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POSITION PAPER

COVID-19 vaccination hesitancy among people with chronic neurological disorders: A position paper

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Abstract

Background and purpose: Health risks associated with SARS-CoV-2 infection are undisputed. Moreover, the capability of vaccination to prevent symptomatic, severe, and fatal COVID-19 is recognized. There is also early evidence that vaccination can reduce the chance for long COVID-19. Nonetheless, the willingness to get vaccinated and receive booster shots remains subpar among people with neurologic disorders. Vaccine scepticism not only jeopardizes collective efforts to end the COVID-19 pandemic but puts individual lives at risk, as some chronic neurologic diseases are associated with a higher risk for an unfavorable COVID-19 course.

Methods: In this position paper, the NeuroCOVID-19 Task Force of the European Academy of Neurology (EAN) summarizes the current knowledge on the prognosis of COVID-19 among patients with neurologic disease, elucidates potential barriers to vaccination coverage, and formulates strategies to overcome vaccination hesitancy. A survey among the Task Force members on the phenomenon of vaccination hesitancy among people with neurologic disease supports the lines of argumentation.

Results: The study revealed that people with multiple sclerosis and other nervous system autoimmune disorders are most skeptical of SARS-CoV-2 vaccination. The prevailing concerns included the chance of worsening the pre-existing neurological condition, vaccination-related adverse events, and drug interaction.

Conclusions: The EAN NeuroCOVID-19 Task Force reinforces the key role of neurologists as advocates of COVID-19 vaccination. Neurologists need to argue in the interest of their patients about the overwhelming individual and global benefits of COVID-19 vaccination. Moreover, they need to keep on eye on this vulnerable patient group, its concerns, and the emergence of potential safety signals.

KEYWORDS
advocacy, COVID-19, infectious disease prevention, neurological disorders, SARS-CoV-2, vaccination, vaccine skepticism

INTRODUCTION

Vaccination is the most cost-efficient method to avoid infectious diseases and mitigate the rate of detrimental outcomes [1]. Moreover, immunization campaigns have been one of the most effective public health interventions so far [2,3]. Since the global outbreak of coronavirus disease 2019 (COVID-19), researchers worldwide have been working tirelessly and collaboratively to develop vaccines against this highly contagious RNA virus. The real-world effectiveness of the vaccines against severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2), the pathogen that causes COVID-19, has been corroborated on a scientific basis. The findings are consistent with and complement the estimates of vaccine efficacy from phase 3 trials with regard to the prevention of symptomatic, severe, and fatal disease [4]. However, the protection against SARS-CoV-2 infection and nonsevere disease wanes over time. This is particularly evident in the elderly population and in those treated with immunosuppressive drugs. Subsequently, regular booster shots are required to maintain the efficacy of protection against COVID-19 [5]. People with the debilitating condition termed long COVID-19 continue to experience symptoms weeks, months, or years after SARS-CoV-2 infection. Up to 30% of infected people, including many who were never hospitalized, have persistent symptoms, which include breathlessness, headache, chest pain, abdominal symptoms, myalgia, and fatigue. Furthermore, cognitive difficulties, anxiety, and depression are additional reported conditions. There is also early scientific evidence of the capability of COVID-19 vaccines to reduce the chance of long COVID-19 [6,7]. The underlying mechanism of action is still under investigation; a shorter time of presence of the virus in the body and a weaker immune reaction in vaccinated individuals are among the possible explanations.

On the global level, the effectiveness of the vaccination against SARS-CoV-2 depends on its uptake. If there are individuals who decline to be immunized, the vaccination coverage and subsequent goal of ending the pandemic are jeopardized. A mathematical modeling study disclosed that a refusal rate of >10% is estimated to be sufficient to weaken the population benefits of vaccination against COVID-19 [8]. Notably, the unvaccinated are a threat to the vaccinated, as they can be the breeding ground for aggressive SARS-CoV-2 variants resistant to current vaccines [9]. Most European countries' vaccination and boostering rates by the end of 2021 are not sufficient to stop the pandemic [10]. Subsequently, several countries returned to measures such as lockdowns and travel restrictions. At the same time, backed by the right to health, some European countries will enforce mandatory vaccination for the entire adult population, vulnerable individuals, or specific workplace settings such as health care providers [11].

At the beginning of 2020, the European Academy of Neurology (EAN) established the EANCore NeuroCOVID-19 Task Force to support neurologists in Europe and beyond to prepare for and manage the challenges of this global crisis [12]. The Task Force consists of neurologists from different subspecialties and represent all parts of Europe (Central, Eastern, Southern, Western Europe). Details on previous projects and activities are provided at https://www.ean.org/ean/eancore-covid-19.

In this position paper, the Task Force (a) summarizes the current knowledge on the prognosis of COVID-19 among patients with neurological disease, (b) discusses potential barriers to vaccination coverage, and (c) formulates strategies to overcome vaccination hesitancy. A survey on vaccination hesitancy in people with neurologic disease among the Task Force members discloses further aspects and supports the lines of argumentation.

NEUROLOGICAL DISORDERS: A RISK FACTOR FOR DETRIMENTAL COVID-19 OUTCOME

Individuals with certain neurological comorbidities are at risk for an unfavorable course of SARS-CoV-2 infection [13–18]. For instance, a recent meta-analysis revealed that patients with prior cerebrovascular disease who had a SARS-CoV-2 infection had a higher risk of severity (odds ratio [OR] = 3.10, 95% confidence interval [CI] = 2.21–4.36, $p < 0.001$) and mortality (OR = 3.45, 95% CI = 2.46–4.84, $p < 0.001$) [13]. Another meta-analysis, this one focusing exclusively on epilepsy, disclosed that these patients are at higher risk for increased severity (OR = 1.69, 95% CI = 1.11–2.59, $p = 0.010$) and mortality from COVID-19 (OR = 1.71, 95% CI = 1.14–2.56, $p = 0.010$). A meta-analysis in patients with dementia as comorbidity also found a higher rate of poor outcome with COVID-19 [18]. Parkinson disease was also associated with poor COVID-19 in-hospital outcomes (OR = 2.64, 95% CI = 1.75–3.99, $p < 0.00001$) [18]. The risk factors for lethality related to COVID-19 in people with multiple sclerosis (MS) include the progressive disease stage and ongoing treatment with anti-CD20 agents [19–21]. Moreover, COVID-19 may activate neuroinflammatory and neurodegenerative pathways, leading to the emergence of nervous system disorders and progression of the underlying neurological disease [22].

SARS-CoV-2 VACCINATION: FROM EQUITABLE GLOBAL ACCESS TO VACCINATION HESITANCY

Early in 2021, our main concern for COVID-19 vaccination was to supply the vulnerable population and prevent unequal distribution [23,24]. However, we are now facing vaccine hesitancy, a phenomenon that the World Health Organization (WHO) listed among the top 10 global threats [25,26]. Vaccine hesitancy refers to delay or unwillingness to get vaccinated despite the availability of vaccine services. It is influenced by factors such as complacency, convenience, and confidence [27,28].

Vaccine skepticism in the context of COVID-19 is in part related to the selective interpretation of SARS-CoV-2 vaccine efficacy and unbiased coverage of side effects of vaccines [29]. The plethora of COVID-19-associated reports, the *infodemic*, an overabundance of information, some accurate and some not, makes it hard for people to find trustworthy sources and reliable guidance when they need it. Action to fight misinformation and increase transparency in all aspects cannot be implemented early enough. Patient stories regarding potential and medically unverified side effects on social media channels are growing in number and fuel vaccine skepticism. In this regard, functional neurological disorders with seizures or paralysis following vaccination are also found in the recent literature, calling for increased awareness of this condition [30,31]. Directed misinformation, political interests, and disagreement among experts further complicate vaccine coverage efforts.

RISK–BENEFIT PROFILE OF SARS-CoV-2 VACCINATION: NEUROLOGICAL VIEWPOINT

Adverse events related to immunization can occur with any vaccine and are a significant source of vaccine hesitancy. Clinical manifestations of side effects include fever/chills, headache, fatigue, myalgia, and arthralgia, or local injection site effects like swelling, redness, or pain. An adverse event following immunization is considered severe if it results in death or significant persistent disability, is life-threatening, requires in-patient hospitalization, or is a congenital anomaly/birth defect [32].

Neurological adverse events following COVID-19 vaccination are generally mild and transient and do not require hospital admission [33]. The WHO lists Guillain–Barré syndrome, seizures, anaphylaxis, syncope, encephalitis, thrombocytopenia, vasculitis, and Bell palsy

as serious neurologic adverse events. A large population-based study of more than 32 million people investigated the neurological adverse events associated with the ChAdOx1nCoV-19 (AstraZeneca, UK) and BNT162b2 (Janssen, Belgium) vaccines as well as SARS-CoV-2 infection [34]. First, they found an increased risk of hospital admission for Guillain–Barré syndrome (15–21 days and 22–28 days), Bell palsy (15–21 days), and myasthenic disorders (15–21 days) in those who received the ChAdOx1nCoV-19 vaccine. Second, an increased risk of hospital admission for hemorrhagic stroke (1–7 days and 15–21 days) was reported in those who received the BNT162b2 vaccine. Given the low incidence and mostly favorable outcome, the benefits of vaccinations outweigh the comparatively small risks of autoimmune adverse events [35]. In contrast, severe and sometimes fatal cerebral venous thrombosis cases, occurring predominantly in young women, have been reported within 4–28 days of vaccination [36]. This rare postvaccine entity was observed with the vector-based ChAdOx1nCoV-19 and Ad26.COV2.S SARS-CoV-2 vaccines is probably caused by platelet-activating antibodies against platelet factor 4, mimicking autoimmune heparin-induced thrombocytopenia and currently named vaccine-induced immune thrombotic thrombocytopenia (VITT) [37,38]. However, even though decision-making can be supported by an advantageous risk–benefit profile from phase 3 trials and real-world evidence, vaccine skepticism is reported among people living with neurological disorders, for example, epilepsy and MS [39–42]. Morover, diminished humoral immune responses after SARS-CoV-2 vaccination in people with neurological disorders on CD20-depleting agents and S1P receptor modulators call for individualized vaccination strategies [43–45].

The recommendation for COVID-19 vaccination and the definition of contraindications among treating doctors is not uniform, for example, for people with Parkinson disease [46,47]. Nonetheless, vaccine hesitancy in people living with MS or autoimmune disorders of the nervous system is not unexpected. The rationale for skepticism is safety, a line of argumentation also brought forward by people living with Parkinson disease and epilepsy [40,47–49]. The concerns are related to the fact that vaccination was previously implicated in the pathogenesis of MS and can trigger, although very rarely, central nervous system (CNS)/peripheral nervous system (PNS) autoimmunity. Although vaccination as the cause of MS has been refuted scientifically, a relapse or disease activation cannot be ruled out [50]. Reports of a first MS manifestation and relapses in established MS in temporal relation to the vaccine shots are available [51–53]. However, there are also reports that suggest that there is no increased risk of relapse activity among vaccinated patients with MS and that benefits outweigh the potential dangers of COVID-19 vaccination [54,55]. Acute CNS or PNS demyelination is a known but infrequent complication of other vaccines and has also been observed in close temporal relation to SARS-CoV-2 vaccination [56,57]. However, individual case reports are not suitable to establish any causality. Such observations must be viewed in relation to the vast number of people vaccinated against SARS-CoV-2 worldwide.

Some patients assume distinct safety aspects for mRNA/vector-based SARS-CoV-2 vaccines and are reluctant until inactivated vaccines are available. However, a study of 1165 people with neuroinflammatory disorders did not find any difference in patient-reported vaccine side effects and no evidence of disease worsening compared to controls after vaccination with these newer vaccines [58].

Taken together, even if the clinical trials of SARS-CoV-2 vaccination were not aimed at elucidating safety and efficacy in neurological disorders, no safety signals have been identified for this subgroup so far, and vaccination with the approved preparations can be regarded as safe.

VACCINATION HESITANCY: A SURVEY AMONG TASK FORCE MEMBERS

Aims and methods

In December 2021, we conducted an online survey (Appendix S1) among the EANcore NeuroCOVID-19 Task Force members, consisting of 21 junior and senior neurologists. EAN office members were excluded from participating in the survey.

The aim was to identify the main barriers and possible solutions to improved vaccine coverage among people with neurological disorders.

Demographic data of the respondents and their experience with COVID-19 vaccine hesitancy among people with certain neurological conditions were collected. The reasons and the arguments against receiving the SARS-CoV-2 vaccination reported by patients with chronic neurological disease were ranked from 1 (most significant) to 10 (least important). Insights into the potential harmfulness of further SARS-CoV-2 vaccine shots if neurological complications had occurred in close temporal relationship to the vaccinations were investigated. One last question was left open for any additional comments. A Likert-style scale was used to identify certain neurological disorders with a higher and lower rate of vaccine skepticism, assessment of arguments against vaccination, and the potential harmfulness of continuing SARS-CoV-2 vaccination when neurological disorders occurred in temporal relationship to the shot. The rating options on the Likert-style scale included: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; and 5, strongly agree.

Descriptive statistics (mean, SD) were calculated using Prism 8.0 (GraphPad Software).

Results

Nineteen of 21 Task Force members replied (91%). The mean age was 48.6 years (interquartile range = 43.4–53.8 years). Almost all respondents worked at university hospitals and were vaccinated against COVID-19 (Table 1). The most common fields of expertise were movement disorders (31.6%), stroke (15.8%), and MS (10.5%).

The encounter of vaccine hesitancy among individuals suffering from neurologic disease was frequent (84%). Autoimmune CNS and

PNS disorders, and MS were the most common diagnoses among people with neurologic disorders not willing to get vaccinated (Figure 1). In contrast, people with motor neuron disease, spinal cord injury, traumatic brain injury, and neuro-oncological diagnoses were less likely to face vaccination with skepticism.

The most important reasons for being hesitant to get vaccinated on the scale from 1 to 10 (1 indicating the most important reason) were the risk of worsening of the underlying neurological disease (mean = 1.6, SD = 1.3) and the fear of interference with genetics (2.9, SD = 1.5). On the other hand, the two least important reasons reported by the patients were the increased risk of infertility (7.6, SD = 2.8) and nonspecific reasons (8.3, SD = 1.8). Additional arguments against vaccination communicated by the patients are listed in Table 2.

All experts discussed the rationale for COVID-19 vaccination with their patients. As a result, more than one third of them were commonly or always able to convince them to get vaccinated (Table 1).

The frontrunners among the suggestions for increasing vaccination coverage were compulsory national vaccination strategies, information campaigns, uniformity among doctors, and trust in a patient–doctor relationship (Figure 2). The introduction of attenuated vaccines was not seen as a significant means to increase the vaccination rate.

Applying further vaccine shots in people with a history of SARS-CoV-2 vaccination-related neurological conditions was regarded as potentially more harmful for some conditions (Table 3). These included acute demyelinating conditions (neutral, 39%; agree, 39%) and sinus vein thrombosis (neutral, 28%; agree and strongly agree, 39%). The rating for another jab after COVID-19 vaccination-associated stroke was neutral for 33% but seen as harmful (34%) and not dangerous in about the same range (33%). No clear tendency could be derived for the other conditions. The respondents made no additional comments in the free text section.

TABLE 1 Demographic data of the participants

Characteristic	*n*	%
Male	11	57.9
Positive SARS-CoV-2 vaccination status	18	94.7
Working place		
University hospital	16	84.2
Urban hospital	1	5.3
Rural hospital	1	5.3
Other	1	5.3
Subspecialization in neurology		
Movement disorders	6	31.6
Stroke	3	15.8
Multiple sclerosis	2	10.5
Dementia	1	5.3
Epilepsy	1	5.3
Motor neuron disease	1	5.3
Neurocritical care	1	5.3
Neuroepidemiology	1	5.3
Neuroimmunology	1	5.3
Neuroinfections	1	5.3
N.A.	1	5.3
Were you able to convince people with chronic neurological disease to get vaccinated?		
Sometimes	12	63.2
Frequently	5	26.3
Always	2	10.5

Abbreviation: N.A., nonapplicable.

Discussion

Our study explored several aspects of COVID-19 vaccination hesitancy among people living with neurological disorders by interviewing their treating neurologists. These findings are unique, as the survey was conducted 1 year after approval of the SARS-CoV-2 vaccines, and we surveyed neurologists with expertise in subspecialties and COVID-19. In contrast, previous studies assessed patient

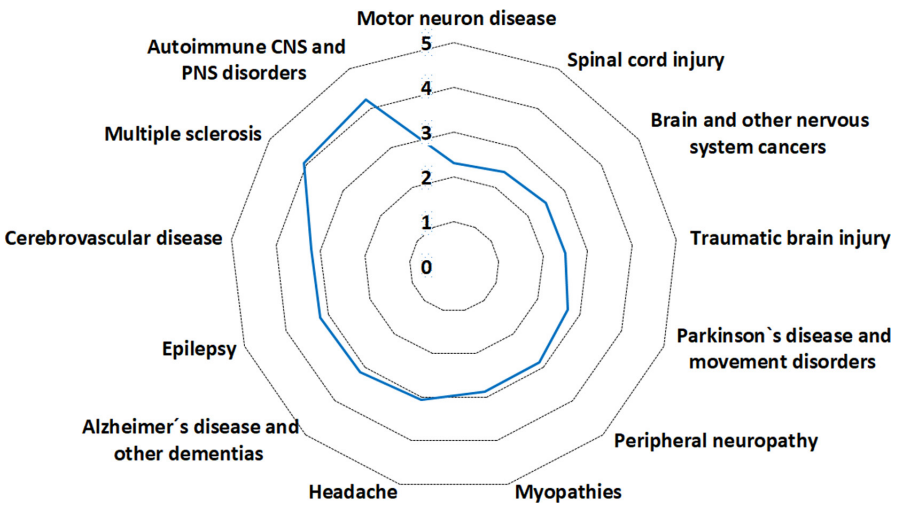

FIGURE 1 Neurological disorders and SARS-CoV-2 vaccine skepticism. The dots within the spider figures show the averaged scoring. Likert-style scale scoring: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. CNS, central nervous system; PNS, peripheral nervous system [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Top arguments against SARS-CoV-2 vaccination

Argument	*n*	Mean	SD	95% confidence interval of the difference	
				Lower	Upper
1. Chance of worsening of neurological disease	17	1.6	1.3	0.9	2.2
2. Higher rate of adverse reaction with chronic neurological disease	15	2.9	1.5	2.1	3.7
3. Interaction with medication for neurological disease	14	4.4	2.2	3.1	5.7
4. Possibility for breakthrough disease despite vaccination	14	4.9	2.5	3.5	6.4
5. Vaccine not tested in people with chronic neurological disease	15	5.8	2.6	4.3	7.3
6. Refusal of vaccination already prior to COVID-19	13	6.0	2.4	4.5	7.5
7. Prefer to wait for attenuated vaccines	13	6.5	2.4	5.1	8.0
8. Fear of interference with genetics	14	6.6	2.7	5.0	8.2
9. Increased risk for infertility	14	7.6	2.8	6.0	9.2
10. No specific reason	14	8.3	1.8	7.2	9.3

Note: Scoring system: 1, most important; 10, least important.

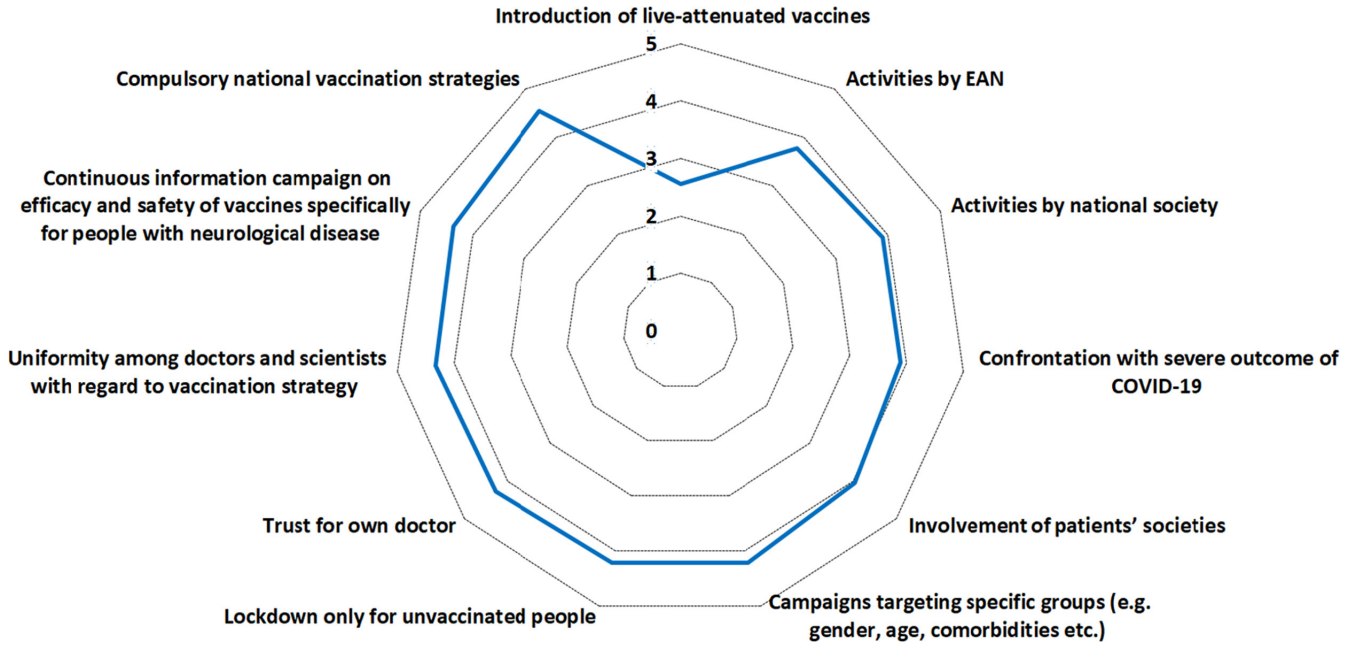

FIGURE 2 Ranking of reasonable interventions aimed at improving vaccine coverage. The dots within the spider figures show the averaged scoring. Likert-style scale scoring: 1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree. EAN, European Academy of Neurology [Colour figure can be viewed at wileyonlinelibrary.com]

motivation before market access and focused on single neurological subspecialties.

The investigation disclosed that SARS-CoV-2 vaccination skepticism is more frequent among individuals with autoimmune diseases of the nervous system. The prevailing argumentation brought forward includes the chance of worsening the neurological condition, the assumption of a higher rate of side effects, and the interaction of the vaccine with medication taken for the neurological disease. Interestingly, hesitancy because of fears of infertility and interference with genetics were not among the prevailing concerns. Although these arguments lack scientific evidence, such and other false information have been promoted by different interest groups and are a significant issue not only in lay discussions.

Moreover, the occurrence of cerebral venous sinus thrombosis or acute nervous system demyelination in timely association with

TABLE 3 Potential harmfulness of another SARS-CoV-2 vaccine shot in the case of prior neurological complications of SARS-CoV-2 vaccination

Adverse event	*n*	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
SARS-CoV-2 vaccination-related acute demyelinating event	18	0 (0%)	4 (22%)	7 (39%)	7 (39%)	0 (0%)
SARS-CoV-2 vaccination-related encephalitis, meningitis, myelitis	18	0 (0%)	6 (33%)	9 (50%)	3 (17%)	0 (0%)
SARS-CoV-2 vaccination-related Guillain–Barré syndrome	18	1 (6%)	6 (33%)	4 (22%)	6 (33%)	1 (6%)
SARS-CoV-2 vaccination-related Bell palsy	18	1 (6%)	5 (28%)	7 (39%)	5 (28%)	0 (0%)
SARS-CoV-2 vaccination-related sinus vein thrombosis	18	2 (11%)	4 (22%)	5 (28%)	4 (22%)	3 (17%)
SARS-CoV-2 vaccination-related stroke	18	2 (11%)	4 (22%)	6 (33%)	5 (28%)	1 (6%)

prior SARS-CoV-2 vaccination was regarded as a caveat for the administration of future SARS-CoV-2 jabs.

Our study also illustrates the importance of neurologists as advocates of public health measures. Some experts could mitigate vaccine skepticism, which might be even higher in individuals who already declined vaccines in the pre-COVID-19 era. This observation is corroborated by a study of Portuguese people living with MS, which found that the most hesitant patients would consider being vaccinated following their physicians' advice [59]. This role as an advocate also needs to be extended to nurses and other health care workers [60]. A stable, trusted doctor–patient relationship will be crucial for further strategies to improve vaccine coverage. In this regard, the experts proposed uniformity among doctors and scientists and targeted information campaigns on various levels. The latter requires special attention, as studies on vaccine information from governmental agencies and professional societies were more challenging to read than the information provided by antivaccination campaigners [61].

Of note, the confrontation with severe COVID-19 outcome, in analogy to antismoking campaigns, was not the frontrunner to mitigate vaccine hesitancy. However, the experts believe that this gentle approach via information campaigns needs to be expanded by more profound interference in citizens´ lives. Almost 90% suggested that vaccination should be compulsory and lockdown a necessary restriction for unvaccinated people. Notably, the responses mirror the course of the pandemic, the vaccination rates at the time of the data collection, and the availability of the different SARS-CoV-2 vaccine preparations. In the meantime, the highly contagious omicron variant of SARS-CoV-2 could lead to such a significant surge in herd immunity that some of the measures above may not be required during the further course of the pandemic [62].

In line with this, 39% of the experts agreed to the potential harmfulness of another vaccination shot in people with previous venous sinus thrombosis but also in the case of an acute demyelinating event of the nervous system. Further studies are mandatory to provide solid recommendations on this critical issue. Neurologists also need to maintain vigilance about side effects, as SARS-CoV-2 vaccines approved in the further course of the pandemic may have a different spectrum of neurological side effects. Moreover, rarer adverse events will be noticed only with an increasing number of individuals immunized. This diligent reporting led to rapid recognition and characterization of VITT-related complications.

This pilot study has limitations. The sample size is small and may be intrinsically biased toward doctors who promote vaccination. In addition, a majority of them work at tertiary care facilities. The members of the Task Force cover half of the European countries and major neurological fields [63,64]. However, experts in headache, sleep disorders, and neuro-oncology were missing.

CONSENSUS STATEMENT

This position paper reinforces the crucial role of neurologists as patient advocates and proposes a multifaceted strategy to overcome vaccine skepticism. Advocacy efforts aimed at raising the rate of vaccine coverage need to emphasize on the one hand the higher risk for an unfavorable course of SARS-CoV-2 infection in individuals with certain neurological comorbidities and immunosuppressive therapies. On the other hand, people with neurological conditions need to be aware of dramatic reductions in serious disease, hospitalization, and death with appropriate COVID-19 vaccination. The early scientific evidence for a lower chance of long COVID-19 in vaccinated individuals should serve as an additional argument to raise the willingness for vaccination and boostering. The knowledge that severe neurological and medical complications from immunization with SARS-CoV-2 vaccines are much rarer than with COVID-19 itself needs to be communicated simply and understandably [34]. Neurologists need to keep an eye on this vulnerable patient group, their concerns, and potential upcoming safety signals. The identification and quantification of vaccine side effects in postmarketing studies and safety databases remain of central importance. The EAN NeuroCOVID-19 Task Force calls for further research dedicated to the emerging phenomenon of COVID-19 vaccine hesitancy among people with neurological disorders. Taken together, neurologists need to argue in the interest of their patients about the overwhelming individual and global benefits of COVID-19 vaccination, as the willingness to

get additional vaccine shots in the further course of the pandemic will play a key role in preventing individual detrimental outcomes and in bringing a closer end to the pandemic.

CONFLICT OF INTEREST

E.M. reports personal fees from sources outside the submitted work. The other authors have no conflict of interest to report.

AUTHOR CONTRIBUTIONS

Martin Rakusa: Conceptualization (lead), data curation (lead), formal analysis (lead), investigation (lead), methodology (lead), project administration (lead), visualization (equal), writing–original draft (lead), writing–review & editing (equal). **Serefnur Öztürk:** Conceptualization (equal), formal analysis (equal), methodology (equal), writing–review & editing (equal). **Elena Moro:** Conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), project administration (equal), writing–review & editing (equal). **Raimund Helbok:** Formal analysis (equal), methodology (equal), writing–review & editing (equal). **Claudio L. Bassetti:** Project administration (equal), writing–review & editing (equal). **Ettore Beghi:** Project administration (equal), writing–review & editing (equal). **Daniel Bereczki:** Project administration (equal), writing–review & editing (equal). **Benedetta Bodini:** Project administration (equal), writing–review & editing (equal). **Giovanni Di Liberto:** Project administration (equal), writing–review & editing (equal). **Thomas M. Jenkins:** Project administration (equal), writing–review & editing (equal). **Antonella Macerollo:** Project administration (equal), writing–review & editing (equal). **Luis F. Maia:** Project administration (equal), writing–review & editing (equal). **Filippo Martinelli-Boneschi:** Project administration (equal), writing–review & editing (equal). **Antonio Pisani:** Project administration (equal), writing–review & editing (equal). **Alberto Priori:** Project administration (equal), writing–review & editing (equal). **Anna Sauerbier:** Project administration (equal), writing–review & editing (equal). **Riccardo Soffietti:** Project administration (equal), writing–review & editing (equal). **Pille Taba:** Project administration (equal), writing–review & editing (equal). **Tim J. von Oertzen:** Project administration (equal), writing–review & editing (equal). **Marialuisa Zedde:** Project administration (equal), writing–review & editing (equal). **Michael Crean:** Project administration (equal), resources (equal). **Anja Burlica:** Project administration (equal), resources (equal). **Francesco Cavallieri:** Conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), project administration (equal), writing–review & editing (equal). **Johann Sellner:** Conceptualization (lead), data curation (equal), formal analysis (lead), investigation (lead), methodology (lead), project administration (lead), resources (lead), supervision (lead), validation (equal), visualization (supporting), writing–original draft (lead), writing–review & editing (lead).

DATA AVAILABILITY STATEMENT

Raw data can be provided on reasonable request.

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