Healthcare disruptions and use of telehealth services among persons with multiple sclerosis during the COVID-19 pandemic

Michelle H. Chen, PhD[1,2], Yael Goverover, PhD[5], Amanda Botticello, PhD [3,4], John DeLuca, PhD [3,4], Helen M. Genova, PhD [3,4]*

1. Institute for Health, Health Care Policy and Aging Research, Rutgers University, New Brunswick, NJ
2. Department of Neurology, Robert Wood Johnson Medical School, Rutgers University, New Brunswick, NJ
3. Kessler Foundation, East Hanover, NJ
4. Department of Physical Medicine and Rehabilitation, New Jersey Medical School, Rutgers University, Newark, NJ
5. Department of Occupational Therapy, Steinhardt School of Culture, Education, and Human Development, New York University, NY

*Correspondence: Helen M. Genova; hgenova@kesslerfoundation.org; 120 Eagle Rock Avenue, Suite 100, East Hanover, NJ 07936-3147; Phone: (973) 324-8390; Fax: (973) 386-1361

Institution where study was performed: Kessler Foundation, East Hanover, NJ

Funding Sources: The preparation of this manuscript was supported in part by a National Multiple Sclerosis Society (NMSS) Grant MB-1606-08779 to Dr. John DeLuca and Kessler Foundation.

Conflict of interest: Dr. John DeLuca receives grant funding from Biogen and consulting and speaking fees from Novartis, Roche, and Celgene. He also participates on the advisory boards of Novartis and Celgene. However, these entities did not have any involvement with the current manuscript. All other authors declare no conflict of interest.

Healthcare disruptions and use of telehealth services among persons with multiple sclerosis during the COVID-19 pandemic

Objective: The current study examined healthcare disruptions and use of telehealth services among persons with multiple sclerosis (pwMS) during the coronavirus disease 2019 (COVID-19) pandemic.

Design: Cross-sectional survey.

Setting: General community.

Participants: Seventy pwMS and 93 healthy controls (HCs). The majority of respondents were from the United States (U.S.; 88%).

Interventions: Not applicable.

Main Outcome Measure(s): Rates of healthcare disruptions (e.g., missing/canceling appointments, experiencing delays) and telehealth use for MS and non-MS medical care and mental healthcare.

Results: In this U.S.-majority, predominantly white and high socioeconomic status sample, 38-50% of pwMS reported experiencing disruptions in their MS and non-MS medical care and 20-33% reported disruptions in their mental healthcare, which were significantly lower than those observed among HCs. Compared to HCs, pwMS were more likely to utilize telehealth than in-person services, especially for mental healthcare. The majority of pwMS and HCs reported being satisfied with telehealth services. Individuals with higher degrees of functional limitation experienced more healthcare disruptions and were more likely to utilize telehealth services than individuals with lower degrees of functional limitation.

Conclusions: Despite high healthcare disruption rates, pwMS frequently utilized and were highly satisfied with telehealth services during the COVID-19 pandemic. Due to physical limitations commonly observed in the MS population which may preclude travel, telehealth services should be continued even after resolution of the pandemic, in order to expand access and reduce healthcare disparities.

Key Words: COVID-19; Multiple Sclerosis; Telehealth; Telemedicine; Healthcare

Abbreviations: MS: multiple sclerosis. pwMS: persons with MS. COVID-19: coronavirus disease 2019. HC: healthy controls. REDCap: Research Electronic Data Capture. USA: United States of America.

To mitigate the transmission of the SARS-CoV-2 virus which causes the coronavirus disease 2019 (COVID-19), many public spaces temporarily shut down or limited access. This significantly disrupted in-person healthcare access and delivery (e.g., canceled appointments, delays). Multiple sclerosis (MS) is a chronic and progressive neurological disorder and is the leading cause of non-traumatic disability among young and middle-aged adults.[1] Persons with MS (pwMS) need routine follow-up visits with their neurologists and are more likely to have medical and mental health comorbidities which would require additional care.[2,3] Therefore, the COVID-19 pandemic may have a greater impact on healthcare for pwMS compared to their healthy counterparts. Indeed, extant research has identified significant reductions in outpatient services after March 2020 compared to the same period in the previous year, including neurology and non-neurology visits, magnetic resonance imaging (MRI) and laboratory tests, and rehabilitation services.[4-9] Many MS providers have changed the way they prescribed disease-modifying therapies,[7,8] due to concerns of safety in relation to COVID-19 (e.g., anti-CD20 therapies).[10] PwMS reported being anxious about their disease-modifying therapy regimen (some stopped them altogether), missing hospital appointments, or not going to the hospital when they had a relapse.[9,11] While informative, these studies did not include a reference group, making it difficult to determine if rates of healthcare disruption was disproportionately affected in the MS population. Another limitation of these studies is the narrow focus on services directly related to MS care, which does not encompass other types of care pwMS may receive due to medical and mental health comorbidities. The current study will address these limitations by including a healthy control (HC) group and delineating among different types of healthcare received.

To minimize unnecessary exposure, telehealth appointments were viable and, in some cases, necessary alternatives to in-person visits. Both pwMS and MS providers reported increased use of

telehealth services during the COVID-19 pandemic.[5,7,8,12] However, telehealth access and use may depend on social determinants of health such as demographic and disease variables (e.g., socioeconomic status, level of functional limitation). There is research suggesting that social determinants of health have had an impact on healthcare during the COVID-19 pandemic.[13,14] Black Americans were more likely to experience healthcare disruptions[14] and less likely to use telehealth services compared to white Americans during the COVID-19 pandemic.[13] In MS research, Moss et al. (2020) found that pwMS who experienced disruptions in their rehabilitation and homecare services were more likely to be older, have a progressive disease course, use walking aids, and have more comorbidities.[4]

The current study examined healthcare disruption and telehealth use among pwMS and HCs during the COVID-19 pandemic. The impact of MS disease variables, social determinants of health, and psychological distress from COVID-19 were also evaluated. Better understanding of how the pandemic has affected the healthcare landscape among pwMS will help inform optimal healthcare policy for this population.

Methods

Participants

The current study was part of a larger cross-sectional investigation of the impact of the COVID-19 on adults with MS, traumatic brain injuries, and strokes. Participants were recruited through word of mouth and online advertisements. The current study only included data of the MS and HC groups. Inclusion criteria included self-reported diagnosis of MS (or no neurological diagnoses for the HC group) and age of 18 years or older. Exclusion criteria included neurologic diagnoses other than MS or diagnoses of serious mental illnesses (e.g., schizophrenia, bipolar disorder). The study was approved by the local Institutional Review Board. All participants provided informed consent via Research Electronic Data Capture (REDCap) tools.[15,16]

Procedures and Measures

The study consisted of an online survey administered through REDCap remotely. Data collection occurred between September and October, 2020. The current study focused on a subset of questions related to demographics, medical history, COVID-19 exposure and stressors, and healthcare utilization. Besides demographics and MS medical history, all questions used in this study were adapted from the *COVID-19: Impact of the Pandemic and HRQOL in Cancer Patients and Survivors* scale.[17] Questions related to cancer were modified to refer to MS. For healthcare questions, we expanded the questions to include MS care, care for a major medical condition, general medical care, and mental healthcare. Refer to Table S1 for details on these questions. While we focused on healthcare utilization in the current manuscript, we also published another paper on changes in occupations of daily living among pwMS during the pandemic.[18]

Statistical Analysis

All data analyses were conducted using R version 4.0.3.[19] Group differences were analyzed using Welch's two samples t tests for continuous variables, Pearson's chi-squared tests for nominal variables, and Wilcoxon rank-sum test for ordinal variables. For healthcare utilization, between-group differences were analyzed by Pearson's chi-squared tests, and within-subject differences (in-person vs. telehealth) were examined using McNemar's tests. For sake of parsimony, major and general medical care were combined into non-MS medical care given no significant differences between these healthcare categories. For chi-squared tests containing cells with expected frequency of less than five, Fisher's exact tests for count data were used. If respondents checked off "prefer not to answer" or "don't know" (which was <5% of overall data), these responses were designated as missing values in statistical analyses. Because healthcare access and shutdown policies may differ by country, we also examined rates of healthcare utilization among only respondents from the U.S. in a sensitivity analysis.

To identify predictors of healthcare disruption and telehealth use, binary variables were created to represent whether an individual experienced healthcare disruptions or used telehealth services. Many of the categorical variables contained categories with limited endorsement, so they were dichotomized for

analyses (see Table S2 for more details). The MS and HC groups were combined in these analyses, except for MS disease characteristics. We also conducted sensitivity analyses with only the MS sample to ensure generalizability. A threshold of $p < 0.05$ was used to determine statistical significance in all analyses.

Results

Demographic and MS Disease characteristics

A total of 70 pwMS and 93 HCs were included in this study. Table 1 summarizes demographic and MS disease characteristics. A significantly higher proportion of pwMS reported being unemployed due to a disability than HCs (31% in MS vs. 1% in HC; $\chi^2(1) = 30.36$, $p < 0.001$). The HC group reported significantly higher household incomes than the MS group (median income: \$50,000-\$74,000 in MS vs. > \$75,000 in HC; $W = 3209$, $p = 0.004$). The MS group reported higher rates of comorbidities including major medical problems other than MS (30% in MS vs. 4% in HC; $\chi^2(1) = 20.75$, $p < 0.001$), depression (46% in MS vs. 13% in HC; $\chi^2(1) = 21.82$, $p < 0.001$), and anxiety (34% in MS vs. 14% in HC; $\chi^2(1) = 9.39$, $p = 0.002$). The majority of the sample was from the U.S.

COVID-19 Exposure and Stressors

Table 2 summarizes COVID-19 exposure and stressors among the MS and HC groups. Significantly more HCs reported known exposure to someone with COVID-19 (7% in MS vs. 23% in HC; $\chi^2(1) = 7.28$, $p = 0.007$) or being tested for COVID-19 (26% in MS vs. 41% in HC; $\chi^2(1) = 4.27$, $p = 0.039$), relative to pwMS. A higher proportion of the HC group had a friend, co-worker, or neighbor who was diagnosed with COVID-19 compared to the MS group (37% in MS vs. 60% in HC; $\chi^2(1) = 8.95$, $p = 0.003$).

Healthcare Disruption and Telehealth Use

Table 3 summarizes rates of healthcare disruption and telehealth utilization during the COVID-19 pandemic. Thirty-eight to 50% of pwMS experienced a disruption (i.e., missing/canceling an appointment,

experiencing a delay) in their MS and non-MS medical care. Sixty-six percent of HCs experienced a disruption in their medical care, which was significantly higher than pwMS ($\chi^2(1) = 12.16$, $p < 0.001$ for missing/canceling appointments; $\chi^2(1) = 3.89$, $p = 0.049$ for delay). Disruption rates in mental healthcare were slightly lower than medical care at 20-33% in pwMS and 26% in HCs, which were comparable between groups ($p > 0.05$). Relatively few pwMS and HCs experienced disruptions in emergency care and fulfilling medical prescriptions (< 17%). Higher proportions of pwMS attended telehealth than in-person appointments across all health care types ($\chi^2(1) = 6.08$, $p = 0.014$ for MS care; $\chi^2(1) = 6.26$, $p = 0.012$ for non-MS medical care; $\chi^2(1) = 19.17$, $p < 0.001$ for mental healthcare), while this was observed in mental health ($p = 0.001$) but not in medical care among HCs. Telehealth use was the most frequent in mental healthcare with 90% in pwMS and 79% in HCs. Among pwMS, 77%, 74-84%, and 93% reported that they were very satisfied or somewhat satisfied with their MS medical, non-MS medical, and mental telehealth care, respectively. Similarly high rates were observed in HCs: 71-80% and 80% for medical and mental telehealth care, respectively. In sensitivity analyses, rates of healthcare disruption and telehealth use among respondents from the U.S. (n = 144) were comparable to rates observed in the overall sample.

Predictors of Healthcare Disruption and Telehealth Use

Contrary to expectations, most demographic and MS disease characteristics were not significantly associated with healthcare disruption or telehealth use (see Table 4). PwMS who experienced mental healthcare disruption had significantly shorter MS disease duration (mean 8.74 years) than pwMS who did not experience mental healthcare disruption (mean 16.00 years; $t(22.35) = 2.62$, $p = 0.015$). Use of an assistive device for ambulation (e.g., cane, wheelchair) was significantly associated with greater non-MS medical telehealth use ($\chi^2(1) = 16.44$, $p < 0.001$). In the overall sample, being unemployed due to a disability ($\chi^2(1) = 12.58$, $p < 0.001$) and number of debilitating symptoms ($t(125.23) = -4.27$, $p < 0.001$) were associated with greater non-MS medical telehealth use. Greater psychological distress from COVID-19 was significantly associated with mental healthcare disruptions ($t(43.54) = -2.12$, $p = 0.040$) and

tended to be related to greater non-MS medical telehealth use (t(144.74) = -1.91, p = 0.057). Sensitivity analyses with only the MS sample yielded similar findings as observed with the overall sample.

Discussion

In this U.S.-majority sample, contrary to our hypotheses, pwMS experienced significantly fewer healthcare disruptions (e.g., missing/canceling appoints, experiencing delays) than HCs during the COVID-19 pandemic. That being said, rates of healthcare disruptions were still high in pwMS, with 38-50% experiencing disruptions with their MS and non-MS medical care and 20-33% with their mental healthcare, consistent with other MS studies.[4-9,11] Regarding telehealth use, 61-62% of the MS respondents used telehealth for their MS and non-MS medical care and 91% used telehealth for their mental healthcare, which are significant increases from pre-pandemic levels (e.g., in a study of two large U.S. MS centers, teleneurology use increased from less than 10% before the pandemic to over 90% during the pandemic).[12] The rate of telehealth use was higher in pwMS than HCs. The current study significantly contributes to our understanding of healthcare utilization during the COVID-19 pandemic and is the first to include a HC reference group and delineate between medical and mental healthcare services among pwMS.

Consistent with prior research,[14] we found that greater psychological distress from COVID-19 was associated with more mental healthcare disruptions and more frequent use of telehealth services among both pwMS and HCs. Thus, anxiety about being infected with or dying from COVID-19 may underlie the high degree of healthcare disruptions observed and more frequent use of telehealth compared to in-person services in our sample. The difference between telehealth and in-person service use was more prominent in pwMS compared to HCs, of which rates of telehealth appointments almost doubled the rates of in-person appointments for MS and non-MS medical care (60% telehealth vs. 39% in-person), and rates of mental telehealth appointments were more than five times higher than in-person appointments (90% telehealth vs. 17% in-person). Given that pwMS are immunocompromised and therefore may be more vulnerable to SARS-CoV-2 infections and complications, it is possible that more pwMS are

choosing telehealth over in-person services in order to minimize risk of infections and mortality. Additionally, our results indicate that rate of telehealth use was the highest for mental healthcare among both pwMS and HCs compared to other types of care. This was not surprising given the nature of mental health services, which can be more easily conducted remotely compared to medical services (which often require physical examinations). Mental health treatment is more important now than ever due to the COVID-19 pandemic. Since the COVID-19 outbreak, there have been significant increases in mental health diagnoses, including higher incidences of anxiety and depressive disorders, trauma and COVID-19 stress-related disorders, substance use disorders, and suicidal ideation.[20,21] The results of this study provide support for the continued use of and expansion of tele-mental health services to meet the increased demands during the pandemic.[21,22]

We further argue that some of the temporary governmental policy changes aimed to expand telehealth services during the COVID-19 pandemic should be made permanent even after the resolution of the pandemic. While the current public health crisis has highlighted the need for telehealth services at a population-wide scale, certain groups of individuals have always had difficulty accessing in-person healthcare, such as individuals with significant physical limitations or lower socioeconomic status[23] as well as rural residents. For example, many pwMS have to travel far to reach a MS clinic, which is challenging for those with significant physical limitations.[24] According to a recent American Academy of Neurology update, telehealth visits saved pwMS 258 km of travel, saved more than $144 of travel costs associated with cognitive testing, reduced lodging costs by 17%, and decreased missed employment by 65%.[25] In support of expanded telehealth use, the current study found that the vast majority of pwMS and HCs (74-93% in the MS group and 71-80% in the HC group) were satisfied with their telehealth experiences. That being said, there are limitations to telehealth, such as the inability to perform physical examinations as well as imaging and laboratory tests. Therefore, clinicians must exercise their clinical judgment and follow the guidelines established by consensus expert panels.[27,28]

Contrary to our hypotheses, most social determinants of health did not predict healthcare disruptions or telehealth use. This may be partly due to the homogeneity of our sample (e.g., 74% identified as white) and definitions of certain categorical variables (e.g., annual household income had only four levels with $75,000 or higher as the highest level which consisted of 41% of the sample; Table 1). Disparities have been evident throughout the COVID-19 pandemic. Extant research has identified higher SARS-CoV-2 infection and death rates among Black and Latinx Americans;[29-31] households with lower income,[13] and U.S. counties with higher poverty rates.[29] In MS, prior to the pandemic, inequalities in healthcare access had been documented in people with lower socioeconomic status and less education as well as non-white and rural residents.[32] Interestingly, a recent multicenter study found that the number of non-white MS patients who utilized tele-neurology increased from pre- to post-pandemic, which the authors attributed to governmental policies that expanded telehealth access.[12] This suggests that continuation of such policies may help reduce healthcare disparities in the MS population.

In contrast to findings from Moss et al. (2020),[4] we did not find significant associations between most MS disease variables and whether respondents experienced healthcare disruption. Paradoxically, we did find that shorter MS disease duration was associated with greater mental healthcare disruptions. It is unclear at this time why we found this association. Future studies may conduct a qualitative interview with pwMS to understand the mechanisms mediating the relationship between disease duration and healthcare disruptions. Importantly, greater degree of functional limitation (i.e., being unemployed due to a disability, use of an assistive device for ambulation, greater number of debilitating symptoms) was significantly associated with more frequent telehealth use among both pwMS and HCs. This may be the result of increased anxiety regarding COVID-19 infections and mortality in functionally limited individuals. Such fears are not unfounded, as illustrated by an epidemiological study of 369 counties across the U.S., in which higher disability rates were associated with higher COVID-19 death rates.[29]

Study Limitations

Given this was an online, anonymous survey study, we were unable verify MS diagnosis status with physicians in the MS sample. The current study had a relatively small sample size which may affect generalizability of these results. There is a potential selection bias given the mode of survey distribution (i.e., Internet-based) and predominantly white and high socioeconomic status sample. Thus, rates of telehealth use may be higher in this sample because respondents were more technologically savvy and had more economic resources. Moreover, we did not collect data on health insurance status (e.g., whether respondents had insurance, private vs. public), which could have affected healthcare disruptions and telehealth use. Further, there were very few respondents who were diagnosed with COVID-19, so we were unable to determine if a history of COVID-19 had an influence on our healthcare outcomes. Finally, we did not collect information about presence of the relapses and use of and changes in disease-modifying therapies for the MS respondents.

Conclusions

In this US-majority, predominantly white and high socioeconomic status sample, high rates of disruptions across MS and non-MS medical and mental healthcare were reported by pwMS during the COVID-19 pandemic, although these rates were lower than those observed in HCs. Telehealth services may counteract these disruptions. PwMS were more likely to utilize telehealth than in-person services, especially for mental healthcare. Greater degree of functional limitation (i.e., being unemployed due to a disability, use of an assistive device for ambulation, greater number of debilitating symptoms) was significantly associated with more frequent use of telehealth services among both pwMS and HCs. Due to significant physical limitations common in the MS population which interfere with travel to MS clinics and high degree of satisfaction with telehealth visits as shown in the current study, telehealth services should be continued for this population even after resolution of the pandemic (in cases when physical examinations are not required), in order to expand access and reduce healthcare disparities.

References

1. Koch-Henriksen N, Sørensen PS. The changing demographic pattern of multiple sclerosis epidemiology. *The Lancet Neurology* 2010; **9**(5): 520-32.
2. Asche CV, Singer ME, Jhaveri M, Chung H, Miller A. All-cause health care utilization and costs associated with newly diagnosed multiple sclerosis in the United States. *Journal of Managed Care Pharmacy* 2010; **16**(9): 703-12.
3. Pohar SL, Jones CA, Warren S, Turpin KV, Warren K. Health status and health care utilization of multiple sclerosis in Canada. *Canadian journal of neurological sciences* 2007; **34**(2): 167-74.
4. Moss BP, Mahajan KR, Bermel RA, et al. Multiple sclerosis management during the COVID-19 pandemic. *Multiple Sclerosis Journal* 2020; **26**(10): 1163-71.
5. Vogel AC, Schmidt H, Loud S, McBurney R, Mateen FJ. Impact of the COVID-19 pandemic on the health care of> 1,000 People living with multiple sclerosis: A cross-sectional study. *Multiple sclerosis and related disorders* 2020; **46**: 102512.
6. Colais P, Cascini S, Balducci M, et al. Impact of the COVID-19 pandemic on access to healthcare services amongst patients with multiple sclerosis in the Lazio region, Italy. *European Journal of Neurology* 2021.
7. Portaccio E, Fonderico M, Hemmer B, et al. Impact of COVID-19 on multiple sclerosis care and management: Results from the European Committee for Treatment and Research in Multiple Sclerosis survey. *Multiple Sclerosis Journal* 2021: 13524585211005339.
8. Morrison EH, Michtich K, Hersh CM. How the COVID-19 Pandemic has changed multiple sclerosis clinical practice: Results of a nationwide provider survey. *Multiple Sclerosis and Related Disorders* 2021; **51**: 102913.
9. Chertcoff A, Bauer J, Silva BA, et al. Changes on the health care of people with multiple sclerosis from Latin America during the COVID-19 pandemic. *Multiple Sclerosis and Related Disorders* 2021; **54**: 103120.
10. Landtblom AM, Berntsson SG, Boström I, Iacobaeus E. Multiple sclerosis and COVID-19: The Swedish experience. *Acta Neurologica Scandinavica* 2021.
11. Alnajashi H, Jabbad R. Behavioral practices of patients with multiple sclerosis during Covid-19 pandemic. *PLoS One* 2020; **15**(10): e0241103.
12. McGinley MP, Gales S, Rowles W, et al. Expanded access to multiple sclerosis teleneurology care following the COVID-19 pandemic. *Multiple Sclerosis Journal–Experimental, Translational and Clinical* 2021; **7**(1): 2055217321997467.
13. Chunara R, Zhao Y, Chen J, et al. Telemedicine and healthcare disparities: a cohort study in a large healthcare system in New York City during COVID-19. *Journal of the American Medical Informatics Association* 2021; **28**(1): 33-41.
14. Czeisler ME, Marynak K, Clarke KE, et al. Delay or avoidance of medical care because of COVID-19–related concerns—United States, June 2020. *Morbidity and mortality weekly report* 2020; **69**(36): 1250.
15. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of biomedical informatics* 2009; **42**(2): 377-81.
16. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *Journal of biomedical informatics* 2019; **95**: 103208.
17. Penedo FJ, Cohen, L., Bower, J. & Antoni, M.H. COVID-19: Impact of the Pandemic and HRQOL in Cancer Patients and Survivors. *Unpublished questionnaire* 2020.
18. Goverover Y, Chen MH, Botticello A, et al. Relationships between changes in daily occupations and health-related quality of life in persons with multiple sclerosis during the COVID-19 pandemic. *Multiple Sclerosis and Related Disorders* 2021: 103339.

19. R Development Core Team. R: A language and environment for statstical computing. Vienna, Austria: R Foundation for Statistical Computing; 2010.
20. Czeisler MÉ, Lane RI, Petrosky E, et al. Mental health, substance use, and suicidal ideation during the COVID-19 pandemic—United States, June 24–30, 2020. *Morbidity and Mortality Weekly Report* 2020; **69**(32): 1049.
21. American Psychological Association. Patients with Depression and Anxiety Surge as Psychologists Respond to the Coronavirus Pandemic, November 2020.
22. Caron C. Nobody Has Openings': Mental Health Providers Struggle to Meet Demand. New York Times. February 17, 2021.
23. Kirby JB, Kaneda T. Neighborhood socioeconomic disadvantage and access to health care. *Journal of health and social behavior* 2005; **46**(1): 15-31.
24. Hyland MH, Robb JF. Teleconsultation will replace most face-to-face interactions in the multiple sclerosis clinic–Yes. *Multiple Sclerosis Journal* 2021; **27**(2): 174-5.
25. Hatcher-Martin JM, Adams JL, Anderson ER, et al. Telemedicine in neurology: telemedicine work group of the American Academy of Neurology update. *Neurology* 2020; **94**(1): 30-8.
26. Andrilla CHA, Patterson DG, Garberson LA, Coulthard C, Larson EH. Geographic variation in the supply of selected behavioral health providers. *American journal of preventive medicine* 2018; **54**(6): S199-S207.
27. Cerqueira JJ, Ladeira AF, Silva AM, et al. Multiple Sclerosis Patient Management During the COVID-19 Pandemic: Practical Recommendations From the Portuguese Multiple Sclerosis Study Group (GEEM). *Frontiers in neurology* 2021; **12**: 257.
28. MS International Federation. MS, the coronavirus and vaccines – updated global advice. 2021. https://www.msif.org/news/2020/02/10/the-coronavirus-and-ms-what-you-need-to-know/.
29. Abedi V, Olulana O, Avula V, et al. Racial, economic, and health inequality and COVID-19 infection in the United States. *Journal of racial and ethnic health disparities* 2020: 1-11.
30. Yancy CW. COVID-19 and african americans. *Jama* 2020; **323**(19): 1891-2.
31. Hooper MW, Nápoles AM, Pérez-Stable EJ. COVID-19 and racial/ethnic disparities. *Jama* 2020; **323**(24): 2466-7.
32. Roddam H, Rog D, Janssen J, et al. Inequalities in access to health and social care among adults with multiple sclerosis: A scoping review of the literature. *Multiple sclerosis and related disorders* 2019; **28**: 290-304.

Table 1. Demographic and disease characteristics.

	MS (N = 70)	HC (N = 93)
	Mean (SD); Range	**Mean (SD); Range**
Age: years	47.66. (12.96); 26 – 73	43.57 (14.60); 18 – 84
Disease duration: years	12.77 (9.84); 5 months – 40 years	-
Years since last exacerbation	3.91 (5.82); <1 month – 28.5 years	-
	Number (%)	**Number (%)**
MS phenotype		
Relapsing-Remitting	48 (68.6)	-
Secondary Progressive	9 (12.9)	-
Primary Progressive	9 (12.9)	-
Not sure	4 (5.7)	-
Used ambulatory assistive devices	31 (44.3)	-
Cane	27 (38.6)	-
Walker	13 (18.6)	-
Crutches	3 (4.3)	-
Knee ankle foot orthosis	7 (10.0)	-
Manual wheelchair	7 (10.0)	-
Power wheelchair	4 (5.7)	-
Scooter	5 (7.1)	-
Female	57 (81.4)	78 (83.9)
Race		
White	52 (74.3)	74 (79.6)
Asian	5 (7.1)	8 (8.6)
Black or African American	3 (4.3)	6 (6.5)
American Indian/Alaska Native	2 (2.9)	1 (1.1)
Other	5 (7.1)	2 (2.2)
Prefer not to answer	3 (4.3)	2 (2.2)
Ethnicity		
Hispanic, Latino, Spanish origin	11 (15.7)	10 (10.8)
Education		
12th grade, no diploma	1 (1.4)	0 (0)
High school graduate	2 (2.8)	4 (4.3)
GED or equivalent	2 (2.8)	2 (2.2)
Some college, no degree	14 (19.4)	6 (6.5)
Associate degree	4 (5.6)	1 (1.1)
Bachelors degree	19 (26.4)	35 (37.6)
Masters degree	22 (30.6)	33 (35.5)
Doctoral degree	8 (11.1)	12 (12.9)
Employment status†		
Employed full-time	23 (32.9)	48 (51.6)
Employed part-time	12 (17.1)	12 (12.9)
Laid off/furloughed due to COVID-19	3 (4.3)	5 (5.4)
Unemployed (unrelated to COVID-19)	1 (1.4)	5 (5.4)

Retired	8 (11.4)	4 (4.3)
Unemployed due to disability	22 (62.9)	1 (1.1)
Other (e.g., student, homemaker)	1 (1.4)	18 (19.4)
Marital status		
Married	36 (51.4)	45 (48.4)
Part of an unmarried couple	3 (4.3)	12 (12.9)
Never Married	18 (25.7)	26 (28)
Divorced	9 (12.9)	4 (4.3)
Separated	1 (1.4)	0 (0)
Widowed	1 (1.4)	4 (4.3)
Other	1 (1.4)	1 (1.1)
Prefer not to answer	1 (1.4)	1 (1.1)
Income†		
< $25,000	12 (17.1)	9 (9.7)
$25,000-$49,000	9 (12.9)	10 (10.8)
$50,000-$74,000	10 (14.3)	3 (3.2)
> $75,000	29 (41.4)	64 (68.8)
Don't know/prefer not to answer	10 (14.3)	7 (7.5)
Comorbidity		
Major medical problems†	21 (30.0)	4 (4.3)
Depression†	32 (45.7)	12 (12.9)
Anxiety†	24 (34.3)	13 (14.0)
Setting		
Large city	18 (25.7)	30 (32.3)
Suburbs of a large city	24 (34.3)	26 (28.0)
Small city	7 (10.0)	4 (4.3)
Town or village	15 (21.4)	26 (28.0)
Rural area	6 (8.6)	7 (7.5)
In USA	59 (84.3)	85 (91.4)

Outside of USA	**MS**		**HC**
Country	**Number (%)**	Country	**Number (%)**
Canada	3 (4.3)	Ghana	1 (1.1)
India	2 (2.9)	Israel	7 (7.5)
Ireland	1 (1.4)		
Netherlands	1 (1.4)		
South Sudan	1 (1.4)		
United Kingdom	3 (4.3)		

Note. Group differences (MS vs. HC) determined by Welch's two samples t tests for continuous variables, Pearson's chi-squared tests for nominal variables, and Wilcoxon rank-sum test for ordinal variables.
†Statistically significant differences groups.

Table 2. COVID-19 exposure.

	MS (N = 70)	HC (N = 93)	MS vs. HC
	Number (%)	**Number (%)**	**p**
Known exposure to someone with COVID-19	5 (7.1)	21 (22.6)	0.007
Tested for COVID-19	18 (25.7)	38 (40.9)	0.038
Positive for COVID-19	3 of 18 (16.7)	2 of 38 (5.3)	N.S.
A family or household member tested positive for COVID-19	8 (11.4)	12 (12.9)	N.S.
A family or household member died from COVID-19	3 (4.3)	3 (3.2)	N.S.
A friend, co-worker, or neighbor diagnosed with COVID-19	26 (37.1)	56 (60.2)	0.003
A friend, co-worker, or neighbor died from COVID-19	12 (17.1)	17 (18.3)	N.S.

Note. Group differences were analyzed by Pearson's chi-squared tests (MS vs. HC). N.S.: not statistically significant.

Table 3. Healthcare disruption and telehealth utilization during COVID-19 pandemic.

		MS		HC	MS vs. HC
MS care (n = 69 received care)	**N**	**Number (%)**	**N**	**Number (%)**	**p**
Missed/Canceled appointment	68	26 (38.2)	-	-	-
Experienced a delay	66	26 (39.4)	-	-	-
Attended in-person appointment	69	27 (39.1)	-	-	-
Attended telehealth appointment	69	42 (60.9)	-	-	-
		p		**p**	
In-person vs. Telehealth		0.014		-	
Non-MS medical care (N = 157)	**N**	**Number (%)**	**N**	**Number (%)**	**p**
Missed/Canceled appointment	62	23 (37.1)	88	58 (65.9)	<0.001
Experienced a delay	62	31 (50.0)	83	55 (66.3)	0.049
Attended in-person appointment	61	24 (39.3)	87	37 (42.5)	N.S.
Attended telehealth appointment	62	37 (59.7)	87	33 (37.9)	0.009
		P		**p**	
In-person vs. Telehealth		0.012		N.S.	
Mental healthcare (N = 51)	**N**	**Number (%)**	**N**	**Number (%)**	**p**
Missed/Canceled appointment	30	10 (33.3)	19	5 (26.3)	N.S.
Experienced a delay	30	6 (20.0)	19	5 (26.3)	N.S.
Attended in-person appointment	29	5 (17.2)	19	3 (15.8)	N.S.
Attended telehealth appointment	30	27 (90.0)	19	15 (79.0)	N.S.
		p		**p**	
In-person vs. Telehealth		<0.001		0.001	
Miscellaneous					
Chose not to seek emergency care	59	7 (11.9)	65	11 (16.9)	N.S.
Difficulty fulfilling prescriptions	65	8 (12.3)	77	12 (15.6)	N.S.

Note. Between-subject differences were analyzed by Pearson's chi-squared tests (MS vs. HC). Within-subject differences were examined using McNemar's test (in-person vs. telehealth). N.S.: not statistically significant.

Table 4. Associations between demographic/MS disease characteristics and healthcare disruption/telehealth use during COVID-19 pandemic.

	Healthcare disruption			Telehealth use		
	MS	Non-MS Medical	Mental	MS	Non-MS Medical	Mental
Disease duration	N.S.	N.S.	0.015	N.S.	N.S.	N.S.
Time since last exacerbation	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
MS phenotype (RRMS vs. PMS)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Use of assistive device for ambulation (yes vs. no)	N.S.	N.S.	N.S.	N.S.	<0.001	N.S.
Age	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Education	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Race (white vs. non-white)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Unemployed due to a disability(yes vs. no)	N.S.	N.S.	N.S.	N.S.	<0.001	N.S.
Number of debilitating symptoms	N.S.	N.S.	N.S.	N.S.	<0.001	N.S
Income level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Financial hardship during COVID-19	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Psychological distress from COVID-19	N.S.	N.S.	0.040	N.S.	0.057	N.S.

Note. Respondents (MS and HC groups combined) were categorized as either having experienced healthcare disruption (i.e., missing/canceling appointment or experienced a delay) or not, and utilized telehealth services or not. Values represent p-values for respective analyses. RRMS: relapsing-remitting MS. PMS: progressive MS. N.S.: not statistically significant.