthy lifestyle means living a healthy lifestyle, like eating nutritious food and being free from alcohol and smoking.

Researchers, who say that stress is the most important effect of this epidemic, both during the illness and after it subsides, predict that those who have been affected by the corona virus for a long time may have more mental health problems. So they are advised to take extra care of their mental health.

It has been recommended that the government take steps to improve the mental health of its people, as well as the efforts it makes to improve their physical health. Some recent studies suggest that children are more vulnerable to long-term exposure to the virus.

In a British study last year, the health of 500 children who were treated for the corona virus was monitored. At least 25% of the children who returned home from treatment were recently re-examined and found to be suffering from long-term exposure to the virus.

It has been found that these children have more problems like fatigue, sleep-related problems, and a lack of emotion. As this is a new form of the corona virus, medical experts are still researching a longer COVID-19 treatment. They have some recommendations for people experiencing this, as shown in [Figure 3](#).



**FIGURE 3** | Proposed recommendations.

- First, adequate sleep and rest are recommended.
- As long-term symptoms of COVID-19 can also affect brain function, it's important to lift your mood and take care of your mental health.
- For that, you need to be calm and active. Maintain a daily routine to keep your motivation high and develop a sense of consistency.
- Relieve yourself from muscle and joint pain and do exercises that strengthen your body.
- Consume adequate fluids and healthy food.

It is worth recalling that last February, the WHO had warned about this type of damage. If we want to say it in the words that they mentioned, "One in ten people is suffering from the corona virus for a long time, and such effects start 12 weeks after corona virus infection." Therefore, we should pay attention and give importance to the health of Corona neurological disability patients, not only during the infection period but also during the recovery from the disease.

## Results and discussion

The proposed neuro machine learning model (NMLM) was compared with the existing COVID-19 detection systems using deep-learning algorithms (CDS-DLA), COVID-19 diagnosis using deep learning algorithms (CD-DLA), ensemble learning algorithms (ELA), and the triangular patient monitoring system (TPMS).

### Computation of persistent cough symptoms

Coronavirus disease-19 (COVID-19) can cause irritation and inflammation in the respiratory tract, causing a persistent cough. And a cough induced by a COVID-19 infection can last for a week or a month. Often this persistent cough

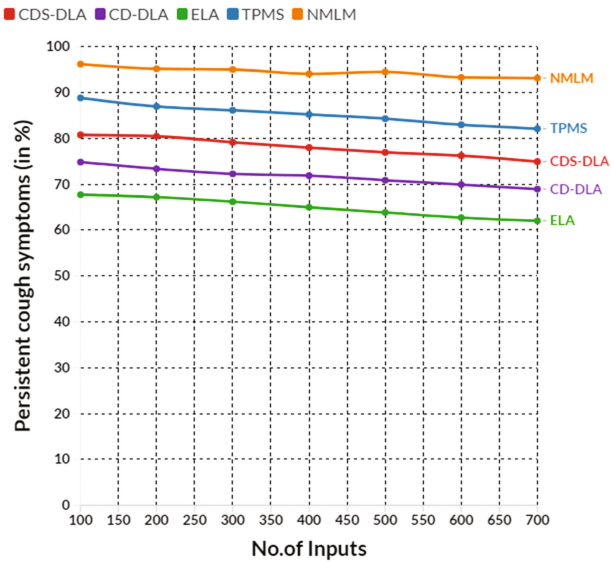


**TABLE 1** | Comparison of persistent cough symptoms.

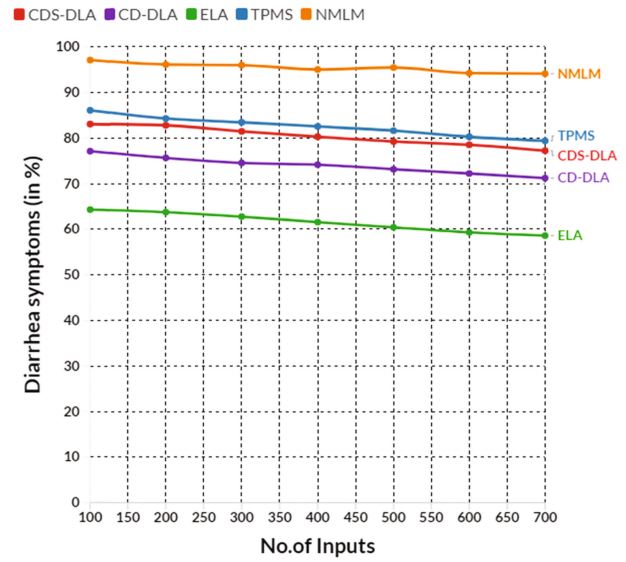
No. of inputs	CDS-DLA	CD-DLA	ELA	TPMS	NMLM
100	80.76	74.82	67.71	88.82	96.18
200	80.43	73.32	67.12	86.95	95.17
300	79.09	72.21	66.14	86.12	95.01
400	77.95	71.83	64.93	85.21	94.05
500	76.90	70.82	63.79	84.29	94.48
600	76.19	69.89	62.68	82.96	93.28
700	74.89	68.89	61.98	82.09	93.13

**TABLE 2** | Comparison of diarrhea symptoms.

No. of inputs	CDS-DLA	CD-DLA	ELA	TPMS	NMLM
100	83.06	77.12	64.31	86.08	97.09
200	82.73	75.62	63.72	84.21	96.05
300	81.39	74.51	62.74	83.38	95.92
400	80.25	74.13	61.53	82.47	94.96
500	79.20	73.12	60.39	81.55	95.39
600	78.49	72.19	59.28	80.22	94.15
700	77.19	71.19	58.58	79.35	94.04



**FIGURE 4** | Comparison of persistent cough symptoms.



**FIGURE 5** | Comparison of diarrhea symptoms.

is accompanied by chronic fatigue, cognitive impairment, dyspnea, or pain. The computation of persistent cough symptoms is shown in **Table 1**.

**Figure 4** demonstrates the comparison of persistent cough symptoms. The corona virus infection has been spreading for over a year now. Researchers are conducting various studies to better understand this virus and come up with ways to treat it. As days go by, this virus changes its shape and becomes life-threatening.

From the comparison in **Table 1**, the proposed neuromachine learning model obtained 94.05% of the management of persistent cough symptoms in a saturation test. In the same range, the existing CDS-DLA reached 77.95%, CD-DLA obtained 71.83%, ELA obtained 64.93%, and TPMS achieved 85.21% of persistent cough symptom management.

### Computation of diarrhea symptoms

According to studies, digestive health can also suffer due to COVID-19. Diarrhea is said to be a common symptom of COVID-19 infection and an early symptom of long-term

COVID-19. COVID-19 symptoms include a sore throat and a runny nose. The computation of diarrhea symptoms is shown in **Table 2**.

**Figure 5** shows the comparison of diarrheal symptoms. Both of these can lead to a hoarse voice. If he/she experienced this type of symptom during the infection period, he/she may experience it again after he/she recovers from the corona virus.

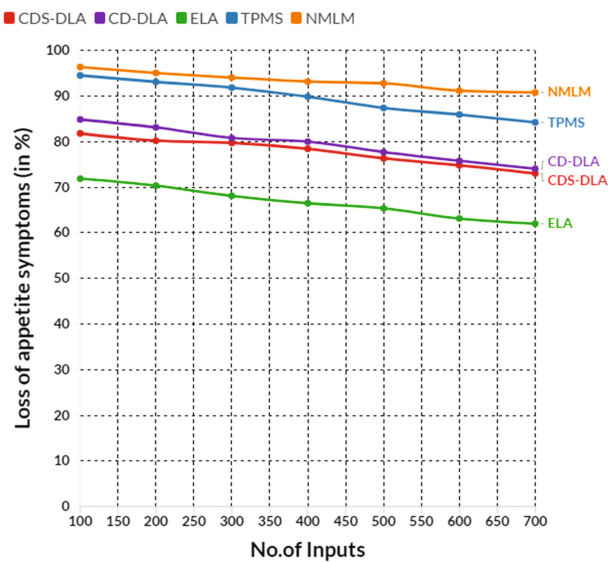
From the comparison in **Table 2**, the proposed neuromachine learning model obtained 94.96% of diarrhea symptoms management in a saturation test. In the same range, the existing CDS-DLA reached 80.25%, CD-DLA obtained 74.13%, ELA obtained 61.53%, and TPMS achieved 82.47% of diarrhea symptom management.

### Computation of loss of appetite symptoms

People who have recovered from COVID-19 have reportedly experienced symptoms such as loss of appetite and taste loss after fully recovering from the disease. In most people, the symptoms of COVID-19 last about 2–3 weeks. The

**TABLE 3** | Comparison of loss of appetite symptoms.

No. of inputs	CDS-DLA	CD-DLA	ELA	TPMS	NMLM
100	81.80	84.86	71.87	94.52	96.35
200	80.17	83.12	70.29	93.10	95.06
300	79.69	80.78	68.09	91.84	94.05
400	78.40	79.97	66.46	89.85	93.16
500	76.29	77.68	65.32	87.38	92.79
600	74.80	75.75	63.12	85.94	91.15
700	72.99	74.02	61.97	84.22	90.78

**FIGURE 6** | Comparison of loss of appetite symptoms.

computation of loss of appetite symptoms is shown in [Table 3](#).

[Figure 6](#) shows the comparison of loss of appetite symptoms. There is one more category of neurologically disabled patients. These patients constitute 10% of the total number of affected neurological disability patients, and they continue to experience symptoms for more than a month. They are called the “long-distance travelers” of the corona virus.

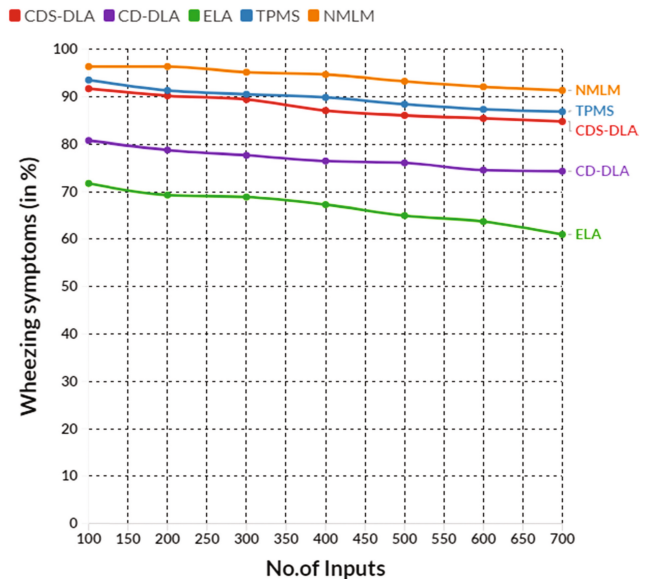
According to the comparison in [Table 3](#), the proposed neuromachine learning model managed 93.16% of the loss of appetite symptoms in a saturation test. In the same range, the existing CDS-DLA reached 78.40%, CD-DLA obtained 79.97%, ELA obtained 66.46%, and TPMS achieved 89.85% of loss of appetite symptoms management.

## Computation of wheezing symptoms

Although COVID-19 is a respiratory disease, it can cause severe breathing difficulties in patients with neurological disability. If a person suffers from such severe symptoms of

**TABLE 4** | Comparison of wheezing symptoms.

No. of inputs	CDS-DLA	CD-DLA	ELA	TPMS	NMLM
100	91.69	80.76	71.71	93.51	96.35
200	90.20	78.79	69.29	91.31	96.36
300	89.40	77.66	68.88	90.51	95.16
400	87.07	76.47	67.28	89.84	94.68
500	86.06	76.08	64.96	88.41	93.25
600	85.42	74.56	63.71	87.32	92.09
700	84.76	74.32	60.98	86.84	91.32

**FIGURE 7** | Comparison of wheezing symptoms.

corona, he/she may face long-term complications. Long-term symptoms of COVID-19 last for at least a month.

Research is being conducted on this particular type of viral infection, and so far, not much detail has been discovered. The computation of wheezing symptoms is shown in [Table 4](#).

[Figure 7](#) shows the comparison of wheezing symptoms. Sometimes you may recover and test negative, but symptoms may last for 2 to 3 months. According to experts, there are two possible causes of prolonged COVID-19 illness.

From the comparison in [Table 3](#), the proposed neuromachine learning model obtained 94.68% of wheezing symptom management in a saturation test. In the same range, the existing CDS-DLA reached 87.07%, CD-DLA obtained 76.47%, ELA obtained 67.28%, and TPMS achieved 89.84% of wheezing symptom management.

First, even after 2 weeks, the virus persists in a small amount in the neurological disability patient’s body. Pathogens may not completely leave the body even after a patient with neurological disability tests negative. Second, the immune system may be deficient even after the virus has

left the body. There are two types of neurological disability patients in this group: those with mild symptoms and those with severe symptoms.

## Conclusion

Long COVID-19 is a new term introduced in the story of the coronavirus pandemic. Research is still ongoing, and you should take care of your body and do everything you can to boost your immune system. Always remember that your body is an asset and needs to be taken care of. Don't lose hope, and keep working on your body.

Even if you are experiencing prolonged COVID-19 symptoms, there is no need to panic. Try to manage symptoms with good sleep and proper rest. You can also do yoga and exercise.

However, if you are still unable to cope with the symptoms, make an appointment with a doctor and follow his/her recommendations and advice. The promising results of the vaccine for long-distance travelers against the corona virus will be revealed very soon. Researchers are monitoring symptoms before and after vaccinations and collecting blood samples to study the immune response to vaccines.

The condition can affect all types of people, including the young, the elderly, those who have been hospitalized once, those who have never been hospitalized before, those who are dealing with chronic conditions, and those who are otherwise healthy.

## Data availability

The data used to support the findings of this study are included in the article. Should further data or information be required, these are available from the corresponding author upon request.

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