

Cluster Analysis to Identify Frailty Profiles in Individuals with Chronic Neurological Diseases: A Strategy Focused on Access to Health and Social Care Services in People with Multiple Sclerosis

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INTRODUCTION

Multiple sclerosis (MS) is an autoimmune neurological disease, and the leading cause of neurological disability in adults. In Italy, 140,000 people were affected in 2024, with 3,600 new cases each year [1]. MS impacts patients' physical, psychological, social, and economic well-being, leading to multifaceted care that includes disease-modifying drugs (DMDs), symptomatic therapies, and rehabilitation [2]. The most common form is relapsing-remitting MS, which can progress to secondary progressive MS over time. Around 15% of patients have primary progressive MS from the onset, for which treatment options are limited. Initially, patients are referred to neurological services for diagnosis and DMD treatment. Still, many, especially those in the progression phase, are no longer followed by clinical centers as the disease progresses and DMDs become less effective [3]. These subjects often present severe forms of the disease and have a significant need for personal care and support, which the Italian system generally struggles to provide [4]. They are at risk of receiving suboptimal health care (sporadic access to a neurologist), and little, if any, multidisciplinary management is provided for their symptoms.

Knowing the accessibility of health and social health services that can meet the needs of people with MS is an important element because it is an indirect indicator of the health system's ability to coordinate and personalize care for people with MS for all phases of their disease.

This study aimed to use cluster analysis to identify relevant subgroups based on the accessibility and satisfaction of health and social care services that meet the needs.

METHODS

Data were obtained from a national cross-sectional study conducted by the Italian Multiple Sclerosis Foundation in 2024, which investigated health and social care needs, including the use and satisfaction of local services.

The following variables were used to study the cluster profiles in the sample: Integrated Care Experience Scale; distance from health, basic necessities and transport services; adequacy of health services on your territory for your needs; completeness of care of symptoms and comorbidities by health specialists; knowledge of MS by non-specialised MS health professionals; MS knowledge by social service workers; level of knowledge of the functioning of and access to social and health services; ability of the clinical centre to refer to specialists for MS symptom management and comorbidities; capacity of the clinical centre to orientate towards rehabilitation services. All variables are based on a Likert scale. Min-max normalization was applied to rescale continuous variables to a 0–1 range. All observations with missing values were excluded, resulting in a final sample of $N = 7,419$.

To reduce dimensionality, we applied ISOMAP, as the data were not standardized, and to capture potential non-linear structures. We selected 5 components, as they jointly explained 85% of the total variance, based on a preliminary Principal Component Analysis (PCA).

Subsequently, we performed clustering using the Density-Based Spatial Clustering of Applications with Noise (DB-SCAN) algorithm [5]. This method is suitable for identifying non-spherical clusters, automatically estimates the optimal number of clusters, and handles outliers effectively.

We performed a grid search to optimize the neighborhood radius (ϵ) and the minimum number of points (minPts) for clustering. We selected configurations with a silhouette score > 0.5 , 2–5 clusters for meaningful and interpretable segmentation, and $< 25\%$ outliers to prevent excessive data loss.

The final parameters were $\epsilon=0.54$ and $\text{minPts}=19$.

Differences between profiles in terms of sociodemographic and clinical characteristics were analyzed using the χ^2 test for categorical variables and the ANOVA test for continuous variables. Statistical significance was set at $\alpha = 0.05$. When ANOVA test yielded significant results, Bonferroni post-hoc comparisons were conducted. Cluster analysis was performed with MATLAB 2024b.

RESULTS

Five clusters, including 7,188 subjects, were identified; DB-SCAN failed to assign 231 individuals to any dense region, and they were therefore categorized as outliers (cluster -1) and removed.

These five distinct profiles reflected varying levels of access and satisfaction with health and social care services in relation to individual needs. They were categorized as follows (Fig.1):

- Low access and poor satisfaction with services received (19.6%);
- Low to moderate access, with more complete health services received for the management of symptoms and comorbidities (32.7%);
- Moderate access, with better perceived adequacy of health services (3.6%);
- Fair access, with good perceived adequacy and completeness of services for managing symptoms and comorbidities (7.6%);
- Sufficient access, meeting basic health and social care needs (36.6%).

Each cluster demonstrated different demographic and clinical patterns, delineating distinct types of service access. Notably, profile 1 included individuals with MS who were older, lived mainly in the south/islands, had a lower educational level, a longer disease duration, higher levels of disability, less use of DMD, and reported more comorbidities. This finding lends support to the hypothesis that individuals affected by more severe forms of the disease and greater care demands frequently face unmet needs, in part due to systemic limitations within the Italian healthcare system.

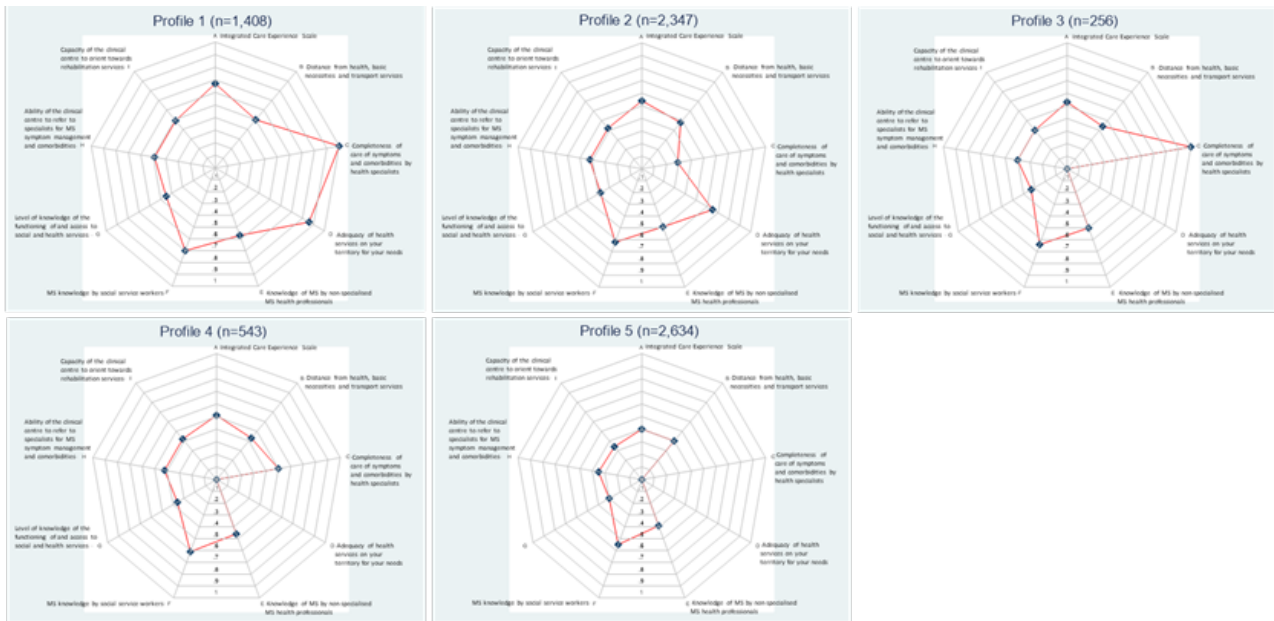
CONCLUSION

Identifying the accessibility profile of services is useful because it could address the health system across targeted care management strategies. This is important in order to save costs and improve the effectiveness of services for groups with different care needs.

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Figure 1. Radar plots displaying rescaled mean values for each profile. Each plot illustrates the mean values of variables within a profile, with all axes scaled to the [0, 1] interval



A) Integrated Care Experience Scale; B) Distance from health, basic necessities and transport services; C) Completeness of care of symptoms and comorbidities by health specialists; D) Adequacy of health services on your territory for your needs; E) Knowledge of MS by non-specialised MS health professionals; F) MS knowledge by social service workers; G) Level of knowledge of the functioning of and access to social and health services; H) Ability of the clinical centre to refer to specialists for MS symptom management and comorbidities; I) Capacity of the clinical centre to orient towards rehabilitation services