Multiple Sclerosis and Related Disorders 69 (2023) 104413

Contents lists available at ScienceDirect

Multiple Sclerosis and Related Disorders

journal homepage: www.elsevier.com/locate/msard

Original article

Disability outcomes in early-stage African American and White people with multiple sclerosis

Maria Petracca [a,b], Raffaele Palladino [c], Amgad Droby [a], Daniel Kurz [a], Nicole Graziano [a], Katherine Wang [a], Claire Riley [d], Jonathan Howard [e], Sylvia Klineova [a], Fred Lublin [a], Matilde Inglese [a,f,g,*]

[a] Department of Neurology, Icahn School of Medicine at Mount Sinai, New York, NY, USA
[b] Department of Human Neurosciences, Sapienza University, Rome, Italy
[c] Department of Public Health, University of Naples "Federico II", Naples, Italy
[d] Department of Neurology, Columbia University Medical Center, New York, NY, USA
[e] Department of Neurology, New York University School of Medicine, New York, NY, USA
[f] DINOGMI, University of Genoa, Genoa, Italy
[g] Ospedale Policlinico San Martino-IRCSS, Genoa, Italy

ARTICLE INFO

Keywords:
African American
Social determinants of health
Cognition
Physical functional performance
Multiple sclerosis
Population heterogeneity

ABSTRACT

Background: Factors driving differences in disease burden between African American and White people with multiple sclerosis (pwMS) remain unclear. Here, we explored whether differences in disability outcomes could be observed after controlling for major sociodemographic factors and comorbidities, and assessed the presence of a possible interaction between MS and race.

Methods: In this cross-sectional study, 120 pwMS within 6 years from disease onset and 82 healthy controls between 18 and 70 years of age, self-identified as either African American or White, were prospectively enrolled. Inclusion criteria for pwMS were: diagnosis of MS according to the revised McDonald criteria, relapsing-remitting phenotype and Expanded Disability Status Scale (EDSS) < 6.5. Study outcomes included: (i) global disability (EDSS); (ii) quantitative mobility and leg function (Timed 25 Foot Walk Test-T25FWT); (iii) quantitative finger dexterity (9-Hole Peg Test-9HPT); (iv) cognitive efficiency and speed performance (Symbol Digit Modalities Test-SDMT). Differences in disability outcomes were assessed employing multivariable linear regression models. Based on their association with MS or disability, covariates included age, gender, race, years of education, total income, body mass index, comorbidities. The interaction between MS and race on disability outcomes was estimated via relative excess risk of interaction and attributable proportion.

Results: Accounting for age, gender, total income, education, body mass index and comorbidities, African American pwMS showed significantly worse performances in manual dexterity and cognition than White pwMS (White pwMS coeff. 3.24, 95% CI 1.55, 4.92 vs African American pwMS coeff. 5.52, 95% CI 3.55, 7.48 and White pwMS coeff. -5.87, 95% CI -8.86, -2.87 vs African American pwMS coeff. -7.99, 95% CI -11.58,-4.38). MS and race independently contributed to the observed gradient in disability severity.

Conclusions: Complex social disparities and systemic racism might contribute to clinical heterogeneity in MS.

1. Introduction

Although a more aggressive disease course has been reported in African American in comparison with White people with multiple sclerosis (pwMS) (Weinstock-Guttman et al., 2003, Cree B a et al., 2004, Naismith et al., 2006, Kister et al., 2010, Ventura et al., 2017, Petracca et al., 2018, Amezcua and McCauley, 2020, Gray-Roncal et al., 2021), differences in disability outcomes might be partly related to sociodemographic factors limiting access to care or influencing lifestyle behaviors (Marrie et al., 2006, Marrie et al., 2008, Amezcua et al., 2021). Sociodemographic disadvantages can indeed delay diagnosis, choice and timing of the therapeutic approach, and lead to the development of comorbidities through unhealthy nutritional choices and physical inactivity (Pampel et al., 2010). Research addressing this issue is still

* Corresponding author at: Largo Paolo Daneo 3, 16132, Genova, Italy.
E-mail address: m.inglese@unige.it (M. Inglese).

https://doi.org/10.1016/j.msard.2022.104413
Received 21 July 2022; Received in revised form 28 September 2022; Accepted 11 November 2022
Available online 13 November 2022

scarce, and no definite conclusion has been reached, given the difficulty to gather comprehensive data of social disparities. Here, in a prospective setting, we evaluated whether differences in disability outcomes between African American and White pwMS could be observed after controlling for social, economic, and biological factors known to affect MS disability, and, for the first time, assessed the presence of a possible interaction between MS and race.

2. Methods

2.1. Subjects

One hundred-twenty pwMS and 82 healthy controls (HC) between 18 and 70 years of age and self-identifying as Black/African American (henceforth referred to as African American) or White were prospectively enrolled between February 23rd 2018 and January 8th 2020. Data on ethnicity (Hispanic/Non-Hispanic) were also collected. Additional inclusion criteria for patients were: a) clinically definite MS according to the revised McDonald criteria, b) relapsing-remitting phenotype, c) EDSS < 6.5. Exclusion criteria for all participants were: a) medically unstable or major hematologic, renal, or hepatic dysfunction, b) pregnancy, c) contraindications to MRI, d) head injury, stroke, seizures, psychiatric disorders or substance abuse. HC were recruited through flyers at the enrolling institution as well as thanks to referrals from enrolled subjects. Data on demographic, socioeconomic and clinical status of all enrolled subjects were collected. Written informed consent was obtained from all participants before the beginning of the study procedures, according to the Declaration of Helsinki. The protocol was approved by the Icahn School of Medicine at Mount Sinai Institutional Review Board (17-00766).

2.2. Outcomes of interest

Study outcomes included (i) global disability, assessed via Expanded Disability Status Scale (EDSS); (ii) quantitative mobility and leg function, assessed via Timed 25 Foot Walk Test (T25FWT); (iii) quantitative finger dexterity, assessed via 9-Hole Peg Test (9HPT), and (iv) cognitive efficiency and speed performance, assessed via Symbol Digit Modalities Test (SDMT).

2.3. Covariates

Based on their association with MS or disability, covariates included age, gender, race, years of education, total income, body mass index-BMI, comorbidities. Total income refers to the total combined family income for the past 12 months, expressed as ordinal variable, with nine categories ranging from less than $5,000 to $100,000+. Comorbidities included ongoing medical conditions falling in the following categories: allergy, HEENT, respiratory, cardiovascular, gastrointestinal, hepatic, genitourinary, hematopioetic/lymphatic, neurological, endocrine/metabolic, musculoskeletal, dermatological, psychosocial/psychiatric, infectious disease, rheumatologic.

2.4. Statistical analysis

Descriptive analyses (means, medians, standard deviations, interquartile ranges, frequency distributions) were employed, as appropriate, to assess and describe the study population. Number of previous treatments before study enrollment was compared with unilinear model, accounting for disease duration. Comparison of treatment transition before study enrollment, as well as the frequency distribution of EDSS and its functional system scores (FSS) across races was tested via Chi-square.

To evaluate the individual and joint effects of disease status and race on disability, we stratified the study population into 4 classes: (1) White controls (reference group), (2) African American controls, (3) White pwMS and (4) African American pwMS.

Differences in disability outcomes (EDSS, T25FWT, 9HPT and SDMT) between the four groups were assessed employing multivariable linear regression models controlled for age, sex, total income, BMI and number of comorbidities.

The model assessing differences in EDSS only included White and African American pwMS. The model assessing differences in SDMT score was also controlled for total years of education.

Within each model, association with covariates was considered significant for $p<0.007$, Bonferroni corrected for multiple comparisons (0.05/7, as the number of variables entered in each model).

To assess the presence of a possible biological interaction between MS and race on disability outcomes using a departure from additivity effects, we estimated the relative excess risk of interaction (RERI) and the attributable proportion (AP) (Palladino et al., 2021).

All statistical analyses were conducted using Stata MP 17.0.

2.5. Data availability

Anonymized data will be made available by request from any qualified investigator.

3. Results

3.1. Study population

Sociodemographic and clinical features of the study population are reported in Table 1.

Among pwMS, no significant differences in disease modifying treatments distribution, nor in time to diagnosis from first symptom were identified ($p=0.450$ and $p=0.363$, respectively). When comparing treatment exposure before study enrollment while accounting for disease duration, no differences emerged between African American and White pwMS ($p=0.286$). Even when analyzing treatment transition before study enrollment, no difference emerged (switch from 1st to 2nd line DMTs occurred in 3% of Africab American and 2% of White pwMS, $p=0.842$; switch from 2nd to 1st line DMTs occurred in 13% of African American and 5% of White pwMS, $p=0.204$; with 1st line DMTs being glatiramer acetate, interferon beta 1a, teriflunomide, dimethyl fumarate and 2nd line DMTs being alemtuzumab, fingolimod, natalizumab, ocrelizumab, rituximab). Looking at the frequency distribution of EDSS and its FSS between African American and White pwMS, the only differences emerged for the pyramidal FSS (score 2 and 3 observed in 34% of African American and 10% of White pwMS, $p=0.017$).

3.2. Disability prediction

Race did not contribute to explain EDSS (African American pwMS coeff. 0.310, 95% CI -0.50, 1.12) or T25FWT scores (White pwMS coeff. 0.450, 95% CI -0.38, 1.28 vs African American pwMS coeff. 1.03, 95% CI 0.05, 2.01).

PwMS showed significantly higher 9HPT scores compared to HC, with African American pwMS showing worse performance than White pwMS (White pwMS coeff. 3.24, 95% CI 1.55, 4.92 vs African American pwMS coeff. 5.52, 95% CI 3.55, 7.48).

PwMS showed significantly lower SDMT scores compared to HC, with African American pwMS showing worse performance than White pwMS (White pwMS coeff. -5.87, 95% CI -8.86, -2.87 vs African American pwMS coeff. -7.99, 95% CI -11.58,-4.38).

We did not observe any departures from additivity for the association of MS and race with disability outcomes (T25FWT: RERI 0.97, 95% CI -0.27, 2.22; AP: 0.94, 95% CI -0.55, 2.43; 9HPT: RERI 0.90, 95% CI -1.51, 3.31; AP: 0.16, 95% CI -0.27, 0.60; SDMT: RERI 2.24, 95% CI -1.99, 6.47; AP: -0.28, 95% CI -0.82, 0.26).

Table 1
Demographic and clinical features of the study population.

	HC		MS	
	White	African American	White	African American
Age	35.49 ± 11.37	35.86 ± 11.84	35.58 ± 10.66	37.67 ± 10.41
Sex (M/F)	15/24	12/31	19/41	15/45
Ethnicity (Hispanic/Non-Hispanic)	1/38	3/40	0/60	8/52
Disease duration	-	-	5.91 ± 5.50	5.47 ± 5.57
DMT (no ther/1st line/2nd line)	-	-	2/29/29	5/25/30
Number of previous DMTs (0/1/2/3/4)	-	-	31/18/7/4/0	31/19/5/4/1
Diagnostic delay (months)	-	-	12.45 ± 28.74	19.18 ± 47.98
Total income (median, range)	8 [3-9]	6 [2-9]	9 [2-9]	6 [1-9]
BMI	24.27 ± 4.37	27.65 ± 4.08	26.07 ± 5.44	30.02 ± 5.48
Comorbidities (median, interquartile range)	1 [1]	0 [0]	1 [1]	1 [2]
Education, yrs	18.83 ± 3.69	15.49 ± 2.39	17.55 ± 3.04	15.32 ± 2.14
EDSS (median, range)	-	-	1.5 (0-6)	2 (0-6.5)
T25FWT	4.04 ± 0.49	5.28 ± 2.02	4.46 ± 0.75	5.54 ± 2.75
9HPT	19.66 ± 2.44	22.55 ± 3.12	22.44 ± 3.78	25.34 ± 5.29
SDMT	45.52 ± 7.12	39.58 ± 9.64	38.51 ± 6.79	34.76 ± 7.75

Abbreviations: 9HPT, 9-hole peg test, BMI, body mass index; DMT, disease modifying treatment; EDSS, expanded disability status scale, SDMT, symbol digit modalities test; T25FWT, timed 25 foot walk test. Total income refers to the total combined family income for the past 12 months and is expressed as ordinal variable, with the relative categories being 1: less than $5,000; 2: $5,000-$11,999; 3: $12,000-$15,999; 4: $16,000-$24,999; 5: $25,000-$34,999; 6: $35,000-$49,000; 7: $50,000-$74,999; 8: $75,000-$99,999; 9: $100,000+.
1st line: glatiramer acetate, interferon beta 1a, teriflunomide, dimethyl fumarate.
2nd line: alemtuzumab, fingolimod, natalizumab, ocrelizumab, rituximab.
All values are expressed as mean ± standard deviation, unless otherwise indicated.

4. Discussion

Recently, a greater burden of disability has been reported in a large cohort of African American with MS relative to White pwMS, despite adjustment for socioeconomic status indicators (Gray-Roncal et al., 2021).

Our analysis extends these findings, demonstrating that a gradient in fine motor performance and cognitive efficiency between African American and White pwMS is already present at an earlier disease stage (6 versus 12-14 years of disease duration), even after accounting for major social confounders and, for the first time, comorbidities. Manual dexterity in altered in most pwMS, across disease stages and phenotypes (Bertoni et al., 2022). Although neural mechanisms underlying hand impairment in MS are not fully understood, previous research focused on progressive MS has highlighted the role of intracortical sensorimotor networks and cerebellar damage (Cocozza et al., 2017, Dubbioso et al., 2022). Interestingly, grey matter damage in African American pwMS seems to affect preferentially cortical and cerebellar regions as well as the thalamus (Petracca et al., 2018, Al-Kawaz et al., 2016), whose involvement in early MS and significant role as driver of cognitive performance is undiscussed (Petracca et al., 2021, Engl et al., 2020). Damage accrual within these areas, as well as maladaptive functional rewiring (Petracca et al., 2018, Cocozza et al., 2018) could partly account for the observed disability gradient. The role of social differences however, recently reported specifically for processing speed and manual dexterity outcomes (Abbatemarco et al., 2022), should not be overlooked.

Indeed, the reasons behind the observed disability gradient are likely multifaceted. More specifically, race is a social construct rather than a marker of intrinsic biological features (Roberts, 2011), and, although we considered both direct (total income) and indirect (education, BMI) indicators of socioeconomic status as well as indicators of access to care (diagnostic delay, disease modifying therapies), complex differences in access to housing, quality of education, employment, disparities in resource utilization, as well as chronic stress induced by exposure to overt and covert racism cannot be fully captured with a limited number of variables. It is therefore likely that unmeasured social differences (and/or their consequences) contribute to our findings.

Specifically, a role for biased treatment strategies and comorbid conditions has been previously suggested (Gray-Roncal et al., 2021, Marrie et al., 2008). In our population we did not identified differences in current treatment distribution, but we cannot exclude that, along the disease course, differences in treatment choices related to access to specialized vs non-specialized MS care might have contributed to the observed gradient in disability. However, we did not identified differences in number of DMTs, and, despite a recent report identifying injection fatigue and subjective worsening as factors increasing the likelihood of therapy switch in African American pwMS (Okuda et al., 2022), no difference in treatment transition prior to study enrollment were present between African American and White pwMS.

In addition to treatment exposure, comorbidities represent a relevant confounding factor when assessing the relationship between race and disability, not only because they significantly affect disability outcomes, but also because the adequate management of comorbidities and their consequent impact might vary according to socioeconomic conditions (Marrie et al., 2008). In our population, however, no significant differences in treatment distribution nor in time to diagnosis were observed, and a disability gradient was present despite accounting for comorbidities. Therefore, in addition to unexplored social factors, a role for gene–environment or gene–gene interactions, that could alter phenotype differentially across racial groups (Boullerne et al., 2021, Beecham et al., 2020), could be hypothesized. However, comparing ours with previous findings (Gray-Roncal et al., 2021), it appears that clinical differences grow to involve more domains along the disease course, with between-group differences in global disability status and walking appearing only at a later disease stage. This, given the difference in disease duration between the two cohorts, might result from changes in access to care over the years (Cole and Franzosa, 2022, "https://www.census.gov/topics/health/health-insurance/library/publications.2021.List_1458400546.html") and/or represent the consequence of social disparities and experienced racism building their effect over time. In line with this hypothesis, analyzing the impact of MS and race on disability, we identified an additive rather than synergistic interaction, suggesting that the two factors independently contribute to the clinical outcome. Indeed, although a previous work also reported a gradient in the distribution of SDMT scores across races/ethnicities (White, Hispanic and Black people), the Authors did not identify any interaction between race/ethnicity and MS case status (Amezcua et al., 2020). Our findings support such observation, pointing to the lack of a synergistic interaction between race and MS.

Our work is not without limitations. First and foremost, the intrinsic difficulty to capture and measure all direct and indirect factors that might contribute to social disparities. Second, although disability accrual, especially in the initial phases of the disease, is partly sustained by por recovery from inflammatory activity (Kappos et al., 2020), we did not collect data on disease activity prior to study enrolment, and therefore could not evaluate differences in recovery from relapses between African American and White pwMS. Third, although we collected data about ethnicity, we did not have the power needed to explore the impact of this factor. Finally, longitudinal evaluations will be needed to

ascertain if the observed gradient is maintained, develops further or tends to resolve over the disease course.

Despite these limitations, our findings are particularly relevant, as the susceptibility to a more aggressive disease course, associated to MS underestimation in the African American community (Langer-Gould et al., 2022), might result in MS-related disability disproportionately affecting this population. More broadly, they raise awareness on factors affecting clinical heterogeneity in MS, which represent the basis to tailor disease management at the individual level. Further studies on minorities and disadvantaged groups should explore the effects of systemic racism and socioeconomic disparities on disease course and disability in MS.

CRediT authorship contribution statement

Maria Petracca: Funding acquisition, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Raffaele Palladino:** Funding acquisition, Formal analysis, Data curation, Writing – original draft, Writing – review & editing. **Amgad Droby:** Funding acquisition, Data curation, Writing – review & editing. **Daniel Kurz:** Funding acquisition, Data curation, Writing – review & editing. **Nicole Graziano:** Funding acquisition, Data curation, Writing – review & editing. **Katherine Wang:** Funding acquisition, Data curation, Writing – review & editing. **Claire Riley:** Funding acquisition, Data curation, Writing – review & editing. **Jonathan Howard:** Funding acquisition, Data curation, Writing – review & editing. **Sylvia Klineova:** Funding acquisition, Data curation, Writing – review & editing. **Fred Lublin:** Conceptualization, Methodology, Funding acquisition, Data curation, Writing – review & editing. **Matilde Inglese:** Conceptualization, Methodology, Funding acquisition, Data curation, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

Maria Petracca has received travel/meeting expenses from Novartis, Roche and Merck, speaking honoraria from HEALTH&LIFE S.r.l., honoraria for consulting services from Biogen and research grants from Baroni Foundation.

Raffaele Palladino has nothing to disclose.

Amgad Droby has nothing to disclose.

Nicole Graziano has nothing to disclose.

Katherine Wang has nothing to disclose.

Daniel Kurz has nothing to disclose.

Claire Riley reports personal fees from Teva Neuroscience, personal fees from Genzyme Sanofi, personal fees from Genentech, personal fees from Celgene, personal fees from Biogen Idec, personal fees from EMD Serono.

Jonathan Howard has nothing to disclose.

Sylvia Klineova has nothing to disclose.

Fred Lublin reports grants and personal fees from Novartis, Biogen Idec, Teva Neuroscience, Sanofi/Genzyme, Celgene, grants from Transparency Life Sciences and personal fees from Bayer Healthcare, EMD Serono, Actelion, Acorda, Questcor/Malinckrodt, Roche/Genentech, Medimmune, Osmotica, Xenoport, Receptos, Forward pharma, BBB Technologies, Akros, TG therapeutics, Abbvie, MedDay and Atara Biotherapeutics.

Matilde Inglese received grants NIH, NMSS, FISM; received fees for consultation from Roche, Genzyme, Merck, Biogen and Novartis.

Funding

Study supported by NIH grant 5R01NS100811.

References

Abbatemarco, JR, Carlson, A, Ontaneda, D, et al., 2022. Association of socioeconomic disadvantage and neighborhood disparities with clinical outcomes in multiple sclerosis patients. Mult. Scler. Relat. Disord. 61 (March), 103734 https://doi.org/10.1016/j.msard.2022.103734.

Al-Kawaz, M, Monohan, E, Morris, E, et al., 2016. Differential impact of multiple sclerosis on cortical and deep gray matter structures in African Americans and Caucasian Americans. J. Neuroimaging 1–6. https://doi.org/10.1111/jon.12393.

Amezcua, L, McCauley, JL., 2020. Race and ethnicity on MS presentation and disease course. Mult. Scler. J. 26 (5), 561–567. https://doi.org/10.1177/1352458519887328.

Amezcua, L, Smith, JB, Gonzales, EG, Haraszti, S, Race, Langer-Gould A., 2020. Ethnicity, and cognition in persons newly diagnosed with multiple sclerosis. Neurology 94 (14), E1548–E1556. https://doi.org/10.1212/WNL.0000000000009210.

Amezcua, L, Rivera, VM, Vazquez, TC, Baezconde-Garbanati, L, Langer-Gould, A., 2021. Health disparities, inequities, and social determinants of health in multiple sclerosis and related disorders in the US: A Review. JAMA Neurol. 78 (12), 1515–1524. https://doi.org/10.1001/jamaneurol.2021.3416.

Beecham, AH, Amezcua, L, Chinea, A, et al., 2020. The genetic diversity of multiple sclerosis risk among Hispanic and African American populations living in the United States. Mult. Scler. J. 26 (11), 1329–1339. https://doi.org/10.1177/1352458519863764.

Bertoni, R, Cattaneo, D, Grosso, C, Baglio, F, Jonsdottir, J., 2022. Distribution and relation of two arm function tests, Box and Blocks test and Nine Hole Peg test, across disease severity levels and types of multiple sclerosis. Mult. Scler. Relat. Disord. 59, 103683 https://doi.org/10.1016/j.msard.2022.103683.

Boullerne, AI, Wallin, MT, Culpepper, WJ, et al., 2021. Liver kinase B1 rs9282860 polymorphism and risk for multiple sclerosis in White and Black Americans. Mult. Scler. Relat. Disord. 55 (July), 103185 https://doi.org/10.1016/j.msard.2021.103185.

Cocozza, S, Petracca, M, Mormina, E, et al., 2017. Cerebellar lobule atrophy and disability in progressive MS. J. Neurol. Neurosurg. Psychiatry 88 (12), 1065–1072. https://doi.org/10.1136/jnnp-2017-316448.

Cocozza, S, Pontillo, G, Russo, C, et al., 2018. Cerebellum and cognition in progressive MS patients: functional changes beyond atrophy? J. Neurol. 265 (10), 2260–2266. https://doi.org/10.1007/s00415-018-8985-6.

Cole, HVS, Franzosa, E., 2022. Title : advancing urban health equity in the United States in an age of health care gentrification : a framework and research agenda. Int. J. Equity Health 1–10. https://doi.org/10.1186/s12939-022-01669-6.

Cree B a, C, Khan, O, Bourdette, D, et al., 2004. Clinical characteristics of African Americans vs Caucasian Americans with multiple sclerosis. Neurology 63 (11), 2039–2045. https://doi.org/10.1212/WNL.64.12.2163.

Dubbioso, R, Bove, M, Boccia, D, et al., 2022. Neurophysiological and behavioural correlates of ocrelizumab therapy on manual dexterity in patients with primary progressive multiple sclerosis. J. Neurol. 269 (9), 4791–4801. https://doi.org/10.1007/s00415-022-11114-x.

Engl, C, Tiemann, L, Grahl, S, et al., 2020. Cognitive impairment in early MS: contribution of white matter lesions, deep grey matter atrophy, and cortical atrophy. J. Neurol. 267 (8), 2307–2318. https://doi.org/10.1007/s00415-020-09841-0.

Gray-Roncal, K, Fitzgerald, KC, Ryerson, LZ, et al., 2021. Association of disease severity and socioeconomic status in black and white Americans with multiple sclerosis. Neurology 97 (9), e881–e889. https://doi.org/10.1212/WNL.0000000000012362.

27.https://www.census.gov/topics/health/health-insurance/library/publications.2021.List_1458400546.html.

Kappos, L, Wolinsky, JS, Giovannoni, G, et al., 2020. Contribution of relapse-independent progression vs relapse-associated worsening to overall confirmed disability accumulation in typical relapsing multiple sclerosis in a pooled analysis of 2 randomized clinical trials. JAMA Neurol. 77 (9), 1132–1140. https://doi.org/10.1001/jamaneurol.2020.1568.

Kister, I, Chamot, E, Bacon, JH, et al., 2010. Rapid disease course in African Americans with multiple sclerosis. Neurology 75 (3), 217–223. https://doi.org/10.1212/WNL.0b013e3181e8e72a.

Langer-Gould, AM, Grisell-Gonzales, E, Smith, JB, Li, BH, Nelson, LM, 2022. Racial and ethnic disparities in multiple sclerosis prevalence. Neurology 10. https://doi.org/10.1212/WNL.0000000000200151.

Marrie, RA, Cutter, G, Tyry, T, Vollmer, T, Campagnolo, D., 2006. Does multiple sclerosis-associated disability differ between races? Neurology 66 (8), 1235–1240. https://doi.org/10.1212/01.wnl.0000208505.81912.82.

Marrie, RA, Horwitz, R, Cutter, G, Tyry, T, Campagnolo, D, Vollmer, T., 2008. Comorbidity, socioeconomic status and multiple sclerosis. Mult. Scler. 14 (8), 1091–1098. https://doi.org/10.1177/1352458508092263.

Naismith, RT, Trinkaus, K, Cross, AH., 2006. Phenotype and prognosis in African-Americans with multiple sclerosis: a retrospective chart review. Mult. Scler. 12 (6), 775–781. https://doi.org/10.1177/1352458506070923.

Okuda, DT, Burgess, KW, Cook, K, McCreary, M, Winkler, MD, Moog, TM., 2022. Hiding in plain sight: The magnitude of unused disease modifying therapies in multiple sclerosis and strategies for reducing the economic burden of care. Mult. Scler. Relat. Disord. 63 (March), 103920 https://doi.org/10.1016/j.msard.2022.103920.

Palladino, R, Chataway, J, Majeed, A, Marrie, RA., 2021. Interface of multiple sclerosis, depression, vascular disease, and mortality: a population-based matched cohort study. Neurology 97 (13), e1322–e1333. https://doi.org/10.1212/WNL.0000000000012610.

Pampel, FC, Krueger, PM, Denney, JT., 2010. Socioeconomic disparities in health behaviors. Annu. Rev. Sociol. 36, 349–370. https://doi.org/10.1146/annurev.soc.012809.102529.

Petracca, M, Zaaraoui, W, Cocozza, S, et al., 2018. An MRI evaluation of grey matter damage in African Americans with MS. Mult. Scler. Relat. Disord. 25 (May), 29–36. https://doi.org/10.1016/j.msard.2018.06.007.

18.Petracca M, Pontillo G, Moccia M, et al. Neuroimaging Correlates of Cognitive Dysfunction in Adults with Multiple Sclerosis. 2021.

Roberts, DE., 2011. Fatal Invention : How Science, Politics, and Big Business Re-Create Race in the Twenty-First Century. New Press, New York.

Ventura, RE, Antezana, AO, Bacon, T, Kister, I., 2017. Hispanic Americans and African Americans with multiple sclerosis have more severe disease course than Caucasian Americans. Mult. Scler. 23 (11), 1554–1557. https://doi.org/10.1177/1352458516679894.

Weinstock-Guttman, B, Jacobs, L, Brownscheidle, C, et al., 2003. Multiple sclerosis characteristics in African American patients in the New York state multiple sclerosis consortium. Mult. Scler. J. 9, 293–298.