The MS-LINK™ Outcomes Study: Study Design and Descriptive Analyses of Patient-Reported Outcomes, Disease, and Sociodemographic Characteristics

Jeffrey English[1], Carlo Tornatore[2], Emily Riser[3], Gabriel Pardo[4], Leorah Freeman[5], Jacob Sloane[6], Jeanie Cote[7], Rana Zabad[8], Tania Reyna[9], *Elizabeth Piette[10]*, *Christina Caon[10]*, Terrie Livingston[11]

Affiliations: [1]Atlanta Neuroscience Institute, GA, USA; [2]Georgetown University Medical Center, Medstar Georgetown University Hospital, Medstar Health, DC, USA; [3]Alabama Neurology Associates, AL, USA; [4]Oklahoma Medical Research Foundation, Multiple Sclerosis Center of Excellence, OK, USA; [5]Dell Medical School, The University of Texas at Austin, TX, USA; [6]Beth Israel Deaconess Medical Center, MA, USA; [7]Memorial Healthcare Institute for Neuroscience, Owosso, MI, USA; [8]University of Nebraska Medical Center, Omaha, NE, USA; [9]University of Texas Health Science Center at San Antonio, San Antonio, TX, USA; [10]EMD Serono, Boston, MA, USA; [11]Octave Bioscience, Menlo Park, CA, USA

Disclosures: JE is a creator, partner, and stockholder in Healthcare Impact Partners, LLC, and HIPnation Operations & Solutions, LLC; was on advisory boards and speaker panels for pharmaceutical companies including Biogen-Idec, Teva, Mallinckrodt, Novartis, Genentech, Genzyme, EMD Serono, and Celgene. Medical Director at Atlanta Neuroscience Institute. **CT** has received research funding from Biogen, Sanofi, and EMD Serono and was on advisory boards for Biogen, Genentech, Sanofi, EMD Serono, TG Therapeutics, and Atara. **ER** has received speaker honoraria from Alexion, Bristol Myers Squibb, and TG Therapeutics, and received research funding from EMD Serono, Roche, Novartis, Teva, Alexion, Bristol Myers Squibb, TG Therapeutics, Corvitas, and Sanofi. **GP** has received speaker honoraria and/or consulting fees from Alexion, Biogen Idec, Celgene/BMS, EMD Serono, Horizon/Amgen, Novartis, Roche/Genentech, Sanofi-Genzyme and TG Therapeutics; received research support (to the institution) from Abbvie, Adamas, Alkermes, Biogen Idec, EMD Serono, Roche/Genentech, Sanofi-Genzyme, Novartis, and Teva, and is on the advisory board for Progentec Diagnostics and Cadenza Bio. **LF** has received fees for consultancy and/or advisory board participation from Hoffmann La Roche, Genentech, EMD Serono, Sanofi, Horizon Therapeutics and TG Therapeutics; has received honoraria for participation in educational programs from Medscape, Inc and the MS Association of America; has received speaking honoraria from the MS Association of America, Genentech, and Merck; has received grant support from NIH/NINDS, PCORI, Genentech, Sanofi and EMD Serono through her institution. **EP** and **CC** are employees of EMD Serono, Boston, MA, USA. **JS** has received consulting fee from Biogen, Genentech, Teva, Banner, Sanofi, Cellgene. Has research contracted with National MS Society. **JC** has received Honoraria for education, consulting, and speaking fees from Biogen Inc., Bristol Myers Squibb Company, EMD Serono, Novartis Pharmaceuticals Corp, Sanofi, and TG Therapeutics Inc. **RZ** is a site investigator/principal investigator for clinical trials funded by Adamas, Biogen, Genentech, EMD Serono, Novartis, Sanofi, Sun Pharma and PCORI; has served as a consultant for Bayer, Biogen, Genentech, Celgene/BMS, Genzyme, EMD Serono, TEVA Neuroscience and TG Therapeutics; Has given unbranded lectures sponsored by TEVA Neuroscience, Novartis, Genentech, Sanofi and BMS in the last 5 years; Has served as a member of the Adjudication Committee for a clinical trial sponsored by Parexel and MedDay Pharmaceutical. **TR** received consulting fees from Biogen, EMD Serono, Alexion, TG Therapeutics. Research support to the institution EMD Serono, TG Therapeutics, Biogen, Novartis, UCB. **TL** is an employee of Octave Bioscience, Menlo Park, CA, USA and former employee of EMD Serono, Boston, MA, USA.

This work was sponsored by EMD Serono (CrossRef Funder ID: 10.13039/100004755).
Authors in italics are employees of EMD Serono.

The investigators would like to extend their heartfelt gratitude to all the participants who contributed to this study.

Scan for this presentation

BACKGROUND

Currently, there are few MS observational studies in North America that collect comprehensive longitudinal real-world PRO data

PROs are currently underutilized in MS research[1]:

- **They can be effectively leveraged alongside provider-reported data and healthcare utilization data**
- **PROs can enhance our understanding of MS disease activity, progression, and treatment**
- **The generalizability of findings from many real-world MS studies has been hampered by homogenous patient populations**

Reference: 1. English J et al., *Neurology*. 2023;100(17 Supplement 2)
MS, multiple sclerosis; PRO, patient-reported outcomes

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

OBJECTIVES

- **To describe the design of the MS-LINK™ outcomes study**
- **To present key socio-demographic characteristics of the study participants**
- **To provide an overview of the key provider- and patient-reported outcomes**
  - **Examine PROs longitudinally in a diverse cohort of people with MS**
  - **Investigate differences in PROs in subpopulations of interest, such as race and age**

MS, multiple sclerosis; PROs, patient-reported outcomes

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

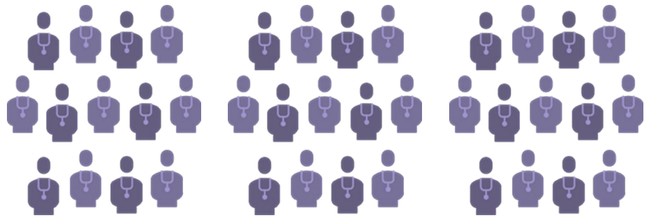
METHODS

MS-LINK™ Outcomes: Study Design

The MS-LINK Outcomes Study was a multi-center, prospective, longitudinal, observational, real-world data collection study focused on collection of PROs over approximately 3 years

1 Patients

≥2000 patients from 9 study sites across the USA



2 Core Data

A Core Data Set collected over 3 years, consisting of baseline patient characteristics and longitudinal clinical outcomes along with provider- and patient-reported outcomes

3 The OM1 Platform

MS-LINK™ partnered with OM1 to leverage their OM1 Origin™, Engine™ and AI technologies to facilitate the collection, processing and analysis of the collected dataset for the study

OM1

OM1 Origin™	OM1 Engine™	OM1 AI
Connecting & Sourcing Platform	Data Processing & Enrichment Platform	Advanced Analytics Personalization Platform

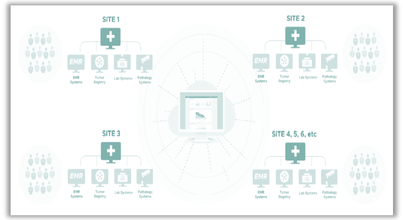
4 Data Analysis and Reporting

OM1's Platform allowed:

1. Patients and clinicians to view their collected data
2. Analyses of data to improve understanding of patient characteristics, treatments, and the outcomes that matter to patients and clinicians

5 Quality Improvement

Site level benchmarking to allow quality improvement and potential development of care pathways



AI, artificial intelligence; PRO, patient-reported outcomes; USA, United States of America

METHODS

Inclusion and Exclusion Criteria[1]

	Key inclusion criteria
✓	Aged ≥18 years of age diagnosed with MS, treated or untreated
✓	Provide complete PROs on a routine basis and report events of interest
✓	Willing to participate in additional follow-up at the site for ≥3 years

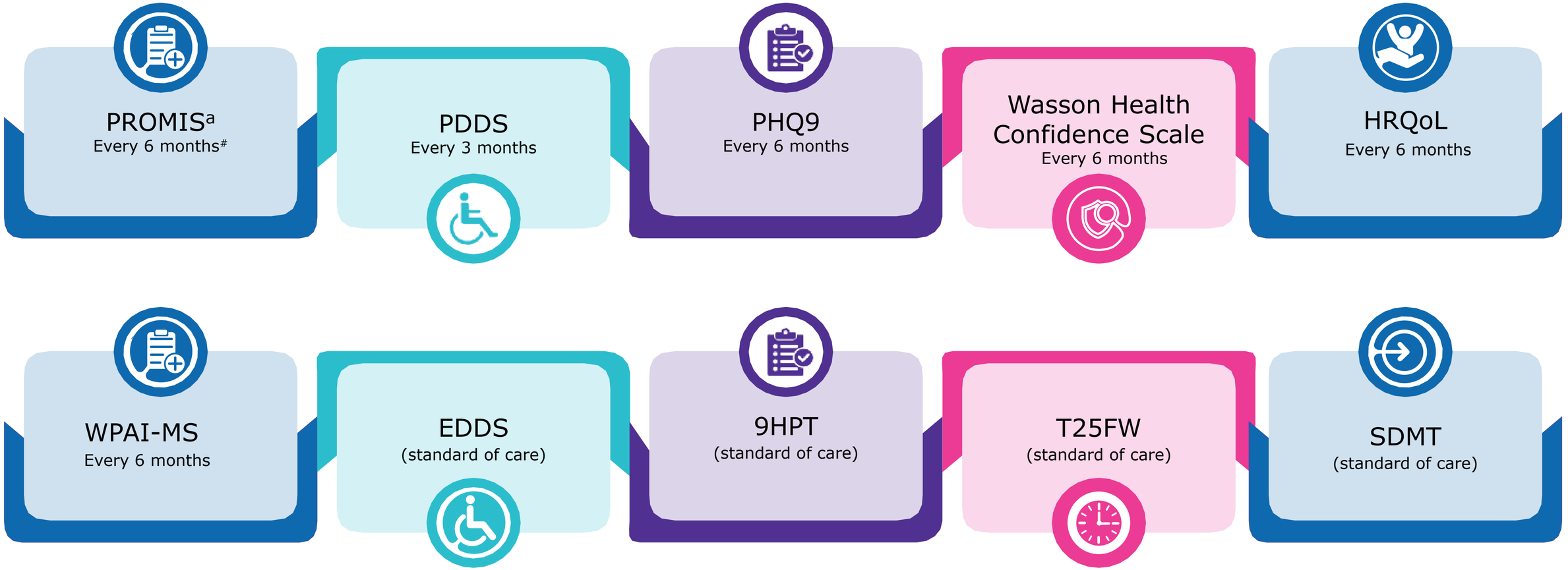
	Key exclusion criteria
×	Unable to complete questionnaires in English
×	Unable to consistently access the internet
×	Patients participating in interventional clinical drug trials at baseline

Reference: 1. https://clinicaltrials.gov/study/NCT04735406 (accessed March 23, 2025)
MS, multiple sclerosis; PROs, patient-reported outcomes

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

METHODS

PROs and clinical outcomes reported[1]



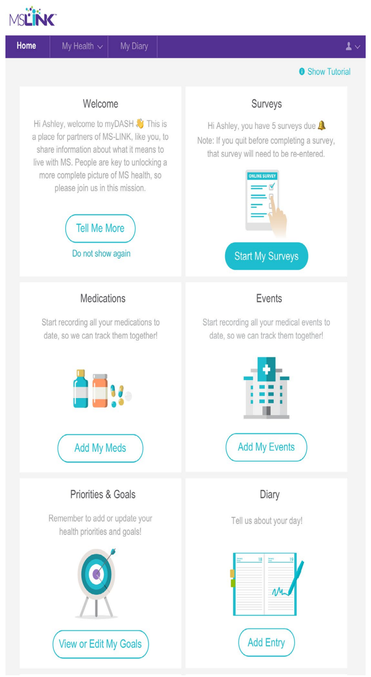
Reference: 1. https://clinicaltrials.gov/study/NCT04735406 (accessed March 23, 2025); [a]PROMIS - fatigue, physical function, anxiety, cognitive function; [#]To limit the burden on patients, PROs were collected approximately every 6 months in a staggered fashion; 9HPT, 9-hole peg test; EDSS, expanded disability status scale; HRQoL, health-related quality of life; MS, multiple sclerosis; PDDS, patient determined disease steps; PHQ9, patient health questionnaire-9; PROs, patient-reported outcomes; PROMIS, patient-reported outcome measurement information system; SDMT, symbol digit modalities test; T25FW, timed 25-foot walk; WPAI-MS, work productivity and activity impairment questionnaire

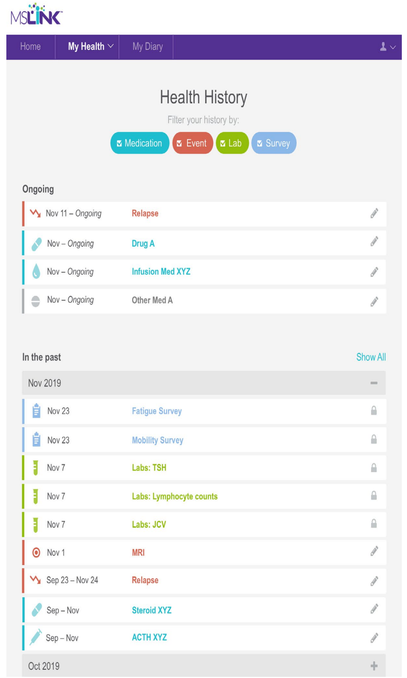
Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

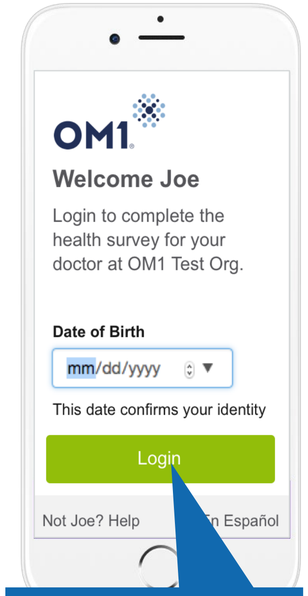
METHODS

myDASH: PROs & Functionality

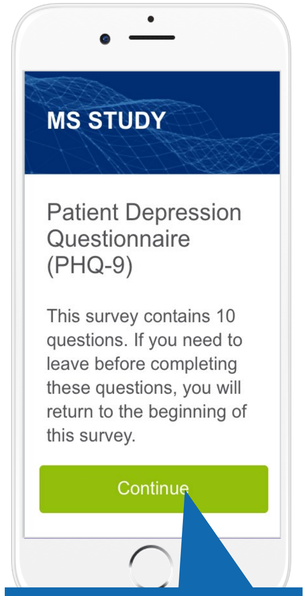
- Patient-reported data are collected through OM1's MS-LINK Patient Portal – myDASH (ex: PROs, medications, events of interest)
- Provider-reported data are collected via the OM1 Origin™ technology by manual entry via OM1 Provider Portal or via EMR extraction
- 4 sites participated in the EMR integration, and 5 sites entered data manually



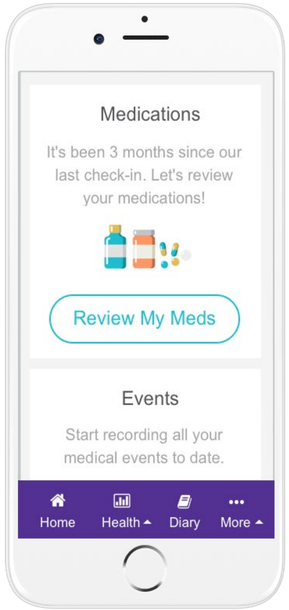


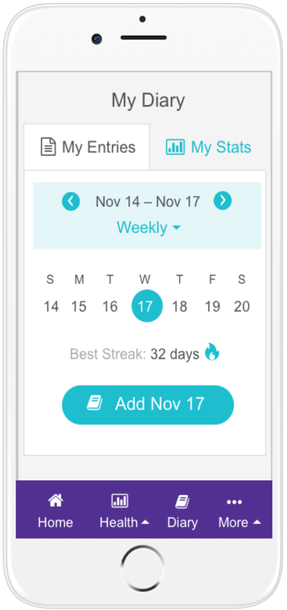


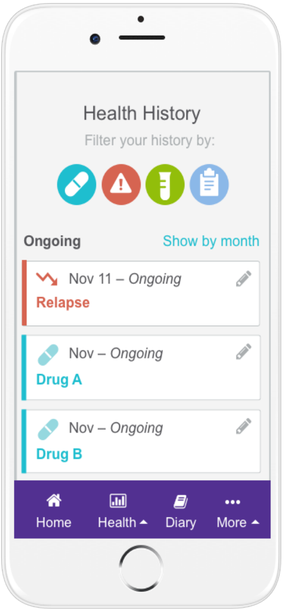
Sent to patients via email and/or text message on a staggered schedule (baseline, 3, 6, 12 months)



PRO examples include:
- PDDS
- PROMIS Fatigue MS
- PHQ-9





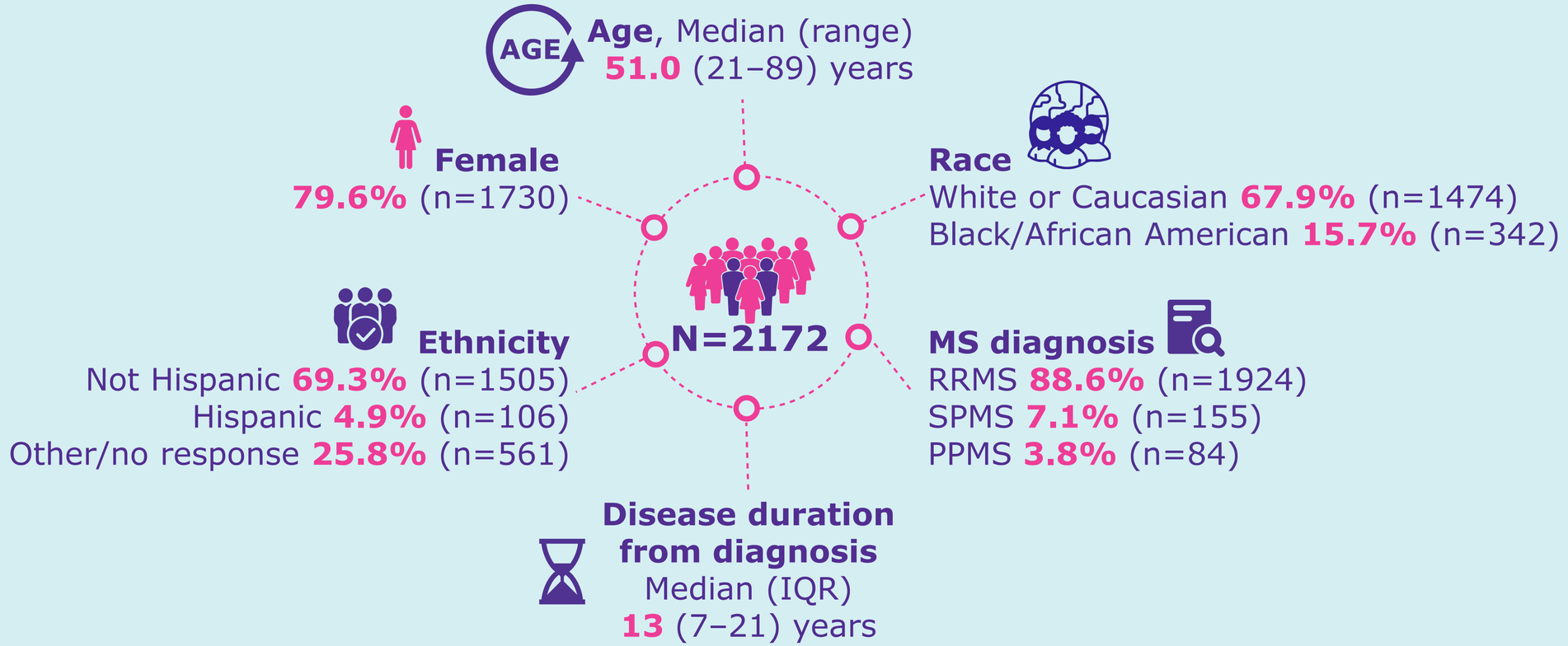


EMR, electronic medical record; PRO, patient-reported outcomes

RESULTS

Baseline characteristics

Key sociodemographic characteristics at baseline



- The study population was socio-demographically diverse in terms of age, race, and ethnicity

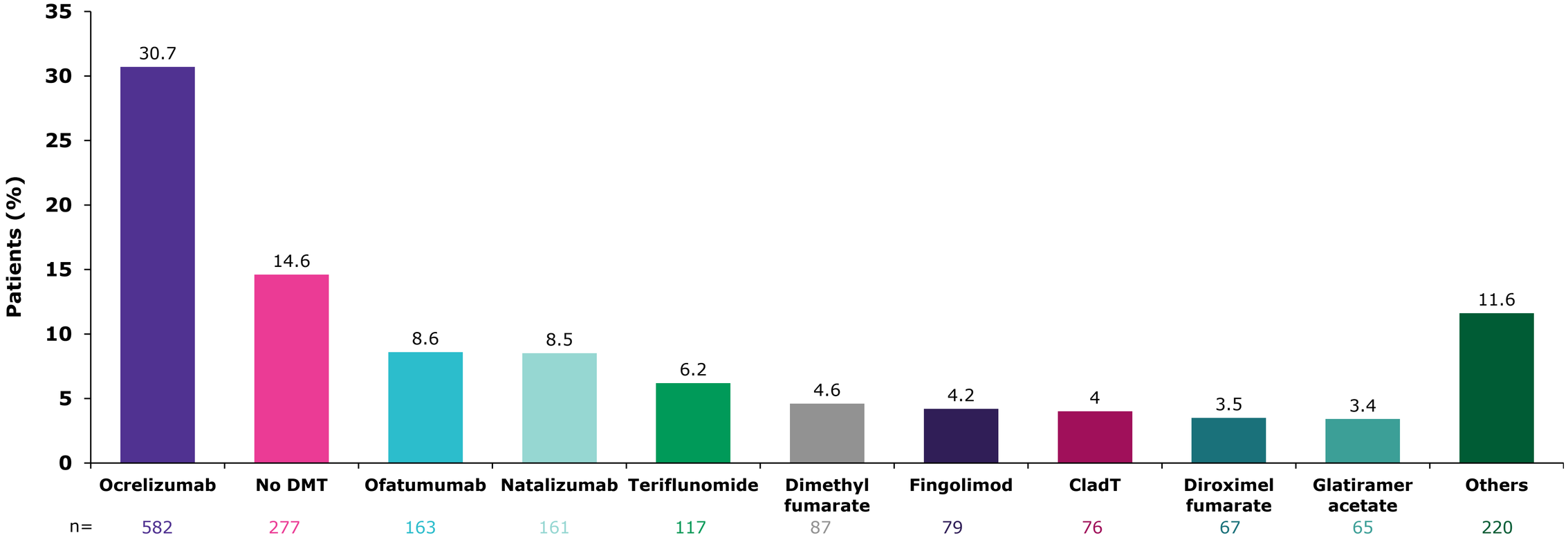
DMT, disease-modifying therapy; IQR, interquartile range; MS, multiple sclerosis; PPMS, primary progressive multiple sclerosis; PRMS, progressive relapsing multiple sclerosis; RRMS, relapsing–remitting multiple sclerosis; SPMS, secondary progressive multiple sclerosis

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS

Baseline characteristics

Use of DMTs at baseline[a] (N=1894)

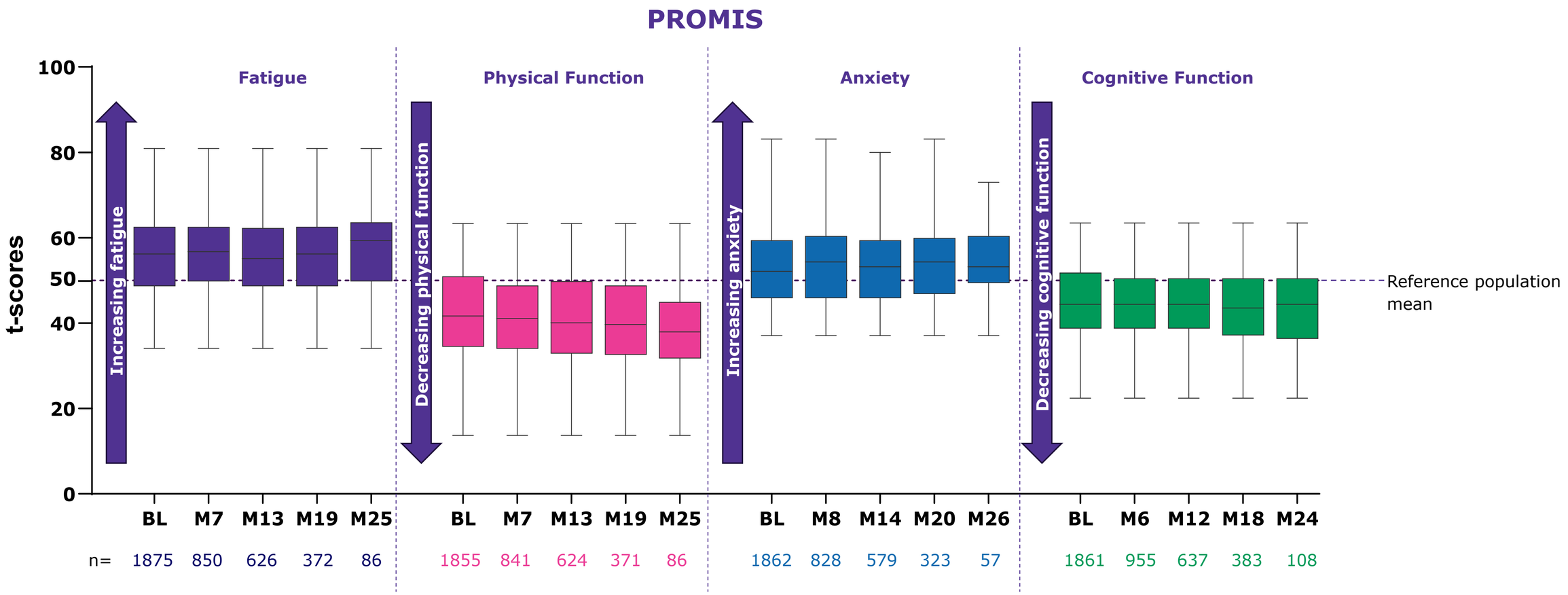


- Approximately 85% of patients reported using a DMT at baseline; infusion therapies were most frequently used

[a]As reported by provider when available, otherwise self-reported by patient; DMT use presented here includes, 10 most common DMTs (including no DMT) used in this cohort.
CladT, cladribine tablets; DMT, disease-modifying therapy; MS, multiple sclerosis

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS — Key longitudinal PROs over time – Overall cohort



- PROMIS – fatigue, physical function, anxiety, and cognitive function scores remained stable over time

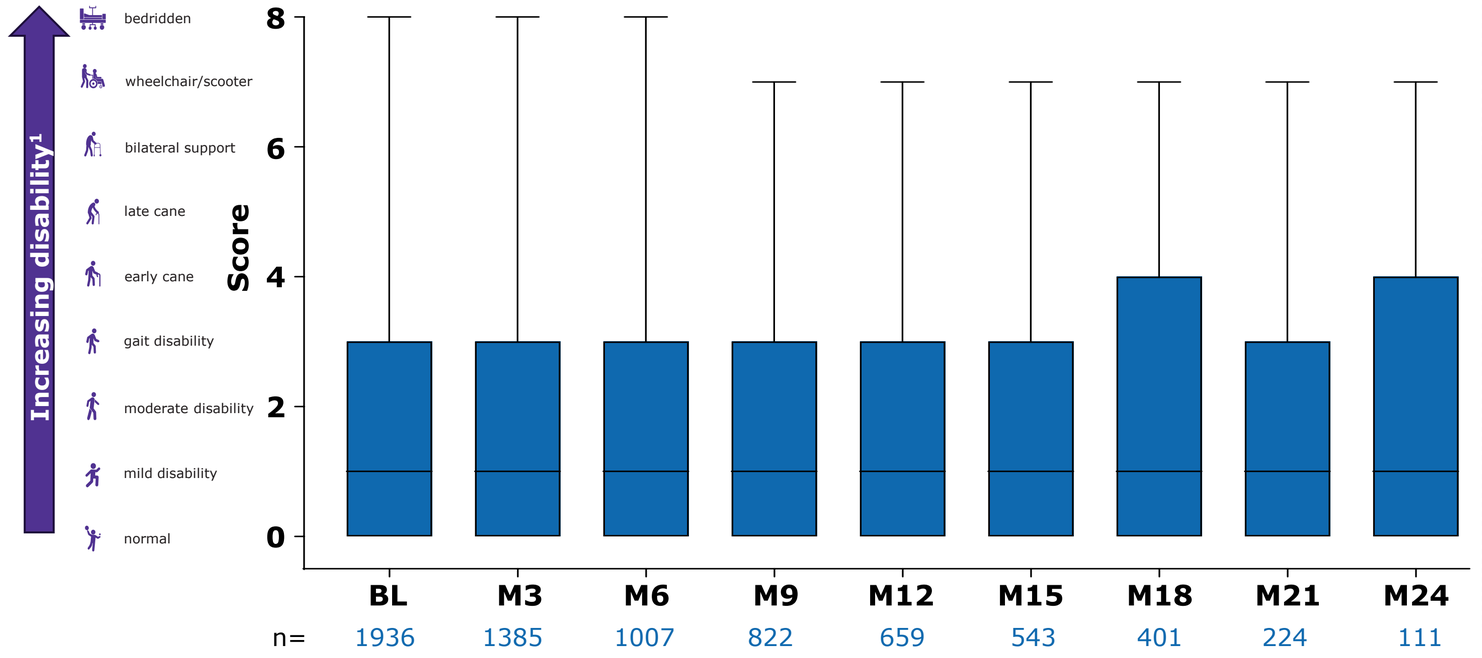
Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. Higher t-scores indicates more fatigue/physical function/anxiety/cognitive function.
BL, baseline; M, collection timepoint in months; MS, multiple sclerosis; PROs, patient-reported outcomes; PROMIS, patient-reported outcome measurement information system

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

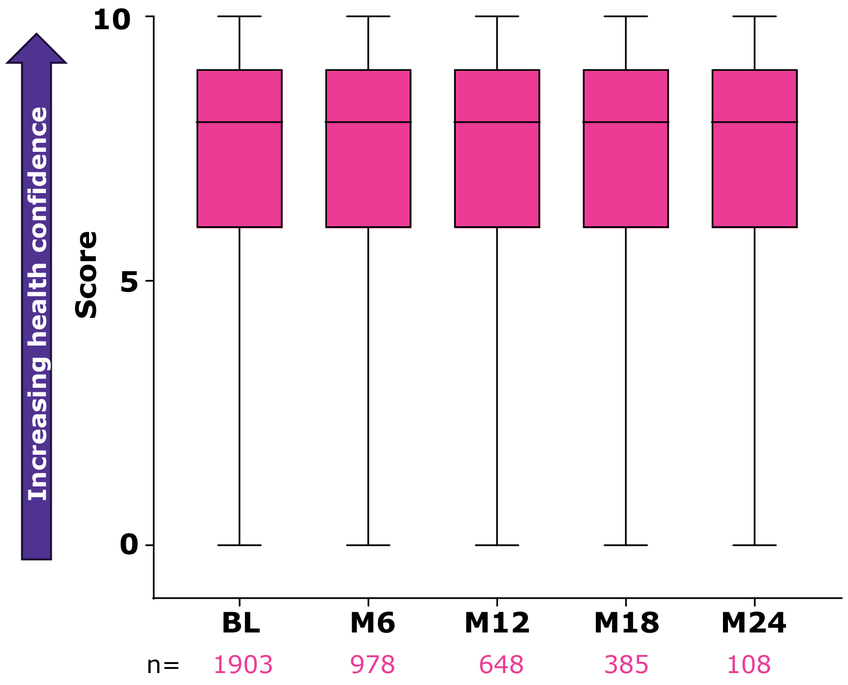
RESULTS

Key longitudinal PROs over time – Overall cohort

PDDS



Wasson Health Confidence Scale



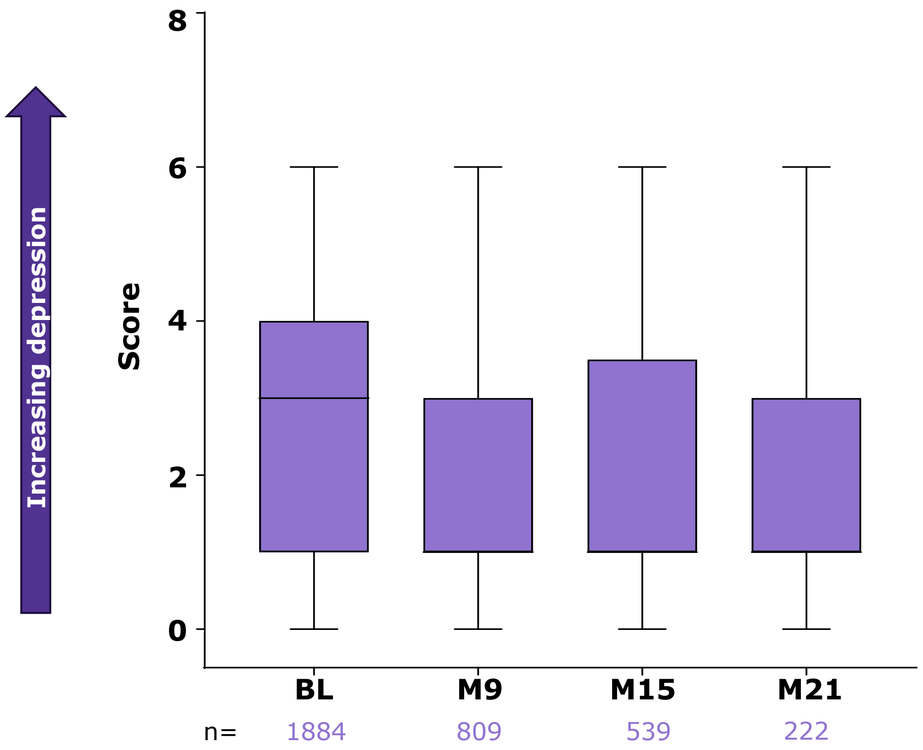
- Overall, PDDS and Wasson Health Confidence Scale scores remained relatively stable over time

Reference: 1. Fox RJ et al. *Int J MS Care*. 2013;15(4):194–201. Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. Higher PDDS scores indicate greater disability. Wasson Health Confidence Scale: 0 (not confident at all) to 10 (very confident).
PDDS scores: 0 (normal), 1 (mild disability), 2 (moderate disability), 3 (gait disability), 4 (early cane), 5 (late cane), 6 (bilateral support), 7 (wheelchair/scooter), 8 (bedridden).
BL, baseline; M, collection timepoint in months; PDDS, patient determined disease steps; PROs, patient-reported outcomes

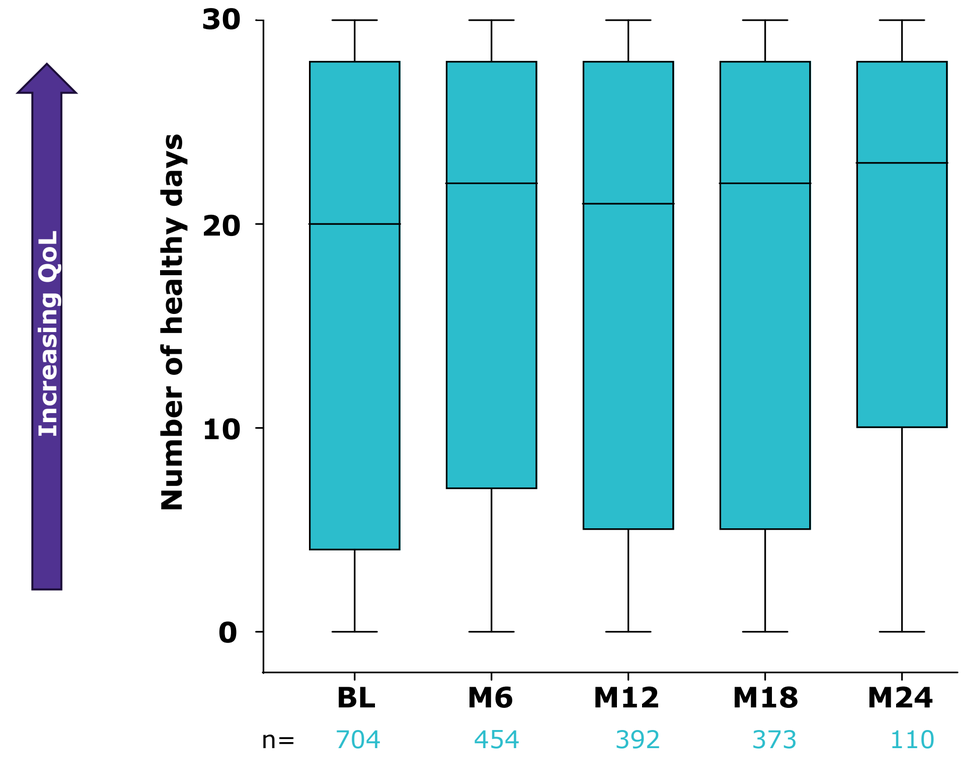
Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS — Key longitudinal PROs over time – Overall cohort

PHQ9 depression scale



HRQoL healthy days[a]



- Overall, PHQ9 and HRQoL scores remained relatively stable over time

[a]Days in the past 30 days when both physical and mental health were good.
Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. PHQ-9 depression severity: 0-4 (no or minimal), 5-9 (mild), 10-14 (moderate), 15-19 (moderately severe), 20-27 (severe).
BL, baseline; M, collection timepoint in months; HRQoL, health-related quality of life; PHQ9, patient health questionnaire-9; PROs, patient-reported outcomes

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS

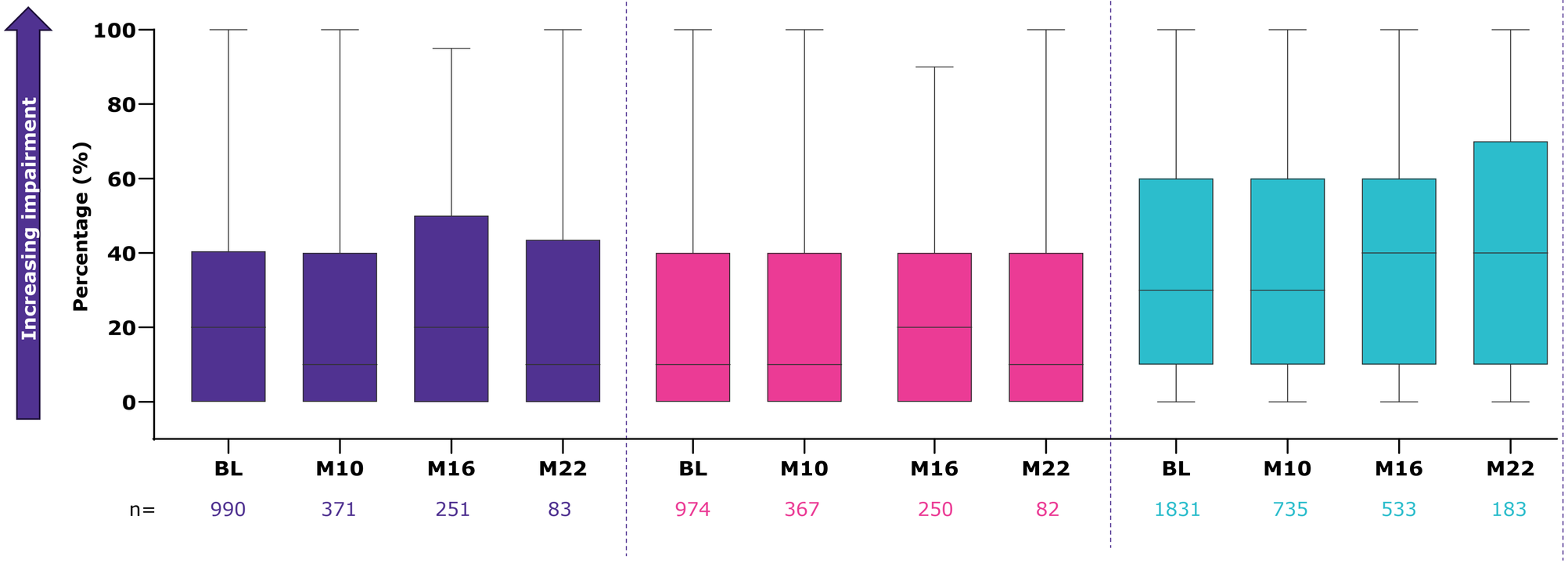
Key longitudinal PROs over time – Overall cohort

Work productivity and activity impairment (WPAI)

Overall impairment

Impairment while working

Activity impairment



Work time missed

Percentage (%)		
Time point	n	Mean (SD)
BL	990	5.87 (16.76)
M10	371	6.33 (17.78)
M16	251	5.35 (14.26)
M22	83	4.05 (10.71)

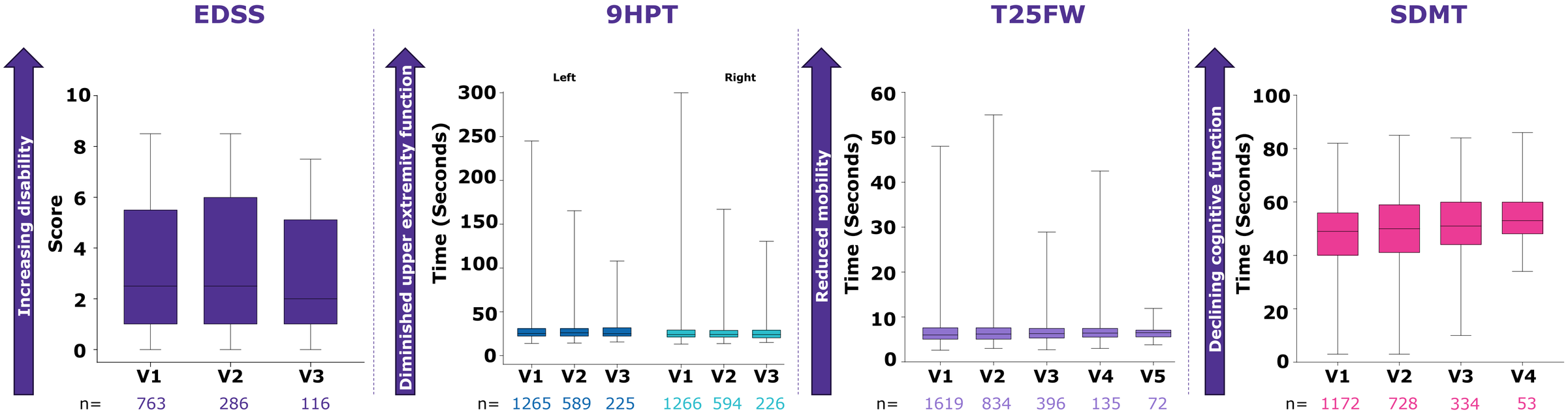
Data were collected on the hours missed from work in the past 7 days due to health impairment. Work time missed is calculated as a percentage of total hours worked.

- Approximately half of the overall cohort remained employed throughout the study duration. Impairment while working and activity impairment were stable over time

Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. A higher WPAI score indicates greater work productivity loss.
BL, baseline; M, collection timepoint in months; MS, multiple sclerosis; PROs, patient-reported outcomes; SD, standard deviation; WPAI, work productivity and activity impairment

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS – Key longitudinal clinical measures over time – Overall cohort



- Clinical measures remained stable over time

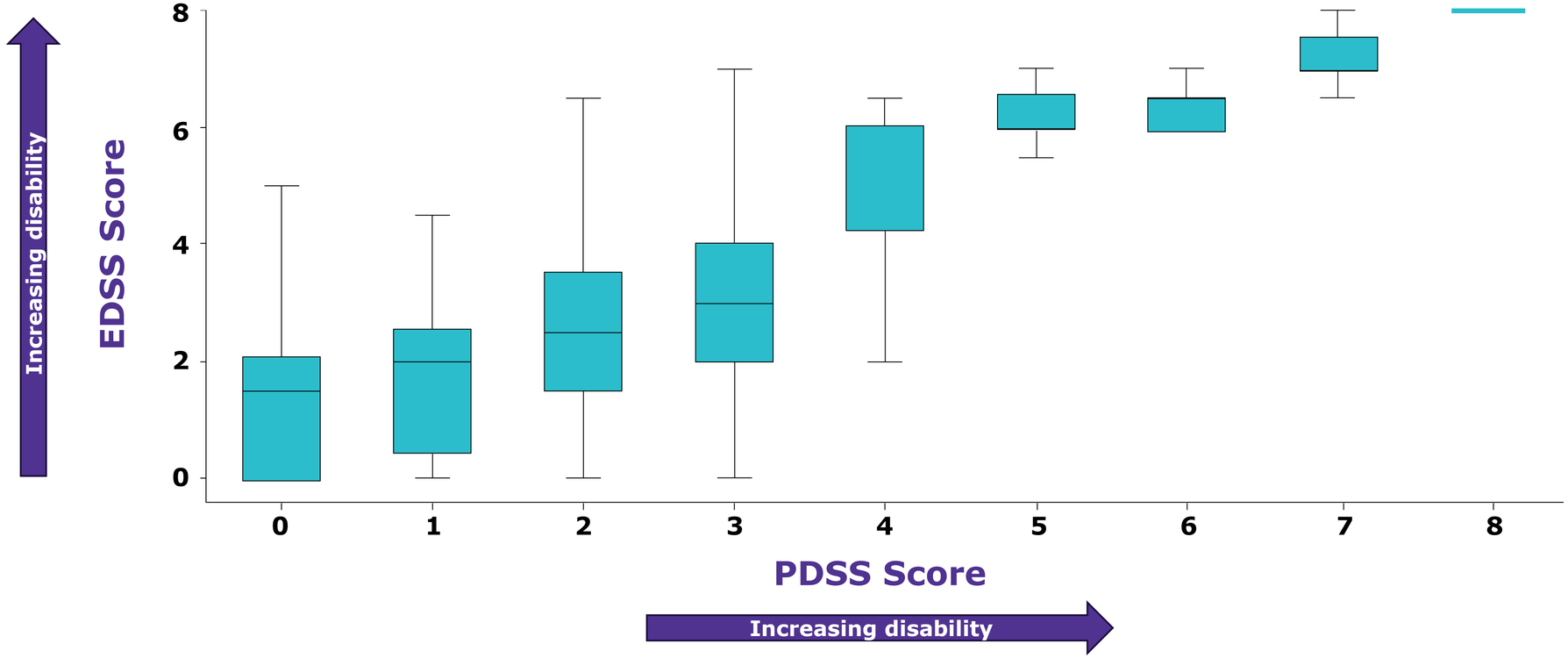
Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. EDSS: 0 (normal neurological examination) to 10 (MS-related death). 9HPT: A higher score (longer time) generally indicates a greater degree of manual dexterity impairment. T25FW: Lower scores (shorter time) indicate faster walking speed and better functional ability, while higher scores (longer time) suggest slower walking and greater disability. SDMT: Lower scores generally indicate cognitive decline, particularly information processing speed.
9HPT, 9-hole peg test; EDSS, Expanded Disability Status Scale; SDMT, symbol digit modalities test; T25FW, timed 25-foot walk; V, visit number

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS

Correlation between EDSS vs PDSS scores

Spearman correlation coefficient: 0.73, $p < 0.005$



- A positive correlation (0.73) was observed between the PDDS scores and EDDS scores

Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. EDSS: 0 (normal neurological examination) to 10 (MS-related death).
PDDS scores: 0 (normal), 1 (mild disability), 2 (moderate disability), 3 (gait disability), 4 (early cane), 5 (late cane), 6 (bilateral support), 7 (wheelchair/scooter), 8 (bedridden).
BL, baseline; EDSS, Expanded Disability Status Scale; M, collection timepoint in months; PDDS, patient determined disease steps; PROs, patient-reported outcomes; V, visit number

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

Subgroup analysis by race

(White or Caucasian vs. Black or African American)

RESULTS

WPAI over time by race

White or Caucasian vs. Black or African American

White or Caucasian Black or African American

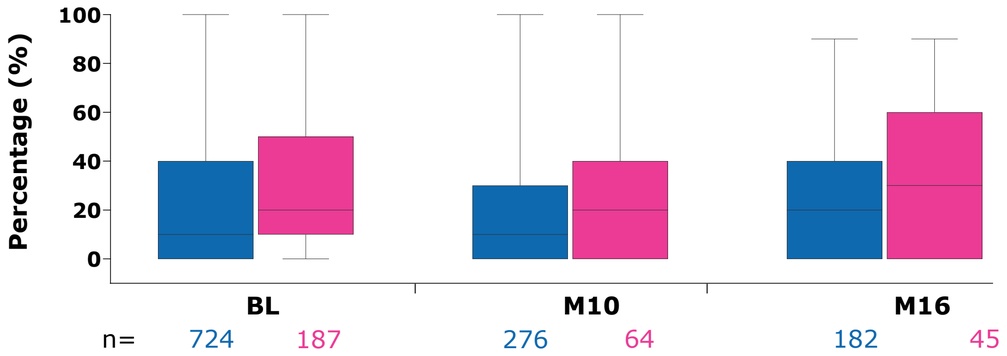
Work time missed

Time point	Percentage (%)					
	White or Caucasian			Black or African American		
	n	Mean	SD	n	Mean	SD
BL	735	5.05	15.42	192	9.28	21.70
M10	279	5.69	16.69	65	9.29	20.94
M16	183	4.40	13.25	45	10.27	18.78

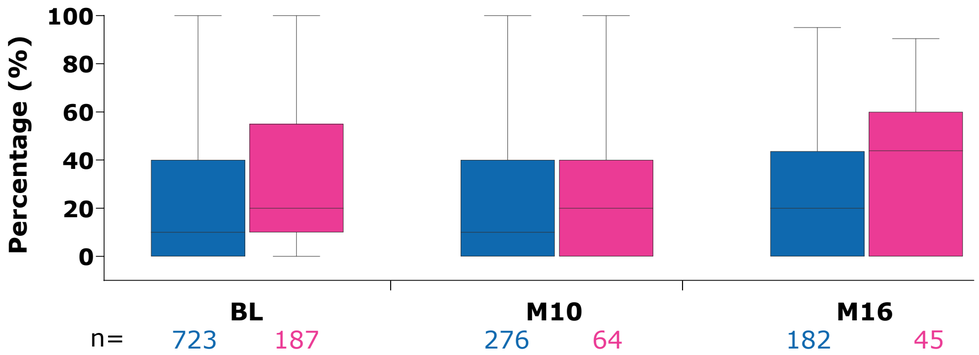
Data were collected on the hours missed from work in the past 7 days due to health impairment. Work time missed is calculated as a percentage of total hours worked.

Increasing impairment

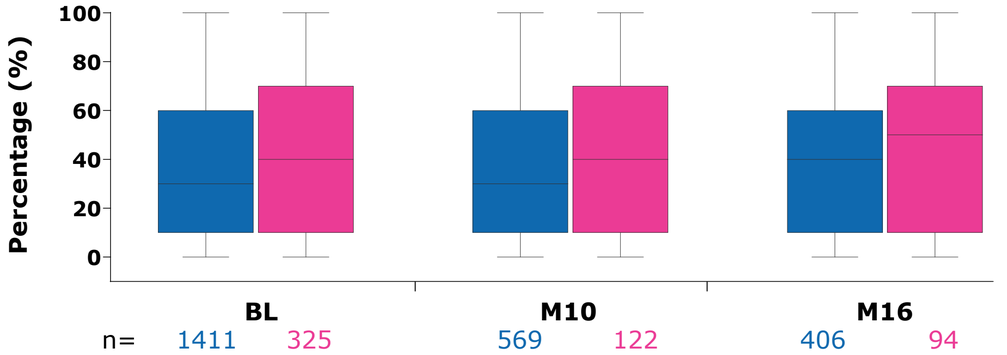
Impairment while working



Overall work impairment



Activity impairment



- Overall, Black/African American patients reported higher work time missed, greater impairment while working, increased overall work impairment, and higher activity impairment compared with White/Caucasian patients

Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. A higher WPAI score indicates greater work productivity loss.
BL, baseline; M, collection timepoint in months; WPAI, work productivity and activity impairment

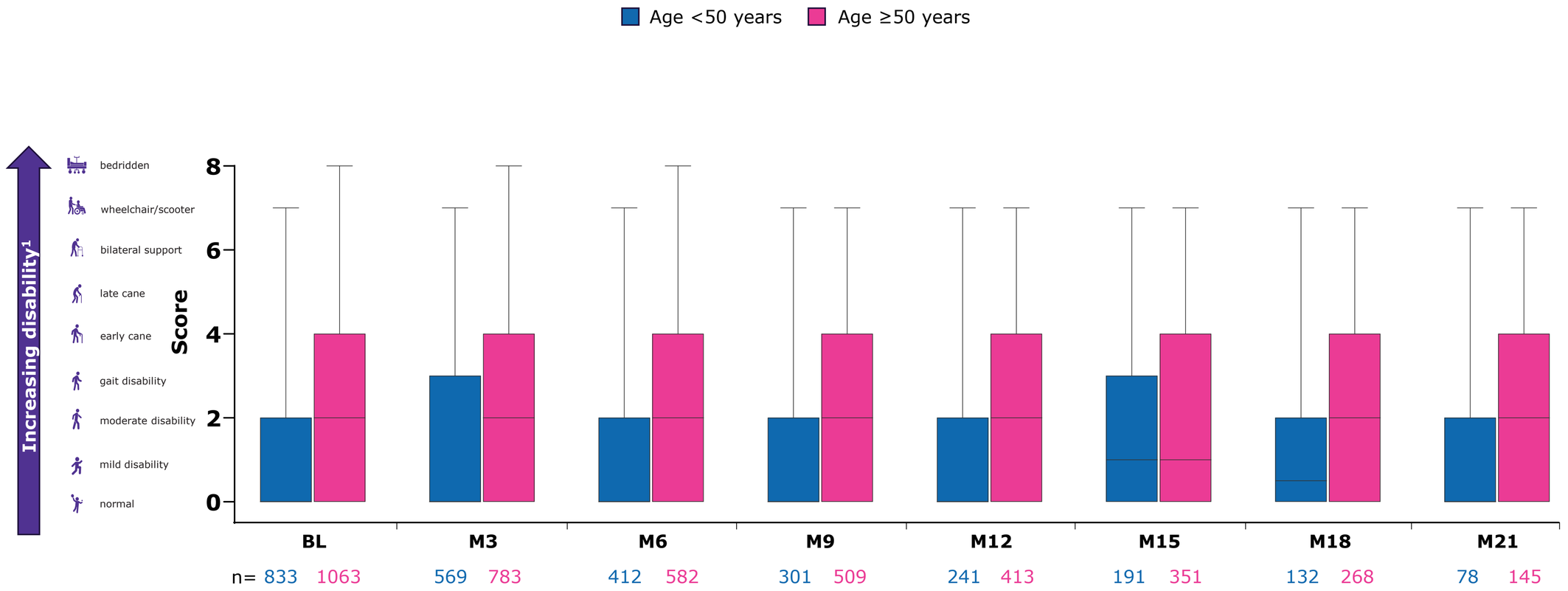
Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

Subgroup analysis by age

(Age <50 years vs. ≥50 years)

RESULTS

PDDS over time by age (<50 vs. ≥50 years)



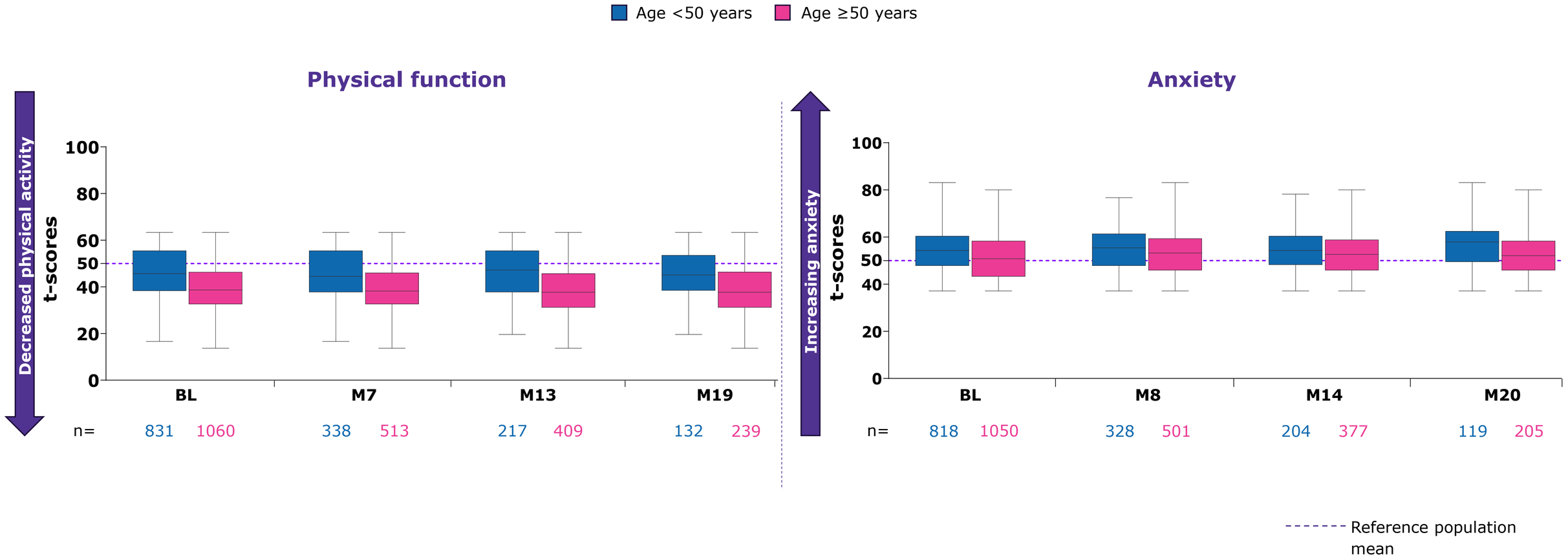
- Overall, patients aged ≥50 years had higher PDDS scores compared with those <50 years old

Reference: 1. Fox RJ et al. *Int J MS Care.* 2013;15(4):194–201. Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. Higher PDDS scores indicate greater disability.
BL, baseline; M, collection timepoint in months; PDDS, patient determined disease steps

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS

PROMIS over time by age (<50 vs. ≥50 years)



- Overall, patients aged <50 years exhibited better physical function but also reported slightly higher levels of anxiety compared with those aged ≥50 years

Graph: The central box represents the interquartile range, while the central line indicates the median value. The whiskers denote the minimum and maximum values. Higher t-scores indicates more physical function/anxiety.
BL, baseline; M, collection timepoint in months; PROMIS, patient-reported outcome measurement information system

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

RESULTS

Subgroup analysis by race (White or Caucasian vs. Black or African American)

- Other longitudinal PROs, including components of PROMIS, PDDS, WHCS, PHQ9, HRQoL, and clinical measures, showed similar trends over time between White or Caucasian and Black or African American participants with MS

Subgroup analysis by age (<50 years vs. ≥50 years)

- Other longitudinal PROs and clinical measures also provided comparable results across age subgroups over time

HRQoL, health-related quality of life; MS, multiple sclerosis; PDDS, patient determined disease steps; PHQ9, patient health questionnaire-9; PROs, patient-reported outcomes; PROMIS, patient-reported outcome measurement information system
WHCS, Wasson health confidence scale

Presented at CMSC Annual Meeting | 28-31 May 2025 | Phoenix, Arizona

CONCLUSIONS

- The MS-LINK™ Outcomes study utilized a decentralized trial approach.
- The use of digital dashboards in the patient and provider portals provided real-time tracking of outcomes and a comprehensive view of the patient experience.
- Patients and providers were able to utilize up-to-date monitoring in clinical or personal settings.
- The diverse patient population improved the generalizability of study findings and facilitated subgroup analyses.