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COVID-19 Among Patients With Multiple Sclerosis

A Systematic Review

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Abstract

Objective

We systematically reviewed the literature on COVID-19 in patients with multiple sclerosis (MS).

Methods

We searched PubMed, Scopus, EMBASE, CINAHL, Web of Science, Google Scholar, and World Health Organization database from December 1, 2019, to December 18, 2020. Three conference abstract databases were also searched. We included any types of studies that reported characteristics of patients with MS with COVID-19.

Results

From an initial 2,679 publications and 3,138 conference abstracts, 87 studies (67 published articles and 20 abstracts) consisting of 4,310 patients with suspected/confirmed COVID-19 with MS met the inclusion criteria. The female/male ratio was 2.53:1, the mean (SD) age was 44.91 (4.31) years, the mean disease duration was 12.46 (2.27), the mean Expanded Disability Status Scale score was 2.54 (0.81), the relapsing/progressive ratio was 4.75:1, and 32.9% of patients had at least 1 comorbidity. The most common symptoms were fever (68.8%), followed by cough (63.9%), fatigue/asthenia (51.2%), and shortness of breath (39.5%). In total, 837 of 4,043 patients with MS with suspected/confirmed COVID-19 (20.7%) required hospitalization, and 130 of 4,310 (3.0%) died of COVID-19. Among suspected/confirmed patients, the highest hospitalization and mortality rates were in patients with no disease-modifying therapies (42.9% and 8.4%), followed by B cell–depleting agents (29.2% and 2.5%).

Conclusion

Our study suggested that MS did not significantly increase the mortality rate from COVID-19. These data should be interpreted with caution as patients with MS are more likely female and younger compared with the general population where age and male sex seem to be risk factors for worse disease outcome.

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Glossary

COVID-19 = coronavirus disease 2019; **DMT** = disease-modifying therapy; **EDSS** = Expanded Disability Status Scale; **MS** = multiple sclerosis; **PRISMA** = Preferred Reporting Items for Systematic Reviews and Meta-Analyses; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus 2; **WHO** = World Health Organization.

Multiple sclerosis (MS) is an inflammatory autoimmune disease of the CNS, which is a leading cause of disability in young adults. Most patients with MS are treated with immunomodulatory medications, which increase the risk of opportunistic infection, infection-related hospitalization, and infection-related mortality rates.[1-4]

The first case of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection (COVID-19) was identified in Wuhan, China, on December 2019. After a rapid spread in China, new outbreaks occurred around almost all countries in the world. In March 2020, the World Health Organization (WHO) declared the outbreak of COVID-19 disease as a pandemic.[5] As of December 22, 2020, a total of 75,129,306 confirmed cases and 1,680,794 fatalities were reported to the WHO worldwide.[6]

As coronavirus pandemic continues, a growing number of studies reported the clinical characteristics and outcomes of COVID-19 among patients with MS. However, there have been limited large observational studies investigating the symptoms, signs, complications, and outcome of COVID-19 in the MS population. The overall effects of COVID infection on MS and those on disease-modifying therapies (DMTs) remain unknown. To answer this question, we conducted this systematic review to bring together previous studies and provide an overall view of the published literature. The main goals of the current reviews are (1) to evaluate COVID infection outcomes in patients with MS (hospitalization/mortality), (2) to evaluate the effects of DMTs on these outcomes, and (3) to determine the clinical features and presentation of COVID-19 in patients with MS.

Methods

Literature Search

A comprehensive literature search was performed in PubMed, Scopus, EMBASE, CINAHL, Web of Science, Google Scholar, and WHO COVID-19 database. We screened the studies, which were published between December 1, 2019, and December 18, 2020. The following search strategy was adapted: ((coronavirus OR Wuhan coronavirus OR novel coronavirus OR coronavirus disease OR COVID-19 OR 2019 novel coronavirus infection OR 2019-nCOV OR severe acute respiratory syndrome coronavirus 2 OR SARS-CoV-2) AND (Multiple Sclerosis OR (Sclerosis, Multiple) OR (Sclerosis, Disseminated) OR Disseminated Sclerosis OR (Multiple Sclerosis, Acute Fulminating))). To identify potentially eligible studies that have not yet been published in full, we also searched abstracts available online from the following scientific meetings: Eighth American and European Committee for Treatment and Research in Multiple Sclerosis (ACTRIMS-ECTRIMS 2020), 145th Annual Meeting American Neurological Association, and Sixth Congress of the European Academy of Neurology. Furthermore, we screened the reference lists of identified articles for inclusion in the study.

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: (1) any type of studies including letters, case report, case series, cross-sectional, case-control, and cohort that reported COVID-19 among patients with MS and (2) written in English. The exclusion criteria were as follows: (1) not reporting outcome of patients with suspected or confirmed COVID-19, (2) preprint articles, (3) reviews, animal studies, hypothesis, and in vitro studies, and (4) articles reporting patients with Middle East respiratory syndrome–related coronavirus and SARS-CoV.

Study Selection

Two authors (M.B. and O.M.) independently screened, retrieved, and excluded reports. The reviewers screened the title and abstract of all retrieved articles. Both reviewers inspected the full text of all potential articles. Any disagreement over inclusion or exclusion of studies was resolved through feedback from a third reviewer (A.A.-S.).

Data Extraction

Data extraction was conducted by 2 reviewers (M.B. and S.V.) separately. The data were extracted from eligible articles including fist author's name, first publication date, location of study, type of study, number of patients with confirmed/suspected COVID-19, number of patients with positive PCR test, age, sex, Expanded Disability Status Scale (EDSS) score, disease duration, course of disease (relapsing-remitting MS, secondary progressive MS, primary progressive MS, and clinically isolated syndrome), DMT exposure, comorbidity (cardiovascular disease, diabetes mellitus, hypertension, chronic pulmonary diseases, malignancy, smoking status, obesity, and others), symptoms of COVID-19, and infection outcome (number of patients who hospitalized/number of death). This study was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.

Quality Assessment

Two reviewers (M.B. and N.N.) independently rated the quality of studies using the Newcastle-Ottawa Scale quality assessments.[7] Based on studies design, different tools were

used. Any disagreements were resolved by the senior reviewer (M.G.H.).

Outcomes

The primary outcome of the study was the assessment of clinical characteristics of COVID-19 among patients with MS. The secondary outcomes included assessment of hospitalization risk factors and proportion of patients required hospitalization, mortality rate, and relation to specific DMTs.

Data Presentation

We used descriptive analysis to report the results. Descriptive statistics were reported as mean ± SD for continuous variables and frequency (%) for categorical variables. Aggregated data were weighted by the number of patients and then combined with individual data. The proportion of patients with MS hospitalized and death among patients with suspected/confirmed COVID-19 with MS that reported in included studies were measured.

Results

Search Result

The PRISMA flowchart is shown in figure 1. A total of 2,679 articles were initially identified. After removal of duplicates, 2,175 articles remained. In the end, 67 published articles consisting of 1,739 suspected/confirmed patients met the inclusion criteria. Among 3,138 conference abstracts, a total of 20 abstracts reporting 2,571 patients with MS with suspected/confirmed COVID-19 were eligible for inclusion in the review. Totally, 87 studies consisting of 4,310 patients across 16 countries were included in our systematic review (figure e-1, links.lww.com/NXI/A476). The quality of evidence for each article is documented in table e-1 in appendix e-1.

Study Characteristics

The characteristics of each study are presented in table e-2, links.lww.com/NXI/A476. In terms of study design, 48 (45 published articles and 3 abstracts) studies were case reports/series,[8,9,e12-e54,e62-e64] 4 (2 articles and 2 abstracts) were pharmacovigilance case series,[10,11,e10,e11] 18 (13 articles and 5 abstracts) were cross-sectional,[12-18,e2-e9,e59-e61] and 17 (7 articles and 10 abstracts) were cohort studies.[19-30,e1,e55-e58] Demographic and clinical characteristics of COVID-19 infection in patients are presented in table 1 and table e-3 in appendix e-1.

Presentation of COVID-19 in Patients With MS

The main clinical characteristics of COVID-19 among patients with MS were fever (68.8%), cough (63.9%), fatigue/asthenia (51.2%), shortness of breath (39.5%), headache

Figure 1 Flowchart of the Study

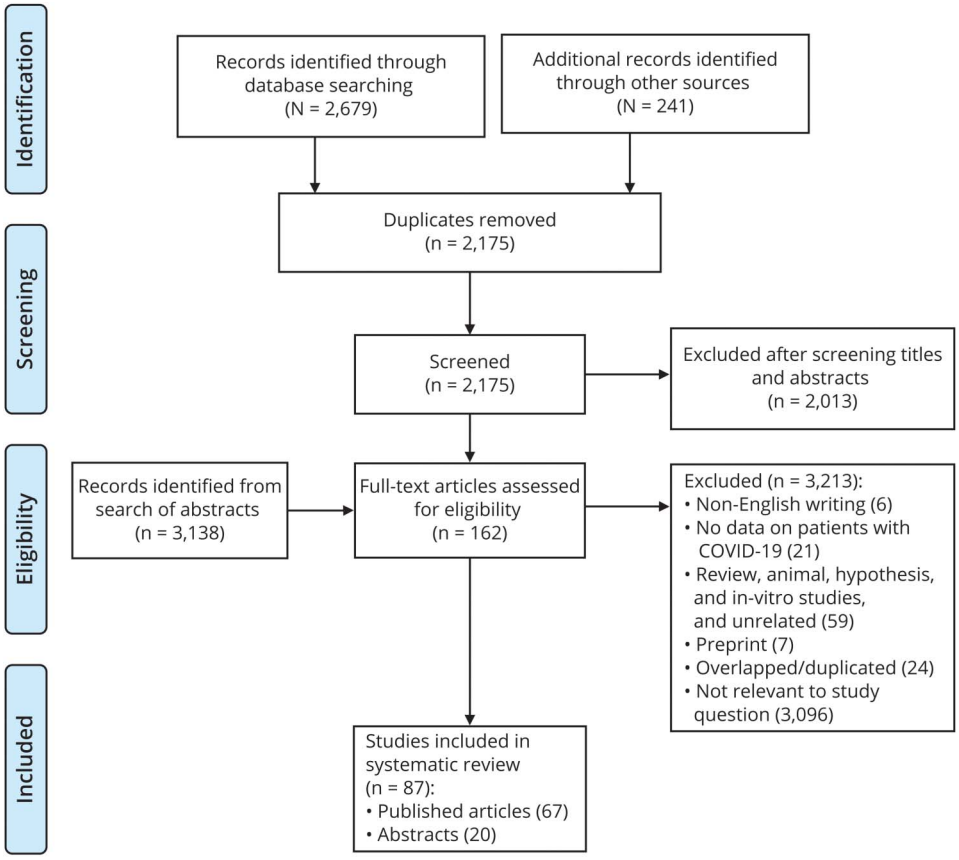

Table 1 Demographic and Clinical Characteristics of COVID-19 Infection in Patients With MS

Characteristics	N (%) or mean (SD)	No. of patients	Study reporting characteristics
Age	44.91 (4.31)	3,249	79
Sex, female/male	2,738/1,084 (2.53:1)	3,860	82
Disease duration	12.46 (2.27)	2,479	56
EDSS score	2.54 (0.81)	1,365	50
Course of MS			
Relapsing	1,241 (77.6)	1,599	57
progressive	261 (16.3)		
CIS	10 (0.6)		
Comorbidity			
Patients with any comorbidity	299 (32.9)	910	44
HTN	357 (22.0)	1,621	44
CAD	107 (6.6)		
DM	193 (11.9)		
Malignancy	124 (7.6)		
Lung disease	168 (10.4)		
Symptoms			
Fever	645 (68.8)	937	59
Cough	599 (63.9)	937	59
Fatigue/asthenia	438 (51.2)	855	57
Shortness of breath	363 (39.5)	919	59
Headache	288 (34.4)	836	58
GI complication	148 (16.4)	902	58
Anosmia[a]	78 (16.2)	480	56
Ageusia[a]	51 (10.6)	480	56
Asymptomatic	70 (5.3%)	1,312	64
DMTs			
B cell–depleting agents	510 (21.9)	2,325	80
Dimethyl fumarate	276 (11.9)		
Fingolimod	219 (9.4)		
Natalizumab	212 (9.1)		
Glatiramer acetate	127 (5.5)		
Interferon	277 (11.9)		
Teriflunomide	137 (5.9)		
Cladribine	98 (4.2)		
Alemtuzumab	40 (1.7)		
No DMT	312 (13.4)		

Continued

Table 1 Demographic and Clinical Characteristics of COVID-19 Infection in Patients With MS *(continued)*

Characteristics	N (%) or mean (SD)	No. of patients	Study reporting characteristics
PCR positive test	763 (35.1)	2,173	69
Hospitalized	837 (20.7)	4,043	83
Death	130 (3.0)	4,310	87

Abbreviations: CAD = cardiovascular disease; CIS = clinically isolated syndrome; COVID-19 = coronavirus disease; DM = diabetes mellitus; DMT = disease-modifying therapy; EDSS = Expanded Disability Status Scale; GI = gastrointestinal; HT = hypertension; MS = multiple sclerosis.
[a] We excluded studies that reported the combined prevalence of anosmia and ageusia.

(34.4%), and gastrointestinal complication (16.4%). Anosmia and ageusia were reported by 16.2% and 10.6% of patients, respectively. In total, only 70 asymptomatic patients with MS (of 1,312 cases; 5.3%) have been reported.

COVID Infection Outcomes in Patients With MS

The proportion of patients hospitalized to all suspected/confirmed cases was 20.7% (837 of 4,043 patients). Three published articles provided information on hospitalization risk factors.[19-21] In these studies, hospitalization was more common among patients with older age, progressive course, and higher disability. Moreover, male sex,[20,21] comorbidity,[20,21] and obesity[19,20] were more frequently present among hospitalized patients.

In total, 130 patients with MS (3.0% of all suspected/confirmed COVID-19 cases) died of COVID-19. The included articles and conference abstracts reported mortality rate of 2.2% (39 of 1,739 patients)[8,9,12,14-16,19-22,24] and 3.5% (91 of 2,571 cases),[10,11,17,18,25-30] respectively. The demographic and clinical characteristics of these patients are presented in table 2.

Effects of DMTs on COVID Infection Outcomes in Patients With MS

The most frequently used DMTs was B cell–depleting therapies (rituximab and ocrelizumab) in the entire cohort, followed by interferons, dimethyl fumarate, and fingolimod (table 1). The frequency of hospitalization in patients receiving B cell–depleting agents was 29.2% (117/400), 20.6% (13/63) in teriflunomide, 14.7% (18/122) in fingolimod, 14.5% (9/62) in glatiramer acetate, 13.9% (15/108) in dimethyl fumarate, 13.0% (10/77) in cladribine, 11.1% (2/18) in alemtuzumab, 11.0 (18/164) in interferon, and 10.1% (11/109) in natalizumab. Patients with no treatment had hospitalization rate of 42.9% (48/112).

The mortality rate among suspected/confirmed patients receiving B-cell depleting agents was 2.5% (12/488), 1.7% (4/241) in interferons, 1.6% (2/127) in teriflunomide, 1.1% (2/189) in natalizumab, 0.8% (1/117) in glatiramer acetate, 0.5% (1/192) in fingolimod, and 8.4% (24/285) in those on no DMT. Among patients who died of COVID-19 infection with their medication reported, no patients were on cladribine or alemtuzumab. The outcome of COVID-19 according to DMT class was summarized in table e-4, links.lww.com/NXI/A476.

Discussion

The aim of the current study was to determine the characteristics and outcome of COVID-19 infection in patients with MS. In this review, all studies in the literature, which assessed COVID-19 among MS that met the review criteria, were included. In total, our study consisted of 87 studies including 4,310 patients with MS with suspected/confirmed COVID-19 infection.

The frequency of asymptomatic individuals in the general population is estimated up to 45% of all infected cases.[31] The low percentage (5.3%) of asymptomatic COVID-19 among patients with MS compared with the general population could be attributed to the fact that there are limited studies that have tested MS cohorts for antibodies to determine the rates of asymptomatic infection in this population. In total, 837 of 4,043 patients with MS with suspected/confirmed COVID-19 (20.7%) required hospitalization. The rate of hospitalization among patients with COVID-19 varies with age, sex, and presence of comorbidities.[32-35] It is estimated that 1% of individuals younger than 20 years to about 20% of those aged 70 years or older would need hospitalization.[32] Hospitalization rates also vary according to the location of the study, race, and phase of pandemic ranging from 2.9 to 30% of all COVID-19 cases.[36-38] It seems that the hospitalization rates in patients with MS fall in the reported range for the general population; however, this has to be interpreted with caution as the demographic characteristics of patients with MS are generally younger and more female predominant than the general population, which should automatically put this cohort of patients at lower risks of hospitalization. Further studies are required to report outcomes after adjustment for variables that increase the rate of hospitalization in general population (e.g., age, sex, and race).

Among the included studies, 3 articles evaluated risk factors of hospitalization due to COVID-19 infection among the MS population.[19-21] Older age, male sex, and having at least 1

Table 2 Characteristics of Patients Who Died of COVID-19

Case no.	Age	Sex	Course of disease	EDSS score	Disease duration	Comorbidity	DMT	Reference
1	63	M	SPMS	6.5	33	Diabetes	None	[12]
2	67	M	PPMS	7.5	2	CHD, diabetes, and HBV	None	[12]
3	68	M	SPMS	6	21	CVD, HTN, depression, and TBC	DMF	[12]
4	82	M	SPMS	6.5	33	Diabetes and BPD	None	[12]
5	54	F	SPMS	7	20	None	RTX	[12]
6	50s	M	RRMS	1.5	23	Overweight	None	[20]
7	30s	F	RRMS	3	5	Obesity	TFL	[20]
8	50s	M	RRMS	3	5	Schizophrenia and obesity	DMF	[20]
9	70s	NR	RRMS	5	47	None	None	[20]
10	50s	M	PPMS	7	22	None	RTX	[20]
11	60s		SPMS	7.5	25	None	None	[20]
12	80s	NR	SPMS	8	51	Chronic myelomonocytic leukemia	None	[20]
13	60s	NR	SPMS	8.5	28	IHD and bronchial obstructive pulmonary disease	None	[20]
14	80s	NR	PPMS	8.5	22	None	None	[20]
15	60s	NR	SPMS	9	48	Colorectal cancer	None	[20]
16	70s	NR	SPMS	9	35	HTN	None	[20]
17	40s	M	SPMS	9.5	28	None	None	[20]
18	42	M	RRMS	NR	18	Hodgkin lymphoma and ITB	RTX	[19]
19	50	F	RRMS	NR	13	HTN, obesity, and hypothyroid	None	[19]
20	60	F	RRMS	NR	19	CAD, HTN, and obesity	Natalizumab	[19]
21	65	F	SPMS	NR	31	ITB and neurologic bladder with indwelling Foley	None	[19]
22	66	M	SPMS	NR	33	Remote history of testicular and prostate cancer and ITB	OCR	[19]
23	71	M	SPMS	NR	30	VTE and obesity	GA	[19]
24	55	F	SPMS	7.5	NR	Myotonic dystrophy	TFL	[8]
25	74	M	SPMS	8.5	NR	CAD, HTN, DM, COPD, and cardiomyopathy	None	[8]
26	43	F	SPMS	6.5	18	Hypothyroid	RTX	[14]
27	59	M	PPMS	4	NR	Obesity	None	[21]
28	57	M	PPMS	7.0	NR	Asthma and HTN	None	[21]
29	59	M	SPMS	5.5	NR	COPD	OCR	[21]
30	42	F	RRMS	6.0	NR	Severe cognitive impairment	Fingolimod	[21]
31	NR	NR	NR	NR	NR	Sjogren syndrome and hypothyroidism	RTX	[16]
32	NR	NR	NR	NR	NR	Morbid obesity	RTX	[16]
33	74	M	SPMS	7.0	NR	NR	None	[15]
34	51	F	RRMS	6.5	14	Obesity, HTN, and rUTI	Natalizumab	[9]
35[a]	76	M	NR	NR	NR	NR	IFN	[10]
36[a]	57	F	SPMS	9.0	18	NR	None	[25]

Continued

Table 2 Characteristics of Patients Who Died of COVID-19 *(continued)*

Case no.	Age	Sex	Course of disease	EDSS score	Disease duration	Comorbidity	DMT	Reference
37[a]	53	M	SPMS	9.0	Unknown	NR	None	[25]
38[a]	48	M	SPMS	4.0	3	NR	RTX	[25]
39[a]	61	M	SPMS	7.5	27	NR	None	[25]
40[a]	55	M	SPMS	8.0	18	NR	None	[25]
41[a]	68	NR	Progressive	4.5	NR	Having comorbidity	None	[26]
42[a]	68	NR	Progressive	8.5	NR	Having comorbidity	None	[26]
43[a]	42	NR	NR	NR	NR	NR	IFN	[11]
44[a]	49	NR	NR	NR	NR	NR	IFN	[11]

Abbreviations: BPD = borderline personality disorder; CAD = cardiovascular disease; CIS = clinically isolated syndrome; COPD = chronic obstructive pulmonary disease; COVID-19 = coronavirus disease; CP = cyclophosphamide; CVD = cerebrovascular disease; DM = diabetes mellitus; DMF = dimethyl fumarate; DMT = disease-modifying therapy; EDSS = Expanded Disability Status Scale; GA = glatiramer acetate; HT = hypertension; IFN = interferon; IHD = ischemic heart disease; ITB = intrathecal baclofen pump; MMF = mycophenolate mofetil; MTX = methotrexate; NR = not reported (information not available); OCR = ocrelizumab; PPMS; primary progressive multiple sclerosis; RIS = radiologically isolated syndrome; RRMS = relapsing-remitting multiple sclerosis; RTX = rituximab; rUTI = recurrent urinary tract infection; SPMS = secondary progressive multiple sclerosis; TFL = teriflunomide; VTE = venous thromboembolism.
[a] Abstract data.

comorbidity were independently associated with hospitalization among patients with MS, which are similar to risk factors observed in the general population.[32-35] Patients with more disability as measured by the EDSS were at a higher risk of severe COVID-19 infection.[20]

The COVID-19 mortality rate among all suspected and confirmed cases with MS was 3.0%. The WHO reports that as of 22 December 2020, a total of 2.2% patients died of COVID-19 worldwide.[6] The overall mortality rate of COVID-19 also differs between different countries, 1.8% in the United States, 2.2% in Europe, 4.6% in Iran, 2.6 in Brazil, and 2.8% in Chile.[6] The mortality rate is less than 1% in individuals aged 20–60 years and increases exponentially (more than 10%) after 60 years.[39-42] Of 42 patients with MS who died of COVID-19, 8 (19.1%) were younger than 50 years and 21 (50.0%) patients were older than 60 years. Fortunately, the overall mortality rates in the MS cohort remain low at 3.0% in general, but these rates are not adjusted for age, sex, and presence of comorbidities.

There is a significant concern about the impact of different DMTs on susceptibility and outcome of patients with MS with COVID-19. Several guidelines and recommendations from expert groups have been published.[43-46] General agreement exists that treatment of patients with MS with interferon and glatiramer acetate does not increase the risk of severe COVID-19, and interferon preparations may be even protective. There is concern that higher-efficacy medications including S1P modulators, B cell–depleting therapies, alemtuzumab, and cladribine may increase the risk of severe COVID-19 in patients with MS. In a study investigating outcome of COVID-19 among French patients with MS, DMT use was not independently associated with COVID-19 severity.[20] This was further supported by a study from New York, which showed no difference between hospitalized and non-hospitalized groups in the terms of DMT exposure.[19] Moreover, it has been suggested that B-cell depletion agents, particularly rituximab,[13,16] and cladribine/alemtuzumab[23] may increase the risk of susceptibility to COVID-19. Evangelou et al.[47] showed that patients with high efficacy therapies were less likely to have COVID-19 compared with those with no DMT.

After pooling all patients and calculating the hospitalization and mortality rates for each DMT, the highest hospitalization rate was in patients with no DMT (42.9%), followed by B cell–depleting agents (29.2%), teriflunomide (20.6%), and fingolimod (14.7%). The highest mortality rate was in patients with no DMTs (8.4%), followed by B-cell depletion agents (2.5%), interferon (1.7%), teriflunomide (1.6%), and natalizumab (1.1%). Although it may appear that patients on no DMTs have higher mortality and hospitalization rates, however, this is confounded by the general practice that older patients or those with advanced terminal stages of MS are usually not treated with DMT as the risk outweighs the benefit in this group of patients. The hospitalization and mortality rates among patients receiving B cell depleting are 2 times higher than other DMTs. However, given prior reports of potential increased risk of COVID-19 in patients treated with B-cell therapies, the high hospitalization and mortality rates in this group should be studied in more details. It could be argued that high hospitalization rate of teriflunomide may be due to small number of reported patients. The hospitalization and mortality rates of DMTs therefore need to be interpreted with caution. Almost all patients with MS who died of COVID-19 were at high risk for developing severe COVID-19 because of age, comorbidity, or severe MS

disability. Taken together, based on the current literature and small number of fatalities, it seems that MS may not dramatically increase the mortality rate from COVID-19.

Diagnosis of COVID-19 in 763 (of 2,173) patients with MS (35.1%) was confirmed by PCR; however we cannot determine the seropositivity among patients with MS because most suspected patients were not tested for the presence of antibodies. There are some similarities and differences between clinical features of COVID-19 reported by studies on MS and those described among the general population.[48,49] Fever was the most common symptoms among patients with MS and the general population.[48-50] The prevalence of cough, shortness of breath/dyspnea in 63% and 39.5% among infected patients with MS with COVID-19 is broadly similar to those identified in other studies on the general population.[51] The pooled incidence of fatigue among all patients with COVID-19 is reported to be 46%,[49,51] which is lower than of 51.2% reported in patients with MS. This difference may be explained by the fact that fatigue is one of the most common symptoms among patients with MS, and nearly 75% of the patients report fatigue during the disease and infections could worsen this symptom.[52]

Our study has several limitations. First, a meta-analysis was not possible due to heterogeneity of studies. Second, it has been suggested that a significant proportion of individuals developed asymptomatic and mild COVID-19, but most patients in this study are symptomatic or admitted to a hospital. Although it remains unknown what percentage of patients with MS develop asymptomatic infection, it is possible that severe COVID-19 is overrepresented in the published literature, and the findings could not be extrapolated to the whole MS population. Third, most of the studies included are case reports/series or based on a small sample of participants. Fourth, without large multicentric studies and results from local and global COVID-19 data data sets,[53] the effect of DMTs on susceptibility and severity of COVID-19 remains unknown. Fifth, articles not published in English and not report clinical information of patients with COVID-19 were excluded, so some studies on the subject may not have been identified. Sixth, we cannot ascertain the incidence of COVID-19 among patients with MS. Population-based studies are needed to determine the true incidence of COVID-19 among patients with MS. Seventh, conference abstracts included inadequate data, and the validity of the results is questionable without proper peer review. However, inclusion of abstracts minimizes publication bias and provides more data that were not available in published format at the time of publication of this work.

In conclusion, our systematic review comprehensively detailed the demographic and clinical characteristics of patients with MS with COVID-19 published to date. Fortunately, the severity and mortality from COVID-19 in patients with MS does not seem to be significantly higher than the general population. However, further larger studies are needed to study this topic closer with adjustments for COVID-19 risk factors. Use of DMTs seems to be generally safe with no significant increased risk of poor COVID-19 outcomes; however, there may be a signal for B cell–depleting therapies slightly worsening COVID-19 infection.

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Saeed Vaheb	Department of Neurology, School of Medicine, Isfahan University of Medical Sciences, Iran	Major role in the acquisition of data; analysis or interpretation of data; additional contributions: revised the manuscript for intellectual content

Appendix *(continued)*

Name	Location	Contribution
Vahid Shaygannejad, MD	Department of Neurology, School of Medicine, Isfahan University of Medical Sciences, Iran	Major role in the acquisition of data; study concept or design; analysis or interpretation of data; additional contributions: revised the manuscript for intellectual content
Amir-Hadi Maghzi, MD	Ann Romney Center for Neurologic Diseases, Brigham and Women's Hospital, Harvard Medical School, Boston, MA	Drafting/revision of the manuscript for content, including medical writing for content; study concept or design; and analysis or interpretation of data

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CORRECTION

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In the Views and Reviews article "COVID-19 Among Patients With Multiple Sclerosis: A Systematic Review" by Barzegar et al.,[1] the third author should be listed as "Mahsa Ghajarzadeh." The authors regret the error.

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