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# Systematic Review on Neurological Complications Associated with COVID Vaccination

**Dr. Gada Kanaka Durga Chandu[1]; Dr. Nithesh Babu Ramesh [2], Dr. Gowtham Ganapathy[3], Dr. Suhail Aamir A[4]**

[1] Postgraduate, Department of General Medicine, Saveetha Medical College Hospital, Thandalam, Chennai, Tamil Nadu, India

ORCHID : 0009-0006-9218-600X

[2] Postgraduate, Department of General Medicine, Saveetha Medical College Hospital, Thandalam, Chennai, Tamil Nadu, India

ORCHID : 0009-0002-3407-1758

[3] Postgraduate, Department of General Medicine, Saveetha Medical College Hospital, Thandalam, Chennai, Tamil Nadu, India

ORCHID : 0009-0001-7900-4121

[4]Assistant Professor, Department of General Medicine, Saveetha Medical College Hospital, Thandalam, Chennai, Tamil Nadu, India

ORCHID : 0009-0003-1194-4795

## ABSTRACT

**Background:** Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) is the cause of Coronavirus Disease 2019 (COVID-19), which first appeared in 2019 and turned into a pandemic in 2020. But reports of neurological side effects after immunisation have sparked questions about the safety of vaccines. The purpose of this systematic review is to assess the prevalence and types of neurological complications correlated with COVID-19 vaccinations.

**Methods:** All case studies of COVID-19 vaccine-associated neurological side effects were included in the extensive search that was carried out across databases, including medRxiv, PubMed, SCOPUS, EMBASE, and Google Scholar. The search was limited to publications published between December 1, 2020, and May 20, 2024. PRISMA-eligible articles comprised peer-reviewed publications, case reports, cohort studies, and clinical trials on neurological problems after COVID-19 immunization. Data extraction was done with an emphasis on patient demographics, time to onset, neurological outcomes, and vaccine types. The included studies were evaluated using standardised criteria.

**Results:** The findings revealed a total of 1908 studies. However, immunisations can cause mild to severe neurological complications. Transverse myelitis (TM), Guillain-Barré syndrome (GBS), multiple sclerosis (MS), Bell's palsy (BP) and cerebrovascular events were the neurological consequences that were most frequently documented. The most common implications were Bell's palsy and GBS, both of which had a low incidence. Neurological effects usually began weeks after inoculation. Possible pathways include immune-mediated responses and molecular mimicry.

**Conclusion:** As a result of receiving the COVID-19 immunisation, neurological side effects are uncommon. The advantages of immunisation surpass the dangers of these unfavourable outcomes in terms of preventing severe COVID-19. Ensuring the safety of vaccines requires ongoing monitoring and reporting of neurological adverse effects. To further understand the mechanisms causing these problems and to enhance vaccine safety protocols, more investigation is required.

***Keywords:*** *Neurological complications, COVID-19 vaccination, Guillain-Barré syndrome, Multiple sclerosis (MS), Transverse myelitis (TM), Bell's palsy, systematic review.*

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## 1. INTRODUCTION

The primary symptoms of COVID-19, or coronavirus disease 2019, are hypoxia and lung damage, which can result in systemic problems and even death. The World Health Organization recorded more than 700 million confirmed cases,

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including more than 6 million deaths, as of the time this study was written.(1) Vaccines against COVID-19 have given rise to fresh optimism in the fight against the deadly epidemic. Numerous theories have been put up to try to explain the

possibility that almost all COVID-19 vaccination types could result in neurological issues, even if the exact relationship between these vaccines and neurological disorders is still unclear. Some of these theories are deduced from earlier studies on different vaccines.[2]

The first vaccines to combat the pandemic were released in early 2021. Furthermore, 68.2% of people on the planet are fully immunized against this illness. The development of COVID-19 vaccines involves four main approaches: the use of viral vectors (replication–non-replication), nucleic acids (DNA–mRNA), live, attenuated, or inactivated viruses, and proteins (spike proteins). Viral mRNA or genome fragments infiltrate human cells and trigger the creation of viral proteins in vaccines based on nucleic acids and adenoviruses.[3] Eventually, these viral proteins are recognized as antigens, which induce the formation of antibodies. Proteins and viral particles act as antigens to stimulate the immune system in vaccines containing inactive or protein viruses.[4]

Adenoviral vector-based vaccines such as Oxford-AstraZeneca (ChAdOx1-S), Johnson & Johnson (Ad26.COV2.S), Sinopharm (BBIBP-CorV) and Sinovac (CoronaVac) are inactivated virus vaccines, while Moderna (mRNA-1273) and Pfizer-BioNTech (BNT162b2) are mRNA-based vaccines. NVX-CoV2373 (Novavax) is the only recombinant spike protein subunit vaccine that is now on the market.[5,6,7]

Vaccines against SARS-CoV-2 that are readily available worldwide stimulate an immune response against COVID-19 through four distinct methods. Genetically modified RNA or DNA is introduced in the mRNA-based vaccines to produce a viral protein that can elicit an immune response against itself. The vaccines developed by AstraZeneca and Janssen, which employ a virus to transfer the SARS-CoV2 genome into cells, come in second. The body can then safely mount an immune response against these antigenic proteins that these infected cells are able to manufacture. The third type of vaccination, known as Sputnik V, is based on proteins and stimulates the immune system by utilizing spike protein or its fragments. Last but not least is the inactivated/attenuated viral vaccine (Sinopharm/Sinovac, CoronaVac), which deactivates or weakens the COVID-19 virus to stimulate the immune system.[8,9]

A number of complications (some confirmed, some unsubstantiated) started to be recorded shortly after the commencement of the mass vaccination efforts. The focus of our discussion here is the neurological system, which seems to be among the most impacted by these vaccinations.[10,11]

Numerous vaccines have been linked to neurological side effects, and SARS-CoV-2 is no exception. Numerous immunizations have been linked to neurological side effects. These include meningoencephalitis (vaccinated against Japanese encephalitis), a GBS and giant cell arteritis (vaccinated against influenza), as well as seizures and periods of hypotonic/hypo responsiveness following the pertussis vaccination. Disinformation and vaccine reluctance have made the global pandemic's challenges more intense. According to reports, there is a low incidence of neurological side effects after SARS-CoV-2 vaccinations.[6,12] For example, AstraZeneca's phase 3 clinical trials identified a small number of transverse myelitis (TM) occurrences. This evaluation lists obtained a comprehensive understanding and management of neurological diseases during COVID-19 periods, this study set out to review research for the COVID-19 vaccine and the most significant neurological complications, such as cerebral venous sinus thrombosis (CVST), Guillain-Barré syndrome (GBS), multiple sclerosis (MS), transverse myelitis (TM), and Bell's palsy (BP), in a systematic approach.

## 2. METHODS

### *2.1 Data Structure*

The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) standards were followed in the conduct of this systematic review. International biomedical journal databases, including medRxiv, PubMed, SCOPUS, Google Scholar and EMBASE, were searched. The primary objective was to locate pertinent publications that, up until May 2024, reported any kind of neurological side effects connected to any kind of COVID-19 vaccination that was authorized.

### *2.2 Search methodology*

A predetermined search strategy comprised a range of keywords from relevant medical subject headings (MeSH) and keywords, such as: "SARS-CoV-2", "Bell's palsy", "AstraZeneca COVID-19 vaccine", "mRNA vaccine", "AZD1222 vaccine", "ChAdOx1 nCoV19 vaccine", "Johnson & Johnson COVID-19 vaccine", "Janssen COVID-19 vaccine", "Pfizer-BioNTech COVID-19 vaccine", "BNT162b2", "Ad26.COV2 vaccine", "Sinovac COVID-19 vaccine", "Moderna COVID19 vaccine", "demyelination", "vaccination". Additionally, we conducted a manual search of other pertinent publications that the included studies cited.

### *2.3. Criteria for inclusion*

All peer-reviewed articles and preprints that recorded neurological complications associated with any particular type of

COVID-19 vaccination were included in our analysis, including case reports and case series that satisfied the following standards: (i) reports of neurological side effects following the COVID-19 vaccine that are either immediate or delayed; (ii) reports of potential correlations between the COVID-19 vaccine and cases accomplishing the diagnostic criteria for multiple sclerosis (MS), Guillain-Barré syndrome (GBS), cerebral venous sinus thrombosis (CVST), transverse myelitis (TM), and Bell's palsy (BP); and (iii) studies that are accessible only in English

### *2.4. Criteria for exclusion*

This study rejected reports without laboratory, imaging, or clinical evidence of neurological complications following vaccination. Review papers, opinions, commentary, and editorials were also disregarded unless they documented negative consequences. As there were insufficient clinical data, reports of neurological ailments during clinical trials were likewise disregarded. Only studies published in English have been included in the review.

### *2.5. Extraction of data*

The two reviewers first evaluated the titles and abstracts of every study they found to be relevant, then they went on to full-text screening the papers they decided were eligible. The data on the following parameters were then extracted by the same reviewers: the authors, the title of the article, the year of publication, the age and gender of the patients, information related to the COVID-19 vaccine, the onset of neurological symptoms, the results of the neurological scrutiny, the results of the MRI, the laboratory initial evaluation, the CSF assessment, the course of treatment, and the clinical outcome of the study.

### *2.6. Analysis of statistics*

Numbers and percentages were used to describe the qualitative data. The terms range (maximum and minimum) and median were used to characterize quantitative data. Because there was not enough data, the significance of the results was assessed at the 5% level but could not be determined. Due to insufficient data, a meta-analysis that was intended to assess the relationship between the laboratory and demographic findings, clinical, radiographic, and outcomes could not be carried out. Fig. 1 displays the study selection flowchart using PRISMA guidelines.

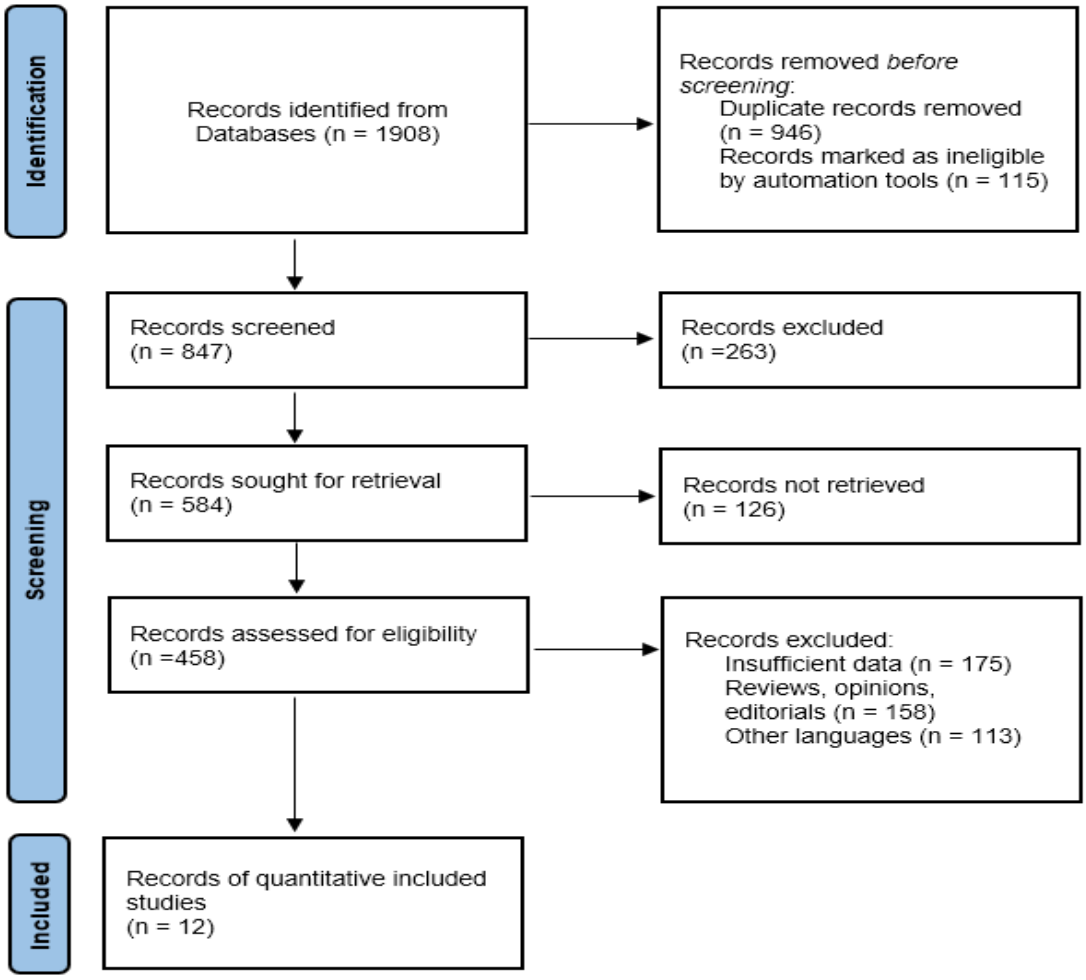


**Fig. 1. Flow diagram for incorporating literature according to PRISMA standards**

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## 3. RESULTS AND DISCUSSIONS

### 3.1 Neurological Complications of COVID19 Vaccines

Neurological complications resulting from COVID-19 immunization are typically moderate and temporary.[5] Headache, exhaustion, and joint and muscular aches are the most often reported adverse effects. Local injection site effects, including swelling, redness, and soreness, are also well-known, identical to with any other injectable vaccine. There are modest neurological complications associated with all COVID-19 vaccination types.

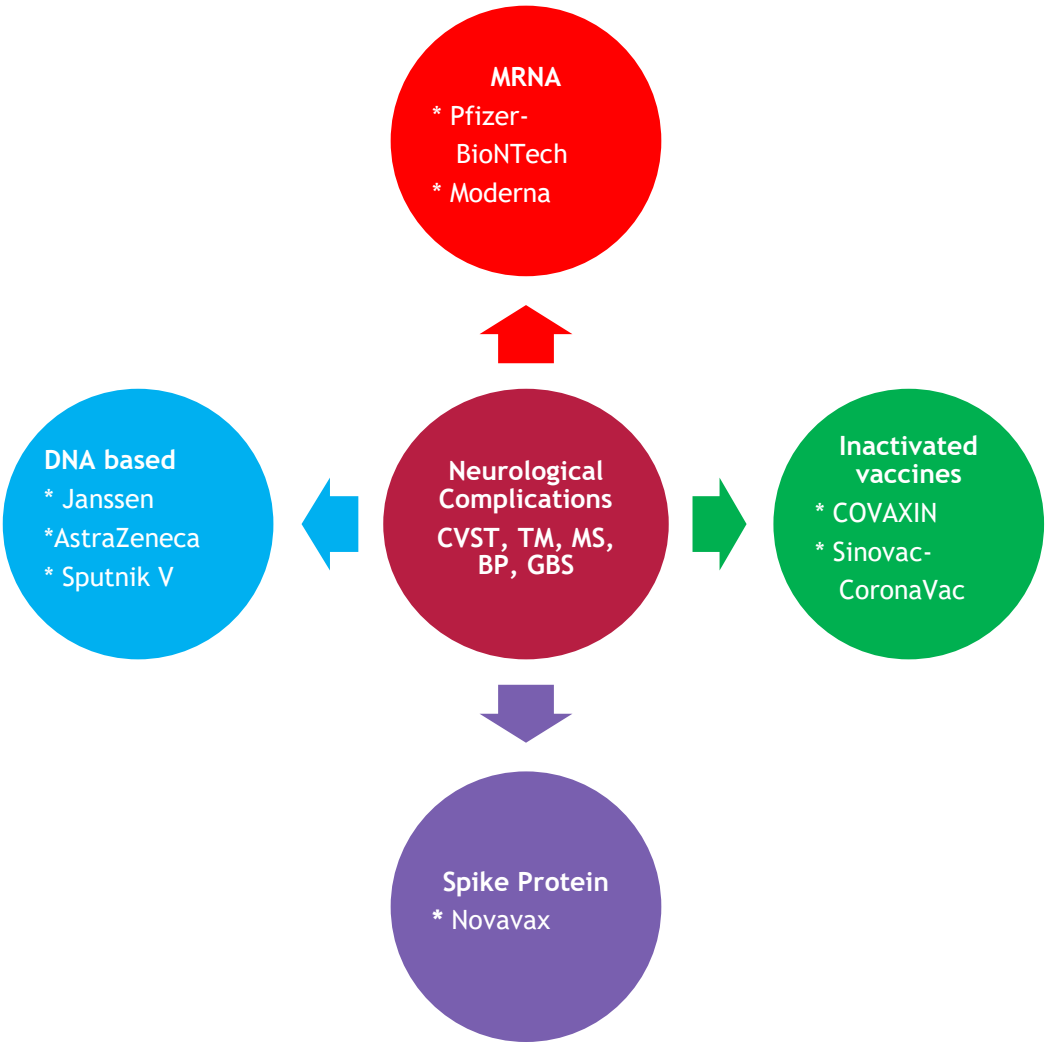


**Fig. 2. A representation of the COVID-19 vaccines with its neurological complications**

The flow diagram of severe neurological complications (cerebral venous sinus thrombosis (CVST), Guillain-Barré syndrome (GBS), multiple sclerosis (MS), transverse myelitis (TM), and Bell's palsy (BP)) following COVID-19 vaccines is shown in Fig. 2. Theoretically, COVID-19 vaccinations may cause immunological-related neurological problems by causing cross-reactivity with nerve fibers, brain tissue, neuromuscular junctions and also spinal cord. This hypothesis is further reinforced by the emergence of different antibodies in individuals with immune-related neurological disorders following COVID-19 vaccinations.

#### *3.1.1 Cerebral venous sinus thrombosis*

The neurological symptoms of cerebral venous sinus thrombosis (CVST) range widely, from mild complaints that are frequently ignored to more concerning symptomatology. Some patients who got adenoviral vector vaccines, like the Ad26.COV2.S or ChAdOx1-S vaccine, for illustration, showed in for admission without any additional neurological signs, only headaches.[13,14]

A study conducted by Krzywicka et al.[15] analyzed cases related to CVST that were submitted to the European Medicines Agency. Eight percent of cases in the ChAdOx1 nCov-19 group and none in the mRNA immunization group had antibodies

against PF4. In 57% of the ChAdOx1 nCov-19 group's CVST cases, thrombocytopenia was noted. The laboratory data related with CVST that occurs after ChAdOx1 nCov-19 differs from that of the mRNA vaccination group.[15] Only the pre-COVID-19 CVST and the ChAdOx1 nCov-19 group had reports of thrombocytopenia.

On the contrary, a percentage of these individuals present with unusual neurological symptoms at first, including aphasia, hemianopia, hemiparesis, seizures, altered states of consciousness, and vertigo.[16,17,18] Notably, patients inoculated with adenovirus-based vaccines do not appear to have significantly different indications of CVST from those who got mRNA-based immunizations. Common symptoms of CVST related with both vaccination technologies included persistent headaches, lethargy, vomiting, and motor impairments.[19,20,21]

The findings of Van De Munckhof et al.[22], Mehta et al.[23], Bikdeli et al.[24] suggest a causal association, as does the specificity of the clinical symptoms of CVST associated with viral vector—based vaccinations and the identification of a pathophysiological mechanism. Moreover, the elevated risk of death linked to this issue emphasizes the significance of prompt diagnosis and intervention.

### *3.1.2 Transverse Myelitis*

Acute transverse myelitis is an uncommon, acquired inflammatory spinal cord disease that causes sudden weakness, loss of sensation, and problems with the bowels and bladder. Although inactivated virus and mRNA-based vaccinations have also been linked to this presentation, adenoviral-based vaccines are more commonly linked to it.[25,26,27,28,29,30] A large spinal cord lesion may be present in an MRI with a fluid-attenuated inversion recovery (FLAIR) sequence or a strong signal of the spinal cord on the T2. The standard course of treatment involves high-dose steroids; in more severe situations, an intravenous immunoglobulins (IVIGs), immunosuppressive medications, or plasma exchange may be required.[31] Following COVID vaccination, cases of both long and short segment myelitis have been recorded; high dosage intravenous steroids have been shown to improve outcomes.

The spinal cord is demyelinated by the acquired disease known as acute transverse myelitis (ATM). With an incidence of about 1.4 instances per million persons, ATM after COVID-19 vaccination is uncommon.[32] Two patients experienced transverse myelitis during the Oxford/AstraZeneca vaccine phase III trial; one patient's case was thought to be idiopathic and occurred 14 days following the booster shot. The second case, which was thought to be unrelated to immunization, was discovered 68 days after vaccination in a patient who had already received a multiple sclerosis diagnosis.[28,29]

It's interesting to note that a subtype of longitudinally extended TM—which affects three or more spinal segments—has been reported relatively frequently.[33] Patients' average age ranged from 40 to 50 years old, and many of them had a history of autoimmune illnesses.[34,35] Vaccine-related ATMs exhibit milder clinical symptoms and shorter intervals than COVID-19-related ATMs.[34,35] They follow different forms of COVID-19 vaccinations, the most popular of which is the adenoviral vector-based vaccine.[5,30,33,36] Transverse sensory level, rectal or bladder dysfunction, and quadriplegia or lower limb paralysis are characteristics of cases. The most common affected spine is the thoracic spine.[34] Leukocyte count and protein levels may be elevated in the CSF of certain patients. Poor prognosis is indicated by older age, receiving the second dose of the vaccine, and having a modified Rankin score of $\geq 3$.[34] In general, transverse myelitis after COVID vaccination continues to occur more frequently than is typical in the general population, and successful outcomes need early diagnosis and treatment.

### *3.1.3 Multiple Sclerosis*

Multiple sclerosis (MS) is a chronic immune-inflammatory demyelinating disease of the central nervous system that can cause permanent impairment. A systematic review found that the majority of those affected were young adults, with a mean age of 33.5 years.[37] After receiving the COVID-19 immunization, the majority of patients are female, in line with the previously documented MS cases.[35,38,39,40,41] Patients with MS (pwMS) are more vulnerable to COVID-19 infection and experience worse outcomes from the illness.[37] PwMS are regarded as vulnerable groups, and numerous nations have declared that they require COVID-19 vaccination.[42,43] Following COVID-19 vaccination, there have been reports of both new-onset and recurrent MS patients.[35,44]

Following mRNA and adenoviral vector-based vaccinations, MS typically develops.[38,45] It was also mentioned that although some patients improved with high-dose steroids, others need more plasmapheresis. Research revealed that the most frequent clinical symptom was sensory abnormalities, with a mean onset period of 6 to 9 days.[35,38] Thirteen patients reported having MS symptoms; five of them had received a prior diagnosis. Nine patients (70%) were women, compared to four men (30%). The age range was 24-64, with 41 being the median. After immunization, symptoms started to show from one day to one month later. Symptoms appeared following the injection of mRNA-based vaccinations in every instance.

Consequently T2 and FLAIR sequences on MRI reveal newly developing signals. Most often, the brain is impacted first, then the spinal cord. CSF may contain particular oligoclonal bands.[35] Seven of the 13 patients' MRIs showed new spinal cord lesions, and all 13 showed new brain lesions. Eight out of nine patients had pleocytosis, and seven of nine had oligoclonal bands seen in the CSF.[46] Notably, the MRI of a few newly diagnosed cases revealed a combination of old and

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new lesions, hence pre-clinical MS history is not ruled out.[47]

After treatment, the lesions go away in the majority of patients, but regrettably, some are unable to return to baseline.[38] According to an epidemiological assessment, the acute recurrence rates following the first and second immunization doses were 0.65 to 2.1% and 0.85 to 1.6%, respectively. However, because of follow-up periods and various vaccine types additional studies revealed that COVID-19 vaccination increased the probability of MS recurrence.[45]

### *3.1.4 Bell's Palsy*

COVID-19 vaccination recipients have been found to have a mononeuropathy called facial nerve palsy (FNP). Generally, FNP, commonly referred to as Bell's palsy (BP) or idiopathic FNP, has an unknown origin in 70% of instances.[48] Acute peripheral facial nerve paralysis or BP accounts for 35.7% of all neurological problems following COVID-19 vaccination.[46] According to estimates, there are 42.8 to 106 cases in incidence for every 100,000 person-years.[49,50] It can also be observed with adenoviral vector-based COVID-19 vaccines, albeit it is most frequently reported to happen following mRNA vaccinations.[51]

Interesting, the latency durations between vaccination delivery and FNP formation in the studied literature range from a few hours to 30 days after a COVID-19 vaccine dose.[52,53,54] According to the combined phase 3 data of the Moderna and Pfizer studies, the rate of BP in the gene with or without therapy was 3.5–7 times higher than anticipated. Since Bell's palsy is such a rare side effect, concerns about a higher risk of developing the condition shouldn't cause anyone to be reluctant to get the vaccine. A number of theories try to explain BP that results after the COVID-19 vaccination: among other things, bystander effect, molecular mimicry, and interferon production. FNP has been identified as an uncommon potential side effect of interferon treatment.

The association between COVID-19 immunization and BP has been shown in a number of case reports, particularly in regard to the mRNA vaccines.[50,52,53,54,55] BP happens either after the first or second vaccination dose, with the first dosage having a larger chance of occurrence.[56,57] Six to fourteen days pass between the immunization and the onset of palsy.[53,58] There are gender disparities in the occurrence: Females are more likely to have it after mRNA immunizations than males after inactivated vaccines.[49,59,60]

Certain investigations have reported an age difference, with older individuals showing a larger risk.[57] Between 49.7 and 62.6 years old is the range of the mean age.[59,61] The left side is more frequently impacted than the right, indicating selection in position.[58] First-line therapies include IVIG, steroids, and plasma exchange; most patients respond to these.[56] Diverse research findings relate to the relationship between BP and the COVID-19 vaccination. Furthermore, cross-reactive antibody production may arise from molecular mimicry between facial nerve self-antigens and vaccine antigens. A case-control study of 37 patients with FNP who received the Pfizer-BioNTech vaccine found no correlation between immunizations and BP (95% CI- 0.37∼1.90, OR = 0.84).[52]

The strategy makes biological sense as it has been demonstrated that COVID-19 vaccines, such as BNT162b2, activate the innate immune system and cause interferon production.[49] Nonetheless, a Hong Kong study that evaluated the risk of blood pressure 42 days after receiving either the BNT162b2 or the CoronaVac vaccine discovered a markedly elevated risk (95% CI 0.886 3.477, OR 1.755 for the BNT162b2 and 95% CI 1.415 4.022, OR 2.385 for the CoronaVac).[49] After receiving the COVID-19 mRNA vaccination, BP was reported substantially more frequently, according to an examination of a self-reporting database.[61]

A bystander effect exposes self-antigens at the site of the vaccination-induced immune response and activates dormant autoreactive cells, causing nerve inflammation.[49,53] Fortunately, the elevated risk of blood pressure is minimal. According to data from Israel's leading healthcare provider, the highest associated group has an additional 4.5 cases per 100,000 people.[57]

### *3.1.5 Guillain-Barré syndrome (GBS)*

The rare but dangerous immune-mediated polyradiculoneuropathy known as Guillain-Barré syndrome (GBS) presents as an instance of areflexic sensorimotor non-length dependent quadriparesis mediated by lower motor neurons. There is a substantial body of medical literature that demonstrates the connection between GBS and COVID infection. Similar to this, it has been discovered that all COVID-19 vaccine types are linked to Guillain-Barré syndrome, albeit adenovirus-based vaccinations have a greater incidence of this condition.[62,63,64,65,66] Older persons are typically affected by post-vaccination GBS two weeks after immunization.

An immune-mediated polyradiculoneuropathy known as Guillain-Barré syndrome (GBS) can develop following certain gastrointestinal or respiratory infections.[67] GBS related to other sources is indistinguishable from its clinical presentation. A demyelinating sensorimotor polyradiculoneuropathy pattern is seen in nerve conduction studies, and albumino-cytological dissociation is seen in CSF examinations. Immunotherapy often has good results. The proposed pathogenesis, which entails autoantibody-mediated immunological destruction of radicles and peripheral nerves, is the process of molecular mimicry between the structural components of peripheral nerves and the vaccine components.

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A fast progressing, symmetrical limb weakness, typically accompanied by hyporeflexia or areflexia, is a common feature of GBS. Although it can resolve on its own, in certain situations it can be fatal due to the compromise of respiratory muscles.[67,68] Relevant tests for the diagnosis include an MRI, a nerve conduction examination, and an investigation of the cerebrospinal fluid (CSF). A few reports of this syndrome after receiving the COVID-19 vaccine show a time correlation between the vaccine and a typical GBS clinical picture, with some cases improving after receiving IVIG.[68,69]

COVID-19 immunization, and its potentially fatal side effects have sparked public alarm in many cases. A prospective observational research conducted in Mexico following the initial administration of BNT162b2 evaluated the neurologic side effects in 704,000 recipients of the vaccination. Three cases of GBS total—0.43 per 100,000 doses—were verified through laboratory, clinical, and electrophysiologic investigations. Interestingly, every single one of these individuals tested negative for COVID-19 and had confirmed gastrointestinal illnesses. But in the United Kingdom, where vaccination rates are high, the Medicine and Health Care Products Regulatory Agency reports that 491 people developed GBS after receiving the ChAdOx1-S vaccine.[70].

More recently, a research based on surveillance data from the US Vaccine Safety Datalink detailed the incidence of GBS in 10,158,003 individuals after receiving the BNT162b2, mRNA-1273 or Ad26.COV2.S vaccines. Among those who received these vaccines, GBS was uncommon: incidence of GBS following mRNA vaccinations was comparable to the background rate that was anticipated, whereas incidence following Ad26.COV2.S vaccinations was somewhat higher. Congruent with these results, a study carried out in Mexico involving more than 80 million doses of seven COVID-19 vaccines (mRNA1273, ChAdOx1-S, BNT162b2, Ad5-nCoV, rAd26-rAd5, CoronaVac and Ad26.COV2.S) discovered an incidence of 1.19 cases per million administered doses overall; recipients of BNT162b2 and Ad26.COV2.S had the highest incidences.[71,72]

ChAdOx1-S immunization against COVID-19 has been correlated to some cases of GBS. The sole motor symptom of this uncommon form of GBS is facial diplegia and bifacial weakness with paresthesia.[73] It's interesting to note that this variety of GBS has also been reported during an infection with SARSCoV-2, indicating a possible role for the immune system's reaction to the spike protein. This association has biological plausibility because the greatest immune response following vaccination is expected to happen within a similar time window, and this is supported by the reported latency period of 11–22 days.[73]

Additionally, 0.13% of GBS and its variations were observed to occur after immunization with either mRNA-1273, BNT162b2 or ChAdOx1-S, according to an analysis of the WHO pharmacovigilance database. This frequency was low, but increased when compared to the full database.[74] It was not, however, higher than the GBS risk connected to the influenza vaccination. As a whole, these findings imply that, even if the risk of GBS may increase following the delivery of several COVID-19 vaccines, it is still low and, in most circumstances, comparable to the background risk, meaning that the benefits of immunization are not exceeded.

**Table 1. Emerging covid vaccinations on neurological complications**

| References | Covid vaccine | Neurological complications | Postvaccination onset duration | Symptoms | Outcomes |
|---|---|---|---|---|---|
| Román et al. [30] | ChAdOx1 nCoV-19 (AZD1222) | Acute transverse myelitis | 10 days | Headache, fever, ageusia,anosmia, exhaustion, diarrhoea, or symptoms related to upper respiratory tract | The vaccine trial was put on hold because to the symptoms of these three cases, and it continued until the sick individuals began to exhibit signs of recovery. |
| Rao et al.[75] | Pfizer | Guillain-Barre syndrome | 21 days | Progressive ascending weakness and paresthesias. | A total of 2 gm/kg of intravenous immunoglobulin was administered as part of the management, and forced vital capacity and negative inspiratory force were |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | regularly monitored. |
| Ryan et al.[76] | AZD1222 - AstraZeneca | CVST | 10 days | Bruising, petechiae, thrombocytopenia, and headache anti-platelet antibody. | The condition is improved. |
| Waheed et al.[77] | Pfizer | Guillain-Barre syndrome | 2 weeks | Malaise and body aches | Areflexia in both the upper and lower extremities, as well as a mild pinprick in both lower extremities up to the knees |
| Aoyama et al.[78] | Pfizer-BioNTech (BNT162b2) | CVST | 5 days | Headache | Symptoms improved after the administration of anticoagulant therapy |
| Fitzsimmons and Nance[79] | Moderna | Transverse myelitis | 1 day | Discomfort in the lower extremities, paresthesia in both feet, lower back pain, difficulty walking, and retention of urine. | After the immunization, the patient gradually recovered and was able to walk around without assistance 25 days later. |
| Obermann et al.[55] | mRNA vaccines (BNT162b2, BioNTech/Pfizer) | Bell's palsy | 2 days | Blood and CSF samples had SARS-CoV-2 antibodies, resulting in facial muscle paralysis. | The state has improved. |
| Soltani et al.[80] | AstraZeneca ChAdOx1-S | CVST | 5 days | Central vein thrombosis, severe thrombocytopenia, and intracranial hemorrhage | During the COVID-19 immunization, medical personnel should be aware of the symptoms, diagnostic techniques, and appropriate management and treatment of CVST. |
| Martin-Villares et al.[81] | Moderna | Bell's palsy | 2 days | Grade III facial palsy (right Bell's palsy). | An increased risk of facial nerve palsy may be linked to VZV-IgG antibodies and a history of facial palsy |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | experienced during pregnancy. |
| Tahir et al.[82] | Ad26.COV2.S | Transverse myelitis | 10 days | Transverse myelopathy of the cervical cord CSF boosted the number of cells | Treated successfully with steroids and plasma exchange |
| Kam et al.[83] | AstraZeneca | CVST | 3 months | Headache | Results from the blood were not noteworthy. A radiological workup revealed no more cerebral problems, but sigmoid sinus thrombosis and left transverse. |
| Prasad et al.[84] | Janssen | Guillain-Barre syndrome | 12 days | Absence of limb, neck, or ocular weakness; distal paresthesia; bifacial symmetrical weakness and limb areflexia | Favorable outcome after IVIG treatment. |
| McKean and Chircop[64] | Vaxzevria AstraZeneca, | Guillain-Barre syndrome | 10 days | Bifacial weakness | It is critical to maintain vigilance so that any potential elevated risk can be appropriately assessed. |
| Benlamkadam et al. (85) | Oxford/AstraZeneca | Guillain-Barre syndrome | 21 days | Dysautonomia and respiratory affection | Management with intravenous immunoglobulin was prescribed. |

Currently recorded neurological adverse reactions to covid vaccinations are summarized in Table 1. According to the data currently available, the advantages of these vaccinations exceed the possible risks; the frequency of severe neurological complications linked to COVID-19 vaccinations appears to be very low when compared to the impact of COVID-19 itself.[5,86,87] The significant number of COVID-19 cases that have been documented and the deaths that resulted from the illness highlight the significance of vaccination campaigns, which have been shown to be quite effective.

## 4. LIMITATIONS

The systematic review has significant limitations. Reporting and/or publication bias may exist because all of the literature that is currently available was published as single case series and reports. Despite the fact that reports of neurological side effects following COVID-19 vaccination exist, they seem uncommon given the overall number of vaccinations administered. Furthermore, conducting a meta-analysis was further complicated by the heterogeneity of clinical data, the small number of reported cases, or the insufficient work-up in some cases. Current recommendations and guidelines state that the risk of neurological problems during and after COVID-19 infection outweighs the advantages of COVID-19 vaccination. However, comprehensive patient-centered research is required, encompassing diagnostic approaches beyond standard clinical care, and pathophysiological mechanism research may yield further insights and therapeutic possibilities.

## 5. CONCLUSION

The COVID-19 immunization has been linked to a wide range of significant neurological problems, according to this comprehensive assessment of post-authorization data. Following adenovector-based vaccinations, the most severe neurological side effect that has been documented in females of reproductive age is cerebral venous sinus thrombosis. Bell's palsy is another significant neurological side effect that was noted after the mRNA vaccination. Due to molecular mimicry and consequent brain damage, other serious, unanticipated side effects of vaccinations include MS, TM, and GBS. By improving the diagnosis and detection of adverse events correlated with vaccines, doctors and neurologists can treat and manage vaccine-related consequences more effectively. In general, the benefits of COVID-19 vaccination outweigh the dangers associated with neurological complications for both individuals and the general population. Further research is necessary to determine whether neurological effects and COVID-19 vaccines are related, primarily because the virus is evolving into new strains and vaccines are becoming more technologically adept to combat them…

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